Project: Forecasting Sales

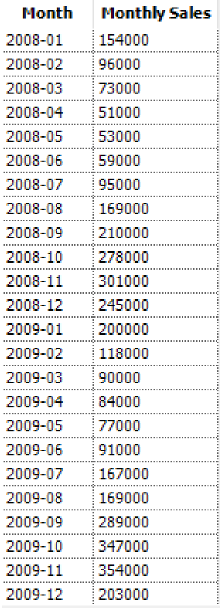
Step 1: Plan Your Analysis

Look at your data set and determine whether the data is appropriate to use time series models. Determine which records should be held for validation later on (250 word limit).

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.

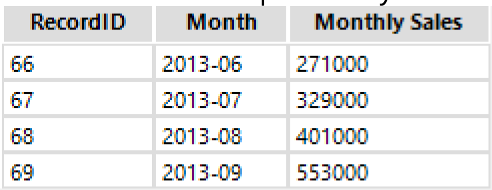
   The dataset does meet the criteria. The data is ordered by month and year with its respective monthly sales. The data is continuous from 2008-2013. The spacing is equal between every two consecutive measurements such that after 2008-03 follows 2008-04. The dataset has no missing data point for either month or sales till the end month of 2013-09. Lastly, each time unit within the time interval has at most one data point. There is no time period with more than one data point.



Month	Monthly Sales
2008-01	154000
2008-02	96000
2008-03	73000
2008-04	51000
2008-05	53000
2008-06	59000
2008-07	95000
2008-08	169000
2008-09	210000
2008-10	278000
2008-11	301000
2008-12	245000
2009-01	200000
2009-02	118000
2009-03	90000
2009-04	84000
2009-05	77000
2009-06	91000
2009-07	167000
2009-08	169000
2009-09	289000
2009-10	347000
2009-11	354000
2009-12	203000

2. Which records should be used as the holdout sample?

   Since I was tasked to forecast the sales for the next 4 months then it would be best for me to hold out the last 4 records of the dataset. The reason its best to use the last 4 records is because it’s feasible and does not cause disruptions. Also, the tasked forecast is followed by these last 4 records and so the model might give more importance on recent months than previous years.



RecordID	Month	Monthly Sales
66	2013-06	271000
67	2013-07	329000
68	2013-08	401000
69	2013-09	553000

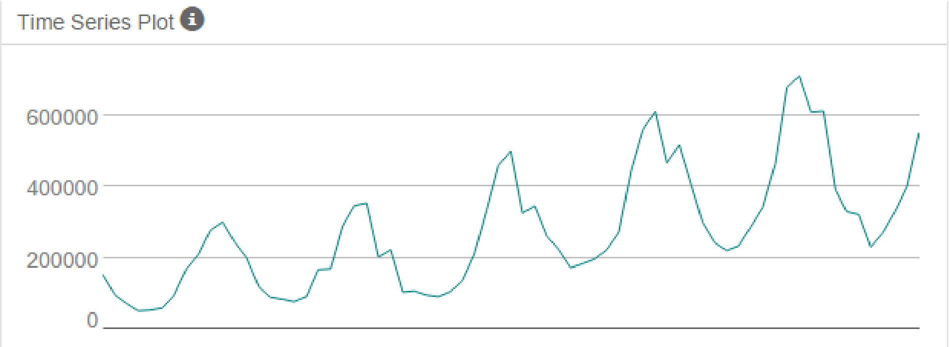
Step 2: Determine Trend, Seasonal, and Error components

Graph the data set and decompose the time series into its three main components: trend, seasonality, and error. *(250 word limit)*

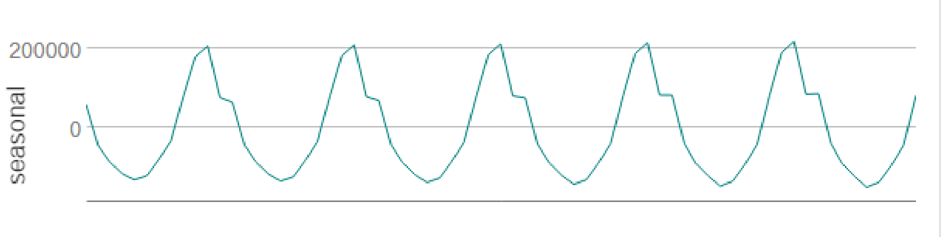
Answer this question:

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.

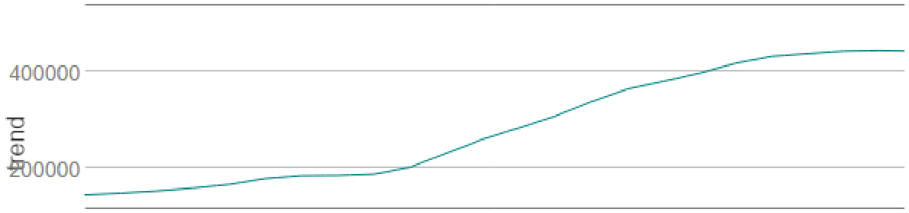
   I simply made use of the TS Plot as it divides the data into the 3 components.



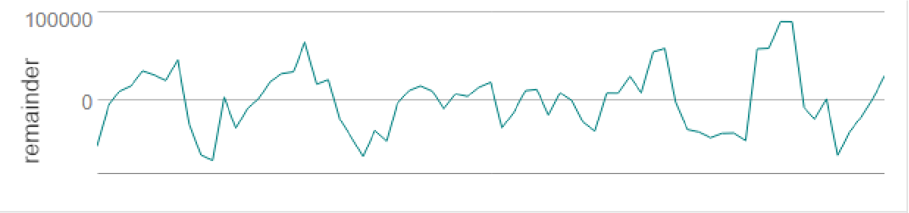
The seasonal component shows the reoccurring spikes in the sales data. These spikes suggest that any ARIMA models used in the analysis have seasonal differencing. When taking a closer look, one would see that there is slight increase in magnitude each time the sales spikes. This small increase suggests that the ETS model use a multiplicative term for seasonality.



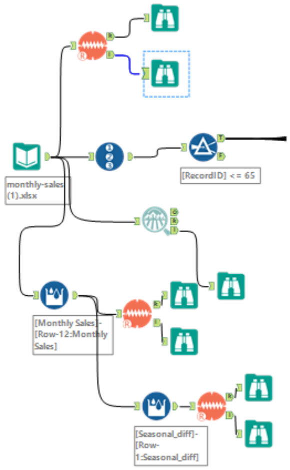
The trend component can tell us the gradual shift to higher or lower values over long period of time. In this case, we could see the general course is a linear uptrend. There is a noticeable increase in video game sales over the years however its not to the point that it is growing exponentially. This suggests the trend component of the ETS model use an additive term.

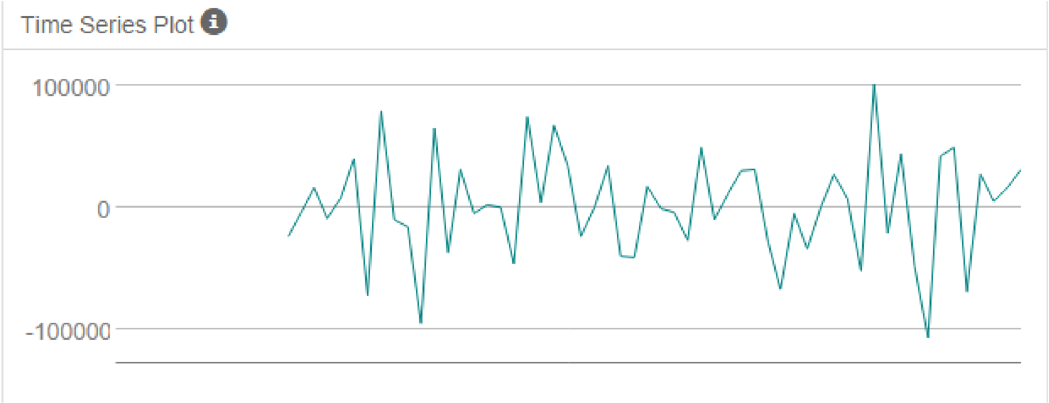


The error component is the remainder that is not accounted for in either trend or seasonality. The graph suggests that any ETS model used for the analysis will make use of a multiplicative term for error as it appears to have fluctuating peak sizes. The ARIMA models would make use of remainder to determine the lag but it would first require the data be stationary.



Since the plot was not stationary, I made a seasonal difference with the use of the multi-row tool then made the first difference. I plot the first difference and we could see that it is now stationary.


monthly-sales (1).xlsx
[RecordID] <= 65
[Monthly Sales]-[Row-12:Monthly Sales]
[Seasonal_diff]-[Row-1:Seasonal_diff]



Step 3: Build your Models

Analyze your graphs and determine the appropriate measurements to apply to your ARIMA and ETS models and describe the errors for both models. (500 word limit)

Answer these questions:

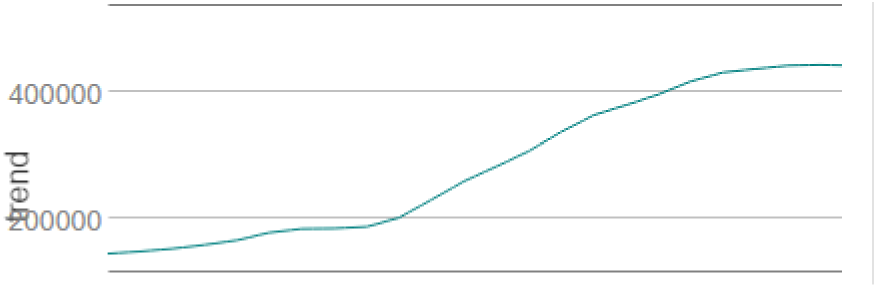
1. What are the model terms for ETS? Explain why you chose those terms.

   The model terms are Error, Trend and Seasonal. There are 2 terms that I took into consideration for the ETS one is ETS(M,A,M) and ETS(M,M(d),M).

   First, we would look at the plots. From the remainder plot, one can see that it fluctuates between large and small over time with varying sizes. Based from this one should most definitely make use of the Multiplicative term for error.

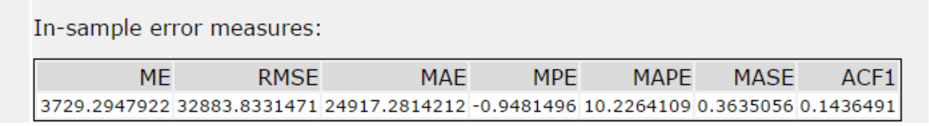
   The seasonal plot at first glance appears to be constant however when looking closer, each time it peaks there is a slight increase. Therefore, we should apply multiplicative term for seasonal.

   The trend plot was a bit complicated as it appears like it could be exponential but on closer inspection it isn't. An additive term should be applied as the trend is linear.



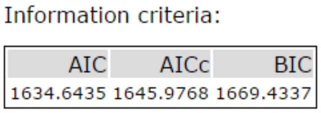
   a. Describe the in-sample errors. Use at least RMSE and MASE when examining results

      ETS(M,A,M) has the following results:



In-sample error measures:

ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
3729.2947922	32883.8331471	24917.2814212	-0.9481496	10.2264109	0.3635056	0.1436491



Information criteria:

AIC	AICc	BIC
1634.6435	1645.9768	1669.4337

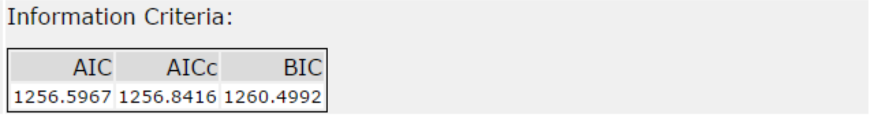
   The results of ETS(M,A,M) show a lot of residue as seen from the RMSE. The ME shows the average difference of 3729.29 between the actual and forecasted which is not a huge gap. The MASE is decent as it is less than 1. The MAPE shows that there was a 10.23% error. Overall the model shows good potential.

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.

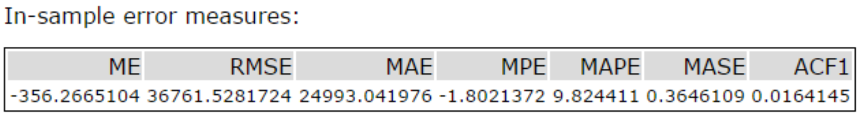
The model terms for ARIMA are Auto Regressive(p) Differencing(d) Moving Average(q) and the same goes for Seasonal ARIMA(P,D,Q). The terms I chose are ARIMA(0,1,1)(0,1,0)[12]. Since the dataset was not stationary, first difference was required to make the data stationary. The first difference also helped reduce significant lag and so there is no need for further differencing. Due to this I added only 1 point on differencing(I) for both. I added a point on MA(q) since there is a strong negative correlation at lag-1. Seasonal MA(Q) does not appear to decrease or increase. Looking at lag-12 of the ACF, it is negative (-0.118) and it reduces to negative lag (-0.011) at lag-24. The PACF on the other hand shows a small negative lag(-0.068) at lag-12 but then there is a negative increase in lag-24(-0.119). Also, lag 12 and 24 does not appear to have any significant correlation and so no MA term was given to seasonality(Q). After building the model, we could see from the resulting ACF and PACF plots that there is no more significant correlation and that means there would not be a need for adding any AR or MA terms. I then made an ARIMA with auto settings and it yield the same results.

a. Describe the in-sample errors. Use at least RMSE and MASE when examining results



Information Criteria:

AIC	AICc	BIC
1256.5967	1256.8416	1260.4992



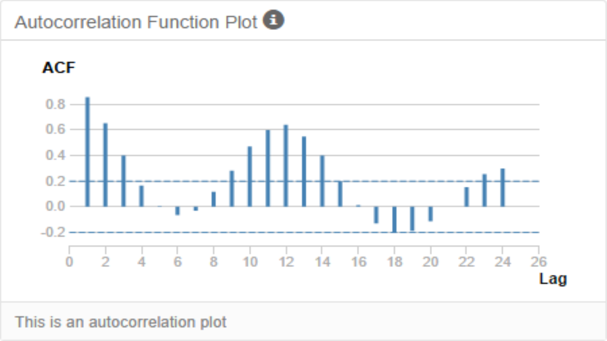
In-sample error measures:

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

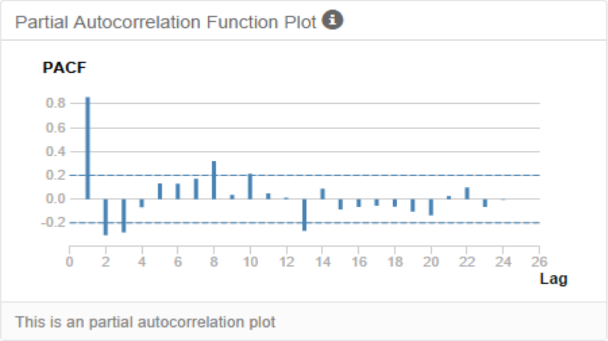
The Mean Error(ME), shows a big gap between the actual and forecasted values as it appears it is underestimating. From the RMSE one can see that there is a big difference as it has lots of residuals. The MASE is good as its value is lower than 1. The MAPE has a 9.82% error and is an improvement from the ETS. Overall the model has a good accuracy.

b. Regraph ACF and PACF for both the Time Series and Seasonal Difference and **include** these graphs in your answer.

Time Series:

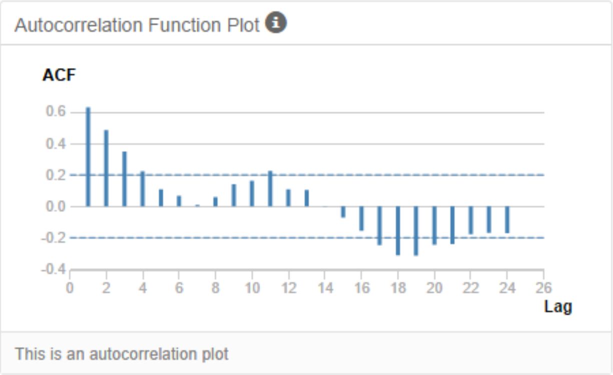

Autocorrelation Function Plot

This is an autocorrelation plot

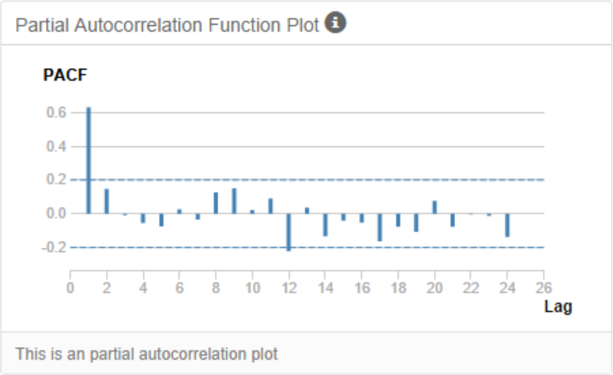

Partial Autocorrelation Function Plot

This is an partial autocorrelation plot

Seasonal Difference

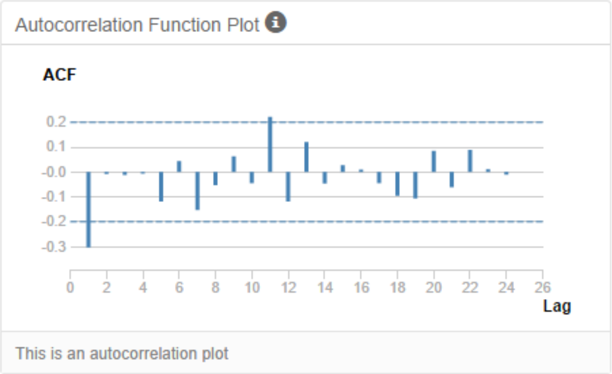

Autocorrelation Function Plot

This is an autocorrelation plot

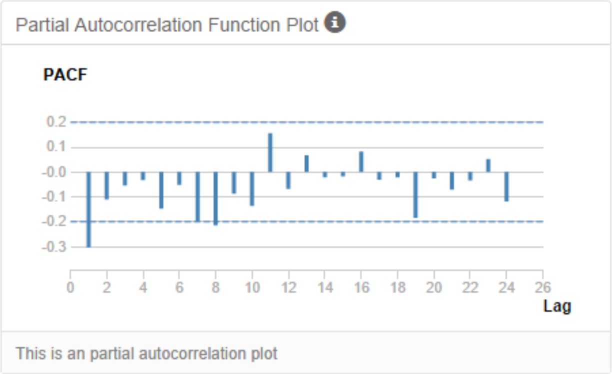

Partial Autocorrelation Function Plot

This is an partial autocorrelation plot

First Difference:

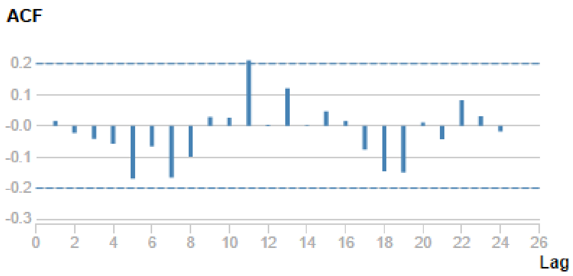

Autocorrelation Function Plot

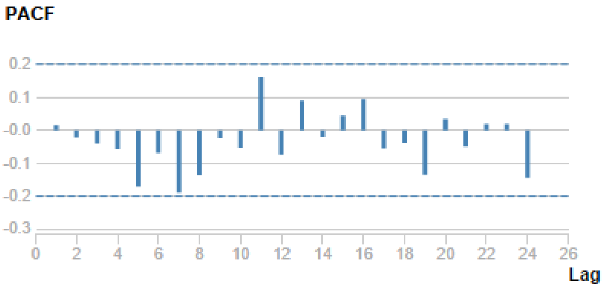
This is an autocorrelation plot


Partial Autocorrelation Function Plot

This is an partial autocorrelation plot

Model Result:





Step 4: Forecast

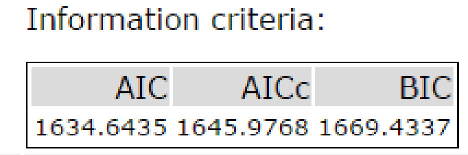
Compare the in-sample error measurements to both models and compare error measurements for the holdout sample in your forecast. Choose the best fitting model and forecast the next four periods. (250 words limit)

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.

When comparing the information criteria of both models, one can see that the ARIMA model stands out because it has a lower AIC than the ETS model.

ETS



Information criteria:

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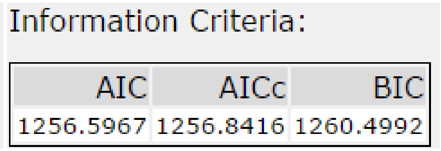
ARIMA

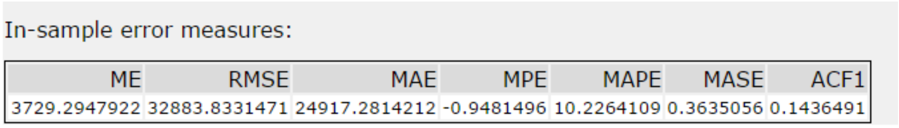


Information Criteria:

AIC	AICc	BIC
1256.5967	1256.8416	1260.4992

From the In-sample error measures, we could see that the ARIMA has a better ME as its value is closer to the actual(on average). Looking at the RMSE,the ETS has a lower value than the ARIMA. MPE shows a negative bias on both models but the ARIMA model still has it lower. MAPE shows the ARIMA having a lower percent error. Both ARIMA and ETS have the similar MASE but the ETS still has it slightly lower.

ETS Model:



In-sample error measures:

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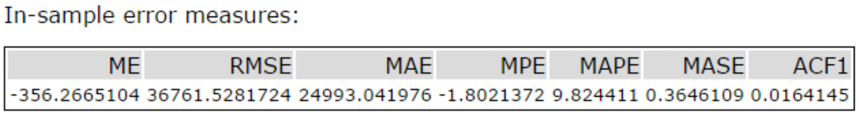
3729.2947922	32883.8331471	24917.2814212	-0.9481496	10.2264109	0.3635056	0.1436491

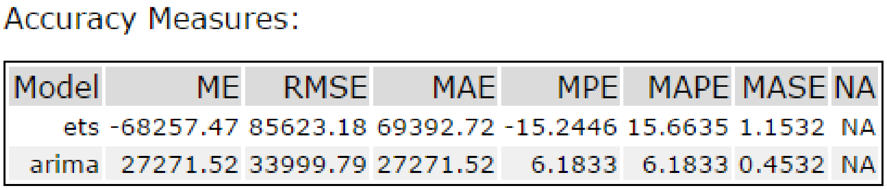
ARIMA Model:



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

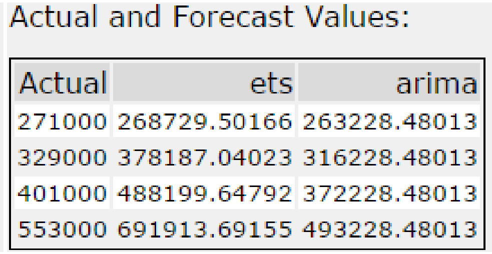
Now looking at the accuracy measures, ME shows the ETS model underestimating by -69257.47 while the ARIMA is overestimating by 27271.52. RMSE also shows a huge gap between the models, the ARIMA has less residue.The MASE shows ETS go beyond the value of 1 meaning while the ARIMA model maintains a value less than 1. MAPE confirms the difference in quality by showing the gap percent wise, as it notices a 15.66% error in ETS while only a 6.18% error in the ARIMA.



Accuracy Measures:

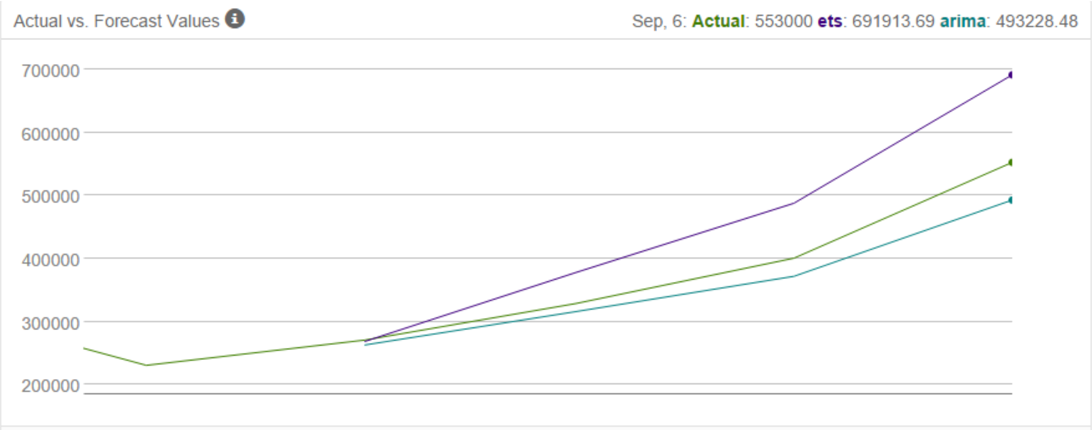
Model	ME	RMSE	MAE	MPE	MAPE	MASE	NA
ets	-68257.47	85623.18	69392.72	-15.2446	15.6635	1.1532	NA
arima	27271.52	33999.79	27271.52	6.1833	6.1833	0.4532	NA

The Actual vs. Forecast Values and Chart makes it clear that ARIMA(0,1,1)(0,1,0)[12] is the better model as its estimates are closer to the actual value than ETS(M,A,M) for all 4 periods.



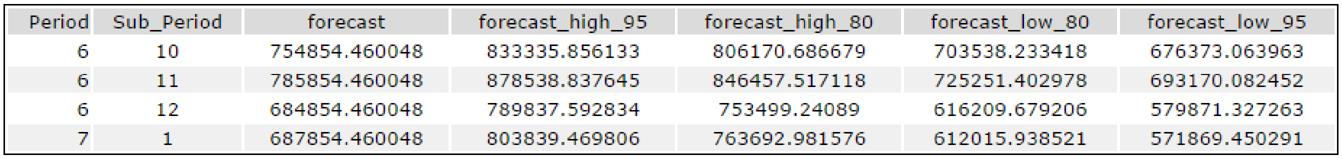
Actual and Forecast Values:

Actual	ets	arima
271000	268729.50166	263228.48013
329000	378187.04023	316228.48013
401000	488199.64792	372228.48013
553000	691913.69155	493228.48013

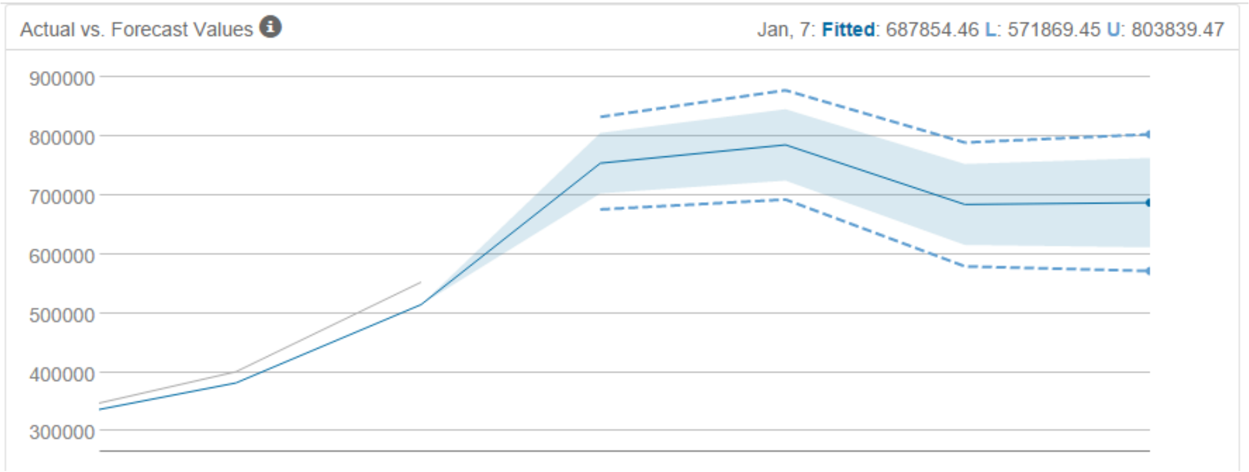


2. What is the forecast for the next four periods? Graph the results using 95% and 80% confidence intervals.

   The forecast listed below is made by making use of the forecast tool with all the 69 records of data and applying the ARIMA(0,1,1)(0,1,0)[12] model.



Period	Sub_Period	forecast	forecast_high_95	forecast_high_80	forecast_low_80	forecast_low_95
6	10	754854.460048	833335.856133	806170.686679	703538.233418	676373.063963
6	11	785854.460048	878538.837645	846457.517118	725251.402978	693170.082452
6	12	684854.460048	789837.592834	753499.24089	616209.679206	579871.327263
7	1	687854.460048	803839.469806	763692.981576	612015.938521	571869.450291



Actual vs. Forecast Values

Jan, 7: **Fitted**: 687854.46 **L**: 571869.45 **U**: 803839.47