Profit Simulation

Inventory Management and Pricing Strategies

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Business Value of Simulation

- Purpose of Simulation: simulation can be used to predict the future behavior of a “system” and determine what you can do to influence that future behavior.
- Business Value: unlike most predicting models, simulation gives you a systematical view rather than a point of forecast.

Real Application of Simulation

Analysis

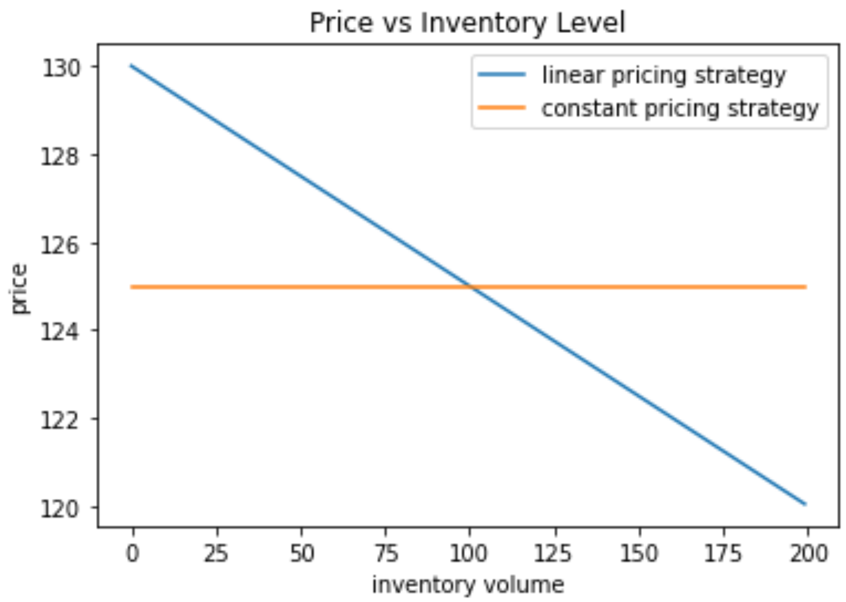
1. Collecting and visualizing data
2. Building models
3. Answering questions based on the predictions
    - What influence the tobacco manufacturing time?
    - What is the demand of tobacco in the future?

How does increasing one more production line influence our profit in the future?

Other business questions ...

Project Overview

- Maximize our profit by choosing the combination of pricing strategy and inventory refill strategy
- Pricing strategy: constant price / linear price (affected by current inventory level)
- Refill strategy: refill our inventory when there is 30%, 15% or 8% invertory left
- 6 strategy combinations and we will simulate each combination for 1000 times
- Choose the combination of strategies with the highest average profit



Discrete Event Simulation

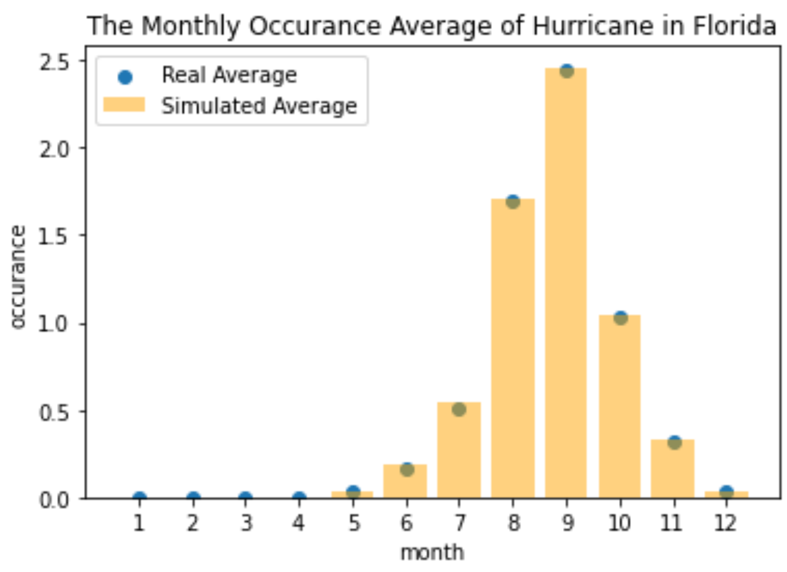
- Poisson Process:
  - Exponential Distribution: the probability distribution of the time between events
  - Homogeneous Poisson Process: the arrival rate of a poisson process does not change by time – the manufacturing time of tobacco
  - Nonhomogeneous Poisson Process: the arrival rate is a function of time – the demand of tobacco (people probably buy more tobacco during holiday season)

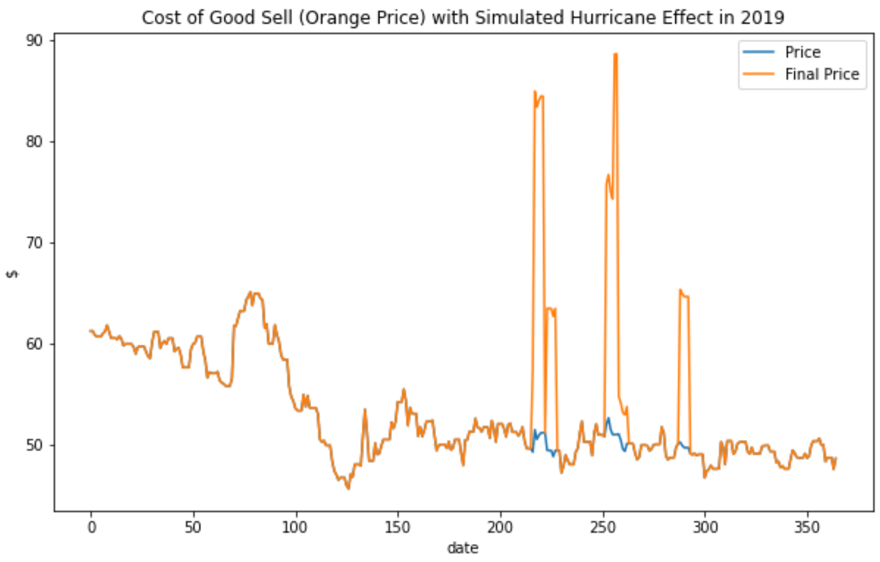
Settings

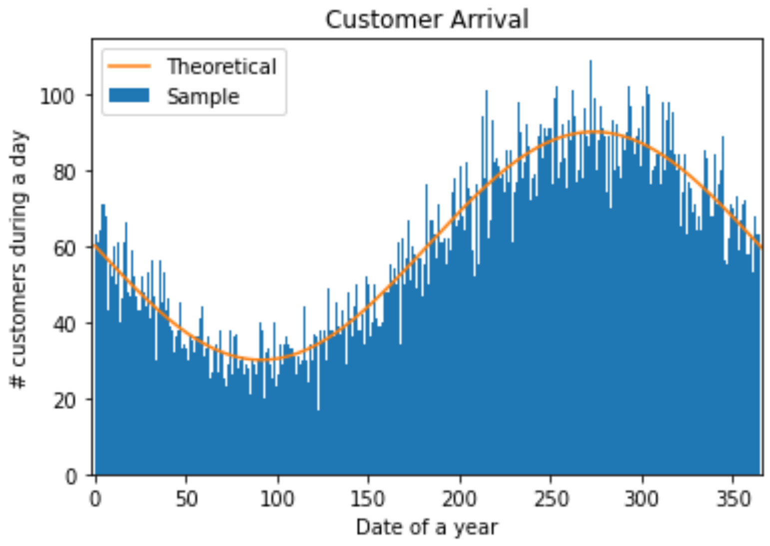
- The company is a fruit store that only sells oranges.
- Inventory
  - Maximum Inventory level: 200 units
  - Start Unit: 50 units
  - Refill Unit: 50 units
  - Freshness Score: (100, 0~5d), (60, 6~10d), (20, 11~15d), (0, above 16d)
  - Queue - First In First Out

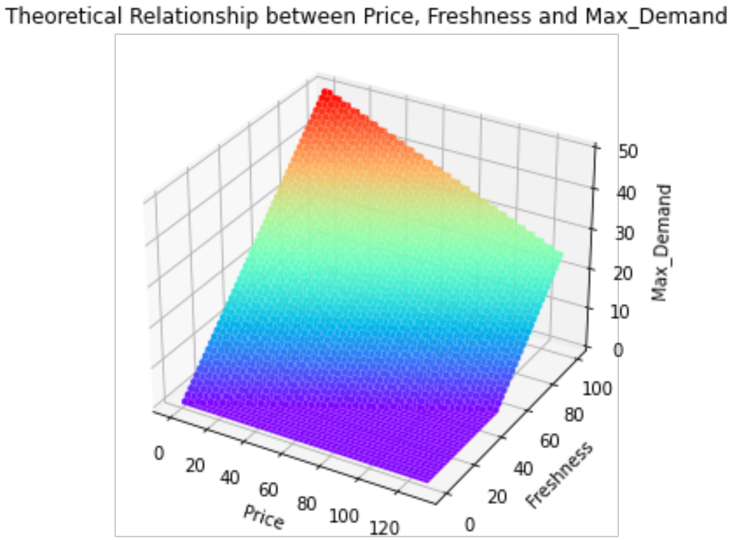
Settings

- Supply:
  - Orange price: 2019 Orange Juice Future Price
  - Natural Disaster (Hurricane): simulated from NOAA Florida Hurricane Historical data
  - Damage Level: Uniform(0, 1) and will make a 5 days orange price strike









Settings

- Demand
  - Daily customer arrival: follow a nonhomogeneous poisson process
  - Willingness: depends on current orange price and freshness

Business Problems

- how many customers come without buying anything (arrived but didn’t buy any oranges)
- how many days the inventory level equals to 0
- how many times we refill the inventory
- how many times we cannot fulfill customers' demand (the inventory level is smaller than the demand)
- what is the average orange freshness we sell to our customers
- how many units of orange are decayed and throwed away
- what is the effect of hurricane on the revenue of recommended strategy?
- what is the fixed/dynamic price elasticity for the business?

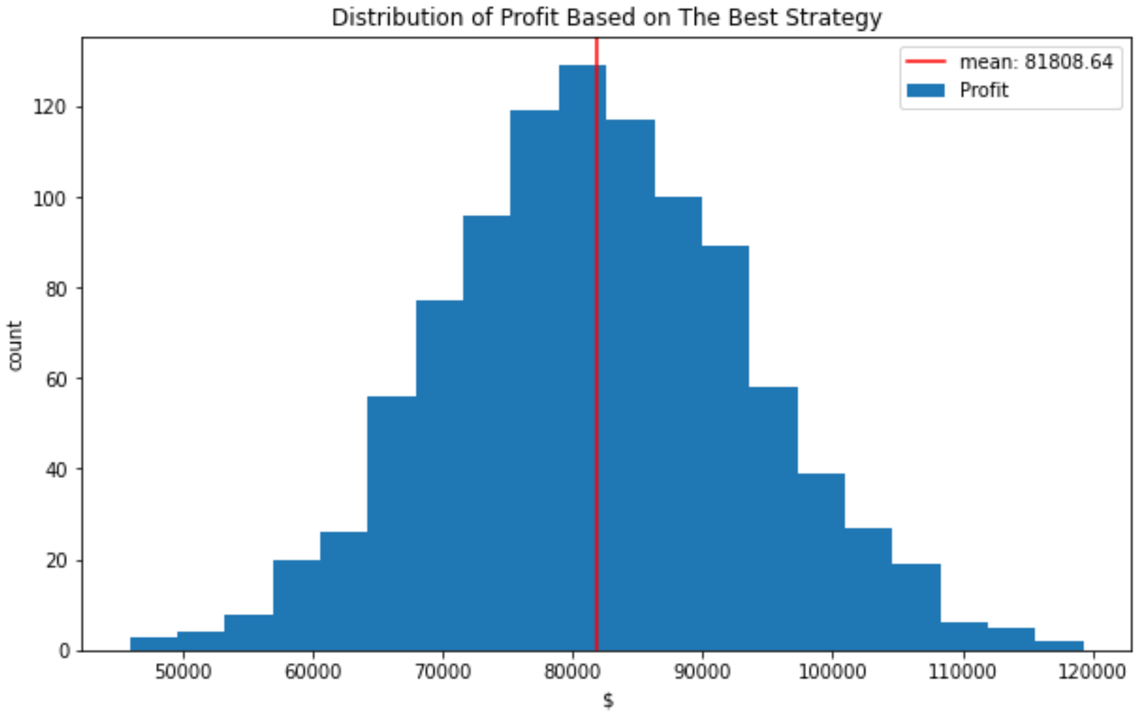
Simulation Results

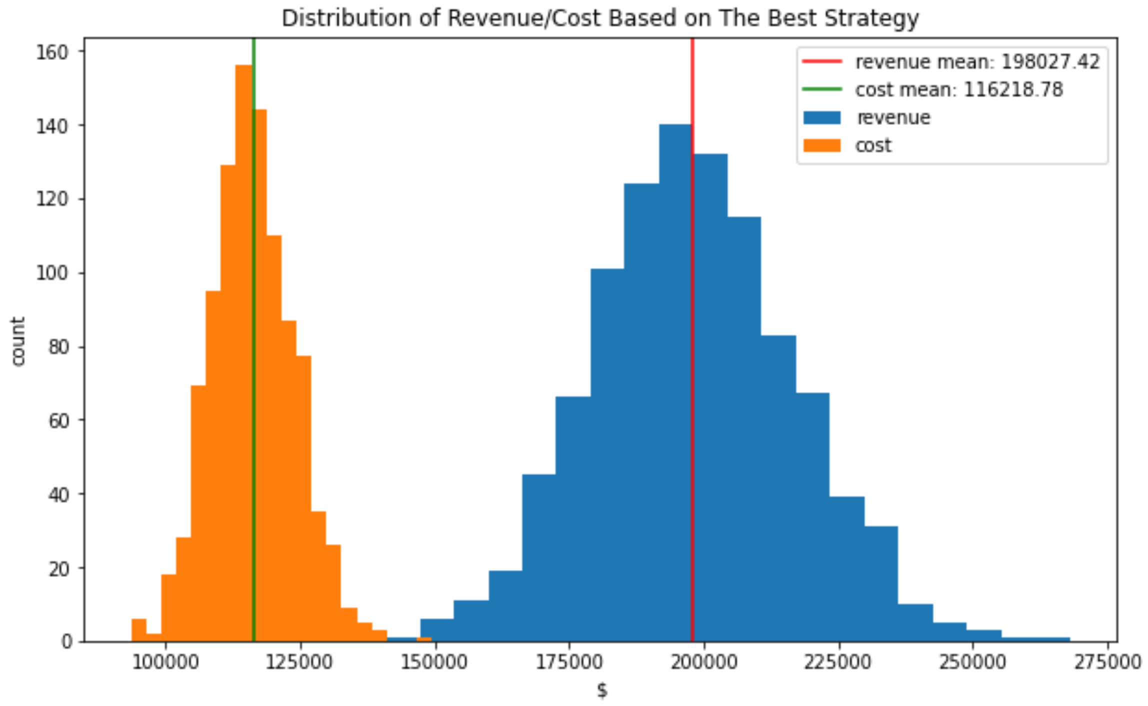
By using linear Pricing and setting refill level at 8%, we can get the highest average profit.
The best strategy is 12 times higher than the worst one.

Pricing / Refill level / Average Profit	8%	15%	30%
Constant pricing	77939.50	62440.08	6780.92
Linear pricing	81808.64	65786.06	8442.41

Simulation Results

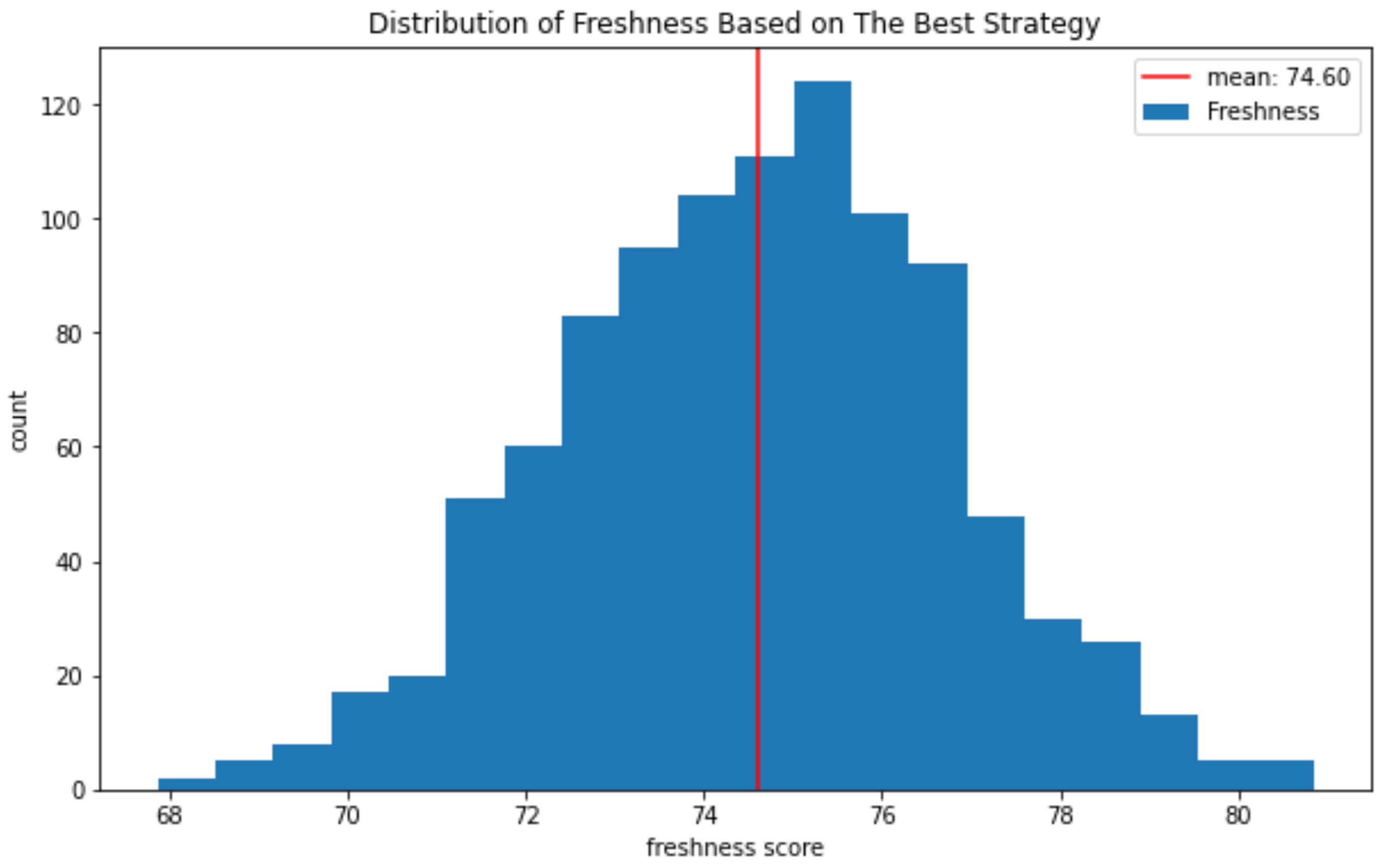
- The expected revenue is $198k and the expected cost is $116k. This makes the expected yearly profit around $82k. And the gross margin is around 41%





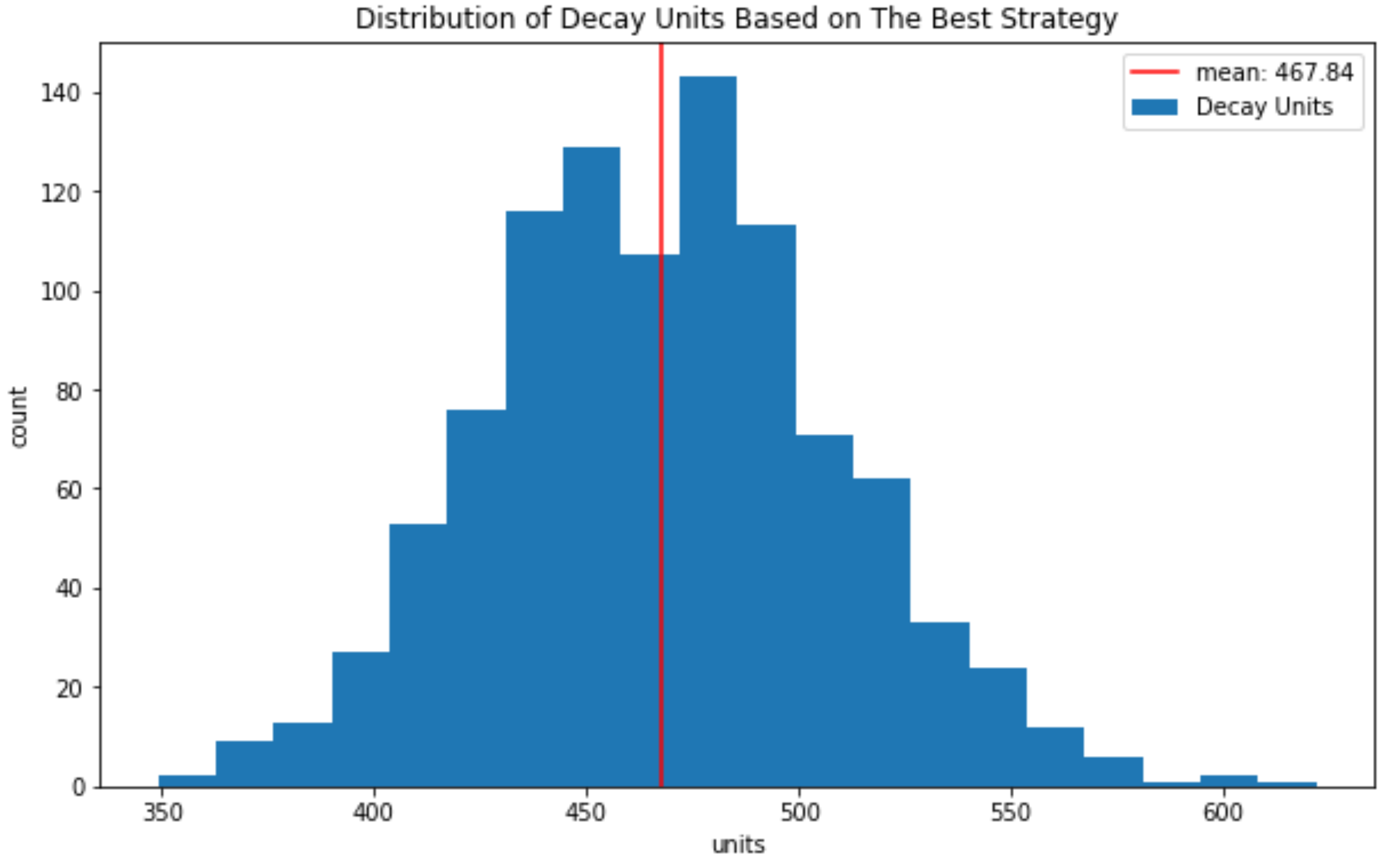
Simulation Results

- What is the average orange freshness we sell to our customers
- The average freshness level is 74.6 out of 100. As a result, the company may face risk of losing customers if they have higher expectations of freshness.



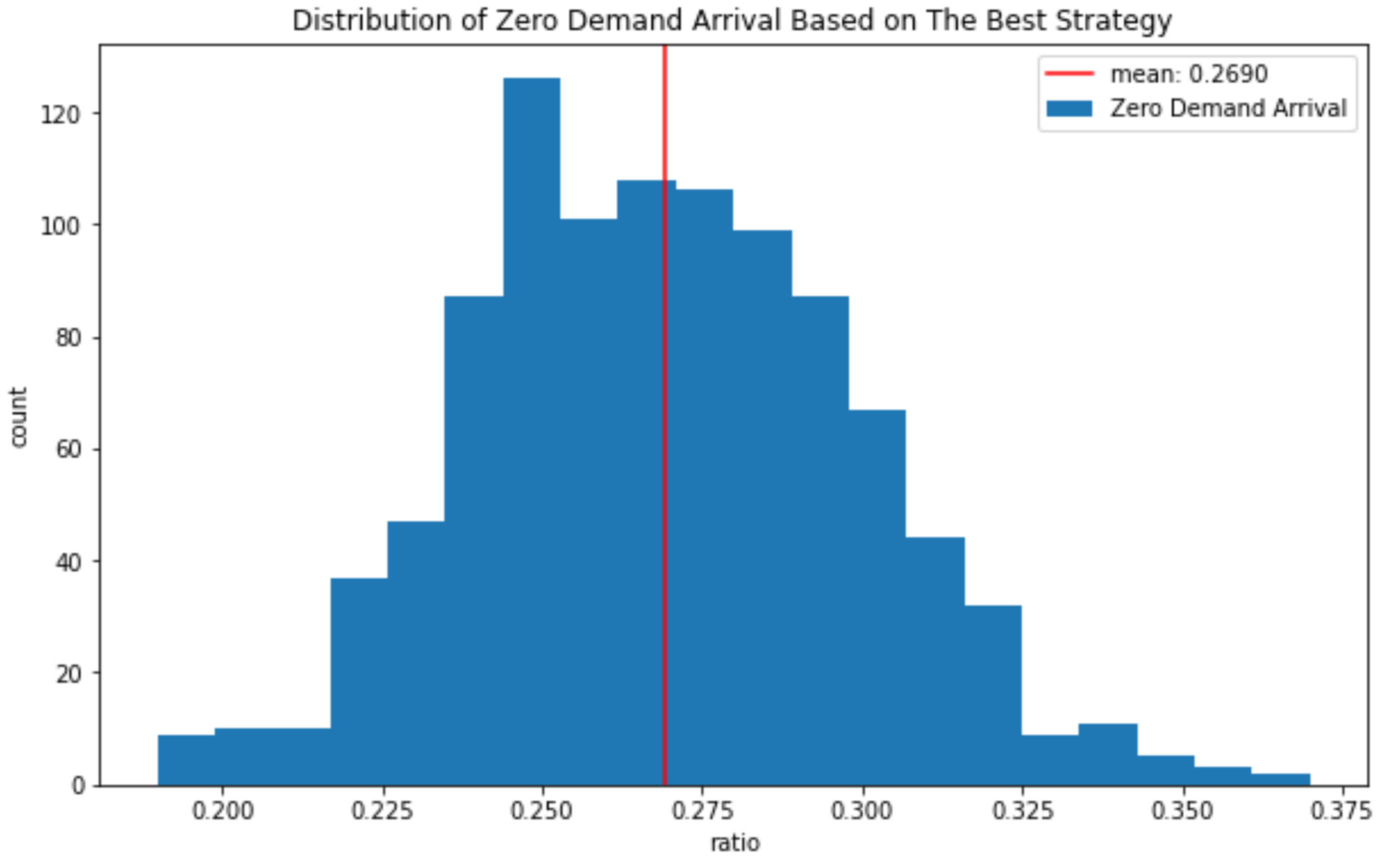
Simulation Results

- How many units of orange are decayed and throwed away per year
- The average number of decayed oranges is around 467 units. This is worth of $14~$20k revenue according to the average selling price.



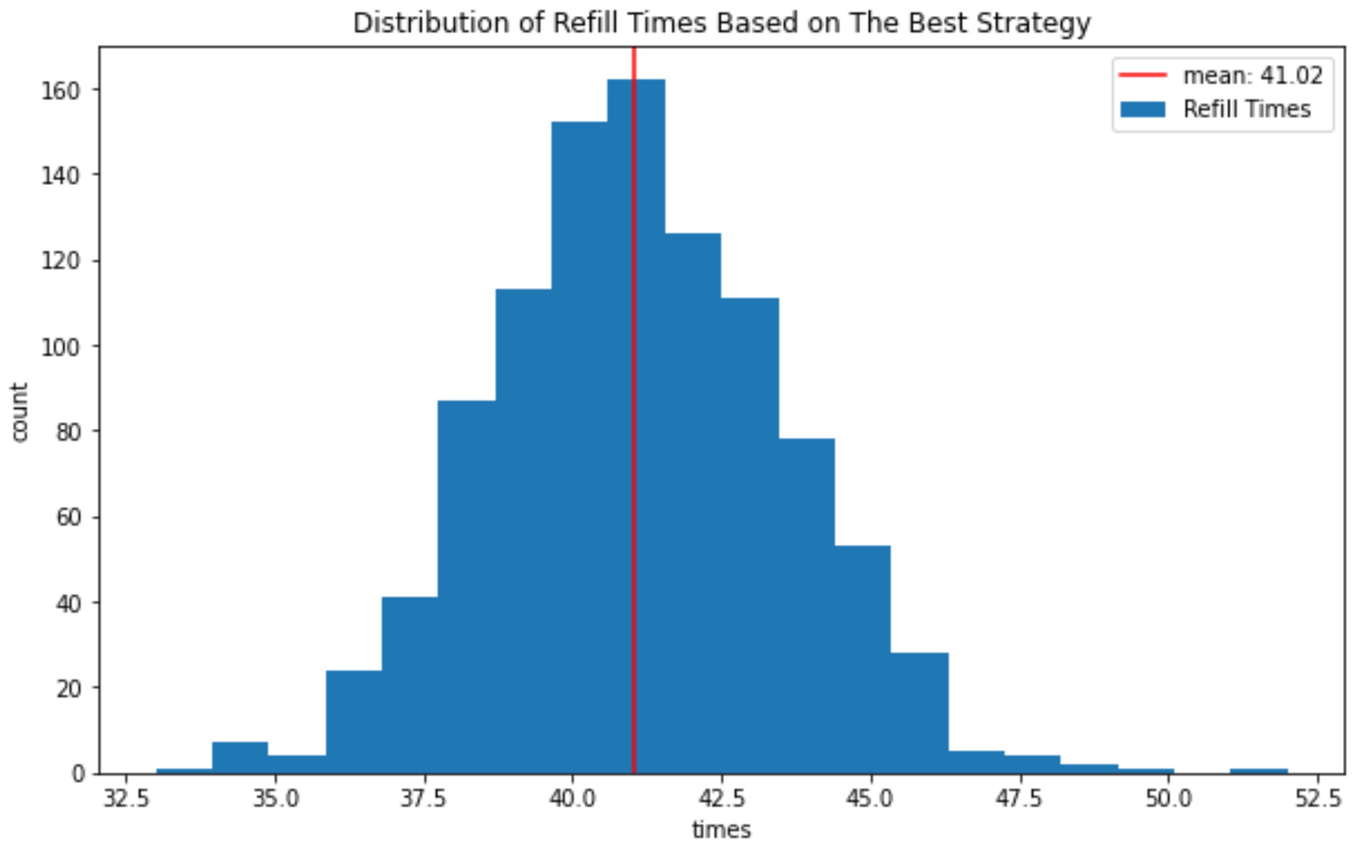
Simulation Results

- How many customers come without buying anything (arrived but didn't buy any oranges)
- Nearly a quart of customers did not buy any orange.



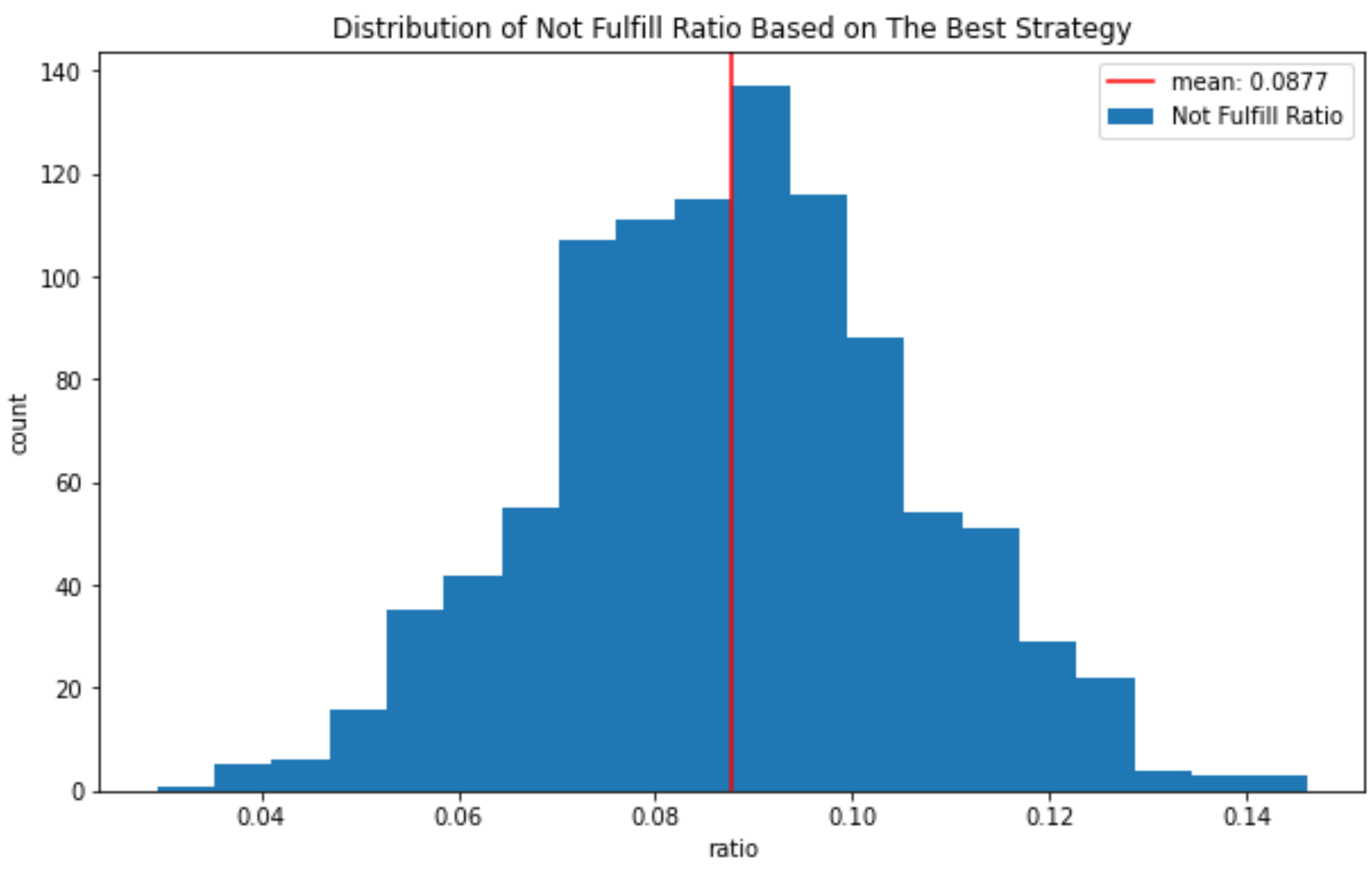
Simulation Results

- How many times did we refill the inventory
- The average inventory refill times is around 41 times per year.
- Every 8-9 days, the company will need to refill again, and the frequency will change correspondingly during the peak and trough.



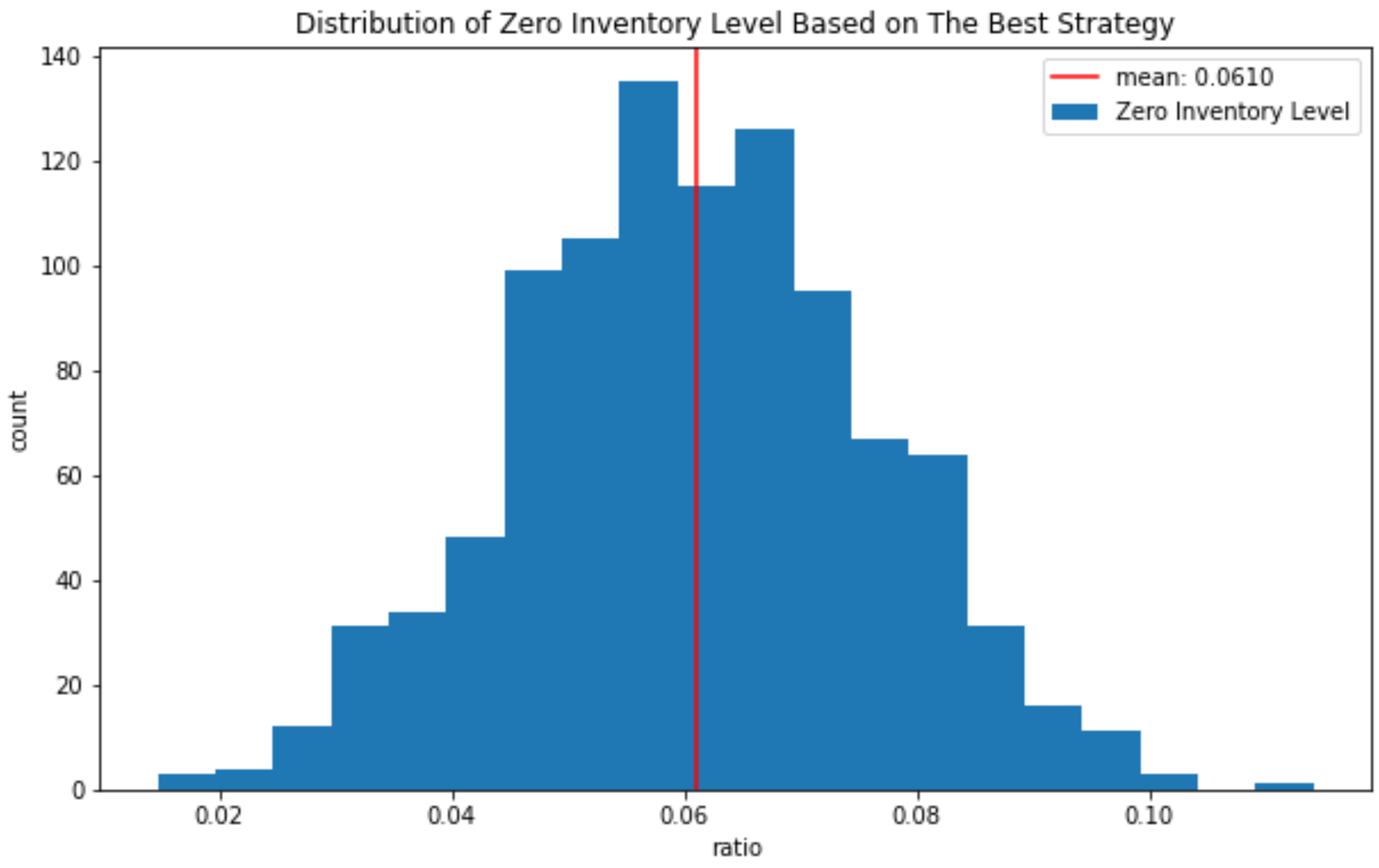
Simulation Results

- How many times we cannot fulfill customers' demand (the inventory level is smaller than the demand)
- The probability that the company cannot meet the customer’s demand due to lack of inventory is 9%.



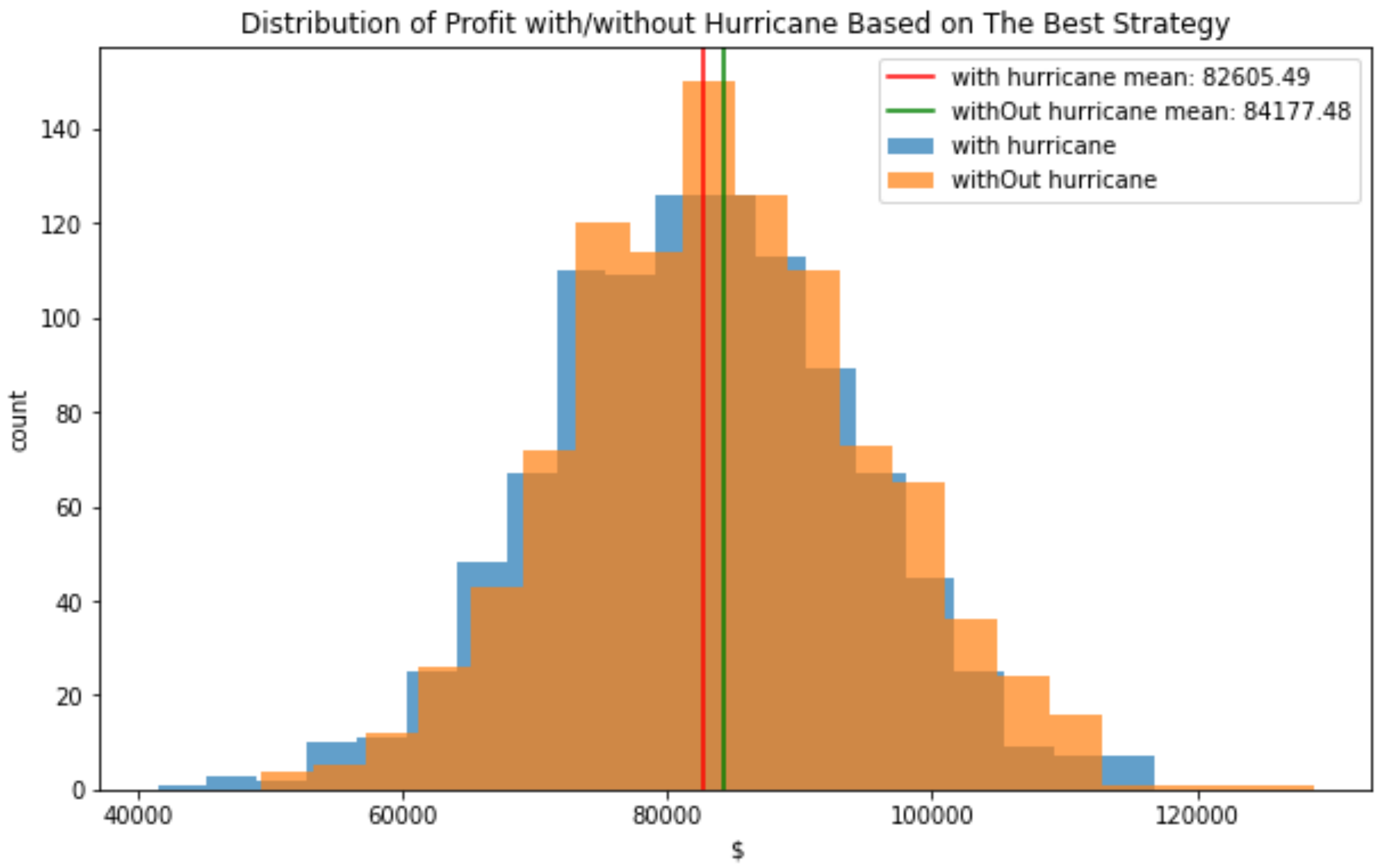
Simulation Results

- How many days the inventory level equals to 0?
- The probability that the company will end a day without any oranges is around 6%.
- To some extent, the current supply chain is efficient enough to meet the demand.



Simulation Results

- What is the effect of hurricane on the best strategy?
- The effect of hurricane is around $1.5k profit annually, which is around 2% profit. Therefore, the influence of natural disaster is under control.



Price Elasticity

$$E = \frac{\%\Delta Demand}{\%\Delta Price}$$

- A measurement of how customers react to price change
- If $|E| > 1$, then the variation in demand is larger than the variation in price, thus we call the product elastic.
- If $|E| < 1$, variation in price results in less drastic variation in demand, so the product is inelastic.

Fixed Price Elasticity

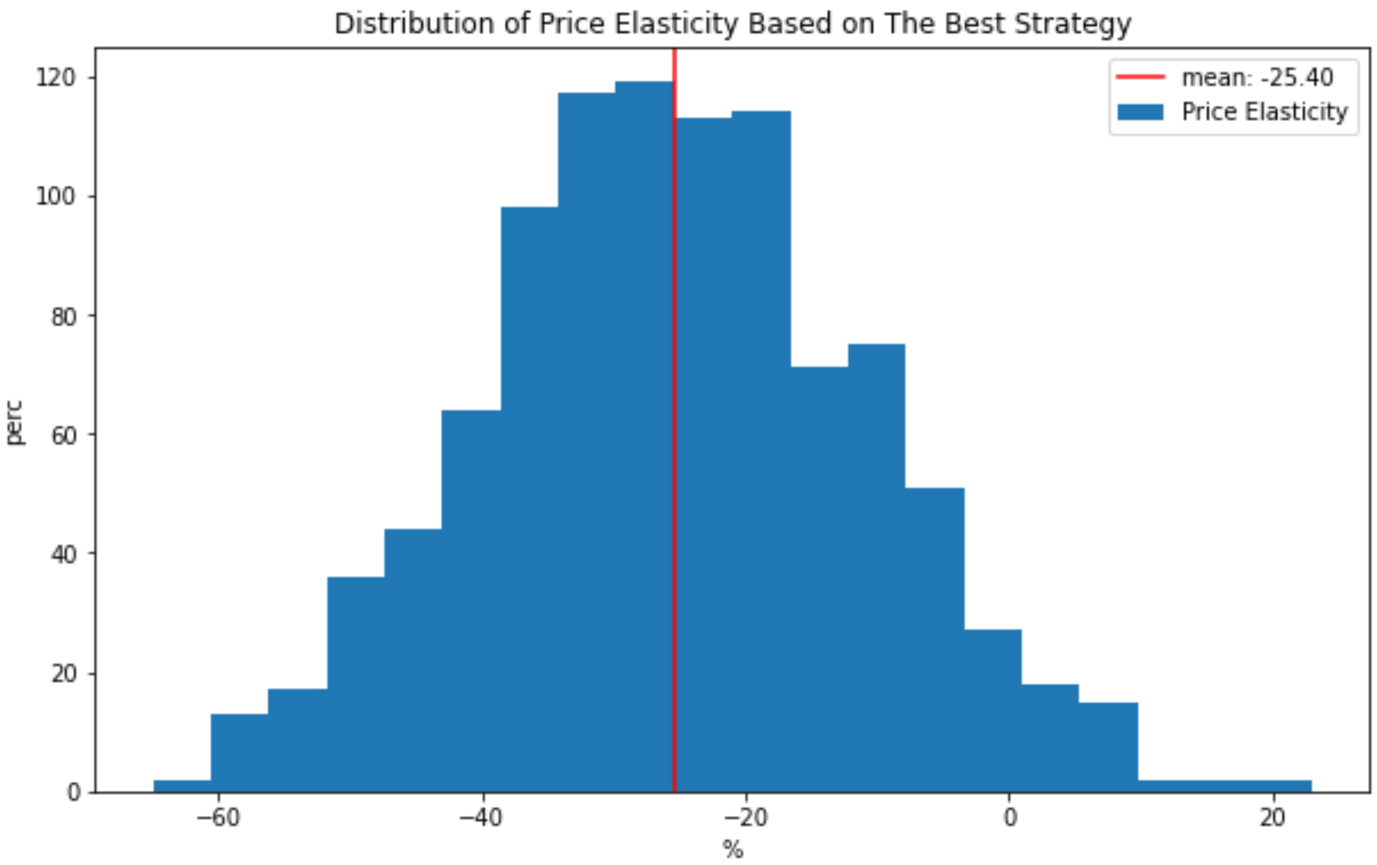
$$logD_t = \beta_0 + \beta_1 P_t + \beta_2 X_t + \epsilon_t$$
$$\epsilon_t \sim N(0, V)$$

confidence interval: (-26.297, -24.501)

median absolute error: 0.76

mean absolute error: 0.8

- In general, this time series model fits well. And, the result indicates we can gain more profitability as we fund more on the products.



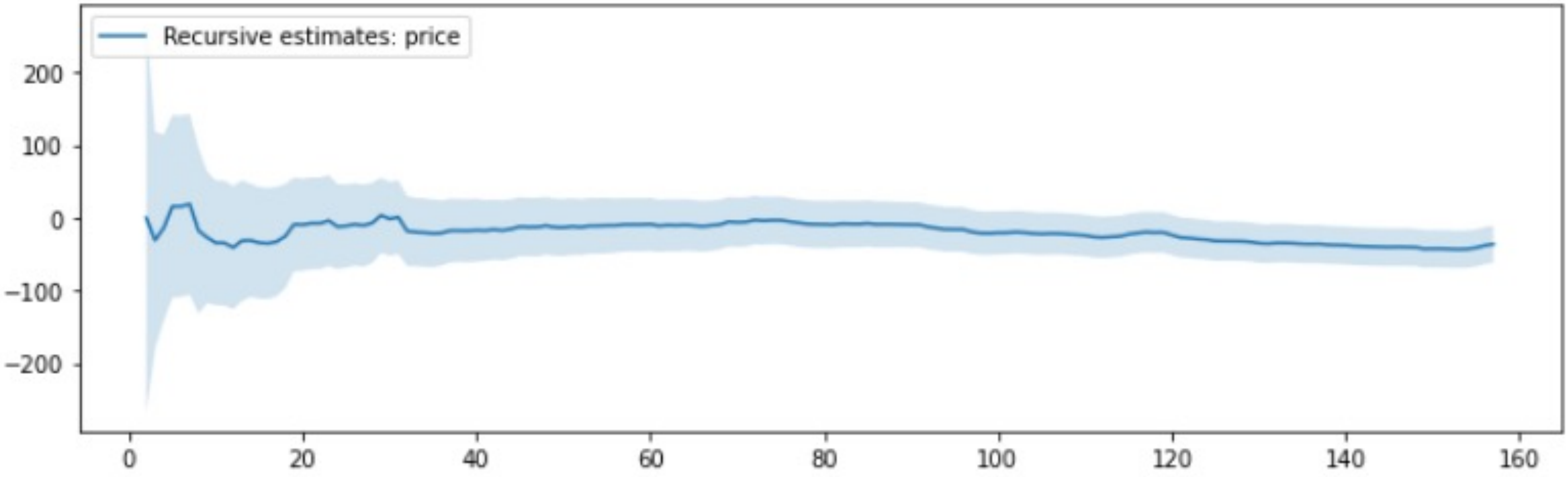
Dynamic Price Elasticity

$$log D_t = \beta_{0,t} + \beta_{1,t} P_t + \beta_2 X_t + \epsilon_t$$
$$\beta_{1,t} = \beta_{1,t-1} + \omega_t$$
$$\epsilon_t \sim N(0, V)$$
$$\omega_t \sim N(0, \sigma_\omega^2)$$

1. This model considers the variations across time.
2. Other time-factors can be included (e.g. weather)
3. Higher forecasting accuracy over fixed price elasticity model
4. Making better decision making

Dynamic Price Elasticity

- median absolute error: 0.7
- mean absolute error: 0.83
- We failed to reject the null hypothesis of stable parameters at 5% level (app.)



Conclusions

- The best strategy is 11 times higher than the worst one.
- To increase profit, we should make more complicated inventory strategies.
- The supply chain is efficient for the current condition.
- The influence of hurricane is under control.
- According to both price elasticity models, our product is competitive on the market. After optimization, we can gain more profitability by decreasing the selling price.
- The settings are relatively simple. In real case, we should also consider the risk of management fault, unexpected competitions, extreme climate change and so on.

Appendix

- CUSUM and CUSUM of squares show we failed to reject the null hypothesis
- Ho: the price elasticity is stable over time
- H1: the price elasticity is not stable over time