Project: Forecasting Sales

Step 1: Plan Your Analysis

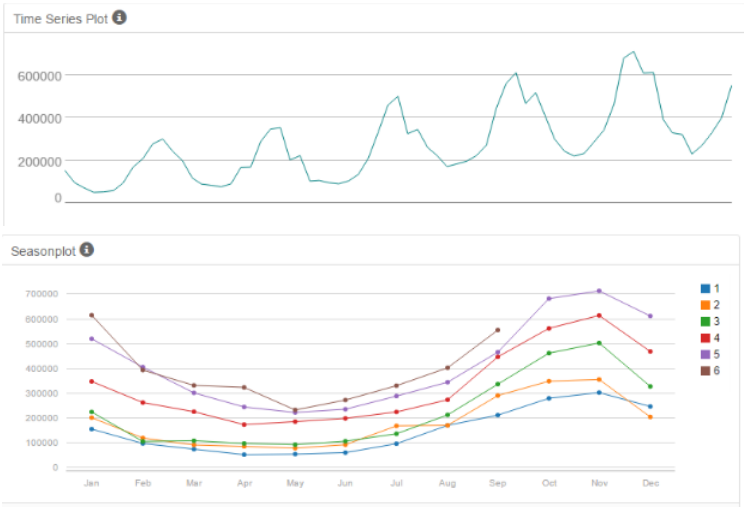
Answer the following questions to help you plan out your analysis:

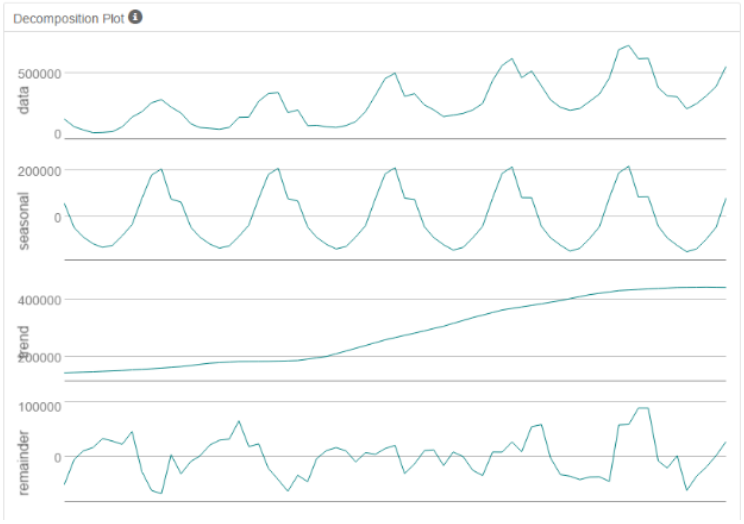
1. Does the dataset meet the criteria of a time series dataset? Make sure to explore all four key characteristics of a time series data. - *each measurement of data taken across a continuous time interval is sequential and of equal intervals, each time unit having at most one data point, ordering matters in the list of observations and dependency of time.*

2. Which records should be used as the holdout sample? - *Holdout sample size depends on how far the prediction is. Since we need to predict the sales for the next 4 months, a 4-month long holdout sample from Jun-13 till Sept-13 should be used.*

Step 2: Determine Trend, Seasonal, and Error components

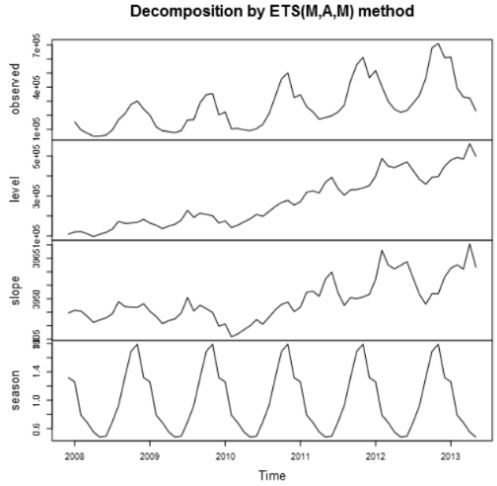
1. What are the trend, seasonality, and error of the time series? Show how you were able to determine the components using time series plots. Include the graphs. -*The time series and decomposition plots are generated using TS plot function.*
   The seasonality and trend show increasing trends, thus multiplication and addition should be applied respectively.
   For error plot, there isn't a trend but rather fluctuations and thus should be applied multiplicatively as well.





Step 3: Build your Models

1. What are the model terms for ETS? Explain why you chose those terms.
    a. Describe the in-sample errors. Use at least RMSE and MASE when examining results – *ETS (M,A,M) is chosen based on the decomposition plot above. A dampened and non-dampened ETS models are run with a holdout sample of 4 months.*



In-sample error measures:

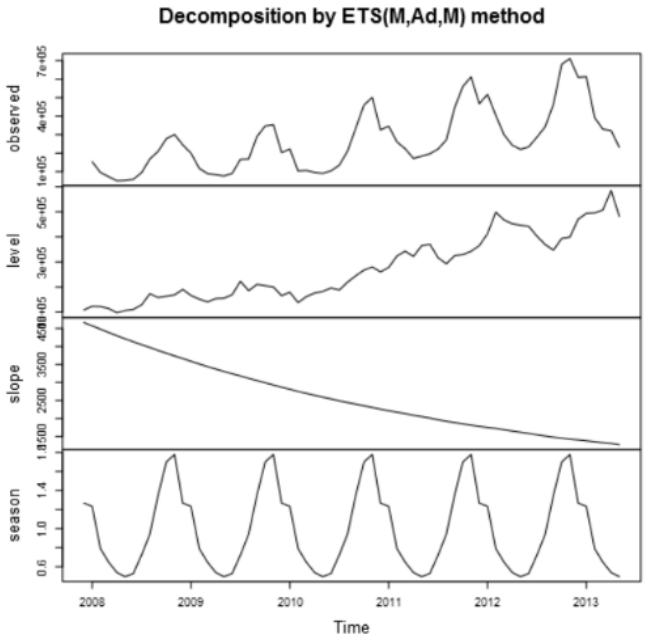
ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
2818.2731122	32992.7261011	25546.503798	-0.3778444	10.9094683	0.372685	0.0661496

Information criteria:

AIC	AICc	BIC
1639.7367	1652.7579	1676.7012

*The AIC value is **1639.74**, RMSE (Moot Mean Square Error) is **32992.73** and MASE (Mean Absolute Percentage Error) is **0.3727**.*

Dampened ETS Model:



In-sample error measures:

	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
	5597.130809	33153.5267713	25194.3638912	0.1087234	10.3793021	0.3675478	0.0456277

Information criteria:

AIC	AICc	BIC
1639.465	1654.3346	1678.604

*The AIC value is **1639.47**, RMSE is **33153.53** and MASE is **0.3675***

Non-Dampened:

Actual and Forecast Values:

Actual	ETS
271000	248063.01908
329000	351306.93837
401000	471888.58168
553000	679154.7895

Accuracy Measures:

Model	ME	RMSE	MAE	MPE	MAPE	MASE	NA
ETS	-49103.33	74101.16	60571.82	-9.7018	13.9337	1.0066	NA

Dampened:

Actual and Forecast Values:

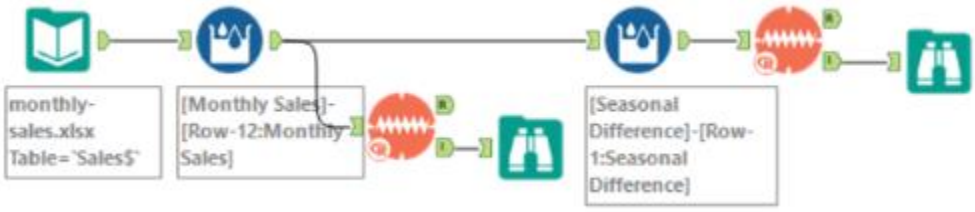
Actual	ETS_damped
271000	255966.17855
329000	350001.90227
401000	456886.11249
553000	656414.09775

Accuracy Measures:

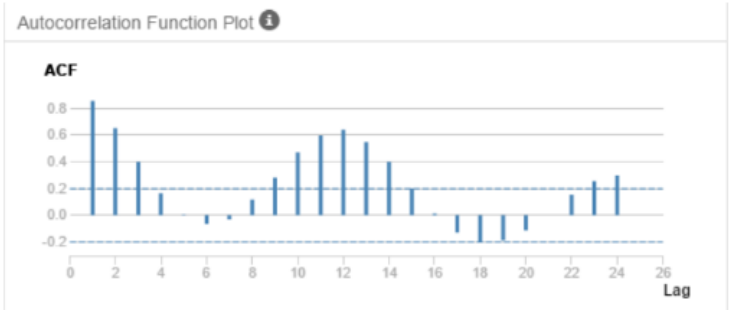
	Model	ME	RMSE	MAE	MPE	MAPE	MASE	NA
ETS_damped		-41317.07	60176.47	48833.98	-8.3683	11.1421	0.8116	NA

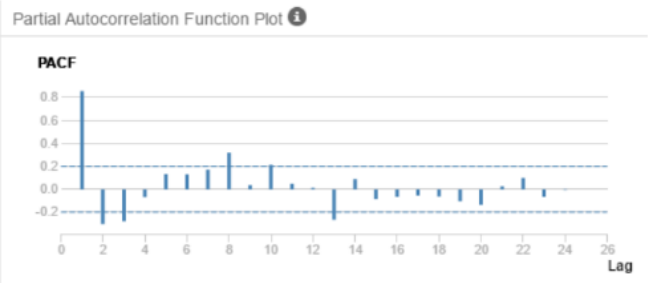
Dampened *model is chosen due to its higher accuracy*.

2. What are the model terms for ARIMA? Explain why you chose those terms. Graph the Auto-Correlation Function (ACF) and Partial Autocorrelation Function Plots (PACF) for the time series and seasonal component and use these graphs to justify choosing your model terms.
    a. Describe the in-sample errors. Use at least RMSE and MASE when examining results
    b. Regraph ACF and PACF for both the Time Series and Seasonal Difference and include these graphs in your answer.

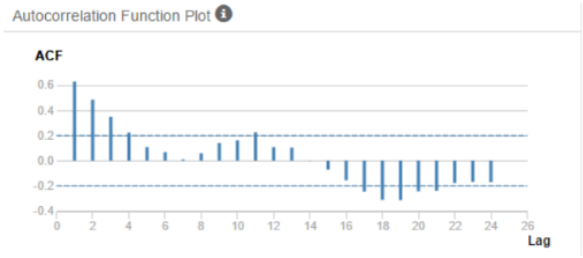


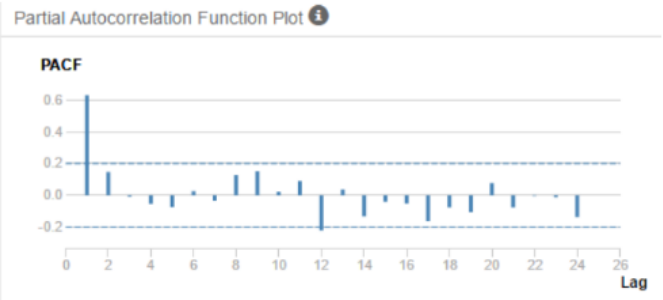
Without differencing, the time series and seasonal component's Auto-Correlation Function (ACF) shows high correlation and the Partial Autocorrelation Function (PACF) shows a significant lag at period 13 which is due to seasonal effect.



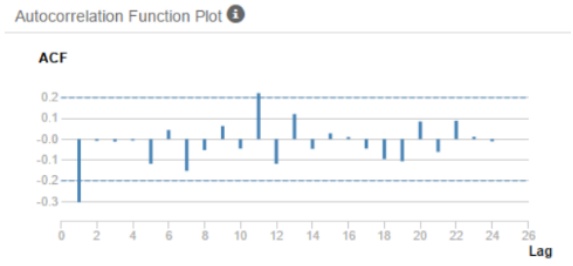


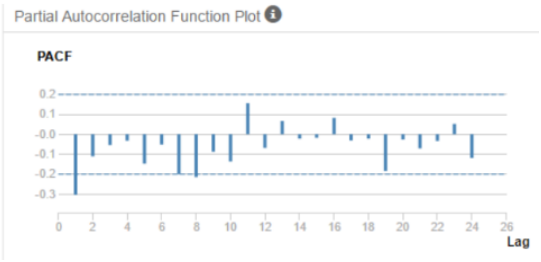
A seasonal difference is then taken. However, the ACF still shows high correlation while the data doesn't have strong correlation in PACF after a seasonal difference is applied.





A seasonal first difference is performed and ACF plot doesn't show strong correlation anymore.





ARIMA(0,1,1)(0,1,0)12 is used as lag-1 is negative and the number of period is 12 months

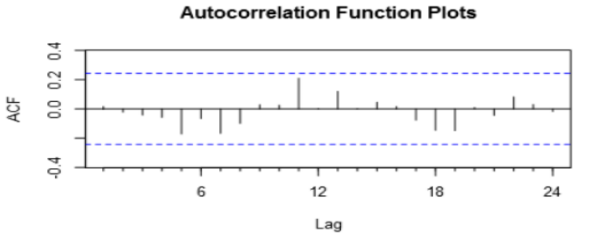
Information Criteria:

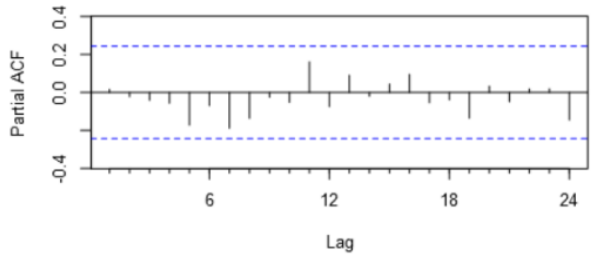
AIC	AICc	BIC
1256.5967	1256.8416	1260.4992

In-sample error measures:

ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
-356.2665104	36761.5281724	24993.041976	-1.8021372	9.824411	0.3646109	0.0164145

*As shown above, the AIC is **1256.60**, RMSE is **36761.53** and **MASE is 0.3646***





Both ACF and PACF doesn't shows significant correlation and no additional AR or MA terms needed.

Step 4: Forecast

Answer these questions.

1. Which model did you choose? Justify your answer by showing: in-sample error measurements and forecast error measurements against the holdout sample.

ETS Model :

Actual and Forecast Values:

Actual	ETS_damped
271000	255966.17855
329000	350001.90227
401000	456886.11249
553000	656414.09775

Accuracy Measures:

Model	ME	RMSE	MAE	MPE	MAPE	MASE	NA
ETS_damped	-41317.07	60176.47	48833.98	-8.3683	11.1421	0.8116	NA

ARIMA Model

Actual and Forecast Values:

Actual	ARIMA
271000	263228.48013
329000	316228.48013
401000	372228.48013
553000	493228.48013

Accuracy Measures:

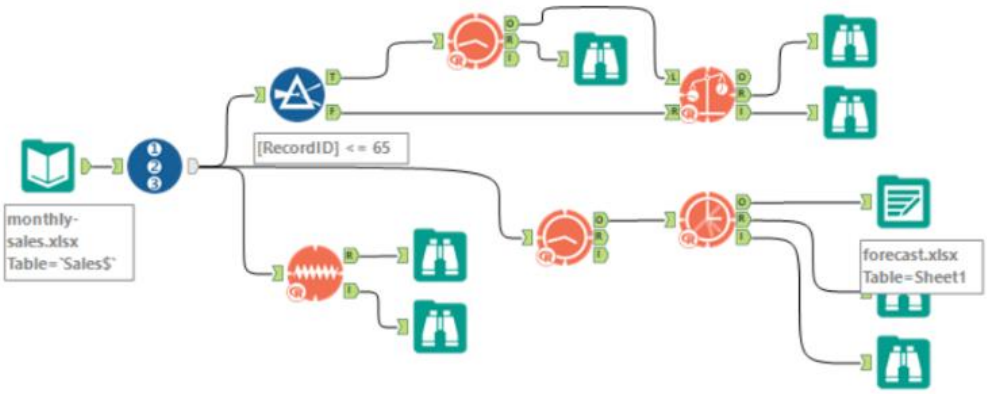
Model	ME	RMSE	MAE	MPE	MAPE	MASE	NA
ARIMA	27271.52	33999.79	27271.52	6.1833	6.1833	0.4532	NA

ARIMA model is better at forecasting sales using holdout sample as validation data as the MAPE and ME value are lower than ETS model.

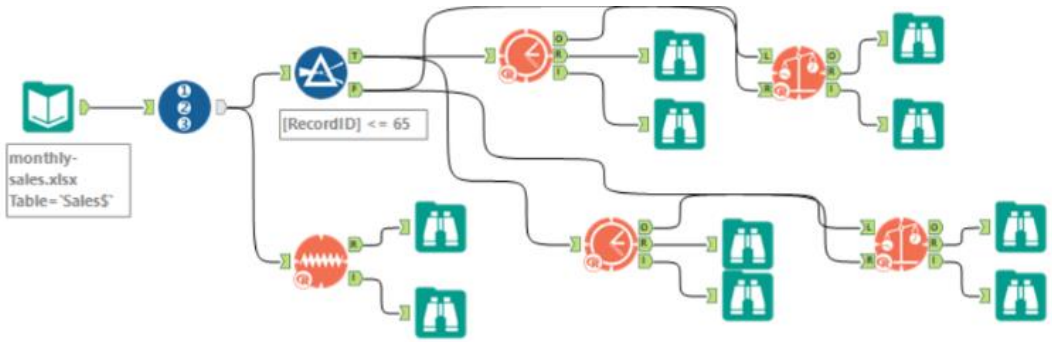
*The RMSE for ARIMA is **33999.79** compared to ETS' RMSE at **60176.47**. ARIMA's MASE value of **0.4532** is also lower than ETS' MASE value of **0.8116**. It is clear that ARIMA model is better since its in-sample error measurements and forecast error measurements are smaller.*

2. What is the forecast for the next four periods? Graph the results using 95% and 80% confidence intervals.

   ARIMA :



ETS :



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The forecast for the next 4 periods (Oct-13 till Jan-14) are ***754,854****,* ***785,854****,* ***684,654*** *and* ***687,854****.*