**Time Series Analysis Using Python**

**Acknowledgement**

We would like to thank our course instructor Miss Ammara for her ongoing support and her excellent teaching methods which helped us to go through this project with ease. The project we were assigned to implement in Python was time series and evidently it being one of the hardest topics to implement, we managed to pull it off in due time. We would also like to applaud the teamwork that took place in this project where every member did his/her own part of the project diligently and without burdening any other member. We would also like to thank our family members for allowing us the time to concentrate on our work without burdening us with housework during this blessed time of Ramadan. We enjoyed constructing this project and could not have done it without the support of all these people as well as our friends who never stopped believing we could do it.

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**1.Time Series**

To start off our report, let’s first understand what is time series? Time series is the data which changes over a period. An example of this would be stock price or sales growth.

There are a few models which allow us to analyze Time series. These models allow us to forecast the observation based on the historical data of the previous time phases for the same observation.

A small condition to this prediction method is to know whether the data is stationary or not, if it is **not** stationary then we apply the differencing factor and conduct the tests once more to check for its prediction and how accurate it may be.

**2. Different types of Variation**

Four kinds of Variation have impact on Time series. These are:

**Seasonal Trend:**

A short-term trend with in a year that may be caused by climatic changes, holidays, temperature or rainfall etc. This type is easy to understand or measure. Also we can say that seasonal variations are the changes that can repeat themselves within a fixed period of time.

**Secular Trend:**

A long-term trend that is more than 5 years. The trend may be Increasing or Decreasing trend. Secular Trend can be linear and Non-linear.

**Cyclic Variation:**

Cyclic Variation also called a business cycle is a long-term trend where changes occur within 3 to 10 years. It is periodic in nature and have peak and troughs. These variations are not regular like seasonal variations.

**Irregular Variations:**

It is a short-term trend that cannot be predicted and are caused by sudden causes like floods, earth quakes, war etc. It is obtained by removing trend and cyclic variations from the original set of time series data.

If we explain irregular variation in terms of probability such as by using method of moving average or using AR (autoregressive) models, cyclic variations are left in residuals.

Now we will get a plot by doing seasonal decomposition on data. It is done by first importing library.



Text

Description automatically generated

**Output:**

Chart

Description automatically generated

We get the residual by differencing trend and seasonal variation from the original data. Residual is the leftover value, and it shows how the points of data deviate from the model.

**3.Dickey-Fuller test**

A lot of tests are available to test if your time series stationary or non-stationary. DT or **Dicky Fuller test** is the test which determines and sets apart stationary from non-stationary data. But before going to discuss dicky fuller test we check graphically if our graph shows curve according to the below figure then our series will be nonstationary.

![Chart, line chart

Description automatically 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And if our graph curve is moving in such a way that the average and time both increase together then series will be stationery and graph looks like this:

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mAA8GDAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAPn++gDm9+oAye3UANby3gD5/voAAAEBAAAAAAAA//8AAAAAAAD//wAAAAAAAAEBAAD//wAA/wAAAAAAAAAAAAAAAAAA/gD/ANv04gDH69EAGwkVABoKFQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAMAAAAYADVOTwDo7qMA1JqJAJ8+QwBN/LIA1bvTALDmRgCARiAAIR4KAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA5PbqAMPqzwDM7tUA+//8AAYCBQALAwgACQMIAO768gD4/vkAAAAAAAAAAAAKAwgABwIGAAcDBgAQBA0ATh0/ACQNHQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA6vjuAOH25wDm+O0AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABAADAA0DCgDz/fYA/P/9APD78wC/6swAAAEBAFf+/ABDGTYAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADq+O4As+PCAOL25wD5/voAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA0O7aABUHEwBJGzwAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABAAAAAQAEFDYAMDnlAFnh3QCVuYcA597JAA8PKABBbWIAOhMPABUCAQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAPX89wDR79kA4PTmAOT26QDg9ecAzvDZAPz//QACAAEAAwECAAMAAgD6//wA/gD/AAAAAAAAAAAAAwACAAIBAQADAAEABAEEAPP89QBIGjoANxQtAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADy+/QA0e/aANTx3ADs+e8AAAEAAAAAAQAA//8AAAAAAAAAAAAAAAAAAAAAAAAAAAAA//8AAAAAAAD/AAAOBQsAEgYPAAgDBgAXCRQA+v77AAL/AQA2EywAtOfCAOD05gD7/vwA/gD+AM/u1wAaCRQAGAkTACoPIgABAQEAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA/v/+ANHv2gDd9OMA4PTnAN/05gD4/foAAAAAAAAAAAAA//8AAAAAAAABAQAA//8AAAAAAAAAAAAA//8AAAAAAAEAAAAWBxIA/gEAAPX89wD2/PcAAAAAAPP99gDO79YAkNelAFggRwAYCRQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEAAAAAAAAAAAAAAAAAAAAAAA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AAAAAAAAAAAAAAAAABAEDAAYCBAAAAQEAAAAAAAD//wAAAAAAAAAAAAAAAAAAAAAAAAAAAAEAAQAjDBwALBAjACALGQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAB0KFwAyEigAKxAjANfx3wD2/fgA9vz4AN304wC558YARgA5ACQNHQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAD62/EAAP3/AAEDAgALOhkABBEHAAIFAwADAQIADwUMACcNHwA+FzMALBAkAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAMBAwADAQIAAAAAAAAAAPPN8fUAACAASURBVAAAAAAAAAAAAPj++gDX8t8A0vDaACEMGgAWCBIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAwECAAIBAQAAAQEAAP//AAAAAAAAAAAAAP//AAIAAQAHAgYACgMIAAUBBQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAwEDAAUCBAAAAAAAAAAAAAAAAAAAAAAAAAAAAPP89gD3/fkAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAD///8A8PrzAPL79QD7//sAAP//AAAAAAAAAQEAAP//AAAAAAAAAAAAAAAAAAABAAAB/wEAGwoWACMNHQAZChUAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFggSAEYZOQDo9+wA9/f4AP4A/gDy+/UAruO+AAgDBwANBAsAFwkSAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAPre8gDyst4A98vpAP3v+QAAAAAACgMJADoUMABFGToAKg8jAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAD4/fkA+f37AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAO/68gDz/PYAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAwECAAwFCgADAQMAAAAAAAAAAAAAAAAAAAAAAAD/AAAHAgYAHwsYACALGQAQBg0AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAPz//QD6/vwAAAAAAAAAAAAAAAAAAAAAAAAAAADY8uAA5fbqAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA/wD/AM/v1wDG69AA2/LiAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAIAAgABAAEAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABsJFgBWHkUAGQkUAAQBBAAAAAAA/gD/AN/05QC15cMAuufHAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Let us now discuss the dicky fuller test. We conduct the **Dicky fuller** test using **Adfuller** from **statsmodel.**



Adfuller function calculate ADF statistics, lags, p-value and critical value. We notice p-value, if p-value is below 0.05 then series will be stationary on the other hand if value will be greater than or equal to 0.05 then the series shows nonstationary behavior. Critical values are the probability of a series to be stationary for example, at 99% its -3.48, 95% -2.88 and 90% it’s -2.57.

Text

Description automatically generated

**4.ACF & PACF**

* ACF (Auto-Correlation Function)
  + The correlation coefficients between lagged values can be plotted to form the autocorrelated function also known as correlogram.
* PACF (Partial Auto-Correlation Function)
  + PACF is a plot that shows the correlation of a series with its lagged values.

You can determine the ARIMA model's AR and MA components using the ACF and PACF plots.

ACF and PACF plots can be used to determine both seasonal and non-seasonal AR and MA components.ACF and PACF are used to find values for P, D, Q in ARIMA model.

ARIMA model has 3 components.

P order of AR.

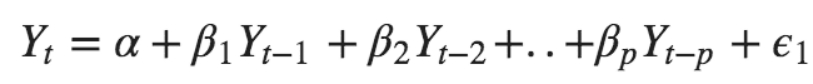
Q order of MA

Integrated ~~ Difference (D)

Auto Regression is a correlation with its past values. P from PACF Plot; if p=3 that means Yt is dependent on past 3 periods. Moving Average has the effects of previous error terms in it. Q from ACF plot. For P current value of y is dependent on how many previous lagged values of current Y. For Q future values of Y is dependent of previous lagged values of white noise i.e., the irregular component. white noise is just the error. The term error here refers to the difference between the actual predicted value. so, we take into consideration the error also to predict the future value.

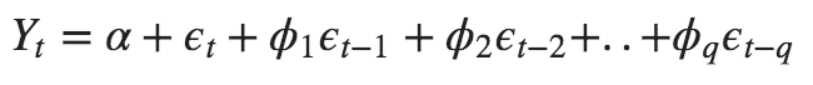
For I Integrated means no of times we difference the data then we must integrated it back to get the original series back.

For AR we have the formula:



(T-1) is the lag1 of the series, beta1 represents the coefficient of lag1 that the model estimates, and alpha represents the intercept.

For MA we have the formula



**Integrated ~~ Differenced**

Integrated means no of times we difference the data then we have to integrated it back to get the original series back.

We difference to remove trend and seasonality to it stationary series as only after making a series stationary we can implement AR and MA.

D is order: How many times we difference the data.

**NOTE: If both P and Q are positive, then the plots are not helpful in determining what values of P and Q are appropriate.**

**5.ARIMA model**

ARIMA model is one of the most Used models to predict the outcome of the future events Which have Occurred with respect to Time. This model Is used when we have Nonstationary data.

First if it’s confirmed our data is non-Stationary then we have to performance of our model For which we have to train our model and then test it with known values. Then we will find the difference in between.

1. We are going to Split our data set into Test and Train data.

Graphical user interface, application

Description automatically generatedTable

Description automatically generated

Both the Split-ed data’s are showing Above.

1. Analyzing the values from the ACF and PACF graphs are difficult And then we still don’t know if it order P,D,Q gives the most Efficient model for which we have created all possible combinations of orders and then find the combination of P,D,Q with the least Root Mean Square Error.

Graphical user interface, text, application, email

Description automatically generated

This is the screen Shot giving us the most Efficient Model which has order p = 3, D = 0 , Q = 3, With the Minimum Root mean square value of 61.9. And in the End printing all possible combination P,D,Q.

Table

Description automatically generated

1. Now Fitting/Training the model with training data and getting the prediction with testing data After which printed the Predicted data.

Graphical user interface

Description automatically generated

1. Plotting the Data. First Graph contains the graph of Training Data using which we got our prediction on training data. And Printing training and Prediction both.

Graphical user interface, chart, line chart

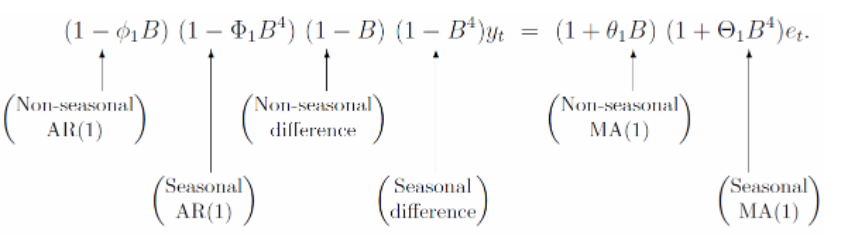
Description automatically generated

We Can see that the Prediction is also Accurate in the form of Trend Line. ARIMA don’t give us the Seasonal Variation.

1. **SARIMA Model**

Just like ARIMA that is used to predict in a linear pattern we use seasonal ARIMA that predicts the output in a seasonal manner. In SARIMA model four new hyper parameters are included in existing ARIMA model for the conversion that are seasonal (p,d,q) or seasonal order and frequency.

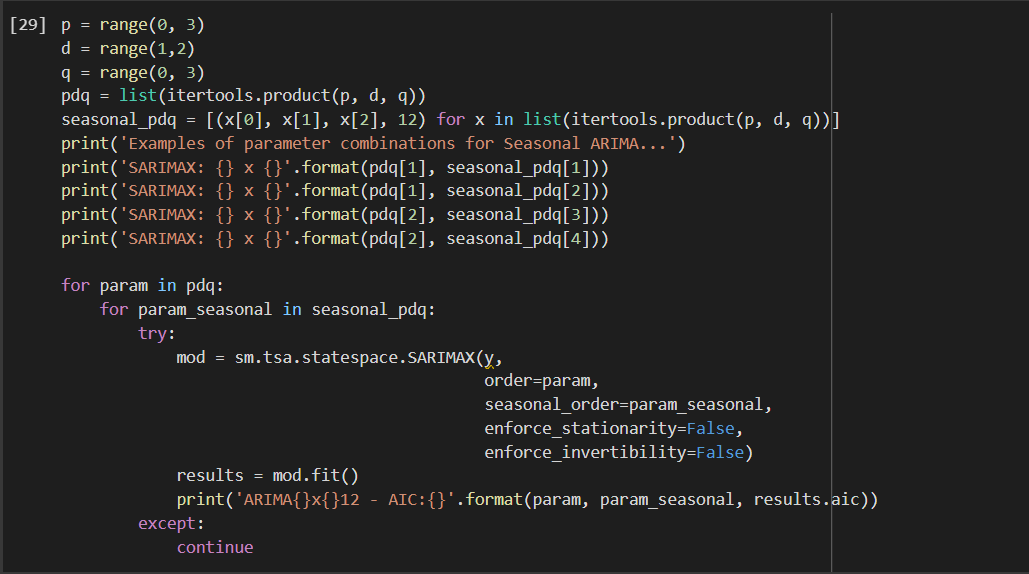
**Mathematical Equation:**

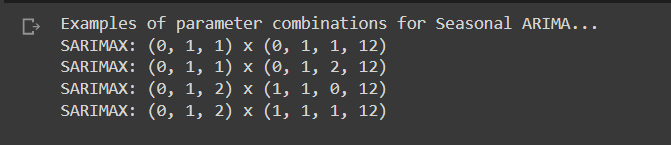
****

**Coding SARIMA MODEL:**

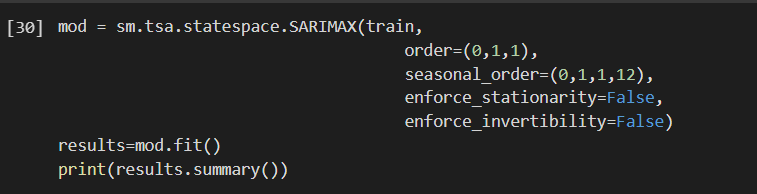
First of all we need normal (p,d,f) that we have obtained using acf and pacf. Then we will import the built in SARIMAX function from python’s statsmodels library.

Now we will initialize pdq with a range and make a list using itertools.Here we are gonna use nested for loop for the combined possible outcomes for our seasonal and non seasonal pdf and s(frequency).

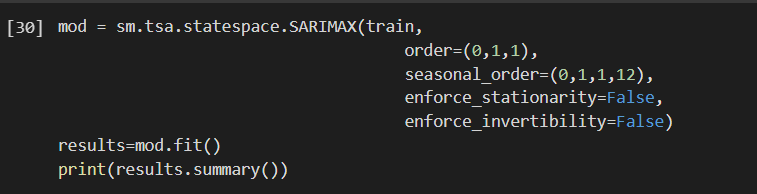
For this purpose we used try except condition so that if the result will return false it will continue the next iteration until all the optimal outcomes are obtained and stored in a list.

Which yields the result of possible combinations that are 

Now we choose 12 as frequency because it is seasonal data over 12 months (1 year). Then we choose one of the possible combinations from above and printed the summary using model. Fit() and print command



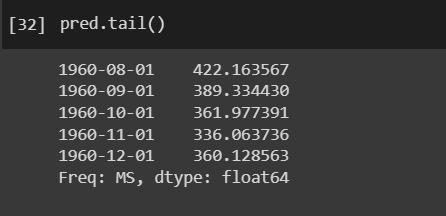
We will obtain the following result

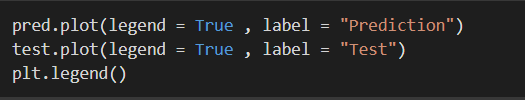


For the prediction purpose we will use the length of training data as the starting point and length of data till the end as the ending point.

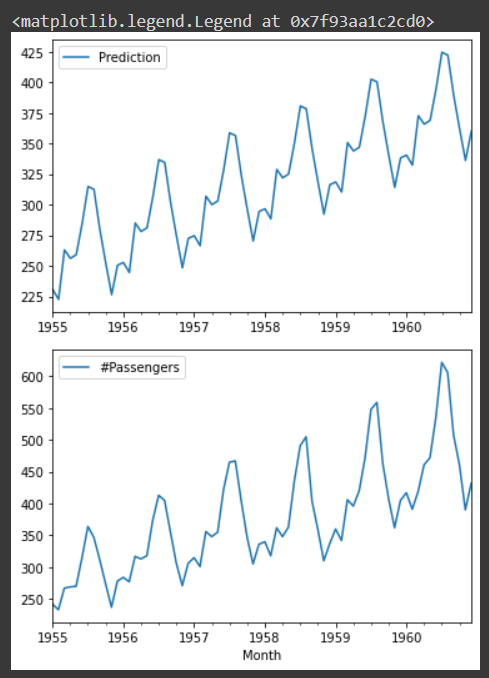


To check fo the correctness we use pred.tail() that shows the number of passengers accordingly to the date.



Now we will plot the Prediction and test using matplotlib library .

The graphs that we obtain are as follows:



**Summary:**

From the above graphs we can clearly see that the test results we obtained are seasonal unlike ARIMA model that gives linear prediction results.

**7.ARMA model**

ARMA is combined from AR (Auto-Regressive) and MA (Moving Average). It means when we are predicting future, we will consider impact of previous lags as well as residual too.

Yt = β₁\* yₜ-₁ + α₁\* Ɛₜ-₁ + β₂\* yₜ-₂ + α₂ \* Ɛₜ-₂ + β₃ \* yₜ-₃ + α₃ \* Ɛₜ-₃ +………… + βₖ \* yₜ-ₖ + αₖ \* Ɛₜ-ₖ

Here, β represents coefficients of AR and a represents coefficients of MA.

ARMA is used to predict future using stationary data. We first apply Dicky fuller test, if result is less than 0.5 it means our data is stationary and now, we can apply ARMA on it. After that we find ACF and PACF to get orders of AR and MA. ACF is used to find order of AR and PACF is used to find order of MA.

* + - * **Information about data:**

Table

Description automatically generated

We have data of total catfish sale in years. This data is stationary which means we can apply ARMA model on it. Data is so much huge so, we just have pasted screenshot of some piece of data.

**Code Screenshots:**

Text

Description automatically generated

First, we include all necessary libraries needed to apply ARMA.

Graphical user interface, text, application, email

Description automatically generatedNow, we read our stationary data of catfish sales in years. Text

Description automatically generated

Here we limit our data from 2000 till 2004 becase we have huge amount of data so, we will perform our operations on this piece of data. Chart

Description automatically generated

Here graph of data is displayed. Red line indicates the mean of data. Chart, histogram

Description automatically generatedWe find ACF of our data here which is 1. Chart

Description automatically generatedWe have found PACF here which is 4. Graphical user interface, text, application, email

Description automatically generated

First of all, we have trained our data from year 2003 till year 2004. After training we have applied ARMA model with order 4 of AR due to PACF and order 1 of MA due to ACF. Next, we fit our data at end of training. Table

Description automatically generated

This is summary of our data. ar.L1, ar.L2, ar.L3, ar.L4 indicates lags of our data which is negative and ma.L1 indicates Moving Average at Lag 1 which is positive. There is also more information about model, their orders, method etc.

Text

Description automatically generated

Here we set our starting and ending dates according to which, our model has to predict future. Text

Description automatically generatedHere we get prediction of our data and also can get residual by subtracting test data with predicted data.

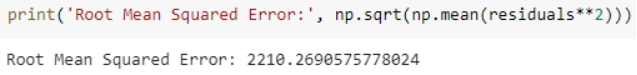
Chart, line chart

Description automatically generated

This is the prediction of our model till year 2004, January. Chart, line chart

Description automatically generatedThis is the residual of our model which we have calculated above. Chart, line chart

Description automatically generated

Blue lines represent our actual data and orange lines represent predictions.We can easily see the difference between both data and check that how much our prediction is accurate. Root mean squared error according to residual is stated below. 

**8.SARMA MODEL**

The SARMA model deals with the ARMA model however in the context of seasonality. The python code for this was not implemented since there were not that many sources and the implementation was a bit more difficult than the rest.

The SARMA can also be written as:

A picture containing text, clock, gauge

Description automatically generated

Seasonal ARMA represents time series in terms of its historic values at lag which is equal to the length of the period and also incorporates the seasonality into the model.

If seasonal and non-seasonal operators are combined, a model is obtained as follows.

A picture containing text

Description automatically generated

This model is known as the mixed SARMA and it denoted by.

A picture containing text

Description automatically generated

It is in SARMA Model where the AR and MA polynomials are factored into a **monthly and annual** polynomial . The annual polynomial may also be refered to as the the **seasonal** polynomial.

Thus, everything we learned about ARMA models also applies to SARMA.

example to better understand this model is taken from github and is explained as follows:

Chart, line chart

Description automatically generated

The above diagram represents reading the csv file with the data set and then fitting it into a model.

Chart, histogram

Description automatically generated

The diagram above represents the residual analysis after the mathematical calculations take place.