OPRE 6332: Homework 2

Problem 1: Forecasting (20 points)

Consider the weekly sales dataset included. This file contains the following columns:

- Date
- Weekly Sales
- Holiday: this column is 1 if the date involves a holiday, and 0 otherwise
- Temperature
- Fuel Price
- CPI: consumer price index; provides a measure for inflation
- Unemployment: percentage of unemployment

Predictive Analysis

Considering the information described above, your goal is to forecast weekly sales. To do so, use the following methods:

1. Naïve Forecast
2. Moving Average, with N=3
3. Weighted Average, with weights $\alpha_{t-1} = 0.5, \alpha_{t-2} = 0.3, \alpha_{t-3} = 0.2$.
4. Exponential Smoothing, with smoothing constant 0.5
5. Linear regression (considering all predictor variables)

For each method, do the following:

- Compute your forecast
- Plot the actual data and your forecast
- Compute the MAE, MSE and MAPE.

Based on your forecasts and the measures of goodness of fit, which forecast method is better?

Problem 2: Modeling (80 points)

To make some extra cash during the pandemic, Mark started selling musical equipment online. To do so, he typically (i) purchases premium "bare bones" musical equipment from various small manufacturers, (ii) fine-tunes and customizes them, and (iii) sells for a premium. He operates his online store in a "make-to-order" fashion, i.e., he first takes new orders and then proceeds to buy and customize the necessary equipment.

Mark always tries to keep the price he pays for the bare-bones systems as low as possible. Through skillful negotiations, he managed to convince local shops to sell him systems for around $5,000 (per system) on average. However, there is a finite supply of such systems available in that price range – Mark figures around 40.

All of Mark's customers come from two distinct geographical regions: the East Coast (E) and the West Coast (W). Due to historical bias, every month, Mark first takes orders from the E and then from the W, and proceeds to fill them accordingly. For instance, if he had 30 orders from the E and 20 from the W, he would fill the 30 from the E first and then only an additional 10 from the W due to the limited capacity.

To keep things simple, Mark typically charges the same price irrespective of the market where the order comes from – currently, $6,500 per order. He is aware that customers typically do not like paying for shipping. As such, he is not charging them any shipping fees beyond the base price for the system. Based on his limited experience, he estimates that the monthly demand is:

- For the East Coast, expected demand is given by max(500-0.072 * price, 0),
- For the West Coast, expected demand is given by max(600-0.08 * price, 0).

Shipping

The equipment is quite heavy and expensive, so Mark always uses a premier parcel delivery service to handle his orders. The delivery service charges a small flat fee, to which it adds a variable cost that depends on the distance and a surcharge that depends on the cost of fuel. Mark always uses ground shipping and estimates that the variable cost associated with shipping one system is typically around $460 for E and $300 for W. In terms of the surcharge, this is expressed as a percentage applied against the variable cost, with the exact percentage value tied to a fuel index. To properly capture this cost, Mark copied the next month's surcharge table from the parcel carrier's website into Table 1 below.

Diesel Fuel Price ($/Gallon)		
At Least:	**But Less Than:**	**Surcharge:**
$2.61	$2.83	4.50%
$2.83	$3.05	5.00%
$3.05	$3.27	5.50%
$3.27	$3.49	6.00%
$3.49	$3.71	6.50%
$3.71	$3.93	7.00%
$3.93	$4.15	7.50%
$4.15	$4.37	8.00%
$4.37	$4.59	8.50%

Table 1 - Surcharge Table for next month

To understand how this surcharge works, if Mark ships one system to the E and then diesel fuel price happens to be $3.3/gallon during the month, then the shipping cost that Mark would pay for that system would be $460 (variable cost) + $460 * 6% (surcharge).

In your analysis, it is OK to consider prices that result in a fractional number of customers (e.g., 25.4 customers). **If you feel that the case or one of the questions are ambiguous, state clearly any additional assumptions that you need to make, and continue the analysis according to those.**

1. (40p) Build a model to forecast Mark's total profit from his online store over the next month, assuming that the fuel price is $3.50.

Treat each of the following questions independently.

2. (10p) How does your answer for the previous question changes if the fuel price is (a) $3.00, (b) $3.25, (c) $3.75, (d) $4.00, or (e) $4.25? [Hint: use Data table]
3. (10p) Assuming the fuel price is $3.50 next month, what would be the price that Mark should charge (identical for customers from E and W) so as to obtain equal profits from the East Coast and the West Coast? [Hint: use Goal Seek]
4. (10p) For each of the fuel price values in Question 2, what would be the corresponding optimal price that Mark should charge (identical for his E and W customers), so as to maximize his total profit over the next month? [It is ok to provide an answer here that is within at most $10 of the truly optimal price.]
5. (10p) Assume that the fuel price is $3.50 next month, but that Mark can charge a different price to his E and W coast customers. What would be the optimal prices to charge, and the resulting total profit? [It is ok to provide an answer here that is within at most $10 of the truly optimal price.]