Capstone Project Report: Dynamic Parking Pricing using Pathway

1. Project Overview:

This project demonstrates a dynamic pricing system for urban parking lots using the Pathway. The goal is to adjust parking prices in real time based on demand-related factors such as occupancy levels, queue length, local traffic conditions, vehicle type, and special days/events.

I developed two pricing models:

- Baseline Linear Model: A simple linear model based on occupancy rate.
- Demand Based Model: A multi-factor pricing strategy using demand function.

The system was tested on historical data and designed to run in streaming mode for real-time deployment.

2. Data Ingestion and Processing:

NOTE: Okay so this is the part where my project is different from the actual idea. So the problem statement said to inject the data streamed with delay and then calculate the prices in real time using the models developed and emitting price predictions continuously. But I was unable to do the real time data-streaming even though I tried to follow the sample notebook step-by-step. Hence, I ingested the data on static mode but the actual calculation is done for each row (can say that it works real-time) and outputs the pricing.

Also before starting the model development, I did EDA to later decide on demand function.

3. Baseline Linear Model :

The model that I used is –

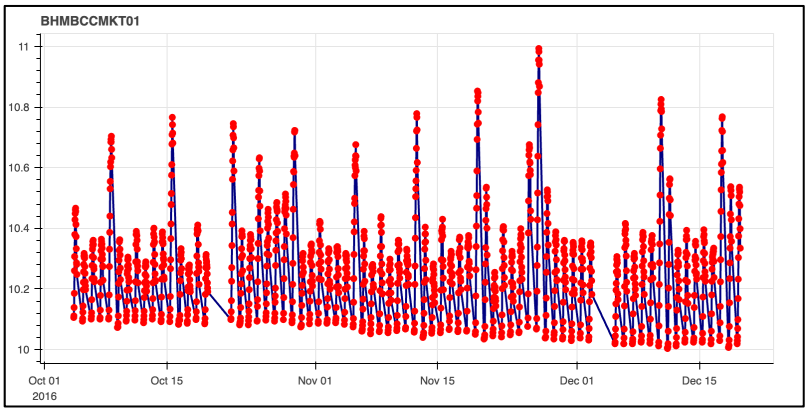
$$Price = BasePrice + \alpha * OccRate$$

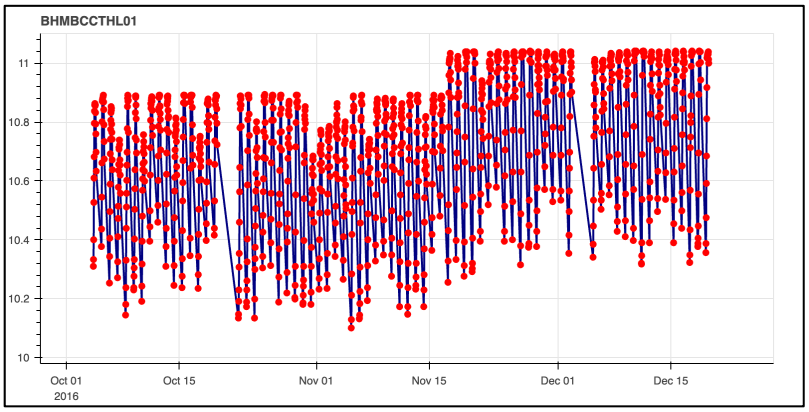
Where, BasePrice = 10 USD, α is sensitivity factor = 1 and OccRate = (occupancy/capacity)

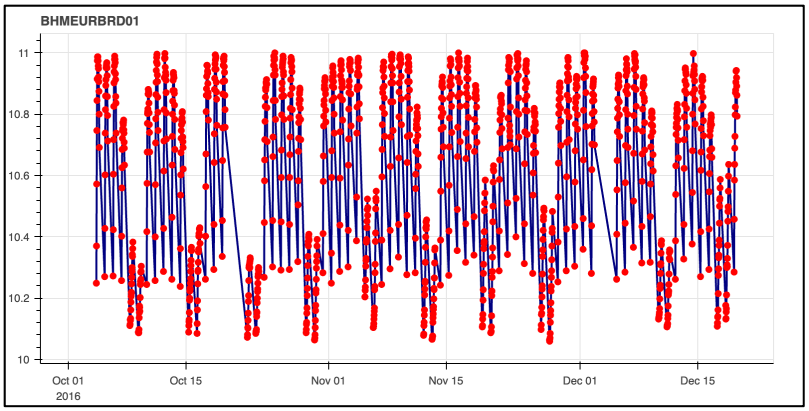
- Price is bounded within 100%-200% of the BasePrice.

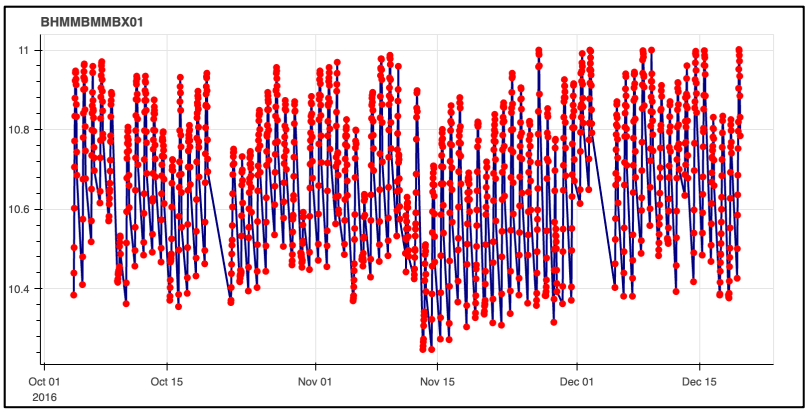
- An assumption that the pricing policy considers 10 USD as lowest is made.

Following are Bokeh plots for each parking lots using this model :





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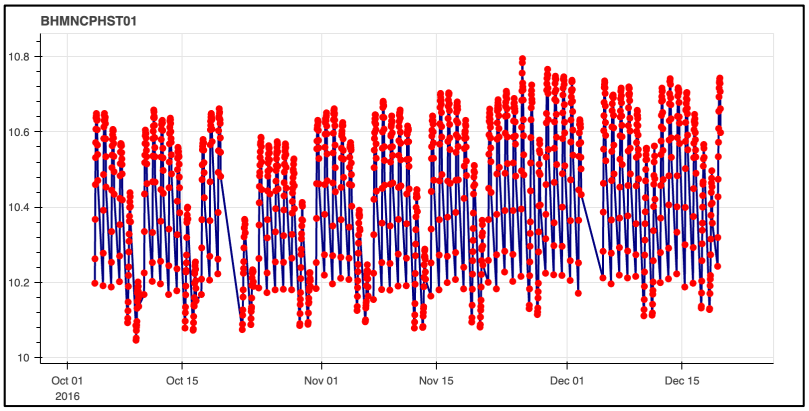
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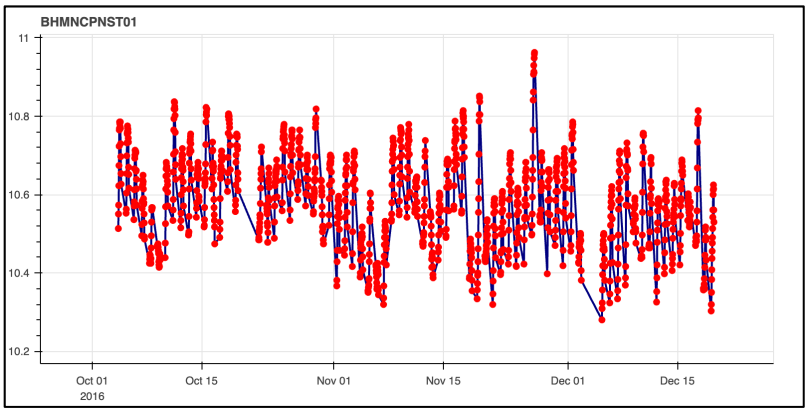
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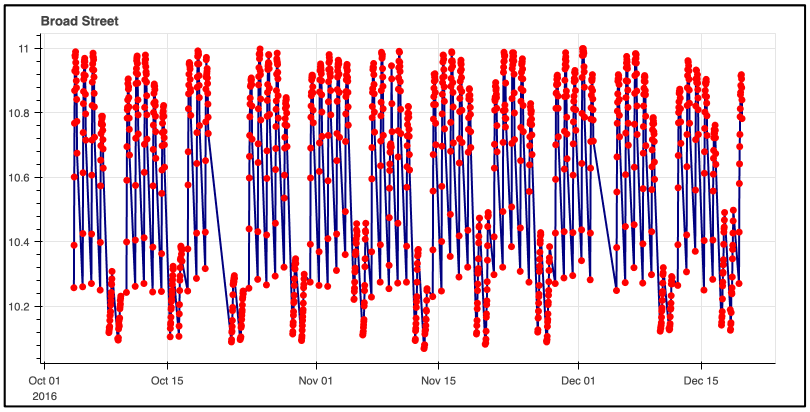
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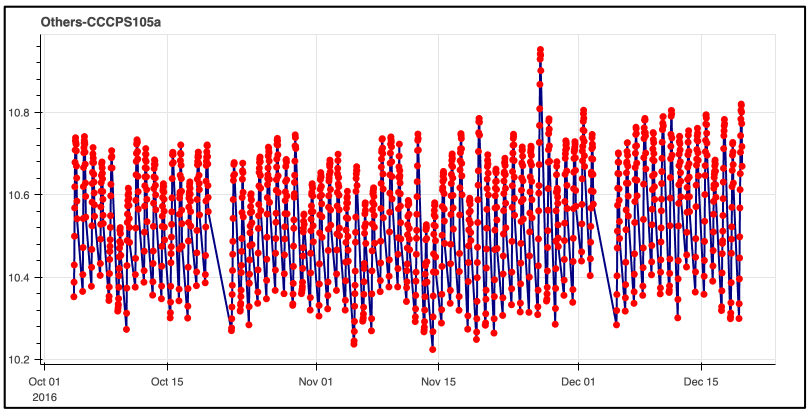
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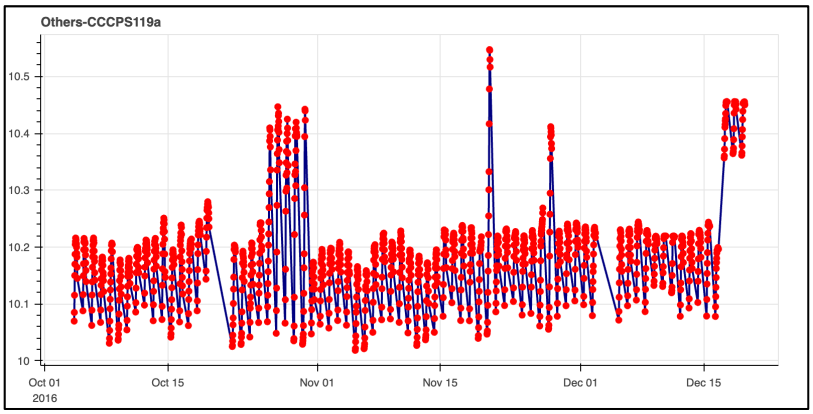
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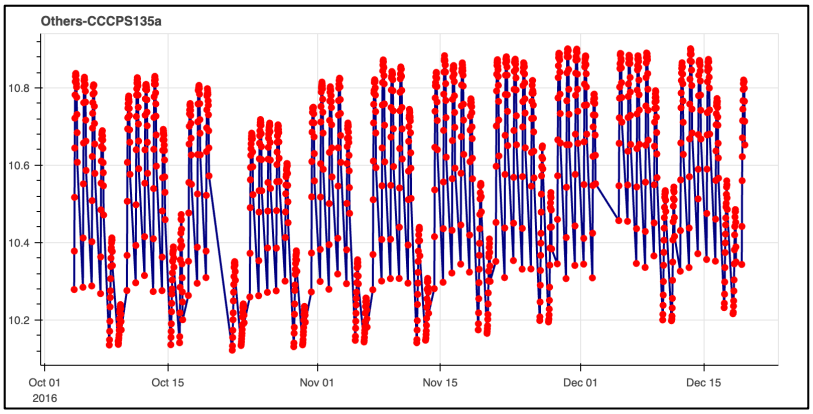
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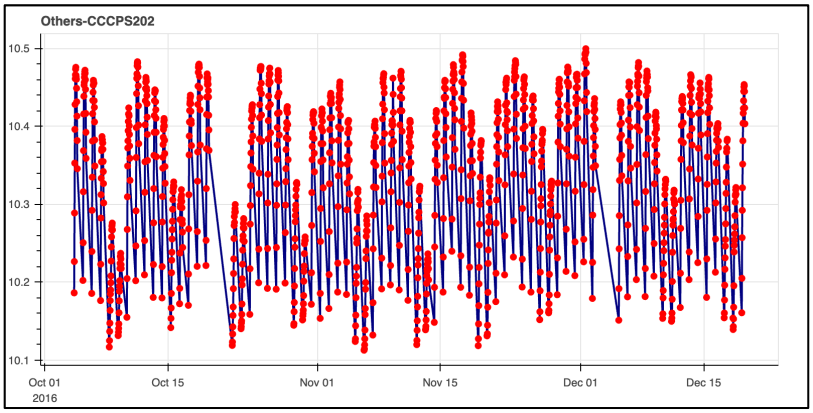
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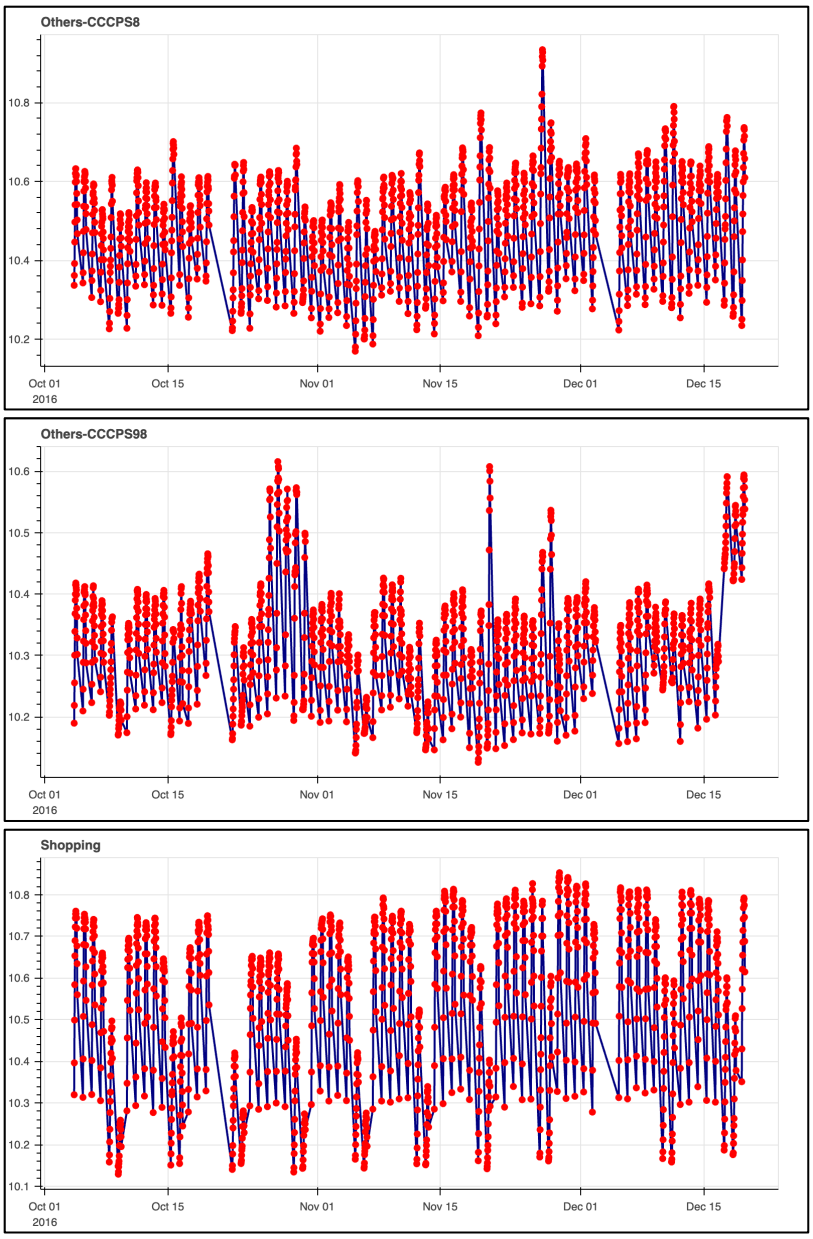


4. Demand Based Model:

The formula I used is –

$$Price = BasePrice * (1 + \lambda * Demand)$$

Where,

Demand =

$\alpha \cdot (Occupancy/Capacity) + \beta \cdot QueueLength - \gamma \cdot Traffic + \delta \cdot IsSpecialDay + \varepsilon \cdot VehicleWt.$

Where I set the values of these parameters as -

```
lambda_ = 0.3
alpha = 1.0
beta = 0.5
gamma = 0.2
delta = 0.3
epsilon = 0.3
```

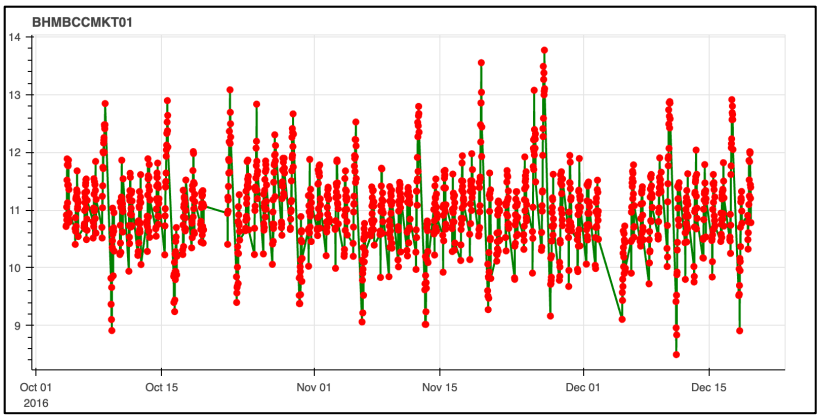
Assumptions:

- The parameters were valued according to EDA
- Occupancy and Queue length directly influence demand
- Heavy local traffic increase demand as the area becomes crowded
- The demand is usually reduced on special days
- The prices vary according to vehicle type and its weight

How the prices react:

- If occupancy is high and queues build up, prices rise to encourage turnover
- If local traffic is heavy, prices may drop to incentivize only those who really need to park
- The model can be extended to factor in competition by adjusting base price or λ based on competing lots nearby

Following are Bokeh plots for each parking lots using this model :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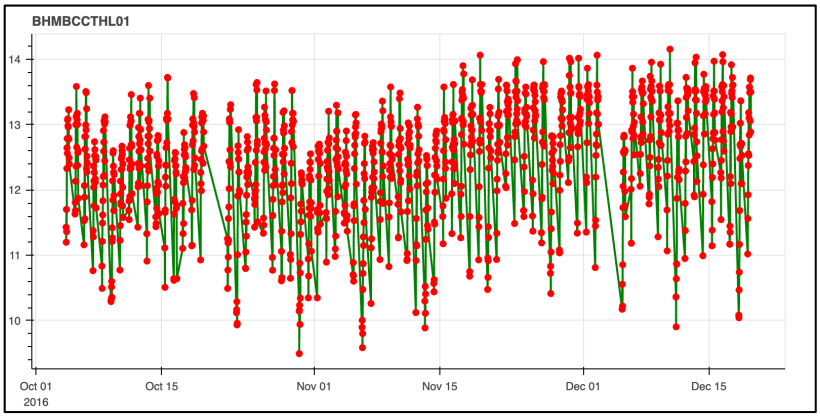
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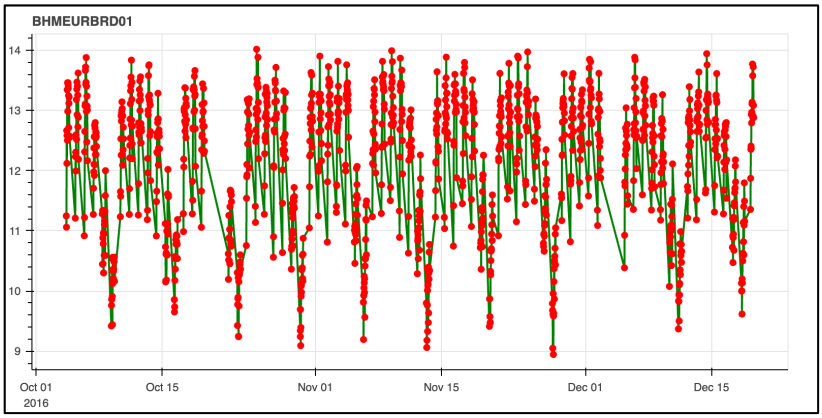
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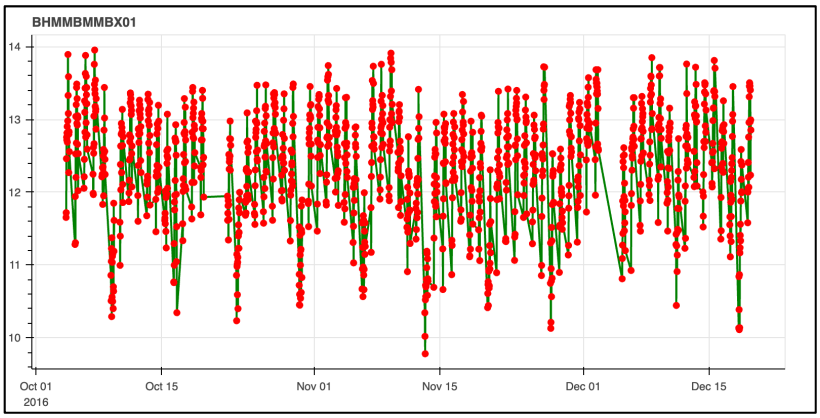
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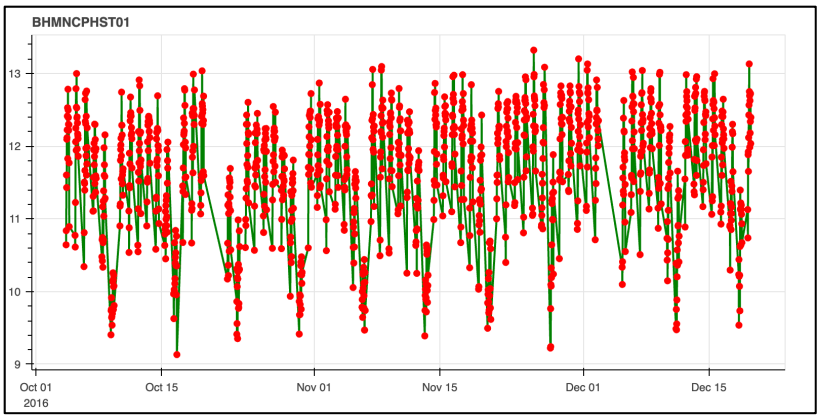
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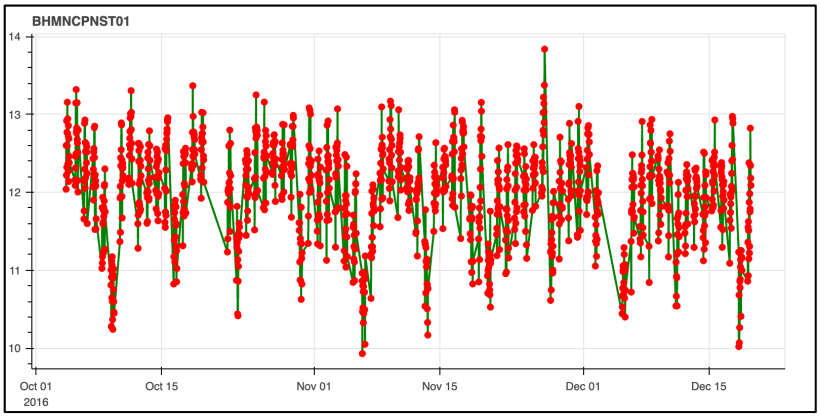
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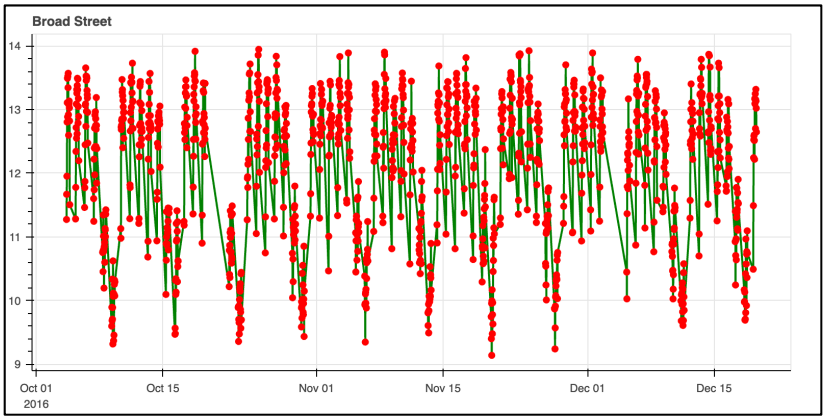
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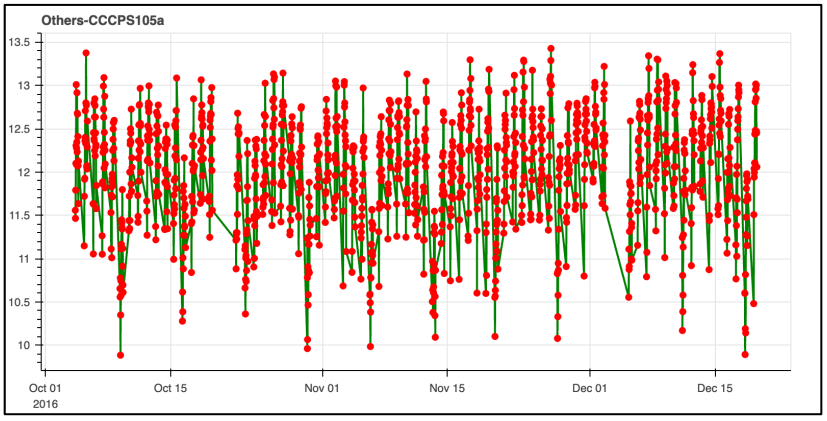
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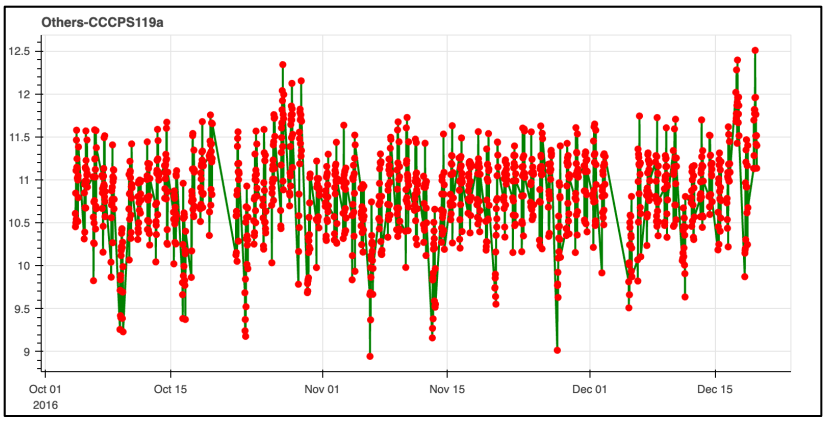
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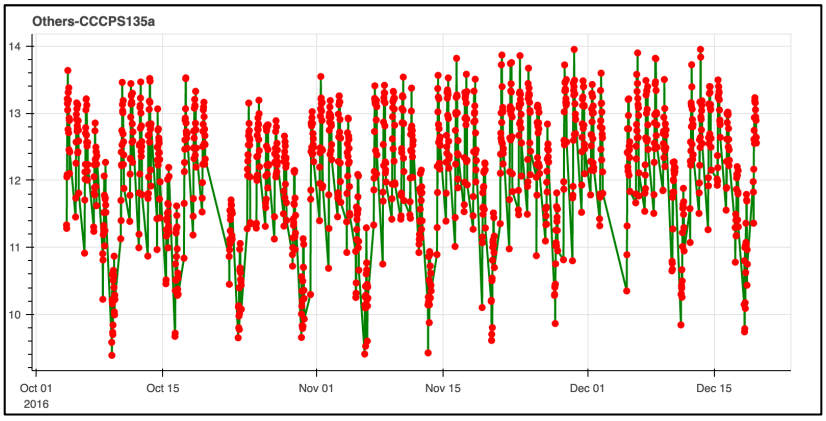
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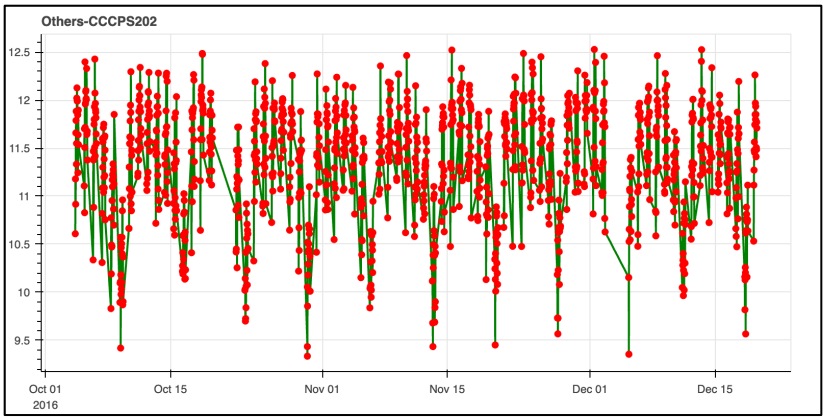
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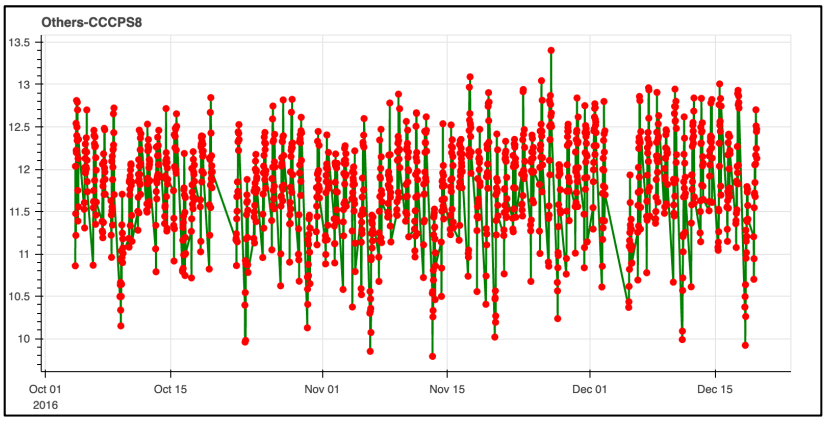
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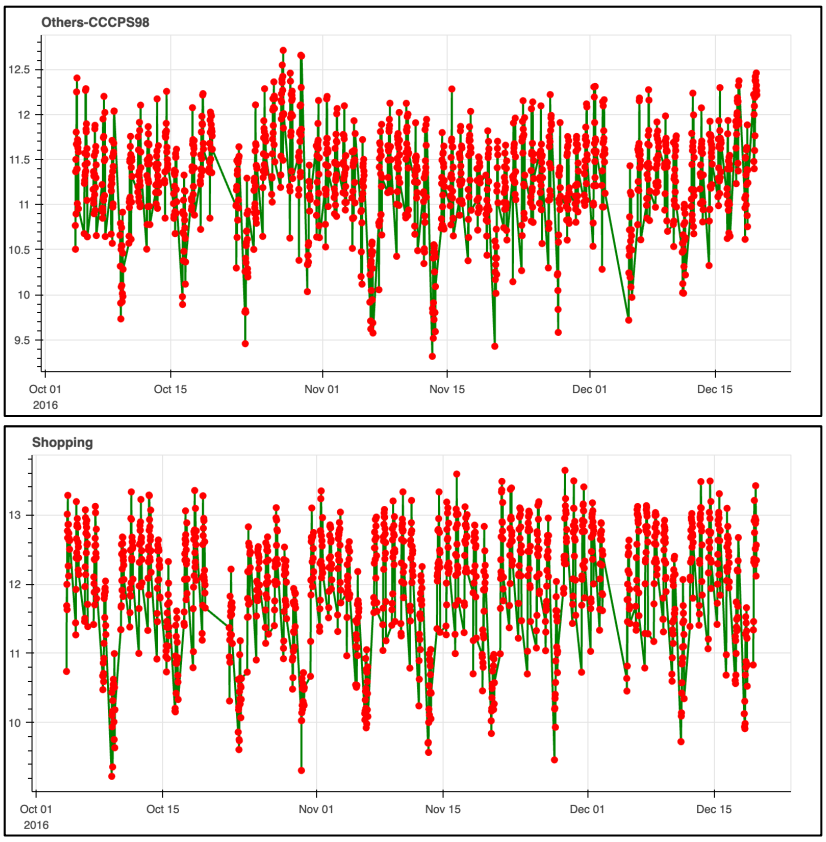

5. Coding Part :

As instructed, I coded the models in python as well as pathway. The python part is uploaded in my GitHub repository and the pathway part is coded in, as instructed, google colab.

Here's the link to Colab notebook: Colab Notebook
Or https://colab.research.google.com/drive/1ILEkRBQXTRK-68uVJWzNPKgKmos9qA0Y?usp=sharing