

# Dynamic Pricing for Urban Parking Lots - Final Report

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## 1. Project Overview

This project simulates real-time dynamic pricing for 14 urban parking lots using real-world data on occupancy, queue lengths, traffic conditions, and vehicle types. The goal is to intelligently adjust prices to reduce overcrowding and optimize space utilization. We implemented three models of increasing complexity, starting from a simple linear logic to a competitive, location-aware strategy.

## 2. Tech Stack

- Python (Pandas, NumPy)
- Pathway (Real-time data simulation)
- Bokeh (Visualizations)
- Mermaid (Architecture diagrams)

## 3. Project Architecture

The architecture follows a stream-based design. Real-time data is streamed into the system using Pathway, processed with feature engineering, and passed through 3 pricing models. Results are visualized with Bokeh.

## 4. Model Descriptions

### Model 1: Baseline Linear Pricing

$$Price = PreviousPrice + \alpha * \frac{Occupancy}{Capacity}$$

Price = PreviousPrice + alpha \* (Occupancy / Capacity)

### Model 2: Demand-Based Pricing

Demand =  $\alpha \cdot (Capacity \cdot Occupancy) + \beta \cdot Queue - \gamma \cdot Traffic + \delta \cdot SpecialDay + \epsilon \cdot VehicleTypeWeight$

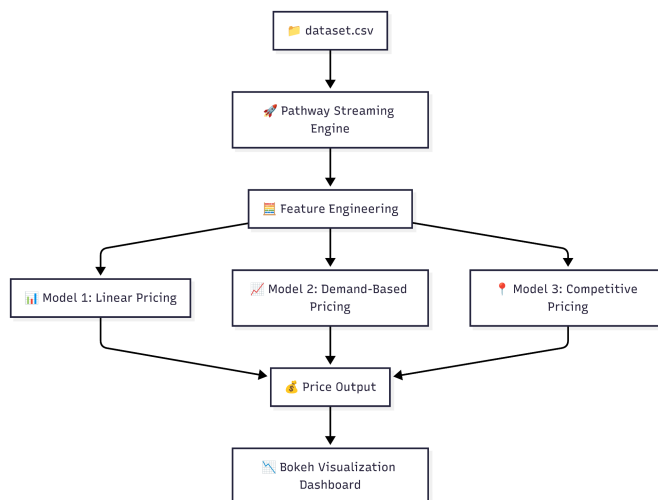
$$Demand = \alpha \cdot \left( \frac{Capacity}{Occupancy} \right) + \beta(Queue) - \gamma(Traffic) + \delta(SpecialDay) + \epsilon(VehicleTypeWeight)$$

### Model 3: Competitive Pricing

Uses haversine distance to detect nearby lots and competitor prices.

## 5. Visualizations

- Time-varying prices for each lot
- Model-wise price comparisons
- Interactive Bokeh dashboard



## 6. Assumptions

- Occupancy drives demand
- Queue reflects unmet demand
- Traffic reduces desirability
- Vehicle weights: car=1.0, bike=0.6, truck=1.5
- Competitor lots are within 1 km

## 7. Final Notes

- Notebook runs end-to-end
- Follows folder structure and documentation guidelines
- Fully commented code and clean output

## Thank You

This system can be a foundation for smart urban parking strategies.