# **Parking Price Optimization Report**

## **Overview**

This report presents a real-time dynamic pricing system for a parking lot based on live demand signals processed using **Pathway**, a real-time data streaming framework. The model adjusts prices intelligently by analyzing occupancy levels over time, combined with location-specific behavior per parking lot.

Data is ingested as a stream (simulated via CSV) and visualized using **Bokeh** in an interactive dashboard. This end-to-end system reflects how a smart parking infrastructure could adapt pricing in real time to optimize usage and revenue.

## **1. Demand Function**

### **Objective**

The objective is to respond to real-time utilization at each parking lot by adjusting prices in a way that:

* Discourages overcrowding during high demand
* Encourages usage during low demand
* Maintains competitiveness in a multi-lot environment

### **Factors Considered**

Your current notebook incorporates the following factors:

|  |  |
| --- | --- |
| **Feature** | **Role** |
| Occupancy Rate | Core metric (Occupancy / Capacity) that defines demand |
| Lot Location | Used to uniquely identify and simulate per-lot pricing |
| Time of Day | Implicitly considered by time-series modeling |
| Competition | Not modeled explicitly yet (can be extended) |

### **Actual Demand Function Used**

Instead of a single demand score, the notebook uses a reactive pricing function that adapts over time:

This logic responds smoothly to utilization changes while keeping prices stable.

## **2. Assumptions**

The implementation operates under the following assumptions:

|  |  |
| --- | --- |
| **Assumption** | **Justification** |
| Occupancy is a proxy for demand | Real-time utilization gives a live estimate of congestion |
| User responsiveness is limited | Gradual price shifts prevent volatility |
| All lots are independent | No interaction of traffic or pricing between lots |
| Competitor pricing is unavailable | Assumed to be fixed or unavailable — placeholder logic for extension |

These assumptions balance simulation realism with computational simplicity.

## **3. Price Response Logic**

Your notebook uses a per-lot loop to simulate price changes, stored for visualization.

### **Logic Summary**

**Case 1: High Demand (Utilization > 0.6)**

* Increase price slightly:

**Case 2: Low Demand (Utilization ≤ 0.6)**

* Decrease price slightly:

**Additional Constraints**:

* Prices are clamped to a range of [10, 20]
* Prices are updated per time step and per parking lot (identified by latitude and longitude)

This mechanism ensures stable and explainable price movements across varying demand levels.

## **4. Visual Insights**

The notebook provides an interactive Bokeh plot featuring:

* Dynamic price trajectories per lot over time
* Hover tooltips showing timestamp, price, utilization, and lot ID
* Color-coded lines for easy visual comparison

This allows operators to:

* Identify pricing trends across different locations
* Detect over- or under-utilized lots
* Evaluate the effectiveness of real-time pricing strategies

## **Future Enhancements**

|  |  |
| --- | --- |
| **Feature** | **Description** |
| Competitor Pricing | Integrate real or simulated data from nearby lots |
| Elasticity Modeling | Track how price changes affect future occupancy |
| Event-Based Adjustments | Consider weather, holidays, and traffic congestion |
| Revenue Optimization | Optimize for total revenue, not just occupancy levels |

These additions would enhance realism and make the model enterprise-ready for smart city integration.

## **Conclusion**

Your dynamic pricing system demonstrates a fully functional simulation of a smart parking backend that:

* Reacts in real time to changing demand
* Adjusts prices per location over time
* Provides visual insights for operators
* Lays the foundation for more advanced strategies

With Pathway powering the real-time data flow and Bokeh providing interactive plots, this pipeline is well-suited for scalable, real-world deployment.