Project: Forecasting Sales

Complete each section. When you are ready, save your file as a PDF document and submit it here: https://classroom.udacity.com/nanodegrees/nd008/parts/edd0e8e8-158f-4044-9468-3e08fd08cbf8/project

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

Four Key Characteristics of a time series data:

- ✓ Time Series is a list of observation where the ordering matters. There is a dependency on time and changing the order could change the meaning of the data
- ✓ Time series data are sequential
- ✓ The data points have equal interval
- ✓ Each time unit having at most one data point

The data set of video game sales have met all these four requirements. Therefore, it is a solid time series data.

The record that should be used as the hold out sample should be the most recent records. And the number of data point should be at least same amount f the number of data point we would like to forecast

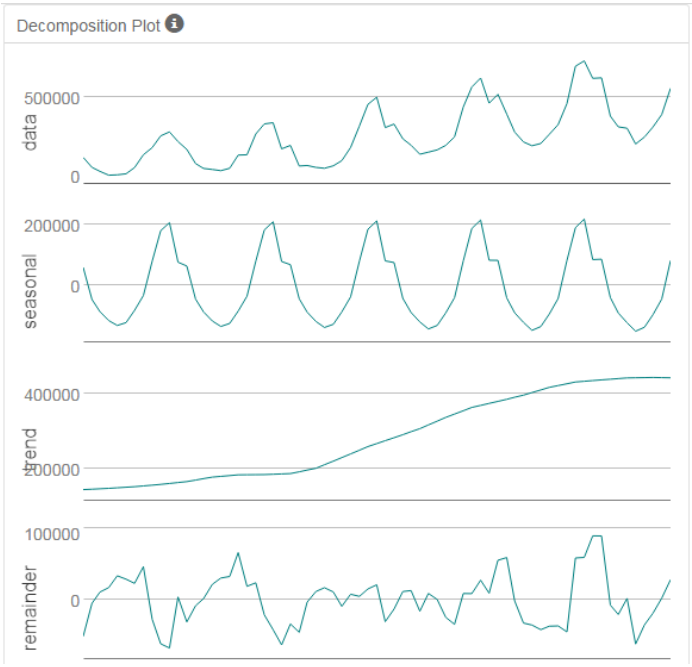
In this case, we want to forecast the sales of video game for the next 4 months, therefore we will take the 4 months of latest sales which is : Year 2013 month 6,7,8,9 to predict sales of year 2013 month 10,11,12 & year 2014 month 1

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.



Based from the decomposition plot we can see that there is
An increase in error (M)
Exponential trend (M)
And an increase in seasonality (M)

(In seasonality at a glance it looked like a constant trend but if we take a look deeper into the data point, the peaks slightly increases over time, therefore we have to include seasonality as increase (Multiplicative model))

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:

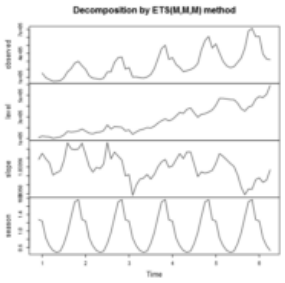
1. What are the model terms for ETS? Explain why you chose those terms.
    a. Describe the in-sample errors. Use at least RMSE and MASE when examining results

    The model term for ETS is ETS (M,M,M)
    Because it has increasing error, exponential increase in trend, and increasing seasonality

ETS M,M,M Result

Plots of Time Series Exponential Smoothing Model ETS_M_M_M_

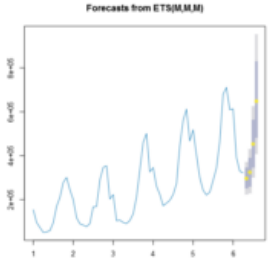
In statistics, a time series is a sequence of data points measured at successive points in time spaced at uniform intervals. Examples of time series are the daily closing value of a stock market index or the annual flow volume of a river. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.



Decomposition Plot separates time series data into several components. Decomposition method is often used to yield information about time series components i.e. trend, cycle, seasonal, etc.

- Observed: This is the actual data.
- Level: This is the overal baseline without seasonal trends.
- Slope: This is the rate of change associated with the Level.
- Season: This shows the seasonal trend of the data.

Not all of the above components will occur each time.



The Forecast Plot shows the historic data in black and the expected value in blue. The orange in the plot shows the 90% confidence interval, and the yellow shows the 95% confidence interval.

Summary of Time Series Exponential Smoothing Model ETS_M_M_M_

Method:
ETS(M,M,M)

In-sample error measures:

ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
-1290.4529219	32059.8977969	24413.1111695	-1.9466585	10.4643339	0.3503952	0.1284335

Information criteria:

AIC	AICc	BIC
1608.0449	1619.6193	1642.587

Smoothing parameters:

Parameter	Value
alpha	0.766296
beta	0.000138
gamma	0.013962

Initial states:

State	Value
l	109364.950379
b	1.033576
s0	1.278758
s1	1.76285
s2	1.706315
s3	1.347014
s4	0.96514
s5	0.69364
s6	0.513554
s7	0.484925
s8	0.528341
s9	0.642998
s10	0.835801

ETS (M,M,M) Dampen Result

Plots of Time Series Exponential Smoothing Model ETS_M_M_M_

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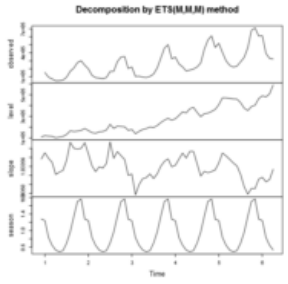

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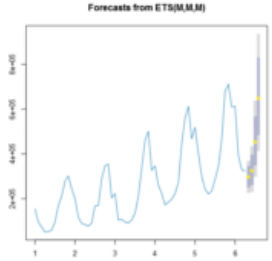

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s7	0.484925
s8	0.528341
s9	0.642998
s10	0.835801

Model	ME	RMSE	MAE	MPE	MAPE	MASE
ETS_M_M_M_	-175503	216070.6	175502.6	-43.5058	43.5058	2.9406
ETS_M_M_M_DAMPEN TREND	-128640	152964.6	128639.7	-32.7399	32.7399	2.1554

ETS (M,M,M)
Average Error (ME) = -175503
Std. Dev.of Mean (RMSE) = 216070.6
Average Absolute Value (MAE) = 175502.6
Average Percentage Error (MPE) = -43.5058
Mean Absolute Scale Error (MASE) = 2.9406

The Average percentage error is very high at -43%
And MASE is way above 1.0 which is 2.94
Personally I don't think it is a good model to use as a prediction

Then I tried to use trend dampen to improve its accuracy. The result improves but still at the state where the model is still not good enough for use as prediction model

ETS (M,M,M) Dampen
Average Error (ME) = -128640
Std. Dev.of Mean (RMSE) = 152964.6
Average Absolute Value (MAE) = 128639.7
Average Percentage Error (MPE) = -32.7399
Mean Absolute Scale Error (MASE) = 2.1554

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.

Since the data set contains seasonality, we need to use seasonality ARIMA Model ARIMA(p,d,q) (P,D,Q) m

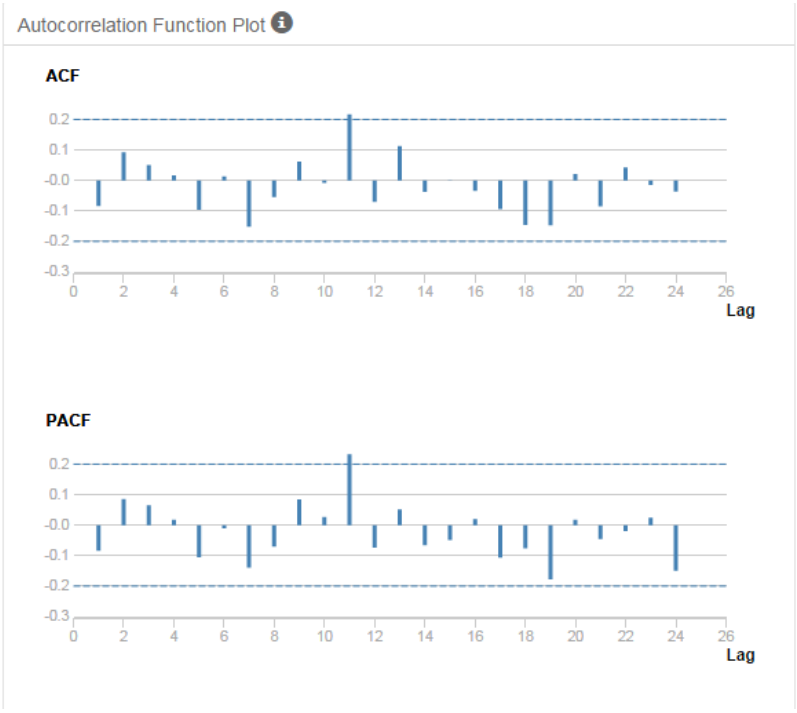
p is the number of autoregressive

d is the degree of differencing,
q is number of moving average term

PDQ is similar with pdq but refer to the seasonality differencing
p is the number of autoregressive
d is the degree of differencing,
q is number of moving average term

m is umber of period for each season, which is 12

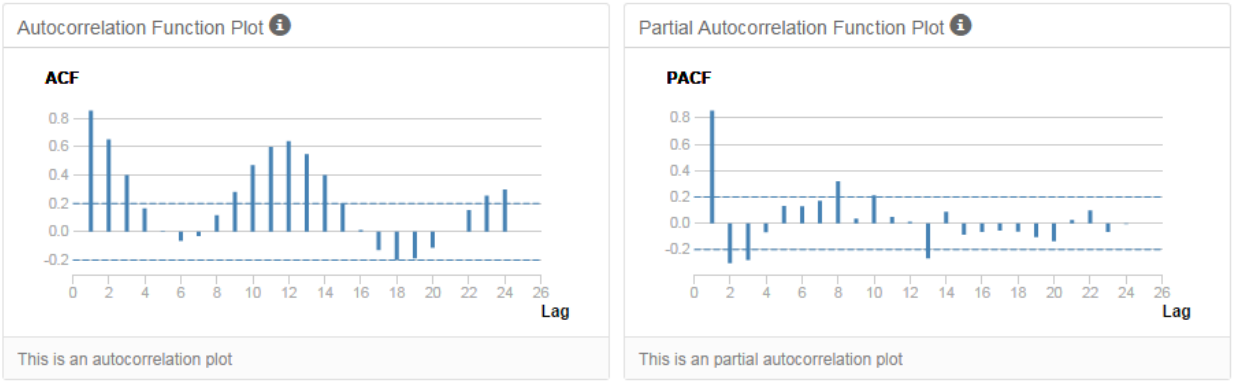
From the excel calculation, we can find that we need 2 times of differencing in order to make the dataset become stationary. So d=2



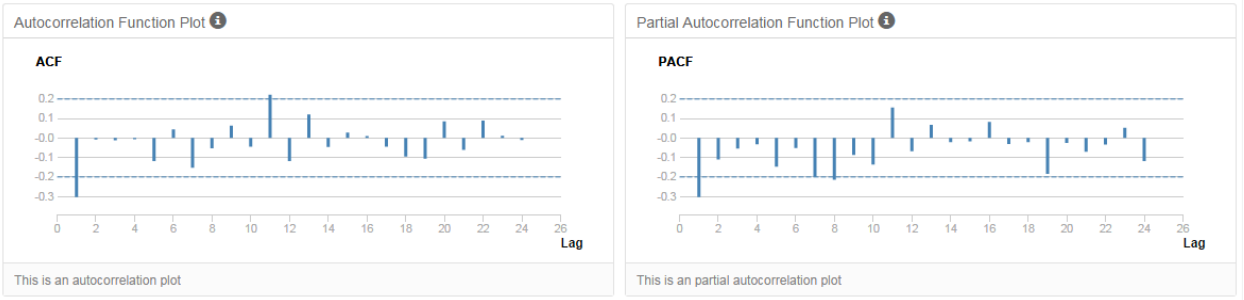
From ACF we can find there's a negative autocorrelation after lag-1, so we use MA model as the best mode
(AR 0, MA 1)

So the term would br (p,d,f,) -> (0,2,1)

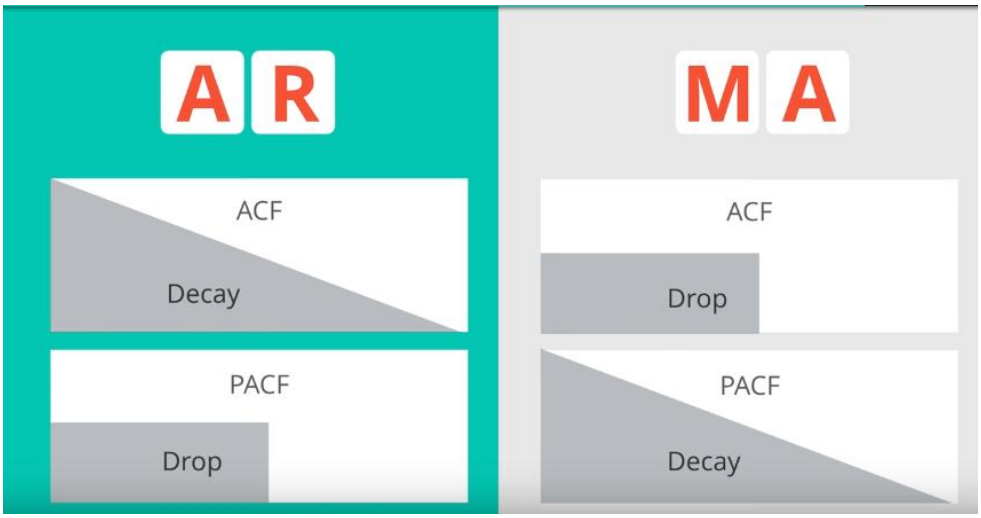
For Seasonal Difference we will take a look at ACF & PACF graph below



At the seasonal difference we can see that ACF is not stationary , so we need to create a seasonal difference. At Seasonal Difference -1 , the ACF graph is now become stationary



The outline for determining AR or MA can be determined from below figure



Since the Seasonal ACF decay, and PACF drops , we will use AR model (AR 1, MA 0), and difference 1
So the term would be (P,D,F) -> (1,1,0)

Since we know m =12

The ARIMA Model would be ARIMA (0,2,1) (1,1,0) 12

Z

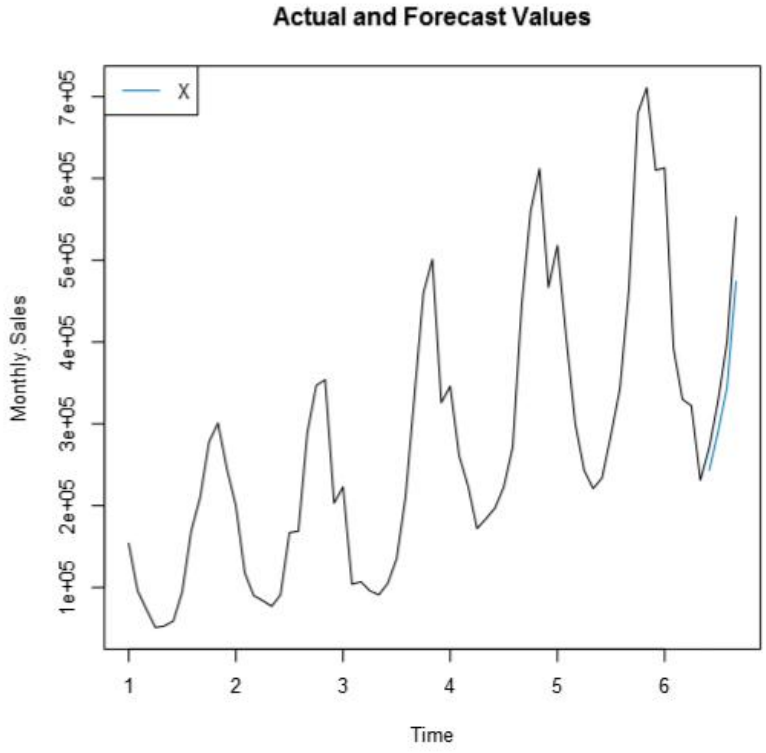
Comparison of Time Series Models

Actual and Forecast Values:

Actual	X
271000	243301.28583
329000	291065.91961
401000	345191.03639
553000	474229.57801

Accuracy Measures:

Model	ME	RMSE	MAE	MPE	MAPE	MASE	NA
X	50053.04	53678.75	50053.04	12.4782	12.4782	0.8318	NA



Model	ME	RMSE	MAE	MPE	MAPE	MASE
ARIMA (0,2,1) (1,1,0) 12	50053.05	53678.75	50053.05	12.4782	12.4782	0.8318

Average Error (ME) = 50053.05
Std. Dev.of Mean (RMSE) = 53678.75
Average Absolute Value (MAE) = 50053.05
Average Percentage Error (MPE) = 12.4782
Mean Absolute Scale Error (MASE) = 0.8318

This is much better model than ETS model with Average percentage error (MPE) 12.48% and Mean Absolute Scale Error well below 1.0 which, is 0.8318

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

Model	ME	RMSE	MAE	MPE	MAPE	MASE
ETS_M_M_M_DAMPEN TREND	-128640	152964.6	128639.7	-32.7399	32.7399	2.1554
ARIMA (0,2,1) (1,1,0) 12	50053.05	53678.75	50053.05	12.4782	12.4782	0.8318

AIC ETS Trend Dampen Method

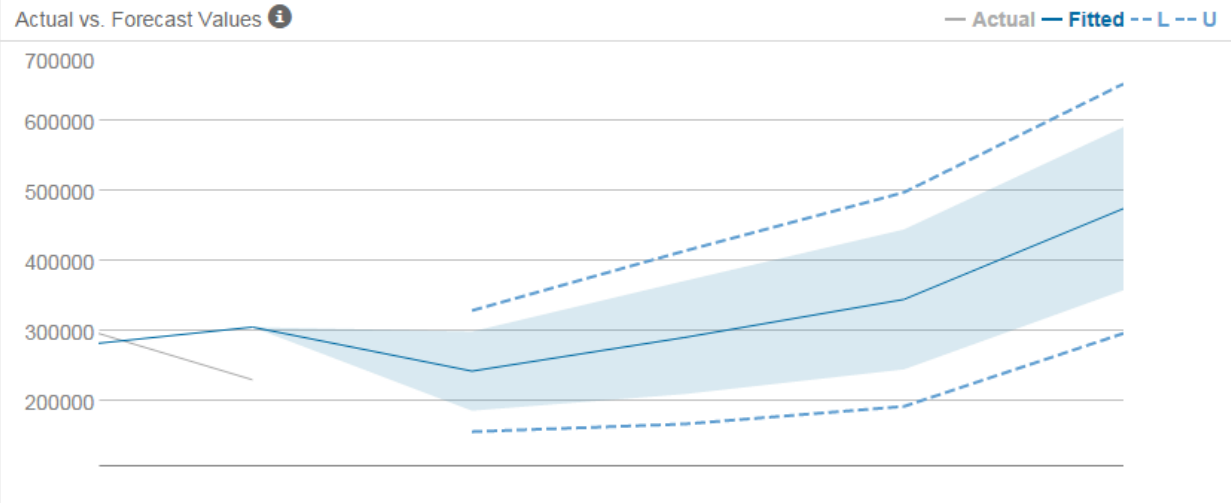
AIC	AICc	BIC
1608.7744	1622.0788	1645.4755

AIC ARIMA(0,2,1)(1,1,0) 12 Method

AIC	AICc	BIC
1250.2133	1250.7239	1256.0088

The best model would be model which has the most least amount or errors, least AIC , and MASE below 1.0. The best model would be ARIMA (0,2,1) (1,1,0)12 model

Forecast for the next 4 periods



Period	Sub_Period	forecast	forecast_high_95	forecast_high_80	forecast_low_80	forecast_low_95
6	6	243301.285829	329373.853369	299581.112679	187021.458979	157228.718288
6	7	291065.919608	414016.622247	371459.062898	210672.776318	168115.216969
6	8	345191.036387	497260.810936	444624.117394	245757.95538	193121.261837
6	9	474229.578014	651524.702542	590156.628814	358302.527215	296934.453487

Before you Submit

Please check your answers against the requirements of the project dictated by the rubric here. Reviewers will use this rubric to grade your project.