Assignment 2: Individual Project

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BUSN9087 Management Analytics Managerial Report

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Managerial Report

ACME Retail, Skytech Builders & International Capital Inc.

0.0 Introduction

This managerial report addresses three distinct problem sets and provides analysis outcomes to support decision-making in each case. The first problem focuses on sales forecasting for ACME Retail, aiming to develop an accurate forecasting model for Q1-2021. The second problem involves energy use prediction for Skytech Builders, utilizing a multiple linear regression model. The third problem revolves around project network analysis for International Capital Inc., constructing the project network and assessing completion time and probabilities.

0.1 Aim of the report

This report aims to provide an overview of the problems and describes the models and analysis outcomes for each case. It aims to equip the respective organizations with valuable insights and practical tools for effective planning, resource allocation, and project management.

1.0 Problem 1: Sales Forecasting for ACME Retail

1.1 The Problem

This section addresses the sales forecasting problem for ACME Retail, utilizing historical sales data spanning three years on a quarterly basis (see table 1.1). The objective is to develop a forecasting model that accurately predicts sales for Q1-2021, with the Mean Absolute Percent Deviation (MAPD) metric serving as the performance evaluation criterion. This section provides an overview of the problem and presents analysis outcomes to support ACME Retail in their decision-making process.

Quarter	Sales (in 1000s)
Q1-18	108
Q2-18	125
Q3-18	150
Q4-18	141
Q1-19	116
Q2-19	134
Q3-19	159
Q4-19	152
Q1-20	123
Q2-20	142
Q3-20	168
Q4-20	165
Q1-21	

Table_1.1 – Historical Data

Quarter	Sales (in 1000s)	1. Expo Smoothing Forecast	Forecast Errors	Trend	2. Adjusted Forecast	Forecast Errors
Q1-18	108	108				
Q2-18	125	108.00	17.00	0	108.00	17
Q3-18	150	118.20	31.80	1.53	119.73	30.27
Q4-18	141	137.28	3.72	4.1625	141.44	0.4425
Q1-19	116	139.51	23.51	3.872925	143.38	27.38493
Q2-19	134	125.40	8.60	1.175906	126.58	7.419294
Q3-19	159	130.56	28.44	1.773088	132.34	26.66499
Q4-19	152	147.62	4.38	4.066552	151.69	0.30868
Q1-20	123	150.25	27.25	3.85034	154.10	31.10025
Q2-20	142	133.90	8.10	0.820298	134.72	7.27974
Q3-20	168	138.76	29.24	1.426256	140.19	27.81376
Q4-20	165	156.30	8.70	3.843919	160.15	4.852087
Q1-21		161.52		4.049972	165.57	
		MAP	17.34		MAP	16.41
		MAPD	12.11%		MAPD	11.46%

Level (α)	0.6
Trend (β)	0.15

Level (α)	0.44
Trend (β)	0.56

MA Weight	0.15

Table_1.2 – Initial forecast, α, β and MA.

1.2 The model

This section offers an explanation of the forecasting model developed for ACME Retail, aiming to achieve accurate sales predictions for Q1-2021 and reporting the MAPD as an indicator of forecast accuracy. The excel solution comprises several stages of improvement, labeled 1 to 6, with the final model designated as "6. Adjusted with 2-Quarter MA" (table 1.2). The model components include the level (α) and trend (β), estimating the baseline value and rate of change of the time series, respectively (table 1.2). Additionally, the MA weight assigns weights to historical data points in the moving average forecasting model.

Calculating Seasonality Index

Quarter	2018	2019	2020	3-year-avg for each quarter	Overall monthly average	Seasonal Index
Q1	108	116	123	116	140	0.825
Q2	125	134	142	134	140	0.953
Q3	150	159	168	159	140	1.134
Q4	141	152	165	153	140	1.089

	Deseasonalised		
Quarter	2018	2019	2020
Q1	130.95	140.65	149.14
Q2	131.16	140.60	148.99
Q3	132.31	140.25	148.19
Q4	129.53	139.64	151.58

Table_1.3 – Seasonality

Initially, the model is developed through exponential smoothing and adjusted forecast *(1&2 in table 1.2)*, resulting in high MAPDs of 12.11% and 11.46%. To address seasonality, seasonality indexes and de-seasonalized data are calculated *(see table 1.3)*. Forecasts without and with seasonality are generated *(see 3&4 in table 1.4)*.

Quarter in numbers	Sales w/o seasonality	3. Forecast w/o seasonality	Seasonality Index	4. Forecast w Seasonality	Forecast Errors	Trend	5. Adjusted Forecast	Forecast Errors	Exponential smoothing with MA of 2 values	With Seasonality	Forecast Errors	Trend	6. Adjusted with 2-Quarter MA	Forecast Errors
1	108	108.00	0.82	89.07	18.93				108	89.070	18.930			
2	125	108.00	0.95	102.93	22.07	7.82	110.75	14.25	108.00	102.930	22.070	7.82	110.75	14.25
3	150	115.49	1.13	130.93	19.07	19.20	150.13	0.13	113.02	128.125	21.875	14.21	142.33	7.67
4	141	130.70	1.09	142.27	1.27	14.77	157.04	16.04	126.41	137.596	3.404	6.01	143.60	2.60
5	116	135.24	0.82	111.53	4.47	-10.89	100.64	15.36	135.01	111.342	4.658	-12.99	98.35	17.65
6	134	126.76	0.95	120.81	13.19	0.48	121.29	12.71	129.63	123.546	10.454	8.57	132.12	1.88
7	159	129.95	1.13	147.32	11.68	15.16	162.48	3.48	128.05	145.169	13.831	12.70	157.87	1.13
8	152	142.75	1.09	155.39	3.39	11.16	166.55	14.55	139.08	151.397	0.603	4.29	155.68	3.68
9	123	146.83	0.82	121.09	1.91	-14.47	106.62	16.38	146.56	120.874	2.126	-15.44	105.44	17.56
10	142	136.33	0.95	129.93	12.07	-1.33	128.60	13.40	139.87	133.309	8.691	8.69	142.00	0.00
11	168	138.83	1.13	157.39	10.61	14.90	172.29	4.29	136.95	155.263	12.737	12.74	168.00	0.00
12	165	151.68	1.09	165.11	0.11	10.86	175.97	10.97	147.99	161.090	3.910	3.91	165.00	0.00
13		157.55	0.82	129.94		-15.10	114.84		156.70	129.236		-16.28	112.95	
				MAP	9.897346		MAP	11.05124					MAP	6.039026
				MAPD	7.06%		MAPD	7.22%					MAPD	3.95%

Table_1.4 – Final stages of forecasting model.

In the final stage, an adjusted 2-Quarter MA approach is employed. The de-seasonalized forecast is computed using a 2-quarter moving average, followed by re-adjustment for seasonality and trend (see 5&6 in table 1.4). Initially, a what-if analysis data table (see tables A1 & A2) explores optimal levels, trends, and MA weights, while the solver (see figure A3) verifies the optimal combination, resulting in a final MAPD of 3.95%. The forecasting model enables ACME Retail to make informed decisions for effective planning and resource allocation.

1.3 Analysis of Outcomes

Answering the two questions, the final sales prediction for Q1-2021, after undergoing the described improvement stages, is **112.95** (in 1000s). Figure 1.5 displays all stages of the model forecasts, depicting the progression and refinement of predictions. The final model prediction plot (6) is highlighted in yellow, while the actual sales are depicted in black. With the final model, a desirable MAPD of 3.95% was achieved. These outcomes indicate that incorporating seasonality and a specific MA approach significantly enhanced the accuracy of the forecast. However, achieving an ideal MAPD below 2% would require further improvements, such as optimizing the number of quarters included in the MA or refining the seasonality adjustments. ACME Retail can use the insights from this analysis to make informed decisions and further improve the model for more accurate forecasts.

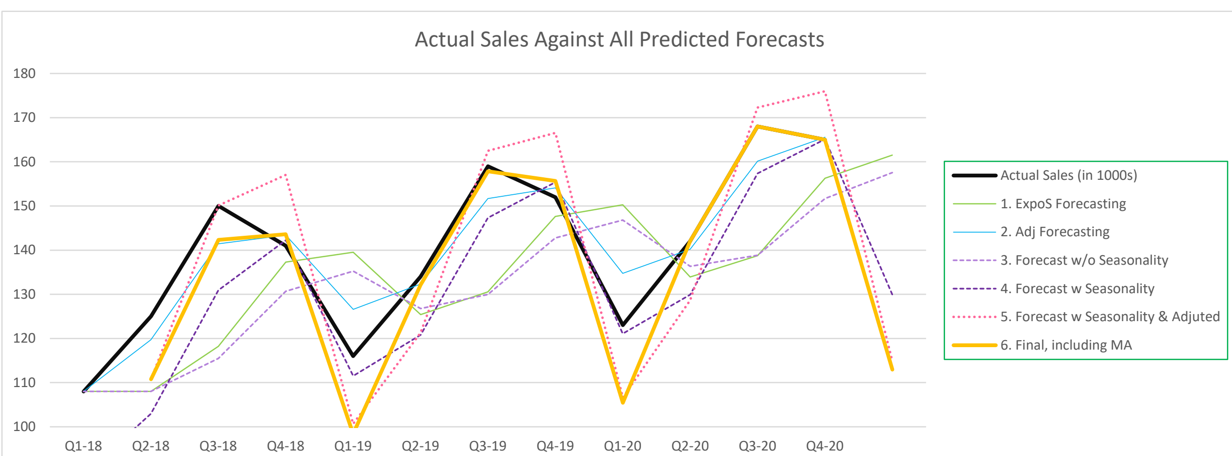

Figure_2.5 – Actual sales vs all forecast sales predictions.

2.0 Problem 2: Energy Use Prediction for Skytech Builders_323

2.1 The Problem

This section addresses problem 2: the monthly energy use prediction for Skytech Builders. The management at Skytech Builders believes that energy use is influenced by the production volumes, daily outside temperature and the number of workdays. Historical data collected over the past year (see table 2.1) has been provided to develop a regression model.

2.2 The model

The developed multiple linear regression model predicts energy use based on the given predictors. Table 2.1 illustrates positive correlations between all predictors and energy use, while scatter plots in figures A4-A6 depict these correlations. Figures 2.2 and A7-A9 display the four regression models utilizing different predictor combinations.

Month	Energy Use	Temperature	Days	Production	Predicted Energy Use
1	450	42	24	121	452.528065
2	442	56	21	116	464.411943
3	499	62	24	132	494.449246
4	484	68	25	109	470.866312
5	479	78	25	115	492.514341
6	507	85	26	119	507.392986
7	515	89	25	118	511.377613
8	501	81	24	116	497.908848
9	513	73	24	132	509.187884
10	480	67	25	127	494.274237
11	492	58	24	122	475.340962
12	466	50	23	117	457.747563
2. Correlation Coefficient		0.7744	0.6325	0.3143	
5. New Prediction		55	25	120	**468.571578**

Table_2.1 – Historical data, predictions & correlation coefficient.

SUMMARY OUTPUT: Model 4 - Production & Temperature

Regression Statistics	
Multiple R	0.872458154
R Square	0.761183231
Adjusted R Square	0.708112837
Standard Error	12.78571473
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	4689.396156	2344.6981	14.3429	0.001589614
Residual	9	1471.27051	163.4745		
Total	11	6160.666667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	229.8930446	71.45103366	3.2174908	0.010532	68.25957696	391.526512	68.25957696	391.5265121
Production	1.374877855	0.557360095	2.4667677	0.035759	0.114041723	2.63571399	0.114041723	2.635713986
Temperature	1.339876197	0.268171849	4.9963343	0.000743	0.733229327	1.94652307	0.733229327	1.946523066

Figure_2.2 – Multiple linear regression model 4.

2.3 Analysis of Outcomes

The analysis of outcomes addresses the given questions on the model. Based on the regression models, not all variables should be included in the final model. Model 4 (figure 2.2) is preferred, including only the production and temperature variables, despite model 3 (figure A9) having a higher R^2 value of 0.79. The P-value of the "Days" predictor exceeds the significance level of 0.05, indicating its lack of statistical significance. Omitting unnecessary variables aligns with the

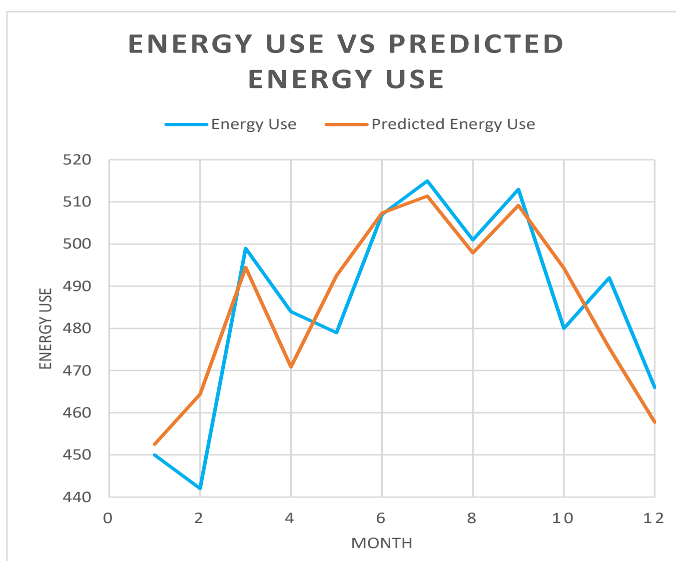

Figure_2.3 – Fit of model 4 predictions to historical data.

principle of model parsimony, favoring simpler models with comparable predictive power. Including unnecessary variables may lead to overfitting to the training data, leading to poorer performance on new data (Gupta, 2021).

Model 4 predicts energy use using the formula:

$$\text{Energy Use} = 229.8930446 + (1.374877855 * \text{Production}) + (1.339876197 * \text{Temperature})$$

For a month with 25 days, a temperature of 55 units, and production of 120 units, the predicted energy use is 468.5. Overall, the analysis demonstrates the effectiveness of the developed regression model in predicting energy use for Skytech Builders and provides a practical method for predicting energy use with new production and temperature values.

3.0 Problem 3: Project Network Analysis for International Capital Inc.

3.1 The Problem

International Capital Inc. (IC), a small investment bank, specializes in securing funds for small-to-medium-sized logistic companies. This managerial report addresses a specific project engagement, where IC follows a standardized project format with variable activity times and circumstances. The objective is to construct the project network based on the given data and analyze the project's expected completion time, as well as the probabilities of completing the project within specific time frames.

Activity	Description	Optimistic	Most Likely	Pessimistic	Predecessor Information	Expected Time (TE)	Variance	ES	EF	LS	LF	Slack
A	Research client firm	4	7	10	--	7	1	0	7	0	7	0
B	Create due diligence rough report	2	5	8	A	5	1	7	12	7	12	0
C	Coordinate needs proposal with client	16	19	28	B	20	4	12	31	12	31	0
D	Estimate future demand and cash flows	6	9	24	B	11	9	12	21	19	24	7
E	Draft future plans for client company	1	7	13	D	7	4	21	28	24	31	3
F	Create and approve legal documents	4	10	28	B	12	16	12	22	21	31	9
G	Integrate all drafts into first-draft proposa	2	5	14	C,E,F	6	4	31	36	31	36	0
H	Line up potential sources of capital	5	8	17	G	9	4	36	44	36	44	0
I	Check, approve and print final legal proposal	2	5	8	G	5	1	36	41	39	44	3
J	Sign contracts and transfer funds	17	29	47	H,I	30	25	44	73	44	73	0

Table 3.1 – Given data and calculations.

3.2 The model

The given data provided, including the activity descriptions, time estimates, and predecessor information is shown in table 3.1, along with the calculated values and earliest/latest start and finish times. Using this information, a project network diagram has been constructed (figure 3.2), along with determining the critical path and use of the PERT method to calculate the project's expected completion time. Statistical analysis was performed (table A10) to calculate the variance and SD of the critical path, assessing the project's overall risk.

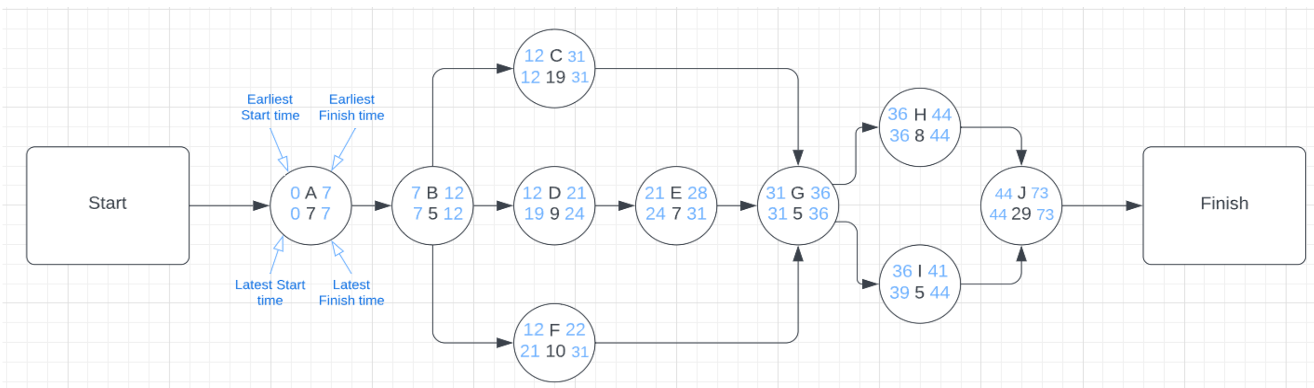

Figure 3.2 – Project network diagram.

3.3 Analysis of Outcomes

The model reveals that the expected completion time for the project is 73 days, considering the critical path A->B->C->G->H->J. Probability of completing the project in 85 days or less in 97.27%, indicating a high likelihood of meeting the target timeframe. Conversely, the probability of the project exceeding 90 days in 0.32%, suggesting a low risk of project delays.

By presenting the project network diagram, expected completion time, and probability calculations, this report gives International Capital Inc. valuable information for project scheduling and risk assessment. It will allow informed decision-making and effective project management to ensure successful outcomes for their clients.

Conclusion

In conclusion, this managerial report has provided valuable insights and practical solutions for ACME Retail, Skytech Builders, and International Capital Inc. The analysis outcomes have demonstrated the effectiveness of the developed models in sales forecasting, energy use prediction, and project network analysis. These findings enable informed decision-making, effective resource allocation, and enhanced project management. By implementing the recommended approaches, the respective organizations can optimize their operations, improve forecast accuracy, and mitigate risks, ultimately leading to improved outcomes and success in their respective domains.

References

Gupta, A. (2021). *Model Selection Techniques -Parsimony & Goodness of Fit*. [online] Geek Culture. Available at: https://medium.com/geekculture/model-selection-techniques-parsimony-goodness-of-fit-fc2f1863ccfd.

Appendix – A

Table A1 – Optimizing level and trend.

Optimising alpha an beta values

3.95%	0.10	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
0.1	14.97%	14.90%	14.83%	14.76%	14.68%	14.61%	14.54%	14.47%	14.40%	14.33%	14.26%	14.18%	14.11%	14.04%	13.97%	13.90%	13.83%	13.76%	13.69%
0.15	12.10%	12.01%	11.91%	11.82%	11.72%	11.63%	11.54%	11.44%	11.35%	11.25%	11.16%	11.07%	10.97%	10.88%	10.78%	10.71%	10.71%	10.77%	10.90%
0.2	9.93%	9.82%	9.71%	9.60%	9.49%	9.38%	9.27%	9.16%	9.05%	8.94%	8.83%	8.76%	8.74%	8.76%	8.87%	8.98%	9.10%	9.35%	9.66%
0.25	8.26%	8.14%	8.02%	7.90%	7.78%	7.66%	7.53%	7.41%	7.29%	7.26%	7.22%	7.24%	7.33%	7.42%	7.56%	7.85%	8.15%	8.44%	8.74%
0.3	6.97%	6.84%	6.71%	6.58%	6.45%	6.32%	6.19%	6.08%	6.03%	5.98%	5.98%	6.06%	6.13%	6.37%	6.64%	6.91%	7.18%	7.45%	7.72%
0.35	5.94%	5.81%	5.67%	5.53%	5.40%	5.26%	5.13%	5.02%	4.96%	4.89%	4.93%	4.99%	5.17%	5.41%	5.66%	5.91%	6.15%	6.40%	6.65%
0.4	5.12%	4.98%	4.84%	4.72%	4.60%	4.47%	4.35%	4.22%	4.13%	4.07%	4.11%	4.23%	4.45%	4.72%	5.00%	5.28%	5.56%	5.90%	6.32%
0.45	4.68%	4.56%	4.48%	4.41%	4.34%	4.27%	4.20%	4.13%	4.09%	4.05%	4.10%	4.31%	4.56%	4.82%	5.07%	5.36%	5.80%	6.25%	6.70%
0.5	4.67%	4.66%	4.64%	4.63%	4.62%	4.60%	4.59%	4.58%	4.56%	4.55%	4.60%	4.81%	5.05%	5.28%	5.56%	5.96%	6.40%	6.83%	7.26%
0.55	5.11%	5.00%	5.02%	5.03%	5.05%	5.06%	5.08%	5.09%	5.11%	5.12%	5.17%	5.44%	5.71%	6.06%	6.49%	6.92%	7.35%	7.78%	8.21%
0.6	5.66%	5.40%	5.44%	5.48%	5.53%	5.57%	5.61%	5.66%	5.70%	5.74%	5.84%	6.14%	6.56%	7.03%	7.51%	7.98%	8.45%	8.92%	9.39%
0.65	6.24%	5.91%	5.90%	5.97%	6.04%	6.12%	6.19%	6.26%	6.33%	6.40%	6.58%	7.06%	7.57%	8.08%	8.60%	9.11%	9.63%	10.14%	10.66%
0.7	6.81%	6.46%	6.39%	6.49%	6.59%	6.68%	6.78%	6.88%	6.98%	7.08%	7.53%	8.09%	8.65%	9.21%	9.77%	10.33%	10.89%	11.44%	12.00%
0.75	7.36%	7.01%	6.90%	7.02%	7.14%	7.27%	7.39%	7.51%	7.63%	7.99%	8.59%	9.20%	9.80%	10.40%	11.01%	11.61%	12.22%	12.82%	13.43%
0.8	7.87%	7.52%	7.41%	7.55%	7.70%	7.85%	7.99%	8.14%	8.47%	9.05%	9.70%	10.35%	11.00%	11.65%	12.31%	12.96%	13.61%	14.26%	14.91%
0.85	8.33%	7.99%	7.91%	8.08%	8.25%	8.42%	8.58%	8.89%	9.46%	10.16%	10.86%	11.56%	12.25%	12.95%	13.65%	14.35%	15.05%	15.74%	16.44%
0.9	8.75%	8.40%	8.41%	8.59%	8.78%	8.97%	9.24%	9.82%	10.56%	11.31%	12.05%	12.79%	13.54%	14.28%	15.03%	15.77%	16.51%	17.26%	18.00%
0.95	9.12%	8.76%	8.88%	9.08%	9.28%	9.53%	10.13%	10.89%	11.68%	12.47%	13.26%	14.05%	14.84%	15.63%	16.42%	17.21%	18.00%	18.79%	19.58%
1	9.42%	9.11%	9.33%	9.54%	9.77%	10.36%	11.14%	11.98%	12.81%	13.65%	14.48%	15.31%	16.15%	16.98%	17.82%	18.65%	19.48%	20.32%	21.15%

Table A2 – Optimizing MA.

Optimising MA Weight

	3.95%
0.1	4.493%
0.15	3.955%
0.2	4.033%
0.25	4.683%
0.3	5.540%
0.35	6.414%
0.4	7.300%
0.45	8.192%
0.5	9.084%
0.55	9.972%
0.6	10.852%
0.65	11.723%
0.7	12.585%
0.75	13.443%
0.8	14.303%
0.85	15.176%
0.9	16.077%
0.95	17.029%
1	18.061%

Figure A3 – Solver parameters, where Z16 = MAPD, J5 = level, J6 = trend and J8 = MA.

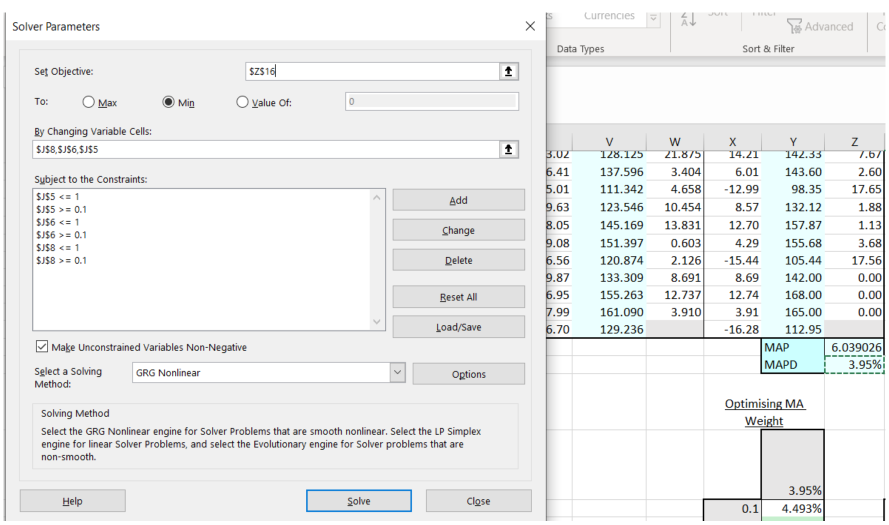

Figure A4 – Temperature vs Energy Use scatter plot.

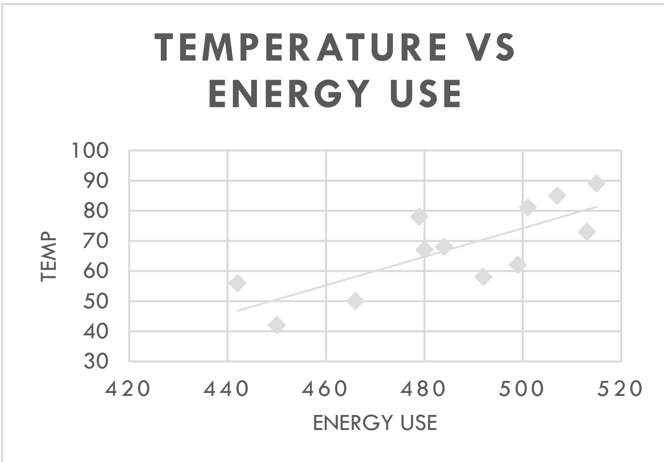

Figure A5 – Days vs Energy Use scatter plot.

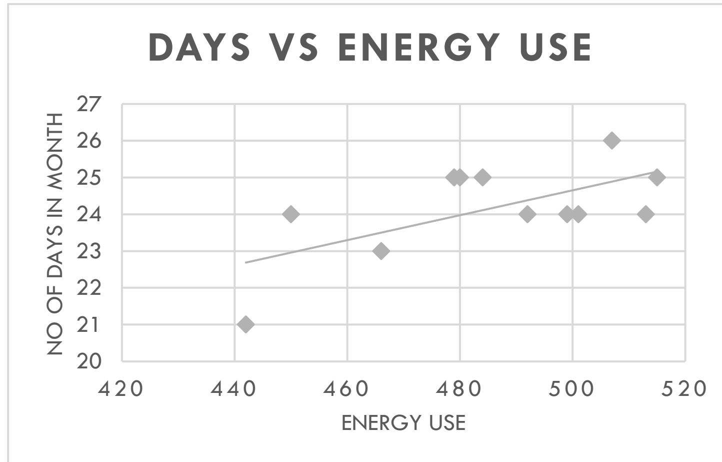

Figure A6 – Production vs Energy Use

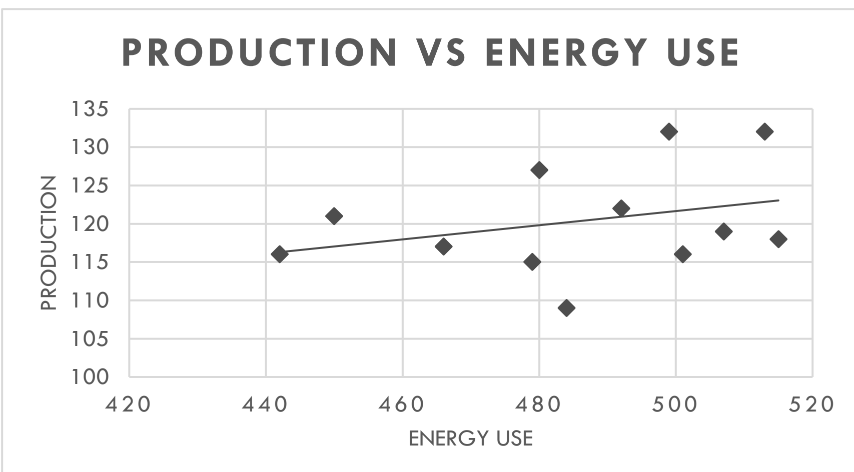

Figure A7 – Multiple linear regression model 1.

SUMMARY OUTPUT: Model 1 - Temperature

Regression Statistics	
Multiple R	0.77441
R Square	0.59972
Adjusted R Square	0.55969
Standard Error	15.70351
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3694.66319	3694.6632	14.98239	0.003105569
Residual	10	2466.003477	246.60035		
Total	11	6160.666667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	400.23788	22.53132	17.76362	0.00000	350.03497	450.44078	350.03497	450.44078
Temperature	1.26718	0.32738	3.87071	0.00311	0.53774	1.99661	0.53774	1.99661

Figure A8 – Multiple linear regression model 2.

SUMMARY OUTPUT: Model 2- Temperature & Days

Regression Statistics	
Multiple R	0.80415696
R Square	0.646668417
Adjusted R Square	0.568150288
Standard Error	15.55191344
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	3983.908561	1991.9543	8.235912	0.00926448
Residual	9	2176.758105	241.86201		
Total	11	6160.666667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	296.526148	97.42684849	3.0435773	0.013937	76.1313048	516.920991	76.1313048	516.9209911
Temperature	1.007379027	0.401936899	2.5063114	0.033513	0.098134592	1.91662346	0.098134592	1.916623463
Days	5.016264107	4.587024031	1.093577	**0.302545**	-5.360305161	15.3928334	-5.360305161	15.39283338

Figure A9 – Multiple linear regression model 3.

SUMMARY OUTPUT: Model 3 - All Variables

Regression Statistics	
Multiple R	0.890450181
R Square	0.792901525
Adjusted R Square	0.715239597
Standard Error	12.6286612
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	4884.801997	1628.2673	10.20966	0.004134161
Residual	8	1275.86467	159.48308		
Total	11	6160.666667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	151.6825726	99.86476453	1.5188798	0.167276	-78.60598733	381.971133	-78.60598733	381.9711326
Temperature	1.122126227	0.329937344	3.4010282	0.009346	0.361289348	1.88296311	0.361289348	1.882963106
Days	4.143033778	3.74288959	1.1069078	**0.300504**	-4.488085095	12.7741527	-4.488085095	12.77415265

Table A10 – Critical path and statistical analysis.

Critical Path

Critical Path	A -> B -> C -> G -> H -> J
Completion time	**73**

Statistical Analysis

Variance of Critical Path	39
Standard Deviation of Critical Path	6.244998

Probability Calculations

Probability of completing project in 85 days or less...	**P(T<=85)**	**97.27%**
Probability project will exceed 90 days...	**P(T>90)**	**0.32%**