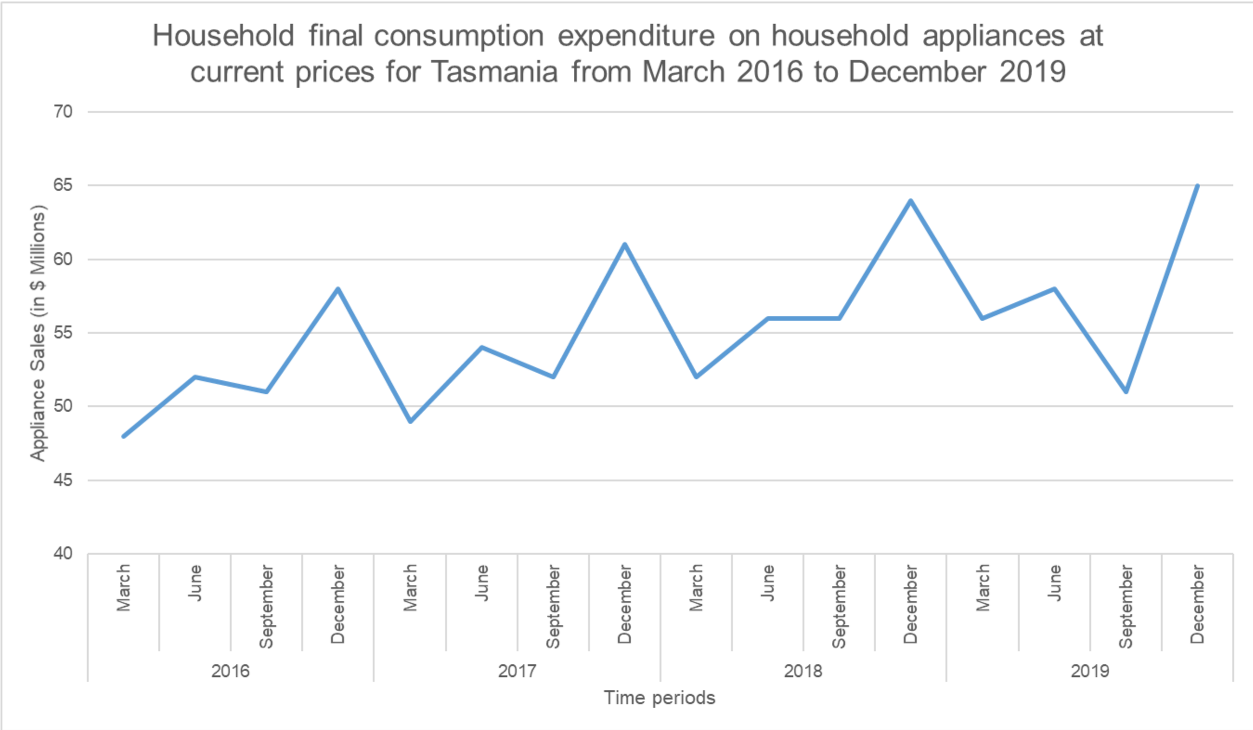
Question Zero (1 page)

Q0) In my last case study report, I identified a relevant time series on the Australian Bureau of Statistics (ABS) website and a reference will be made to this time series in this report as well as in the XLS file submitted along with this report.

<u>Line chart of the relevant time series for the last 4 years</u>:



Questions 1 & 2 (1 page) – The Regression

Q1) Instead of using the (multiplicative) Winters' Exponential Smoothing (WES) model, which was used in my last case study report, in this report I used a multiple regression model with quasi-explanatory variables to estimate appliance sales for Tasmania. This model is appropriate for the time series as the time series has trend (upward constant linear trend) and seasonal (additive seasonality) components.

Firstly, I created a time variable (or time index) from 1 to 16 for each quarter from March 2016 to December 2019 and 3 dummy variables (Dummy March / Dummy June / Dummy September) with Dummy December as the baseline for the quarterly effect.

Year	Quarter	Appliance Sales	Time	Dummy March	Dummy June	Dummy September
2016	March	48	1	1	0	0
	June	52	2	0	1	0
	September	51	3	0	0	1
	December	58	4	0	0	0
2017	March	49	5	1	0	0
	June	54	6	0	1	0
	September	52	7	0	0	1
	December	61	8	0	0	0
2018	March	52	9	1	0	0
	June	56	10	0	1	0
	September	56	11	0	0	1
	December	64	12	0	0	0
2019	March	56	13	1	0	0
	June	58	14	0	1	0
	September	51	15	0	0	1
	December	65	16	0	0	0

I then used the 'Regression' analysis tool from the Data Analysis ToolPak add-in in Excel to perform the multiple regression. I inputted Appliances Sales as the response variable and Time and the 3 dummy variables as predictor variables and I also told the tool to output the residuals and respective residual plots. Following is the summary output that was generated by the analysis tool.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.952542808
R Square	0.91
Adjusted R Square	0.87
Standard Error	1.794879079
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	347	86.75	26.92768959	0.0000
Residual	11	35.4375	3.221590909		
Total	15	382.4375			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	57.31	1.346159309	42.57482721	0.0000	54.34962334	60.27537666	54.34962334	60.27537666
Time	0.47	0.100336791	4.671765922	0.0007	0.247910212	0.689589788	0.247910212	0.689589788
Dummy March	-9.34	1.304378281	-7.163374413	0.0000	-12.21466724	-6.472832761	-12.21466724	-6.472832761
Dummy June	-6.06	1.284937874	-4.718126939	0.0006	-8.890629193	-3.234370807	-8.890629193	-3.234370807
Dummy September	-9.03	1.27313115	-7.093731072	0.0000	-11.83339277	-6.229107231	-11.83339277	-6.229107231

The overall regression equation for the multiple regression model is:

$$\widehat{\text{Appliance Sales}} = 57.31 + (0.47 * \text{Time}) – (9.34 * \text{Dummy March}) – (6.06 * \text{Dummy June}) – (9.03 * \text{Dummy September})$$

Q2) The meaning of the intercept is that when Time, Dummy March, Dummy June, and Dummy September are all 0, appliances sales will be $57,310,000 on average in the December quarter (the baseline). The meaning of the coefficient of the time variable is that for every unit increase in Time (this means for every quarter), appliance sales increase by $470,000 on average (this is while holding all other variables constant). The meaning of the coefficient for the September dummy variable (Dummy September) is that relative to the December dummy variable (the baseline), appliance sales in the September quarter are $9,030,000 less on average (this is while ignoring the seasonal effects of the other quarters).

Questions 3 & 4 (1 page) – R^2 and the Dummy Variables

Q3) The coefficient of determination, also known as R^2, refers to the explanatory power of the multiple regression model with quasi-explanatory variables. It is a number between 0 and 1 and it represents the percentage variation in appliance sales that is explained by the variation in the predictor variables.

The R^2 value for my regression is 0.91 (91%) and this means that approximately 91% of the variation in appliance sales is explained by the regression model. The remaining 9% of the variation in appliance sales is explained by some other variables or factors which I cannot include in my regression model.

A modification to R^2 is Adjusted R^2 which is a similar calculation to R^2 however Adjusted R^2 considers the sample size and the number of predictor variables used in the regression model. The Adjusted R^2 value for my regression is 0.87 (87%) and this means that approximately 87% of the variation in appliance sales is explained by the regression model while considering the sample size and the number of predictor variables used. Since both the R^2 and Adjusted R^2 values are close to 1, this indicates that the model has significant predictive power.

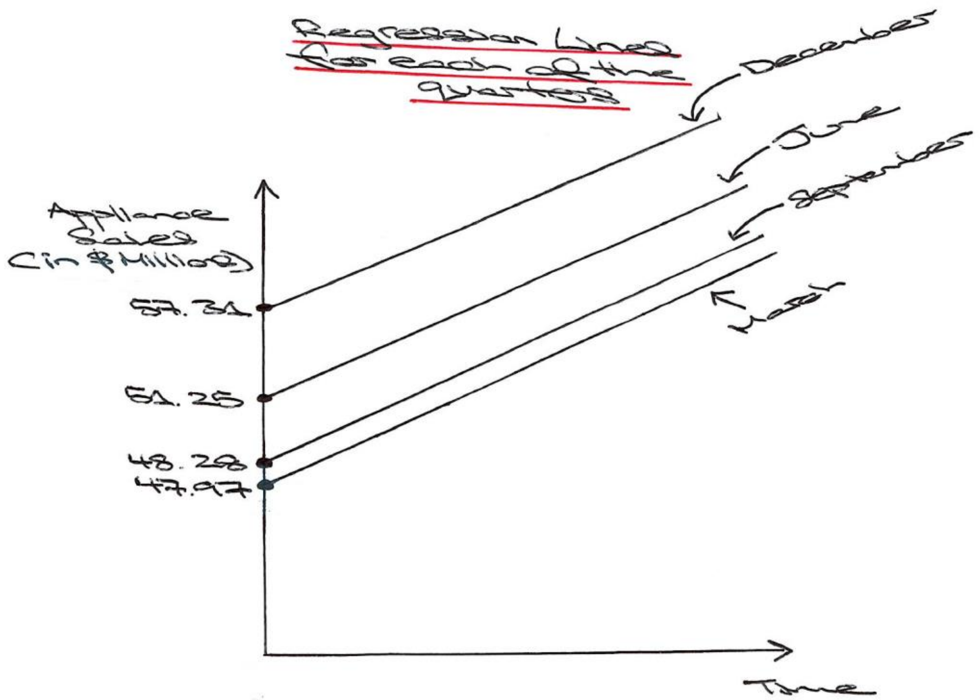
The coefficient of determination is an important statistic, however, this statistic can be biased and easily manipulated. Each time a variable is added to a regression model, the R^2 value increases, giving the impression that having more variables means that the model will have better explanatory power. Obviously, this is not the case, and this also presents multicollinearity issues that would need to be addressed. Thus, the coefficient of determination is an important statistic that should be used with caution.

Q4) <u>The regression equation for March is</u>: $\widehat{\text{Appliance}}$ Sales = 47.97 + (0.47 * Time)

<u>The regression equation for June is</u>: $\widehat{\text{Appliance}}$ Sales = 51.25 + (0.47 * Time)

<u>The regression equation for September is</u>: $\widehat{\text{Appliance}}$ Sales = 48.28 + (0.47 * Time)

<u>The regression equation for December is</u>: $\widehat{\text{Appliance}}$ Sales = 57.31 + (0.47 * Time)



Questions 5 & 6 (one page) – Tests

Q5) The appropriate test to test the overall significance of a regression model is the F test and I used this test to test the overall significance of my multiple regression model with quasi-explanatory variables. The null hypothesis (H_0) is that all the coefficients of the seasonal dummy variables are 0 ($a_i = 0$) meaning there are no relationships present between the predictor and response variables and the alternative hypothesis (H_1) is that at least 1 of the coefficients of the seasonal dummy variables is not 0 (at least 1 $a_i \neq 0$) meaning there is at a least 1 relationship present between the predictor and response variables.

The F statistic that was generated by the model is 26.93, which is a large F statistic, and the p-value is smaller than 0.05 (p-value < 0.05) which means that I can reject the null hypothesis (H_0). This means that there is evidence that at least 1 of the coefficients of the seasonal dummy variables is not 0 at the 5% significance level and that there is at least 1 relationship present between appliance sales and the predictor variables. The multiple regression model is significant in explaining the variations in appliance sales and has some predictive ability. This also proves that seasonality is present in the model.

Q6) The appropriate test to test the individual significance of a coefficient in my regression is the t test.

<u>Testing the individual significance of the coefficient for the time variable</u>:

The null hypothesis (H_0) is that there is no linear relationship that exists between time and appliance sales ($\beta_{Time} = 0$) and the alternative hypothesis (H_1) is that there is a linear relationship that exists between time and appliance sales ($\beta_{Time} \neq 0$).

The t statistic that was generated by the model is 4.67 and the p-value is smaller than 0.05 (p-value < 0.05) which means that I can reject the null hypothesis (H_0). This means that there is evidence of a significant linear relationship between time and appliance sales at the 5% significance level.

<u>Testing the individual significance of the coefficient for the September dummy variable (Dummy September)</u>:

The null hypothesis (H_0) is that there is no difference between the September dummy variable and the December dummy variable (the baseline) and the alternative hypothesis (H_1) is that there is a difference between the September dummy variable and the December dummy variable (the baseline).

The t statistic that was generated by the model is -7.09 and the p-value is smaller than 0.05 (p-value < 0.05) which means that I can reject the null hypothesis (H_0). This means that there is a significant difference between the September quarter and the December quarter (the baseline) at the 5% significance level.

Questions 7 & 8 (one page) – Forecasts and Performance

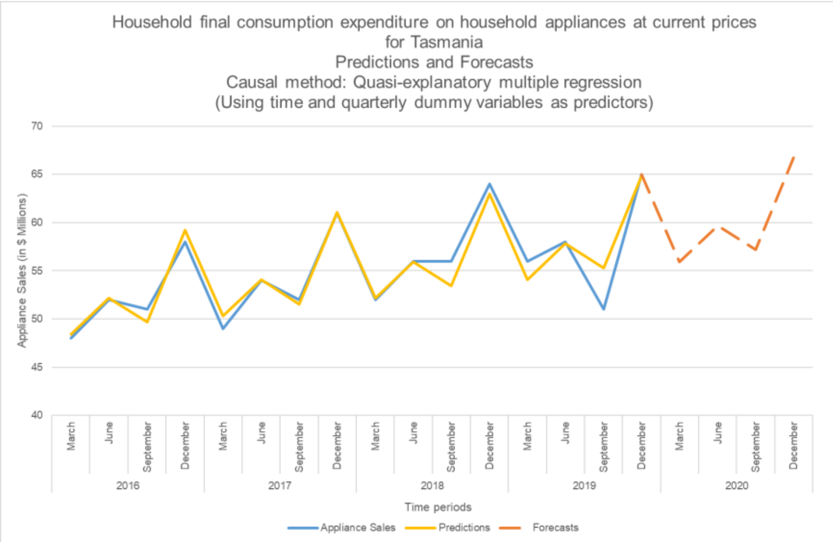
Q7) I produced forecasts to forecast appliance sales for the upcoming 4 quarters (each quarter beyond my sample period) using my regression equation.

<u>My working for the September forecast (September 2020) is</u>:

$$\widehat{\text{Appliance Sales}} = 57.31 + (0.47 * \text{Time}) - (9.34 * \text{Dummy March}) - (6.06 * \text{Dummy June}) - (9.03 * \text{Dummy September})$$

$$\widehat{\text{Appliance Sales}} = 57.31 + (0.47 * 19) - (9.34 * 0) - (6.06 * 0) - (9.03 * 1)$$

$$\therefore \widehat{\text{Appliance Sales}} = 57 \text{ (in \$ Millions)}$$



Time Index	Year	Quarter	Appliance Sales	Predictions	Forecasts
1	2016	March	48	48	
2		June	52	52	
3		September	51	50	
4		December	58	59	
5	2017	March	49	50	
6		June	54	54	
7		September	52	52	
8		December	61	61	
9	2018	March	52	52	
10		June	56	56	
11		September	56	53	
12		December	64	63	
13	2019	March	56	54	
14		June	58	58	
15		September	51	55	
16		December	65	65	
17	2020	March			56
18		June			60
19		September			57
20		December			67

Above I plotted a line chart of my original data against time and included my forecasts as well as my predictions. I can conclude that the multiple regression model with quasi-explanatory variables is a suitable model for the original data as the forecasted and predicted values fit reasonably well with the actual time series data and they extrapolate the upward constant linear trend and additive seasonality components that were observed from the original data.

Q8) After considering my answers to all of the previous questions, there are no modifications that I would suggest to arrive at an improved regression model because my model has high explanatory power, my model can explain the variations in appliance sales and all predictor variables are significant. However, modifications in general that can improve a regression model include removing insignificant predictor variables one at a time and redoing the model, merging monthly data into quarterly data to better assess the seasonal effects of the model or using regular explanatory variables instead of quasi-explanatory variables.

Model	MAE	MSE	MAPE	RMSE	Residuals Plot(s)	ACF Test of Residuals
1. (multiplicative) WES model [EXCEL SOLVER]	1.53	4.65	2.82	2.16	No	Yes
2. Multiple regression model with quasi-explanatory variables	0.97	2.21	1.80	1.49	Yes	Yes

After assessing the accuracy and adequacy (unbiasedness) of my model from Case Study Report #1 and my regression model above (using the above error criteria summary table), the model I would use to utilise for my specific business case would be the multiple regression model with quasi-explanatory variables. This is because the regression model performed better and has smaller error criteria compared to my model from Case Study Report #1.

Questions 9 & 10 (one page) – Judgmental Forecasting

Q9) Subjective assessment methods in the context of judgmental forecasting are used in the short to medium term by organisations to produce forecasts using new and weighted information. These methods are used when some major change or structural break (i.e. COVID-19) has occurred in the forecasting context that is not accounted for by other techniques.

Jury of Executive Opinion is a subjective assessment method that American home appliance retailer *HomeAppCo* should use to forecast appliance sales. *HomeAppCo* has possible future plans of expanding and launching stores across Australia and this decision should be made by corporate executives after evaluating the economic and environmental factors or circumstances that currently exist that will impact future forecasts.

COVID-19 has resulted in an income effect which has seen a reduction in incomes as people have lost their jobs, working hours have been reduced and businesses have shut down. This has caused a reduction in home appliance purchases as "Australians have suffered a $102bn blow to household income" (Karp 2020). Moreover, COVID-19 has also resulted in a substitution effect because lockdown laws and social distancing measures have forced people to change their lifestyles and adjust to life at home and this has led to an increase in home appliance purchases. Appliances right now which are being purchased include bread makers, toasters and coffee machines as "more Australians substitute their takeaway lattes for a home-brewed cup" (Powell 2020).

Therefore, corporate executives at *HomeAppCo* should make a final decision as a group about forecasting appliance sales by weighting each executive's opinion about the income effect and the substitution effect. However, *HomeAppCo* needs to be aware of judgmental biases such as groupthink which can influence and lead to inaccurate or erroneous forecasts. Groupthink by the world's political leaders and infectious-disease specialists was a possible factor that led to the global coronavirus outbreak in the first place (Shanker 2020).

Q10) Scenario analysis in the context of judgmental forecasting is an exploratory method used in the medium to long term by organisations to produce forecasts. In particular, scenario analysis is used when there is an absence of relevant data or information and the economic and business environment is turbulent. This describes the current global coronavirus outbreak situation. COVID-19 has created an uncertain future for companies and *HomeAppCo* needs to evaluate different potential outcomes when forecasting appliance sales.

One way that *HomeAppCo* could implement scenario analysis is by establishing a best, base and worst case scenario of what the aftermath of the COVID-19 situation is going to be like for the American home appliance retailer. A best case scenario would look similar to the forecasts generated by the multiple regression model with quasi-explanatory variables with predicted growth in appliance sales with seasonal effects and as people start earning more money, higher incomes and purchasing power will lead to increased home appliance purchases. Alternatively, a worst case scenario would entail not expanding into Australia because COVID-19's impact being so detrimental that *HomeApp*Co sees that similar businesses are closing down and have not been able to recover or as people spend more time outside their homes after lockdown restrictions are lifted that there will be much less demand for household appliances. Hisense Group, a Chinese home appliance manufacturer who sells appliances to Australia is an example of a similar business that is currently struggling to survive COVID-19 (Tang 2020).

HomeAppCo needs to strategically consider and evaluate all the scenarios that they formulate when planning for the future. Organisations now know that they need to incorporate unprecedented global events such as COVID-19 into their scenario analysis. Companies need to be flexible and proactive and need to know how to quickly adapt to unforeseen circumstances and radical change, maximise on potential opportunities and mitigate potential threats.

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