MGMTMSA 408 – Operations Analytics – Spring 2024

Final Exam – Answer Sheet - Q3

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Please follow all instructions on the Final Exam question sheet.

Q3 - Grocery store inventory optimization

Part 1: A constant order quantity

a)

minimize(Q) E[Cu(D-Q)+ + Co(Q-D)+]

where
Q = order quantity = number of strawberries stocked on a given day
D = demand = number of strawberries demanded on a given day
Co = overage cost = cost of selling a single extra strawberry = $1.5
Cu = underage cost = cost of buying a single extra strawberry = $3

b)

The optimal constant order quantity for training data is 1469 units.

c)

The average profit of this constant order quantity using the training data is $4074.27.

d)

$$\underset{Q}{minimize} \quad \mathbb{E}[c_u(D-Q)^+ + c_o(Q-D)^+]$$

where

Q = order quantity = number of strawberries stocked on a given day

D = demand = number of strawberries demanded on a given day

c_o = overage cost = cost of selling a single extra strawberry = $1.5

c_u = underage cost = cost of buying a single extra strawberry = $3

The average profit of this constant order quantity using the test data is $4074.47.

Part 2: A contextual ordering policy

a)

My tree splits on the variables 'temperature' and 'prev.demand'.

b)

The proposed ordering policy is given as follows:
Node 2 has proposed order quantity 1302 (temperature <= 62.5)
Node 4 has proposed order quantity 1369 (temperature > 62.5 and temperature <= 65.5)
Node 5 has proposed order quantity 1414 (temperature > 65.5 and temperature <= 67.5)
Node 8 has proposed order quantity 1461 (temperature > 67.5 and temperature <= 70.5)
Node 9 has proposed order quantity 1510 (temperature > 70.5 and temperature <= 72.5)
Node 11 has proposed order quantity 1575 (prev.demand <= 1406.5)
Node 12 has proposed order quantity 1560 (prev.demand > 1406.5)

c)

The average profit of this contextual ordering policy using the test set is $4174.85

Part 3: A different contextual ordering policy

a)

demand = 64.01934679788383 + 0.10899557app.logins + 19.73334574temperature - 0.07492321prev.demand + 0.08497646prev.demand.2

This gives us the conditional mean of demand using the predict function. But the demand that we want is the 66th percentile of the conditional distribution. Hence, we will make an adjustment.

demand(actual) = demand(predicted) + residuals(66th percentile)

b)

The average profit of this contextual ordering policy using the test set $4181.509329122083.

Part 4: An idealized ordering policy

a)

The average profit of this poilicy on test data is $4246.68

b)

Coefficient of prescriptiveness (part 2) = 0.5828929795017727
Coefficient of prescriptiveness (part 3) = 0.621562796133109

c)

The metric is R^2. The coefficient of prescriptiveness is similar to R^2 as:

1. Relative Improvement: Both metrics measure the improvement of a more complex model (contextual policy or predictive model) over a simpler baseline (constant policy or mean model). The coefficient of prescriptiveness compares the contextual policy to the constant policy, while R^2 compares the predictive model to a model that only predicts the mean.

2. Normalization by Ideal Performance: The coefficient of prescriptiveness normalizes the performance improvement by the difference between the idealized and constant policies, analogous to how R^2 normalizes the explained variation by the total variation.

3. Interpretation: Both metrics yield a value between 0 and 1, where 1 indicates perfect prediction or prescriptiveness, and values closer to 0 indicate poor performance improvement over the baseline.