SAS OPTIMIZATION CHALLENGE

Report

SAS Poets
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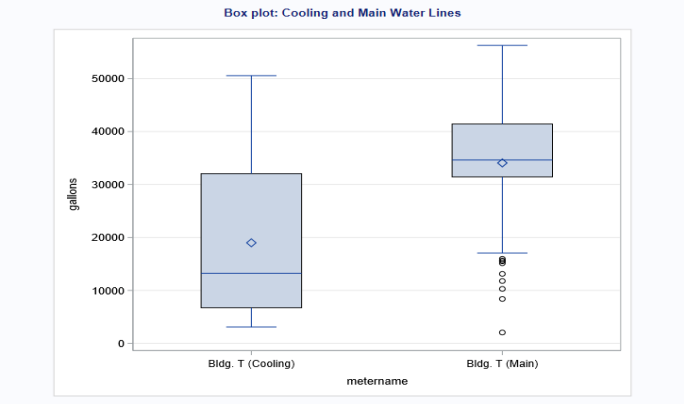
Problem Statement

Building T in XYZ Corporation meets its water requirements from two sources, the Water Co. and its own water storage tank. Based on a year and a half of historical weekly gallon usage of water, we need to predict their water requirements for the next 4 weeks. To meet the predicted requirements, XYZ has two contract options at hand, each involving a certain cost. We need to optimize the cost function to help XYZ decide which contract to opt for. There are multiple constraints like water in the storage tank should not drop below 30000 gallons at any point, at least 25% of the water requirements should be met from the water storage tank, etc., which needs to be met while optimizing the cost.

Forecasting the requirements for next 4 weeks

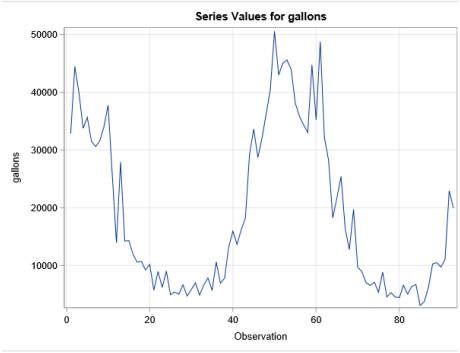
Exploratory Data Analysis

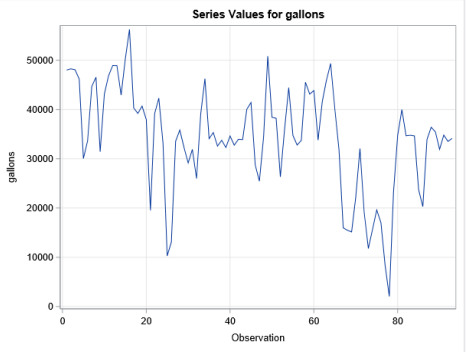
We observed that the distributions for cooling and main types are significantly different through our initial data analysis. Hence they needed to be predicted through different models and added up to calculate the final demand.



Here we can observe that main has more water requirements than cooling and less variance than cooling.

Time series graph for Cooling and Main:





We can observe that cooling peaks during summer whereas main dips during summer.

ARIMA model has been used to forecast the water requirements for the next 4 weeks.

Forecasting for Main

Name of Variable = gallons	
Mean of Working Series	34075.47
Standard Deviation	10681.6
Number of Observations	93

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	97.58	6	<.0001	0.672	0.356	0.286	0.381	0.357	0.256
12	105.29	12	<.0001	0.177	0.140	0.122	0.062	0.064	-0.017
18	112.14	18	<.0001	-0.133	-0.141	-0.058	-0.022	-0.055	-0.127

Maximum Likelihood Estimation					
Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|	Lag
MU	34420.5	2782.4	12.37	<.0001	0
AR1,1	0.68136	0.07425	9.18	<.0001	1
AR2,1	0.26506	0.13961	1.90	0.0576	52

Constant Estimate	8060.67
Variance Estimate	59232610
Std Error Estimate	7696.272
AIC	1935.705
SBC	1943.302
Number of Residuals	93

Correlations of Parameter Estimates			
Parameter	MU	AR1,1	AR2,1
MU	1.000	-0.009	-0.109
AR1,1	-0.009	1.000	-0.015
AR2,1	-0.109	-0.015	1.000

Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	13.47	4	0.0092	0.103	-0.227	-0.129	0.208	0.121	0.014
12	15.89	10	0.1028	0.027	0.018	0.046	-0.070	0.110	0.050
18	20.79	16	0.1867	-0.130	-0.124	0.044	0.080	0.032	-0.042
24	33.10	22	0.0605	-0.164	0.056	0.138	0.054	-0.103	-0.191

Forecasting for Cooling

Name of Variable = gallons	
Mean of Working Series	18991.63
Standard Deviation	13805.26
Number of Observations	93

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	364.24	6	<.0001	0.915	0.869	0.813	0.759	0.699	0.623
12	444.10	12	<.0001	0.549	0.471	0.369	0.265	0.177	0.076
18	486.81	18	<.0001	-0.018	-0.098	-0.175	-0.249	-0.322	-0.401

Maximum Likelihood Estimation					
Parameter	Estimate	Standard Error	t Value	Approx Pr > |t|	Lag
MU	20140.1	5646.7	3.57	0.0004	0
AR1,1	0.89839	0.04470	20.10	<.0001	1
AR2,1	0.24545	0.15995	1.53	0.1249	52

Constant Estimate	1544.143
Variance Estimate	28498110
Std Error Estimate	5338.362
AIC	1868.129
SBC	1875.727
Number of Residuals	93

Correlations of Parameter Estimates			
Parameter	MU	AR1,1	AR2,1
MU	1.000	-0.037	0.032
AR1,1	-0.037	1.000	-0.172
AR2,1	0.032	-0.172	1.000

Autocorrelation Check of Residuals									
To Lag	Chi-Square	DF	Pr > ChiSq	Autocorrelations					
6	11.90	4	0.0181	-0.261	0.123	0.084	-0.025	0.176	0.002
12	17.40	10	0.0660	0.029	0.173	-0.002	-0.041	0.109	-0.088
18	19.45	16	0.2458	-0.042	0.004	-0.040	0.008	0.013	-0.118
24	25.70	22	0.2646	-0.053	-0.094	-0.016	-0.087	-0.007	-0.174

Model for variable gallons	
Estimated Mean	20140.05

Autoregressive Factors	
Factor 1:	1 - 0.89839 B**(1)
Factor 2:	1 - 0.24545 B**(52)

Forecasts for variable gallons				
Obs	Forecast	Std Error	95% Confidence Limits	
94	20442.2901	5338.3621	9979.2927	30905.2875
95	20804.8350	7176.2836	6739.5777	34870.0923
96	23406.2625	8370.3758	7000.6274	39811.8976
97	24367.4799	9222.0597	6292.5750	42442.3848

Outlier Detection Summary	
Maximum number searched	2
Number found	2
Significance used	0.05

Outlier Details				
Obs	Type	Estimate	Chi-Square	Approx Prob>ChiSq
61	Additive	15282.0	26.87	<.0001
13	Additive	13804.0	27.29	<.0001

Model for variable gallons	
Estimated Mean	34420.53

Autoregressive Factors	
Factor 1:	1 - 0.68136 B**(1)
Factor 2:	1 - 0.28506 B**(52)

Forecasts for variable gallons				
Obs	Forecast	Std Error	95% Confidence Limits	
94	34404.3648	7696.2725	19319.9480	49488.7816
95	34353.4628	9312.9683	16100.3803	52606.5453
96	35958.4281	9974.8532	16408.0750	55508.7812
97	36308.9650	10267.642	16184.7570	56433.1730

Outlier Detection Summary	
Maximum number searched	2
Number found	2
Significance used	0.05

Outlier Details				
Obs	Type	Estimate	Chi-Square	Approx Prob>ChiSq
21	Additive	-16944.4	7.24	0.0071
67	Shift	-10390.0	7.78	0.0053

Final Prediction for the following 4 weeks:

[1]	gallons
1	54847
2	55158
3	59365
4	60676

Business Insights

How many gallons will XYZ buy from The Water Co. each week?

Week	WaterCo Quantity used
1	41,135
2	35,000
3	35,000
4	35,000
Total	146,135

How many gallons will XYZ use from their Water Storage Tank each week?

Week	Water Tank Quantity used
1	13,712
2	20,158
3	24,365
4	25,676
Total	**83,911**

What is XYZ's projected total water cost at the end of the next four weeks?

Week	Water Tank Cost
1	2,468.1
2	3,628.5
3	2,436.5
4	2,567.6
Total	**11,100.7**

What is XYZ's projected ending Water Storage Tank inventory at the end of each week?

Week	Inventory = Prev Weeks inventory + precipitation - Amount from tank used by building T	Precipitation	Amount from tank used by building T
1	60,788	12,000	13,712
2	58,630	18,000	20,158
3	56,265	22,000	24,365
4	52,589	22,000	25,676
Total	**228,272**	**74,000**	**83,911**

How much money will XYZ save by choosing the recommended contract over the alternative contract?

Recommended Contract: Contract B

Week	Total Cost
1	7,404.3
2	7,828.5
3	6,636.5
4	6,767.6
Total	**28,637**

Alternative Contract: Contract A:

Week	Total Cost Used
1	8,638.3
2	8,687.4
3	7,186.5
4	7,317.6
Total	**31,829.8**

We will end up saving $3,129 which is 10% lesser than what contract A would end up costing.

How many more/less gallons will be in the Water Storage Tank at the end of the four-week period compared to if the alternative contract was chosen?

Week	Inventory = Prev Weeks inventory + precipitation - Amount from tank used by building T	Precipitation	Amount from tank used by building T
1	60,788	12,000	1,712
2	64,999	18,000	13,790
3	52,634	22,000	34,365
4	38,958	22,000	35,676

Recommendations

We recommend XYZ Co. to go ahead with Contract B as Contract 2 is 10 % cheaper than Contract A.

We can use our forecasting model to predict water needs for longer duration so that we can negotiate better with Water Co. and we can initiate a bidding process to invite more bids which would be evaluated using our optimization model. That way we can save more cost for XYZ Co.