Due Date: February 27, 2023

Assignment 5

MSCI 719
University of Waterloo

You can submit the assignment in a pdf file, Jupyter notebook, or you can write down your discussion and explanation in Excel or R Markdown, etc. You are welcome to use any software. Please make sure to submit the file that contains your analyses, too (Excel file, R codes, etc.).

1 Prediction models

In the model we discussed in class, we assumed that the demand for each week in 2019 is equal to the demand for the same week in 2018. Suppose that the demand of week n in 2019 is

$$\begin{aligned}\text{demand of week } n \text{ in 2019 } =& \alpha(\text{demand of week } n \text{ in 2018} - \text{Av. demand in 2018 up to week } n-1) \\ &+ (1-\alpha)(\text{demand of week } n \text{ in 2017} - \text{Av. demand in 2017 up to week } n-1) \\ &+ \text{Av. demand in 2019 up to week } n-1\end{aligned}$$

for a given $\alpha \in [0, 1]$.

1. Use the first 5 weeks of 2019 as the testing data. Calculate MSE on test data for different values of α, which value minimizes the error? (*15%*)
2. Use 2017 and 2018 data as the training data. Consider the number of periods and the number of weeks as predictors for demand in the year 2019. Fit a linear regression model to predict demand for 2019. Calculate MSE on the same testing data set as part 1. (*20%*)
   Hint: For each week you need to have a dummy variable.
3. Calculate the MSE for the model discussed in class on the testing data set. Which one of these three models performs best for predicting demand? (*15%*)

2 Weekly allocation vs. 10-week allocation

Use the best prediction model you developed in Part 1 to predict the demand for 2019. Consider the following two scenarios:

1. At the beginning of week 1 in 2019, an allocation plan is created for the whole 10 weeks, and at the beginning of each week (week 1-10) inventory is allocated to stores based on the plan, independent of overstocking/understocking during each week.
2. At the beginning of each week, the allocation plan is updated by considering the available inventory at each store. Assume that the allocation to each store should not exceed the demand minus the available inventory at the store at the beginning of the week.

Suppose the following assumptions hold.

- The holding and shortage costs are 3 and 5 per unit, respectively.
- Each item that remains in the distribution center at the end of week 10, incurs 2 dollar cost.
- Target inventory at the beginning of week 1 (available inventory at the distribution center) is 20000.
- The inventory allocated to each store at the beginning of each week should be between 150 and 1000.
- Available inventory at the beginning of week 1, at stores 1, 2, and 3 are 55, 83, and 110, respectively.

Develop an inventory plan for each scenario and answer the following questions.

1. What is the total cost under each scenario? (*35%*)
2. Which scenario is less expensive? How do you explain this? (*15%*)