SAS optimization competition report

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Introduction and Business Problem

Corporation XYZ has its headquarters located at Building T which gets its water from two different sources. The first source is The Water Co., with which the XYZ Corporations, like other firms in the area, has a contract in place to furnish water to its Building T at a set price per gallon. XYZ's own Water Storage Tank is the second source. Precipitation is collected, treated, stored, and used to provide water to Building T, and this process has a per-gallon cost. Corporation XYZ needs to find out its Total weekly water demand forecasts for the next four weeks based on the previous historical data. These projections will be used as inputs to take various business decisions on the basis of an optimization model.

Objectives

Each week, the gallons utilized in Building T are divided into two categories: cooling and main. The total amount of gallons consumed each week in Building T is made up of Cooling and Main with no distinction in water quality between the two groups. The time period begins the week of March 29, 2020 and ends the week of January 02, 2022. For the next four weeks, XYZ Corporation requires total weekly water demand predictions.

To construct an optimization model that minimizes total water cost over the next four weeks by identifying the ideal combination of gallons to purchase from The Water Co. and to utilize from the Water Storage Tank, using total water demand projections from Objective 1 and the additional information provided in the case. For each week, the sum of the two figures must be more than or equal to the expected water demand.

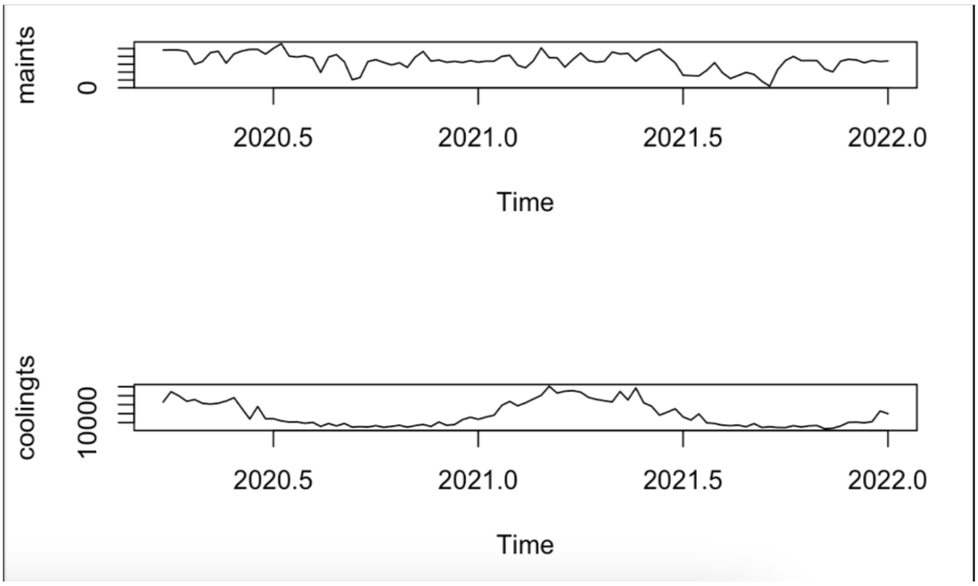
The sum of (Price*Quantity bought from The Water Co.) + (Treatment Cost*Quantity used from the Water Storage Tank) for each week equals the total water cost for the next four weeks.

In addition to that we need to calculate the expected ending Water Storage Tank inventory for XYZ at the end of each week and the money that XYZ will save if the recommended contract is chosen over the alternative contract and gallons that will be in the Water Storage Tank at the end of the four-week period if the alternative contract was chosen.

Case Analysis

1. Forecasting:

   The gallons used in Building T each week are broken down into two categories: Cooling and Main. The figure below is the time series plots from the cooling and main separately. We can see that the two plots have different trends: Cooling usage has a pattern of seasonality, while the pattern of the main usage is more stationary. So it's necessary to forecast them separately.



   We used the arima model to forecast the demand for the next 4 weeks in R studio. The frequency of the data is about 52 weeks. Due to the small amount of data we have, we can only consider the smaller cycle, so the parameter d we choose is 1 and p is 2.

2. Optimization:

- Variables used in the model and relationship between variables:

Tank Water

Week No.	Inflow	Tank Water	Treatment Unit Fee	Treatment Fee	storage
1	12000	TWU1	0.18	2160	Storage(i) = Storage(i-1) + Inflow(i)-TWU(i)
2	18000	TWU2	0.18	3240	
3	20000	TWU3	0.1	2000	
4	22000	TWU4	0.1	2200	

Purchased Water				
Week No.	**Purchased Water**	**Purchase Fee (Contract 1)**	**Purchase Fee (Contract 2)**	**Purchase Fee (Final)**
1	PWU1	If PWU(i) > 25000, fee = PWU(i) * 0.15, else 25000 * 0.15	If PWU(i) > 35000, fee = PWU(i) * 0.12, else 35000 * 0.12	Choose the contract with the lowest cost
2	PWU2			
3	PWU3			
4	PWU4			

- Targets and Constraints
  - Targe

    $$Min(Total\ Cost) = Tank\ Water\ Cost + Purchased\ Water\ Cost$$

  - Constraints：

    1: Water Storage Tank must NOT drop below 30,000 gallons during any week.

    $$Storage \geq 30000$$

    2: as a member of EESCI, at least 25% of all water supplied to Building T each week must come from the Water Storage Tank.

    $$Tank\ Usage\ Rate(i) = TUR(i) = \frac{TWU(i)}{TWU(i) + PWU(i)} \geq 0.25$$

    3: sum of water used from tank and water used from procurement must >= to forecasted water demand for each week.

$$TWU(i) + PWU(i) \geq Forecast\ Demand(i)$$

Solutions and Recommendations

- Forecasting results:

Week No.	Purchased Water/gallons
1	56344.64
2	56209.59
3	56918.96
4	57401.27

- **Contract II** will provide XYZ Corporation with the lowest total water cost over the next four weeks. Total water cost over the next four weeks is : $26,400
- The amount of gallons that XYZ corporation will buy from The Water Co. each week:

Week No.	Purchased Water
1	28369
2	28299
3	31889
4	34003

- Amount of gallons utilized by XYZ from their Water Storage Tank each week for their building T:

Week No.	Water from Tank
1	27975
2	27910
3	25030
4	23398

- XYZ’s projected total water cost at the end of the next four weeks will be $26,400.
- XYZ’s projected ending Water Storage Tank inventory at the end of each week:

Week No.	**Water Storage Tank Inventory/gallons**
1	46525
2	36614
3	31584
4	30186

- The amount of money saved by XYZ choosing the recommended contract over the alternative contract:

1. Total water cost at the end of the next four weeks will be $26400 if XYZ chooses the recommended contract.
2. Total water cost at the end of the next four weeks will be $27956 if XYZ chooses the alternative contract.
3. Therefore, XYZ will save **$1556** by choosing the recommended contract over the alternative contract.

- Gallons in the Water Storage Tank at the end of the four-week period compared to if the alternative contract was chosen:

Week No.	**Water Storage Tank Inventory with recommended contract**	**Water Storage Tank Inventory with alternative contract**	**Difference**
1	46525	49801	-3276
2	36614	42308	-5694
3	31584	36461	-4877
4	30186	**30000**	186

Appendix:

Forecasting using R (code reference):

```
library(forecast)
# load data set
data <- read.csv("/Users/ningb/OneDrive - purdue.edu/2022_SAS_Optimization/CASE COMPETITION/rawdata_bldgt.csv")

# 1. The gallons used in Building T each week are broken down into two categories: Cooling and Main. First, we divide data into two parts: cooling and main
cooling_data <- subset(data, metername =="b'Bldg. T (Cooling)'")
main_data <- subset(data, metername =="b'Bldg. T (Main)'")

# change to time series
coolingts <- ts(cooling_data$gallons, start = c(2020, 13), end = c(2022,1), frequency = 52)
maints <- ts(main_data$gallons, start = c(2020, 13), end = c(2022,1), frequency = 52)
# 2. plot cooling time series and main time series separately, we can see they have different trends:
# The first is relatively stable, the second has obvious seasonality.
# they are very different so we need to forecast them separately
plot(coolingts)
plot(maints)


# 3. Here we choose arima to forecast the next four weeks gallons
# fit the arima model to cooling time series
cooling.arima<-Arima(coolingts, order=c(2,1,1))
# Make a 1-step through 4-step forecast(four weeks)
predict_cooling <- predict(cooling.arima, n.ahead = 4)
# Obtain the forecast of cooling part
predict_cooling$pred

# fit the arima model to main time series
main.arima<-Arima(maints, order=c(2,1,1))
# Make a 1-step through 4-step forecast
predict_main <- predict(main.arima, n.ahead = 4)
```

```
# Obtain the forecast of main part
predict_main$pred

# combine the cooling part and main part
predictdt <- predict_cooling$pred + predict_main$pred
predictdt
# forecast results:
# 56344.64  56209.59  56918.96  57401.27
```