

TIME SERIES FORECASTING USING ADVANCED STATISTICAL TOOLS

Submitted in partial fulfilment of the requirements for the award of
Masters of Science degree in Mathematics

by

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DEPARTMENT OF MATHEMATICS

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this project report is the bonafide work of **PRIYATHARSHANI.B (40630006)** who carried out the project entitled "**TIME SERIES FORECASTING USING ADVANCED STATISTICAL TOOLS**" under our supervision from **November 2021 to May 2022.**

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ABSTRACT:

A time series is a series of data points that occur in succeeding order over a particular period of time. Time series forecasting helps to forecast the future value over a certain period of time. Fundamental analysis and technical analysis create a way to forecast the stock price movements. Fundamental analysis is a method of analyzing securities by deciding the terminal value of the stock. It uses both past and present data, which will be helpful for long term investments. Whereas, technical analysis is a method of deciding the future value of a stock based on market trends and prices of a stock. It uses only the past data that is helpful for trading.

Information Technology industry plays a leading role in developing the economic growth of the country. Forecasting Information Technology stock market returns is one of the most challenging tasks and it also helps in increasing portfolio diversification. In this re-search work, a particular company daily close price is collected from National Stock Exchange of India Ltd (NSE), for the year 2021. Here close price is chosen as a parameter since it reflects all the activities of the index that happened in a particular trading day. Single exponential smoothing and moving average are coupled with Autoregressive Integrated Moving Average (ARIMA) as single exponential-ARIMA and MA-ARIMA models to improve the forecasting stock market returns. This experiment shows that combining the techniques produce more accuracy when compared with individual forecasting models.

KEYWORDS:

-  Time series forecasting
-  Stock market exchange
-  Single Exponential
-  Moving Average
-  Autoregressive Integrated Moving Average
-  MA - ARIMA & Single Exponential - ARIMA
-  MAPE

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CHAPTER -1

INTRODUCTION:

1.1 TIME SERIES:

Time series is a collection of data at different points in a regular interval of time. Daily weather reports, yearly rainfall in Tamil Nadu, monthly sea surface temperature are some examples of time series. Time series analysis convey how data changes over a particular period of time whereas time series forecasting can recognize the direction in which the data is changing. In other words, time series analysis is all about evolving models to gain an understanding of the data to understand the underlying causes. Forecasting then takes the next step of predicting extrapolation of what might happen in the future. There are many real time applications of time series. Some of them are, economic forecasting, sales forecasting, budgetary analysis, stock market analysis, census analysis etc.,

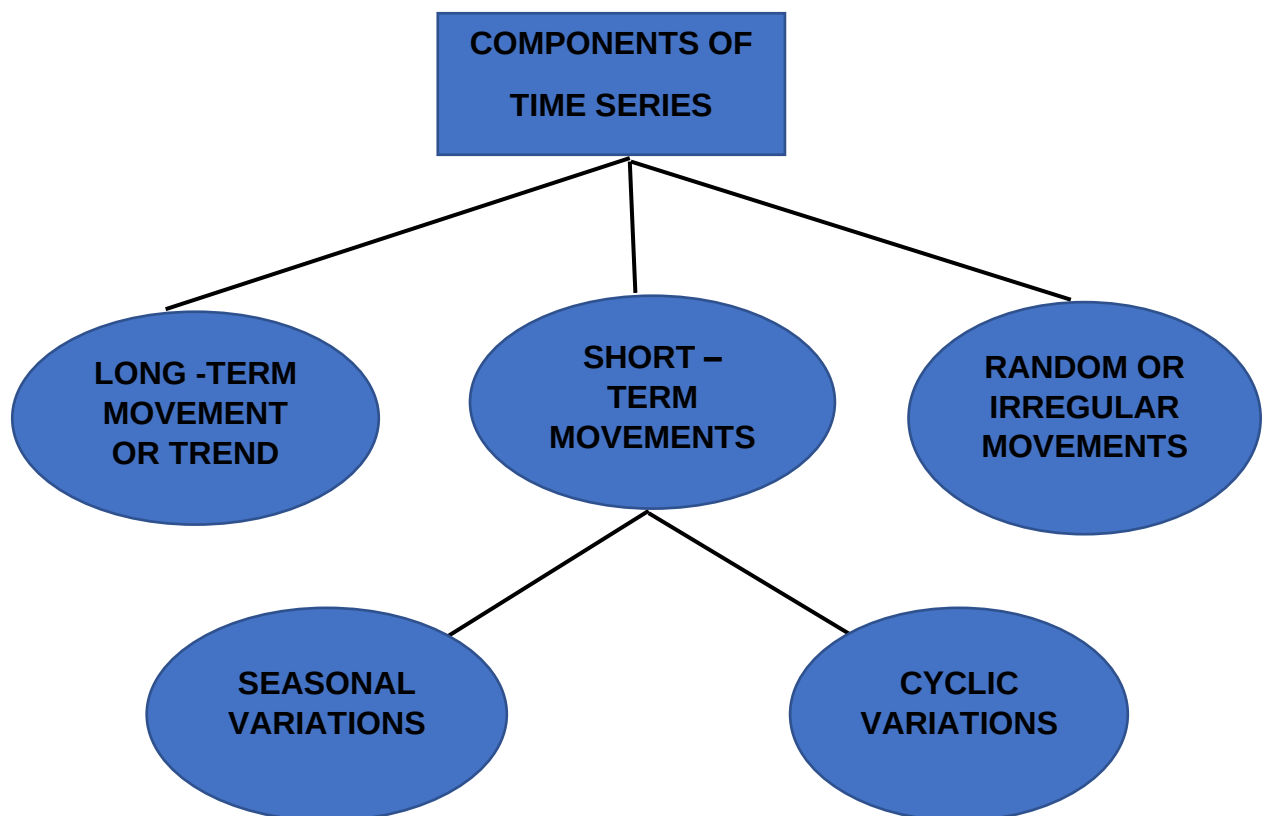
Table 1.1 Example of dataset for their respective fields

FIELD	TOPIC	DATA
Medicine	Blood pressure tracking, weight tracking, heart rate monitoring, cholesterol measurements.	MRI scanning and behavioral test dataset.
Epidemiology	Disease rates, mosquito population. Mortality rates.	U.S. cancer incidence rates from the center for disease control
Physical Sciences	Global temperatures, monthly sunspot observations, pollution levels.	Global air pollution from our world in data
Social sciences	Birth rates, population, migration data, political indicators.	Population without citizenship from Eurostat.
Economics	Gross Domestic Product (GDP), Consumer Price Index (CPI)	India GDP from the federal reserve economic data.

1.1.1 COMPONENTS OF TIME SERIES:

The several reasons which influence the values of an observation in a time series. They are the components of time series and the components are,

1. Trend – T
2. Seasonal variation – S
3. Cyclical Variation – C
4. Irregular Variation – I



TREND - T:

Trend exhibit the general movement of the data to increase or decrease, during a longer period of time. It doesn't necessary that the increase or decrease in trend lies in the same direction within the given period of time. Trend is normally the outcome of long-term factors such as changes in population, production of goods, demographics, technology or consumer preferences.

SEASONAL VARIATION - S:

The seasonal component is the systematic pattern of variability within particular period of time, such as a year. The variability does not always denote the seasons of the year (i.e., winter, spring, summer, fall). It can also be within-week or within-day seasonal behavior.

CYCLICAL VARIATION - C:

Any ordered pattern of series of values above or below the trend line remaining more than one year can be attributed to the cyclical component. Cyclical variation is due to multiyear cyclical movements in the economy.

IRREGULAR VARIATION – I:

Irregular variations are purely random or irregular and short in duration. Irregular variation occurs due to phenomenon of unforeseen events like wars, earthquakes or floods.

1.2 STOCK MARKET:

A stock is nothing but an equity of share. Stock market is a place where all the financial securities are bought or sold by the investors or the traders in the stock exchange. By buying the share, we're making an investment within the company. Because the company grows, the value of our share too can increase. We will get profit by selling the share in the market. The profit or loss depends on which stock, the trader is investing. Here, prediction plays a major role but predicting a stock is a challenging task. Stock market prediction is defined as trying to determine the future value of a stock for a company or any other financial instrument traded on an exchange. Whereas Forecasting uses the data set from the past, combines with present trend to come up with a future event outcome.

Investment can be done in two ways, intra-day trading or long-term trading. In intra-day trading, traders buy and sell the stock at the same day. On the other hand, in long-term trading the time period between buying and selling ranges within a few months to few years. In short, traders hold the stock less than a day in intra-day trading but in long-term trading traders can hold the stock as long as they wish to. Stock price depends on various known and unknown factors like closing price, Relative Strength Index, oscillator, calamity, international events, human behavior etc., By creating accurate forecast model investment risk and uncertainty can be minimized. There are many statistical techniques that can be used by stock market analysts to forecast the data to enhance the investment flow into the stock market.

CHAPTER -2

2 LITERATURE SURVEY:

- ✚ M. Mallikarjuna and R. Prabhakara Rao [18] (2019) took 24 stock market indices in three different categories (such as developed, emerging and frontier markets) to find appropriate forecasting technique of each category for the time period 2000-2018. They tried different methodology and concluded that no single method can be applied uniformly to all markets.
- ✚ Zoran Ivanovski et.al [20] (2018) forecasted extrapolation of number of tourist using moving average method and explained about seasonality, trend, regression, forecasting and centred moving average. As time series helps to predict the future by understanding the past behaviour of the data, the forecasted moving average model for the timeseries data performed well by providing the accurate number of tourist guests.
- ✚ Kumar Manoj and Madhu Anand [5] used ARIMA model for predicting sugarcane production in India. This study explains in detail about model identification, parameter estimation and diagnostic checking for the collected timeseries data for the period of 62 years (1950-2012). Predicted ARIMA (2,1,0) model accurately predicted the rise and fall in production.
- ✚ Nambirajan M et.al [11] collected a 12 years dataset from yahoo finance and trained the model using Random Forest classifier algorithm. Most important part of quantitative strategy is Back testing by which the accuracy of the model is obtained. Finally, they created a simple GUI application, that helps the user to predict the stock with 79 percentage of accuracy.
- ✚ Israa Ali Alshabeeb et.al [3] investigates about the quantitative effect of covid-19 pandemic by examine cases and death rate in four different countries. Data collected for the period October 2020 to the end of April 2021. Here, moving average method and single exponential smoothing method to achieve their objective.
- ✚ Kuljeet Singh et.al [4] studied about implementation of exponential smoothing for forecasting time series data. Here, the tourist data set for Himachal

Pradesh has been collected for the year 2008-2017 and exponential smoothing has been performed by varying the smoothing co-efficient from 0-1. By using the error measures Mean Absolute Deviation (MAD), Mean Squared Deviation (MSD) and Mean Absolute Percent Error (MAPE) best forecasted model was found.

- ✚ Nirmala M and Sundaram S.M [13] (2010) predicted rainfall in Tamil Nadu. In this paper they discussed about various statistical methodologies and machine learning methods for prediction. They collected data from Indian Institute of Tropical Meteorology, Pune for the time period 1871-2006 (136 years). First 100 years is taken as training data and next 36 years is taken as test data and concluded that hybrid model ARIMA-ANN outperformed when compared with other original models.
- ✚ G. Peter Zhang (2003) [2] combines the linear ARIMA model and the nonlinear ANN model aiming to change the perspective in time series data. This paper explains about the importance of hybrid model. The proposed hybrid model performs better in terms of accuracy compared with individual models.
- ✚ Suhartono et.al [16] (2017) explains about forecasting a time series data in economics and business with trend, seasonal and calendar variation patterns. Here ARIMAX used as classical linear models and neural network as modern non-linear models. In this study, hybrid model is formed by combining classical linear model and modern non-linear models and results shows hybrid model performed well than individual forecasted models in terms of accuracy.

CHAPTER -3

3.1 AIM OF THE STUDY:

This study aims at forecasting stock market returns using statistical methods and to find the most appropriate forecasting technique for the collected secondary time series data.

3.2 SCOPE OF THE STUDY:

To achieve the objective of this re-search work, a daily closing price of TCS, with the parameters for a period from 1st January 2021 to 31st December 2021, having a total of 248 data, has been collected from **National Stock Exchange of India Ltd (NSE)**. In this study TCS is chosen, since it's one of the leading IT sectors in 2021 and closing price is chosen because it reflects all the activities of the index that happened in the particular trading day.

CHAPTER - 4

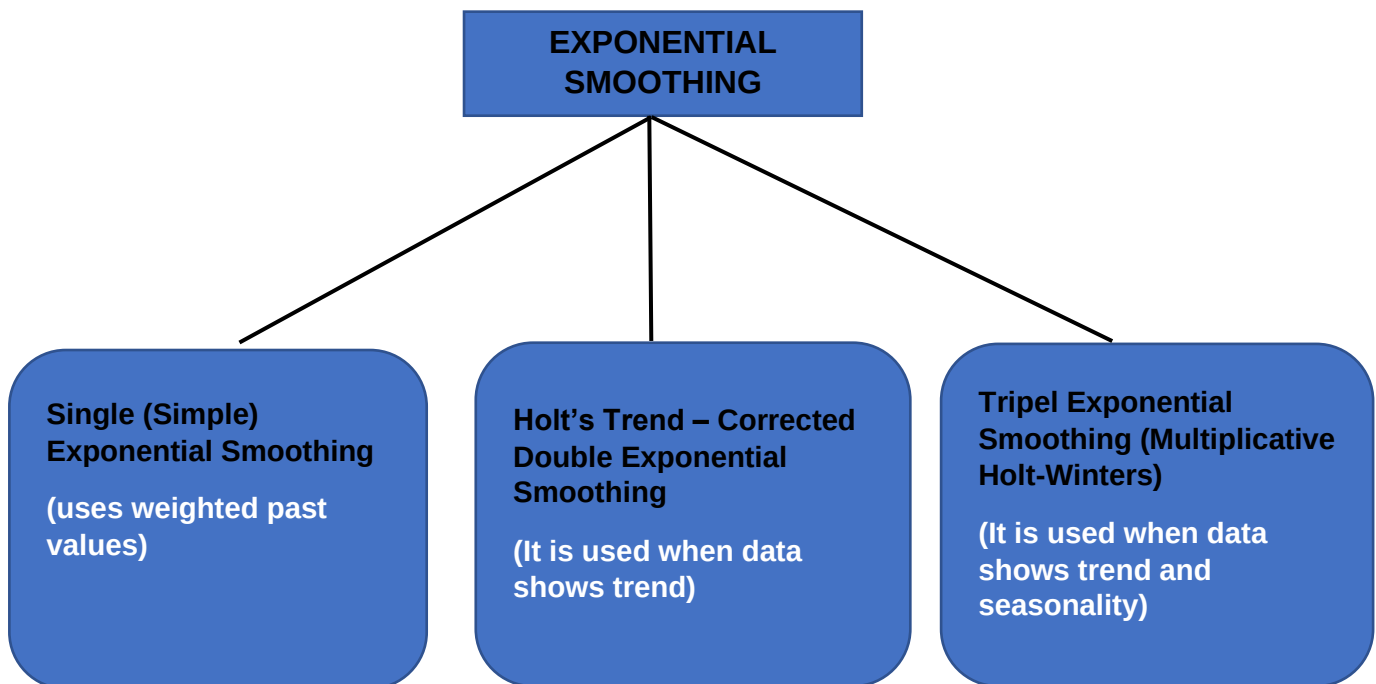
4.1 METHODOLOGY:

In time series analysis there are many methodologies that can be used for forecasting. In this research paper, the following methodologies are used. They are,

- ✚ Single Exponential Smoothing
- ✚ Moving Average
- ✚ Autoregressive Integrated Moving Average
- ✚ Hybrid model

4.1.1 SINGLE EXPONENTIAL SMOOTHING:

Exponential smoothing is one of the time series methods that helps to forecast future values. Here, newer data is given more weight as it is relevant.



In this research work, single exponential smoothing method is applied to forecast the stock exchange closing data. This method can be used when there is no trend or consistent growing pattern in the data and helps to forecast the future value using weighted past values. The below illustration gives a clear idea how single exponential method is forecasted.

$$F_t = \alpha X_t + (1-\alpha) F_{t-1},$$

Where F_t is the forecast value.

X_t is the observed value.

F_{t-1} is the predicted value with exponential smoothing at time $t-1$.

α is the constant called as smoothing co-efficient or smoothing factor that ranges between 0 to 1.

4.1.2 MOVING AVERAGE:

Moving average is one of the best approachable techniques for pre-treating of time series data. Unweighted moving average is the most common moving average method. It is used to filter random white noise from the data and smooths it by replacing each data point with the average of k neighbouring points, where k is called the order or length of moving average. In general, higher the length of moving average, greater the smoothing effect is. For given N data points and T , the length of the moving average, $MA(T)$, the forecast F_{T+1} is given by

$$F_{T+1} = \sum_{i=1}^T \frac{X_i}{T} \quad \text{----- (1)}$$

$$F_{T+2} = \sum_{i=2}^{T+1} \frac{X_i}{T} \quad \text{----- (2)}$$

Combining the above two equations, we get

$$F_{T+2} = F_{T+1} + \left[\frac{X_{T+1} - X_1}{T} \right] \quad \text{----- (3)}$$

From the above equation, we can see that each new forecast, F_{T+1} is an adjustment of the immediate preceding forecast.

4.1.3 AUTOREGRESSIVE INTEGRATED MOVING AVERAGE (ARIMA):

In 1970, Box and Jenkins introduced the ARIMA which includes AR (autoregressive), MA (moving average) and I (differencing) in the model formulation. It is also known as Box-Jenkins methodology which composed of model identification, parameter estimation and diagnostic checking with time series data. ARIMA (p, d, q) model has shown efficient ability in financial forecasting and it constantly outperformed complex structural models, where p denotes the order of

autoregressive part, d represent the order of differencing and q is the order of moving average. The ARIMA (p, d, q) model is illustrated as below,

$$\phi(B) (1 - B)^d (Z_t - \mu) = \theta(B) a_t$$

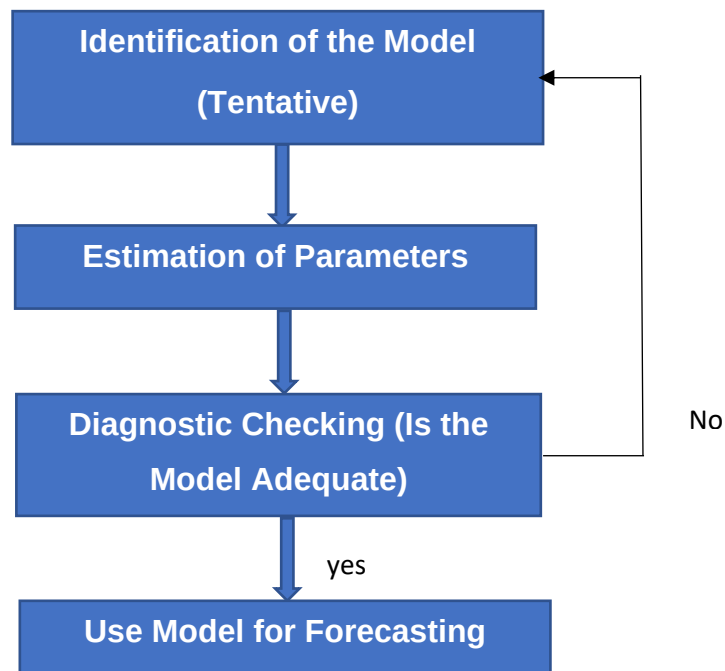
Where Z_t represent the observed value at time t,

B denote the backward shift operator and

$$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots - \phi_p B^p$$

$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \dots - \theta_q B^q$$

ARIMA MODEL CONSTRUCTION:



4.1.4 HYBRID MODEL:

Hybrid model helps to advance the timeseries forecasting by combining the best of statistical methods or machine learning methods such as simple moving average, exponential smoothing, Autoregressive Integrated Moving Average, Neural Network, Multiple linear regression etc., The idea behind hybrid model is that this combination compensates for the limitations of one approach with the strength of

the other. The main advantage of hybrid method is that it gives more accuracy in forecasting than individual forecasting models.

4.2 ERROR MEASURE:

Error is nothing but a difference between actual (or observed) value and forecasted value. In this research work, Mean Absolute Percentage Error (MAPE) is used to forecast the error. Smaller the MAPE value, better the forecasted value.

MAPE is illustrated as below

$$\mathbf{M} = \frac{1}{n} \sum_{t=1}^n \left| \frac{A_t - F_t}{A_t} \right| \times \mathbf{100}$$

Here,

M - Mean Absolute Percentage Error

n - Number of elements in the data set

A_t – Observed Value

F_t – Forecasted Value

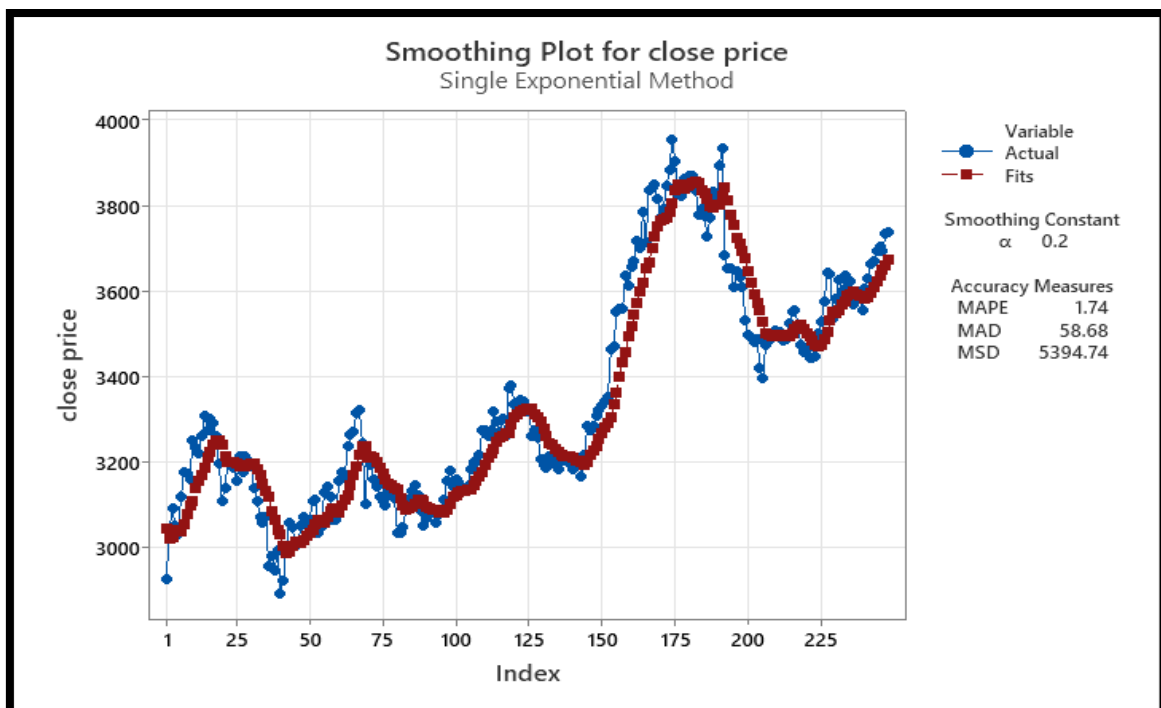
CHAPTER – 5

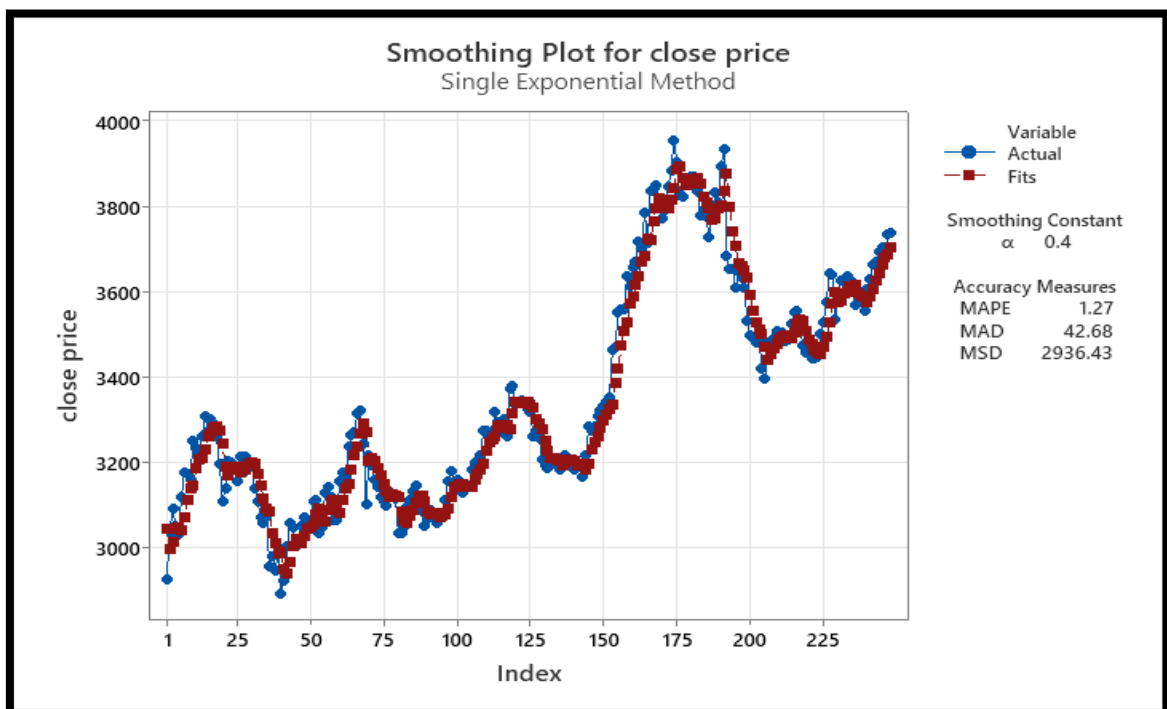
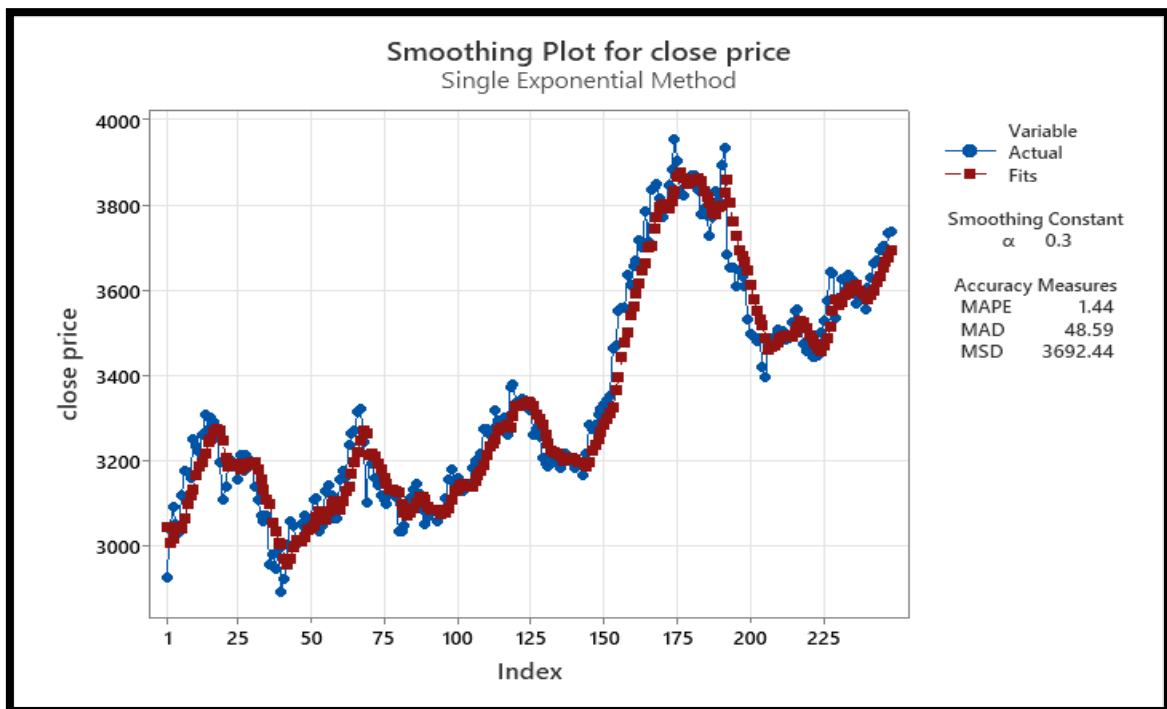
5 RESULT AND DISCUSSION:

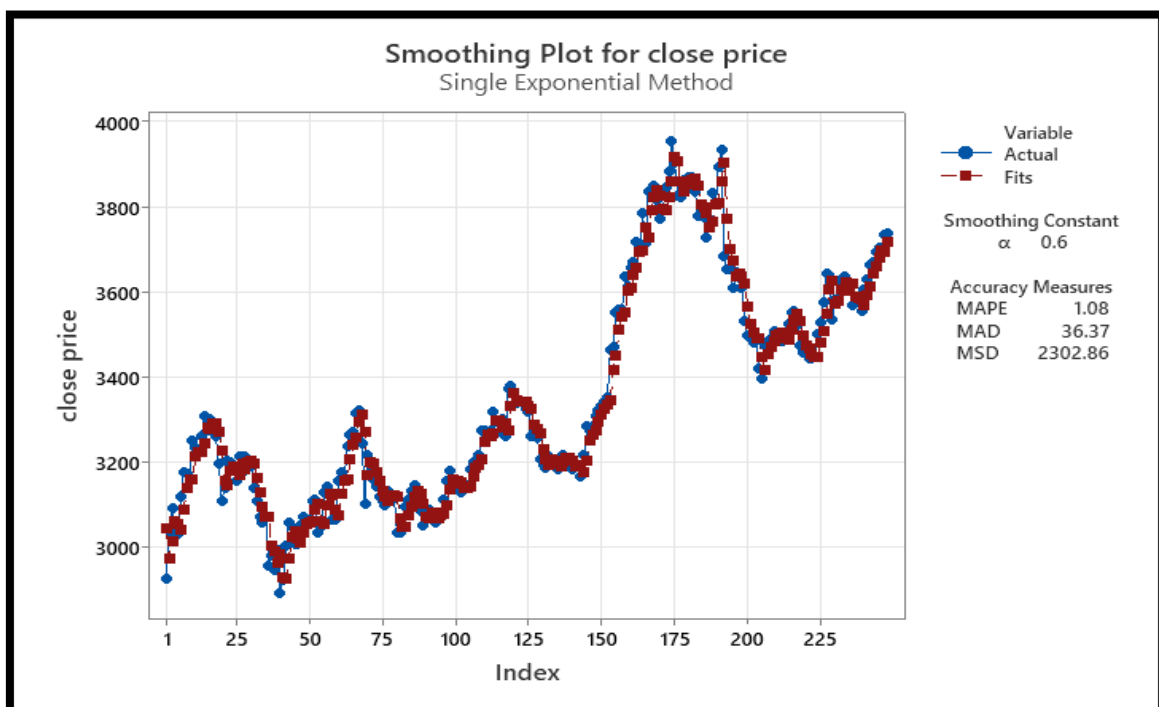
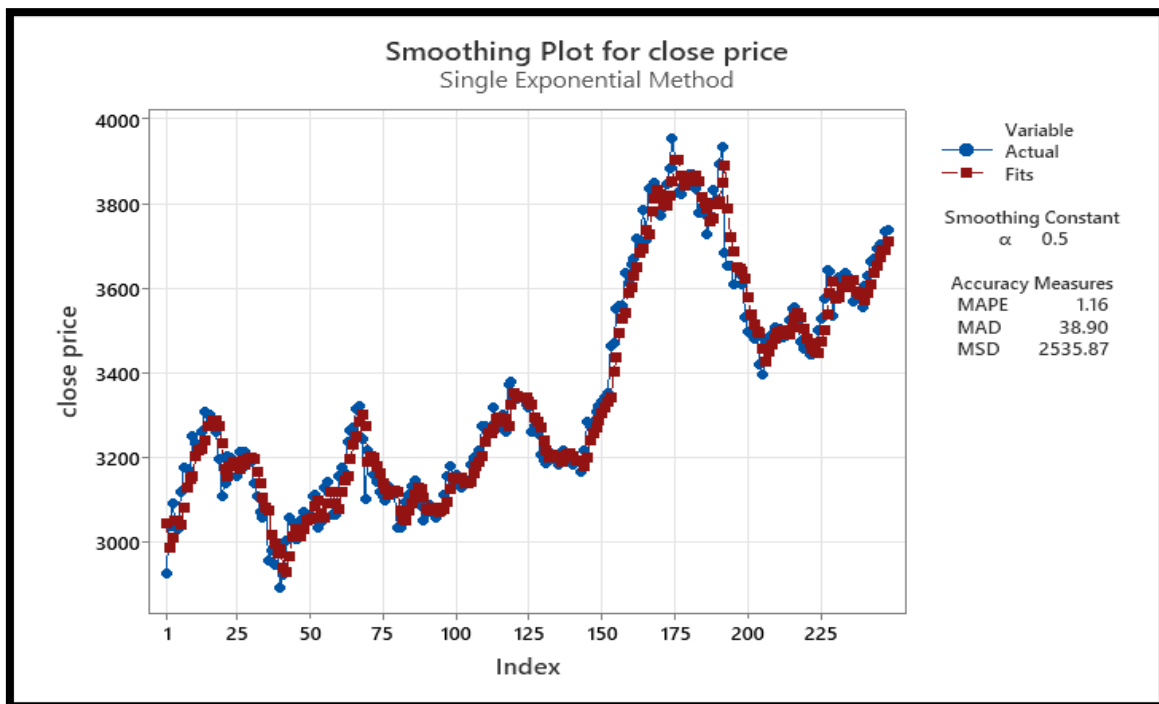
After applying the methodologies for forecasting the TCS data, the results which are obtained during this experimental work has been discussed in this chapter.

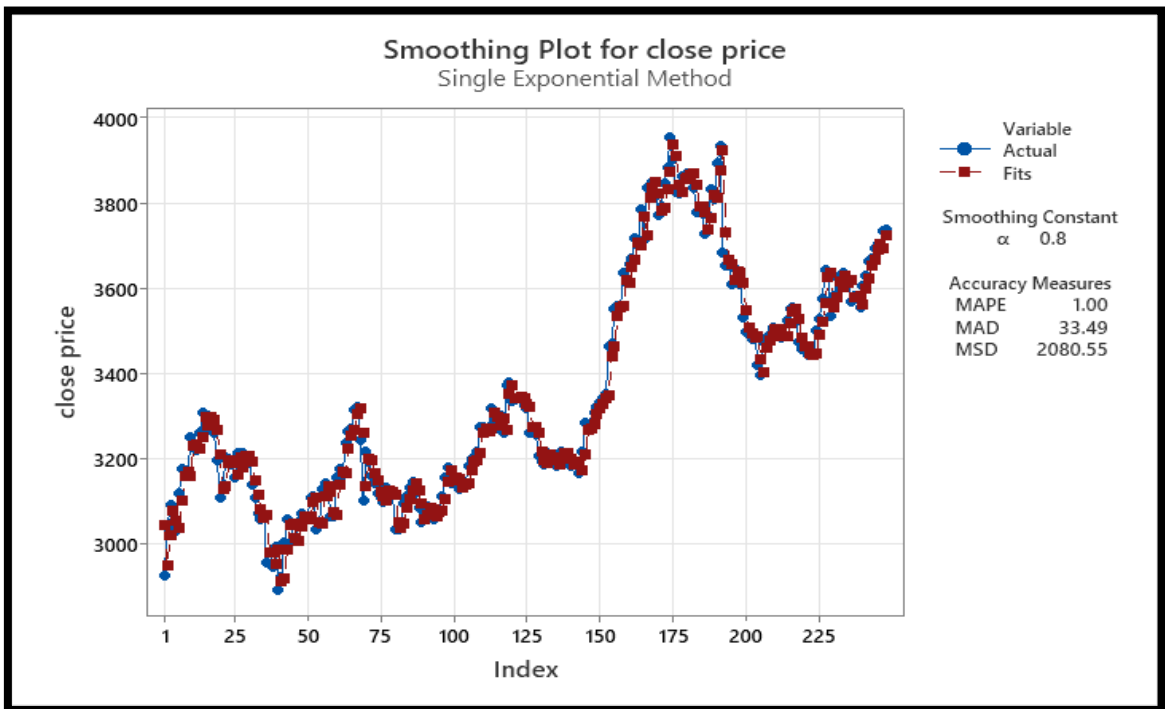
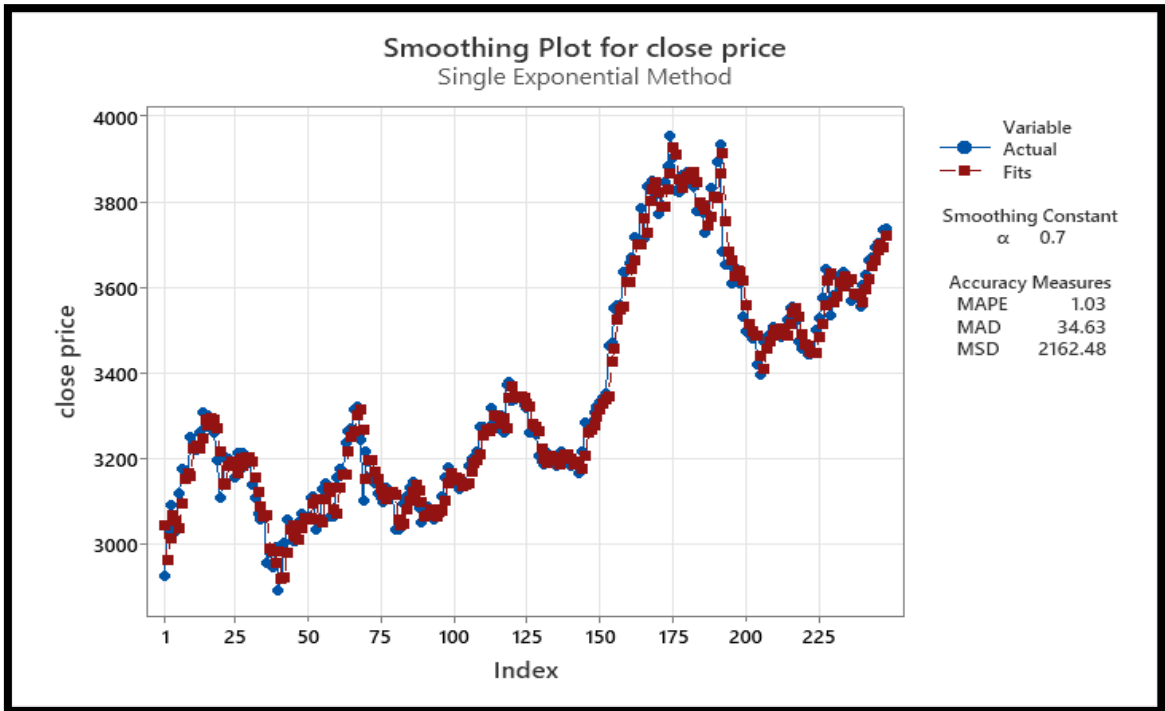
5.1 SINGLE EXPONENTIAL SMOOTHING:

In single exponential smoothing method, TCS close price for the year 2021 is given as the input. By varying the smoothing factor α , from 0.2 to 0.9 different forecasted models are obtained as shown in Fig 5.1. The best forecasted model is found using the error measure “MAPE”.









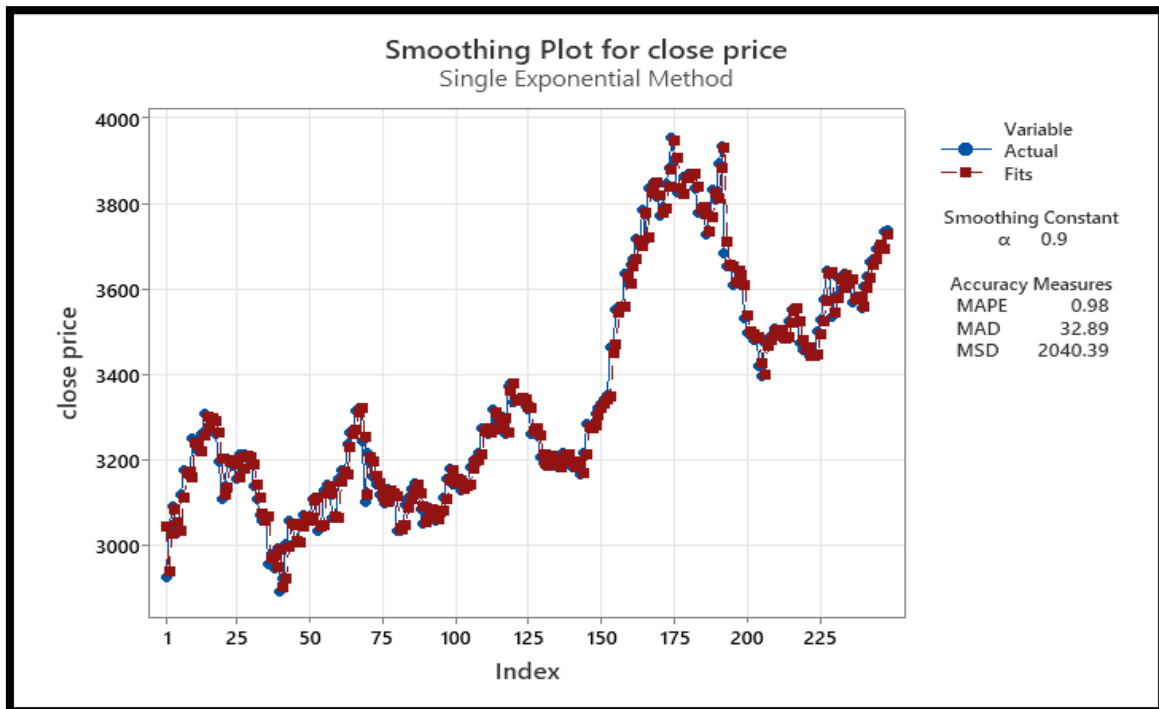


Fig:5.1 Single Exponential Smoothing Plots of Close Price (TCS) of ' α ' ranges from 0.2 to 0.9

Table 5.1: MAPE values of Single Exponential Smoothing Method for TCS close price

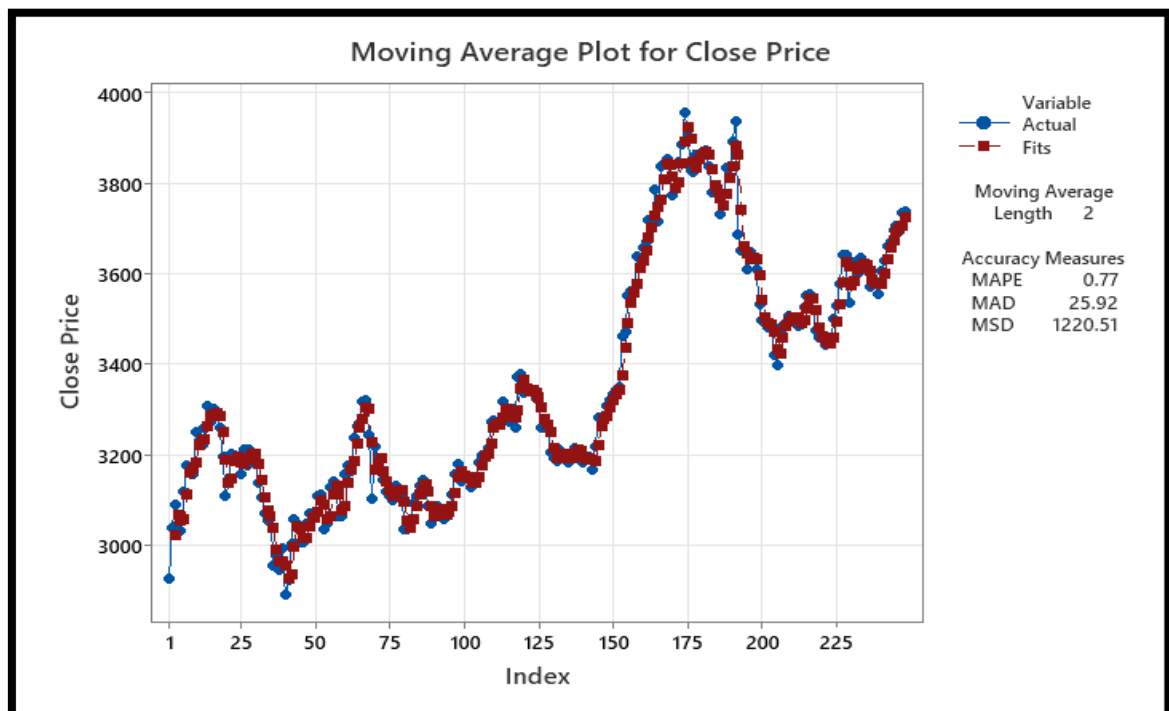
Smoothing co-efficient(α)	MAPE
0.2	1.74
0.3	1.44
0.4	1.27
0.5	1.16
0.6	1.08
0.7	1.03
0.8	1.00
0.9	0.98

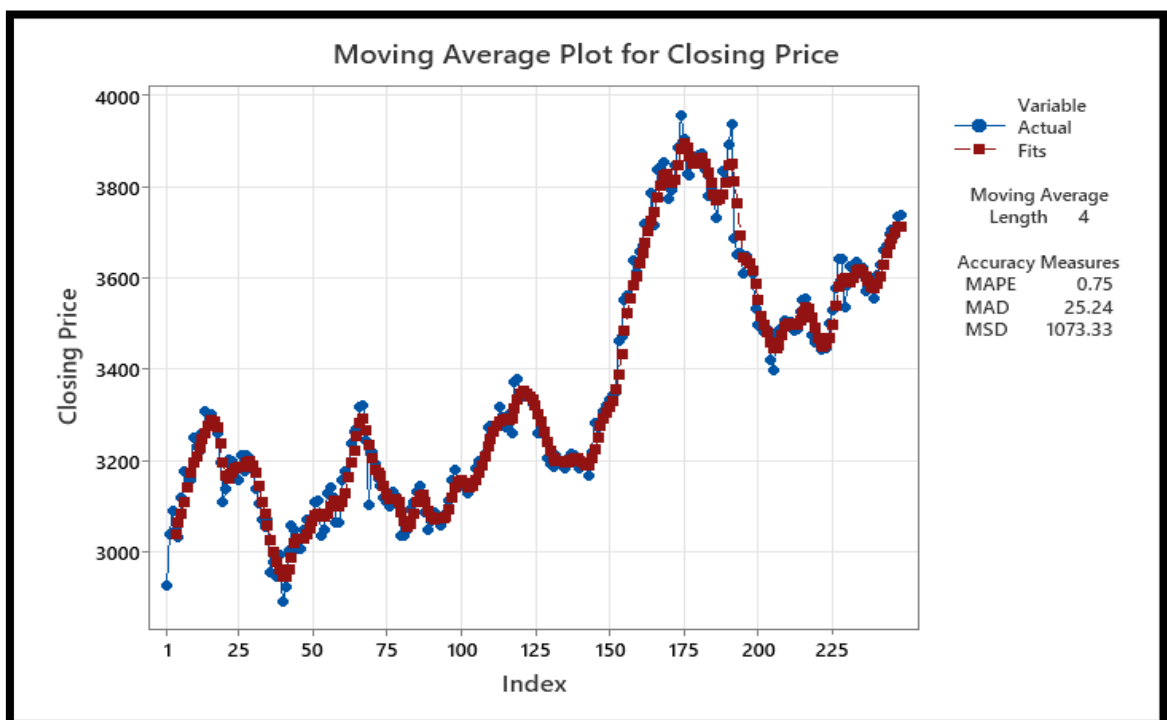
The above table illustrates the error measure (MAPE) for various smoothing co-efficient or smoothing factor denoted as α , for single exponential smoothing forecasted models. It is clearly seen that MAPE value is minimum when α is 0.9,

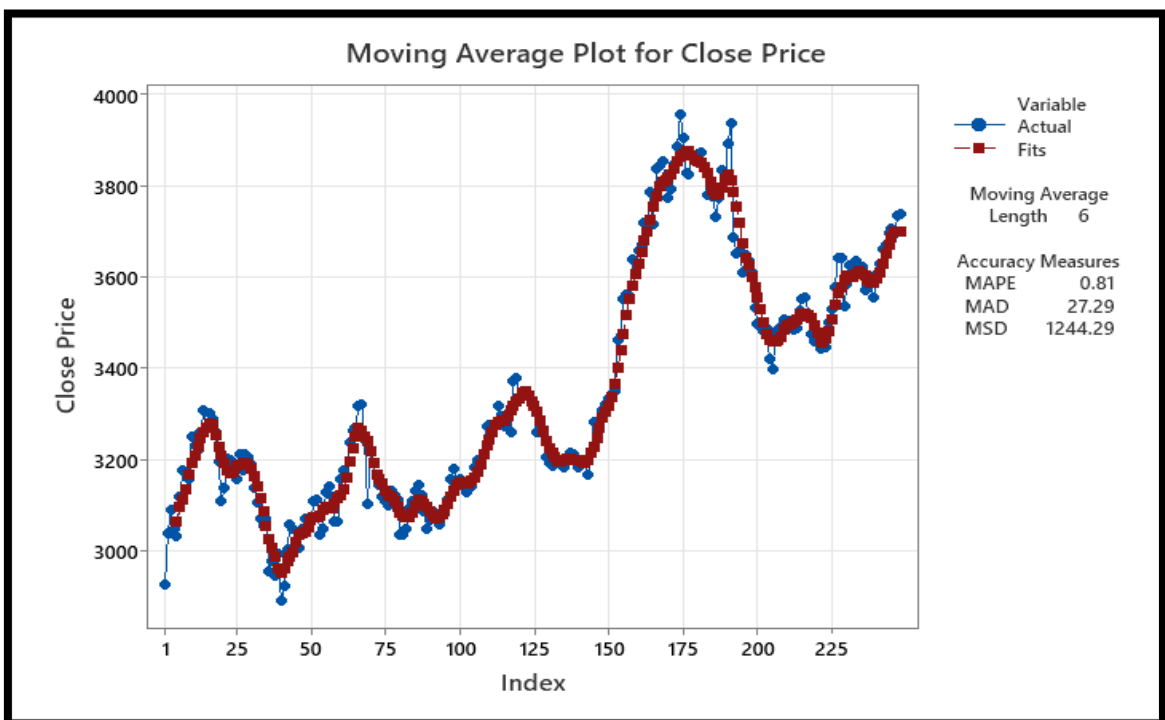
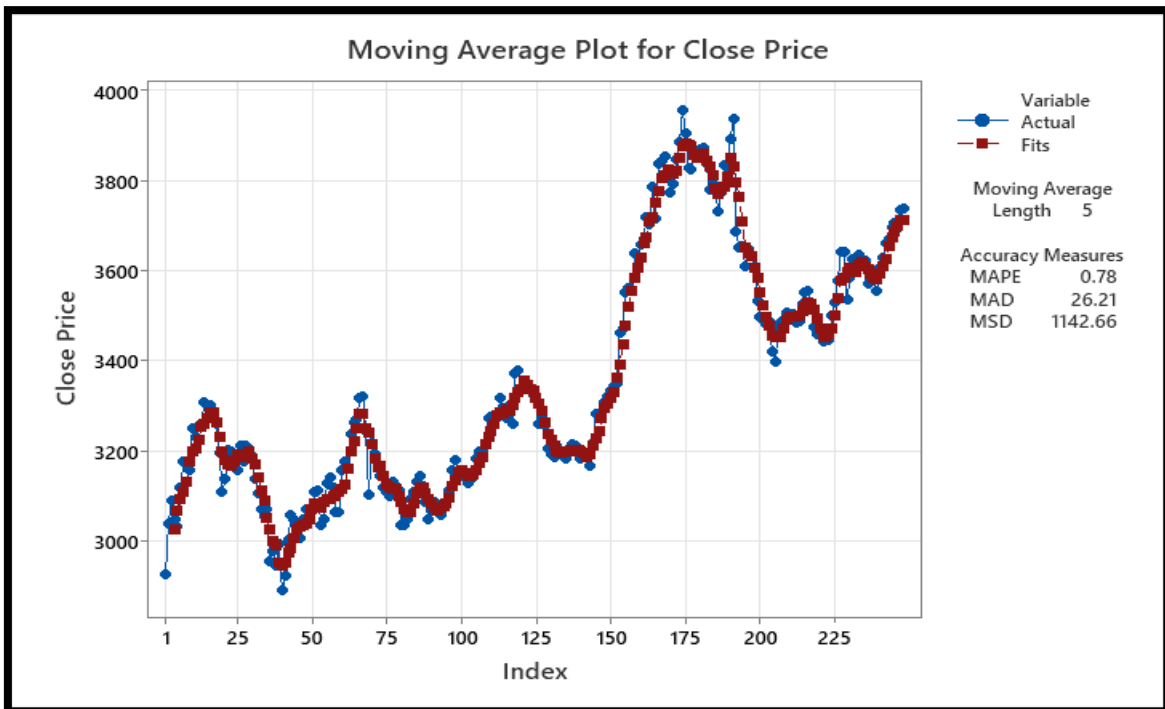
compared with other smoothing factors. **So, the best model among the single exponential methods is considered as exponential method of $\alpha = 0.9$.**

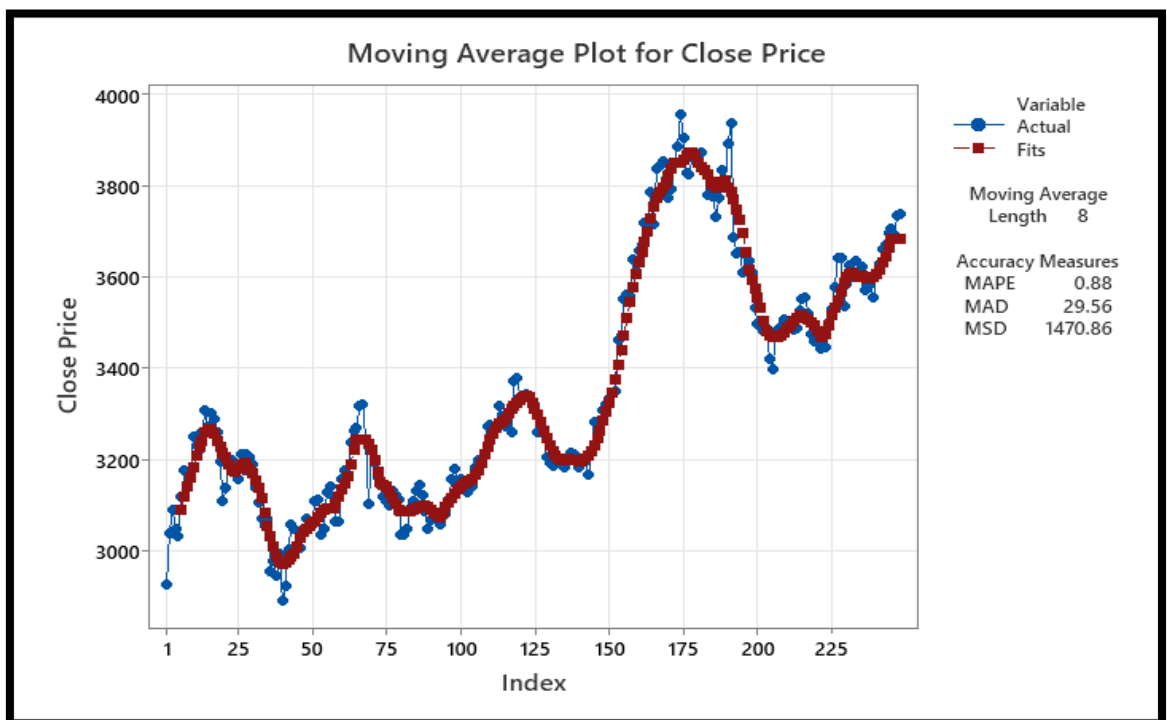
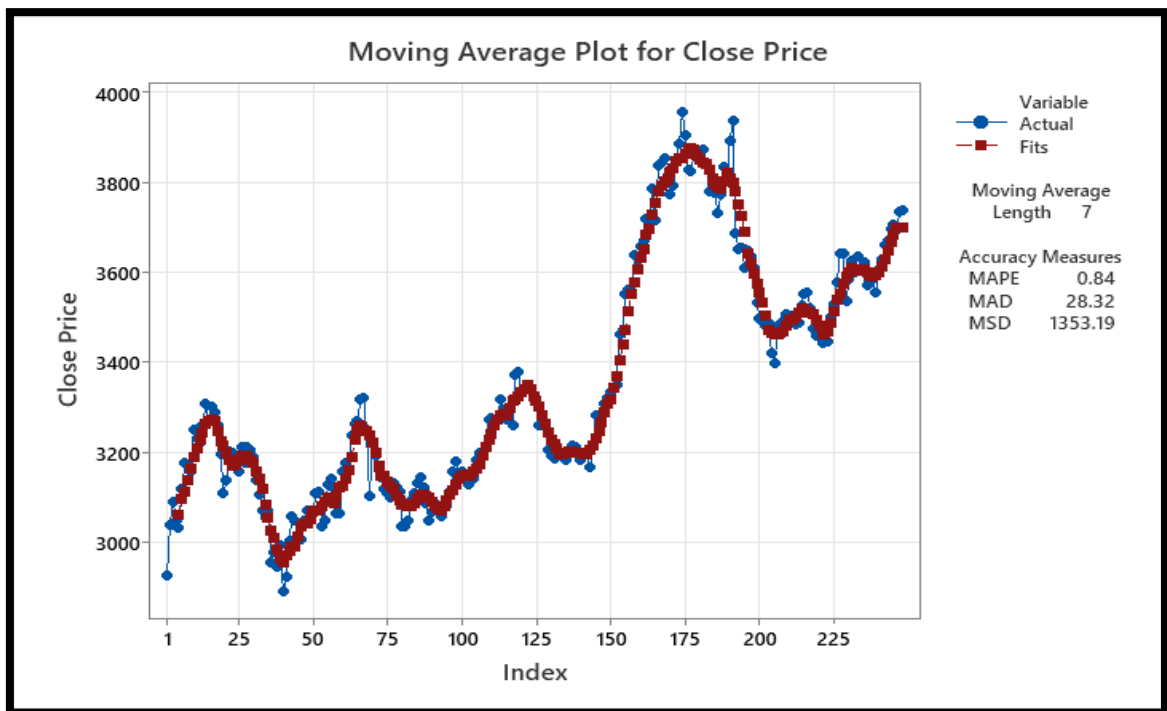
5.2 MOVING AVERAGE:

In moving average method, TCS close price for the year 2021 is given as the input. By varying the length from 2 to 9 different forecasted models are obtained as shown in Fig 5.2. The best forecasted model is found using the error measure “MAPE”.









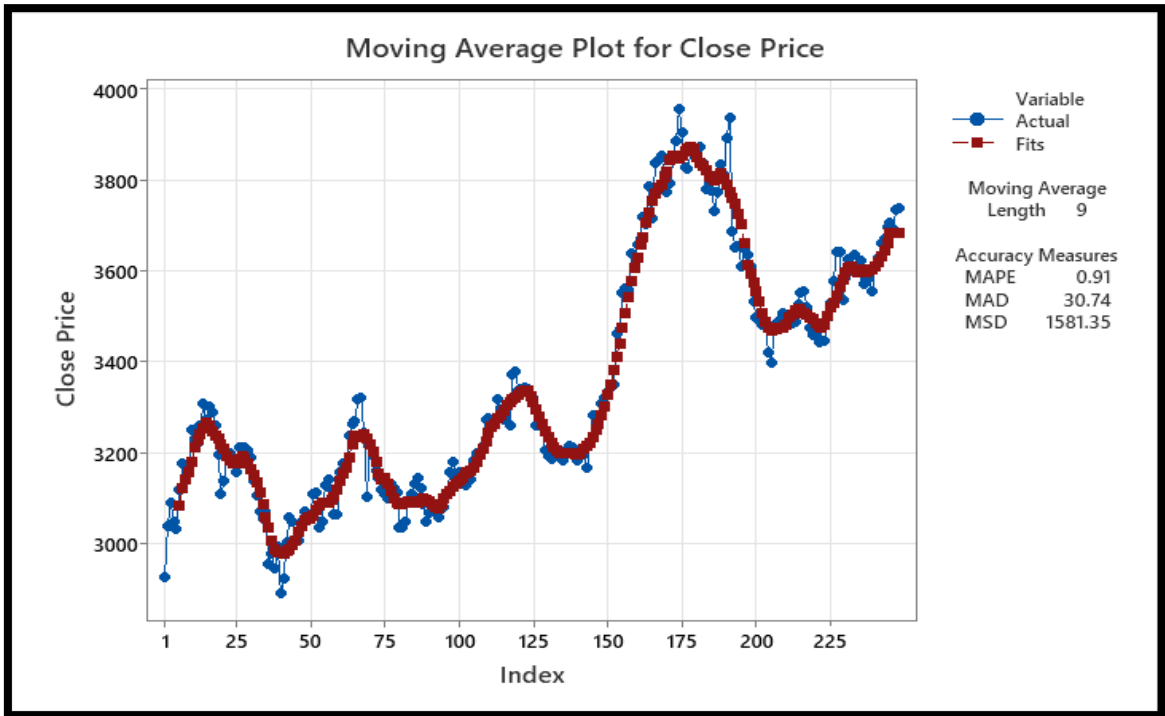


Fig 5.2: Moving Average Plots for Close Price in TCS of lengths 2 to 9

Table 5.2: MAPE values of Moving Average Method for TCS close price

LENGTH	MAPE
2	0.77
3	0.74
4	0.75
5	0.78
6	0.81
7	0.84
8	0.88
9	0.91

The above table illustrates the error measure (MAPE) for various length of moving average of forecasted models. It is clearly seen that length 3 is minimum when compared with all other lengths. So, the best model among the moving average is considered as moving average of **length 3**.

5.3 AUTOREGRESSIVE INTEGRATED MOVING AVERAGE:

Time series plot is a pictorial representation that illustrates data points at succeeding intervals of time. A good starting point for the time series analysis is the graphical plot of the data. Time series chart can be used to decide whether the data points are random or exhibit any pattern. As shown in fig 5.3, we can see the time series have random walk pattern.

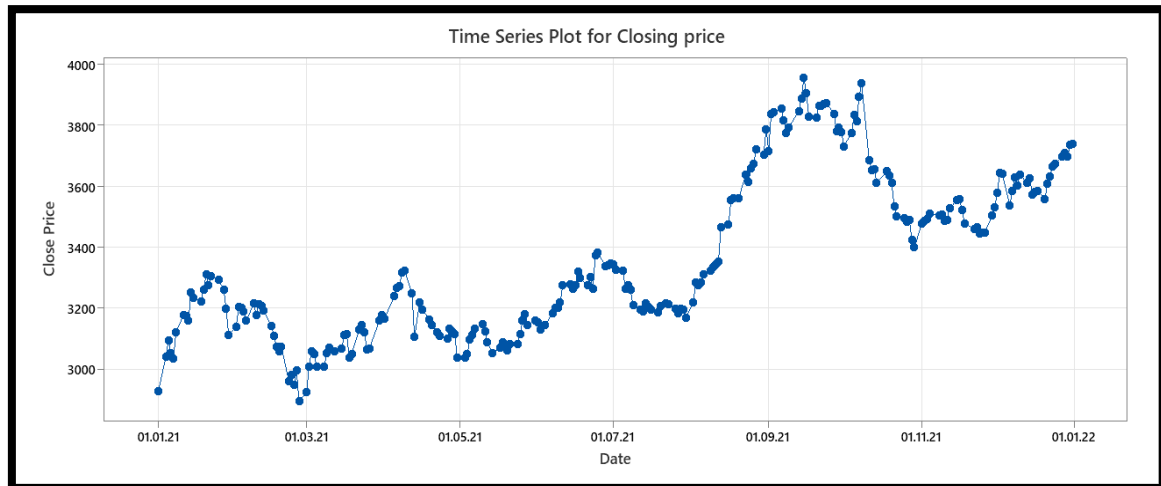


Fig 5.3: Time Series plot of daily closing price in TCS (2021)

From the Fig 5.4, the time series seems to be non-stationary, since Autocorrelation function dies down slowly. If the time series is not stationary, it can be converted into stationary series by differencing. After first differencing, the time series of TCS becomes **stationary** as shown in Fig 5.5 & 5.6.

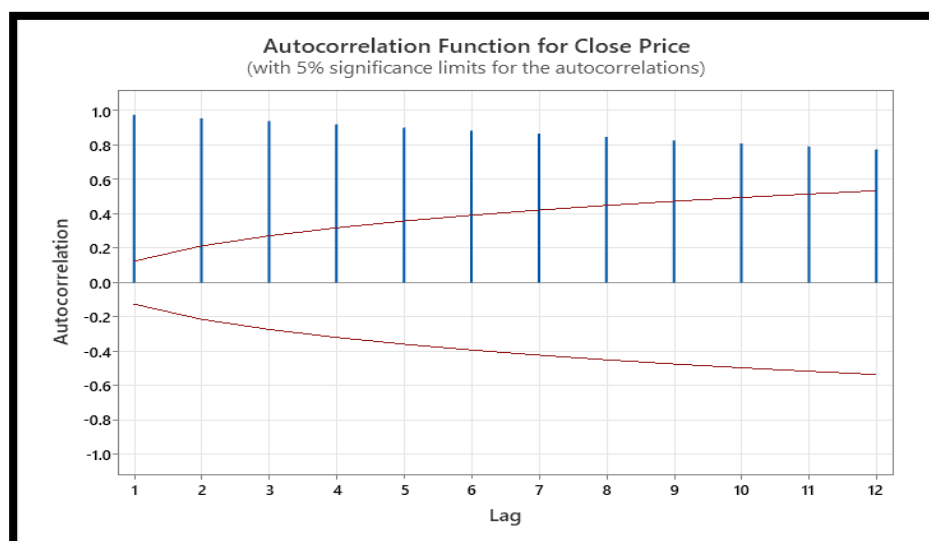


Fig 5.4: Correlogram of TCS

Autocorrelation function (ACF) and Partial Autocorrelation function (PACF) helps in the identification phase of plots of the series. The Autocorrelation plot of time series shows how the values are correlated with the past values of the series whereas the Partial Autocorrelation calculate the degree of association between y_t and y_{t+k} when the effect of other time lags 1,2,3 K -1 are somehow removed.

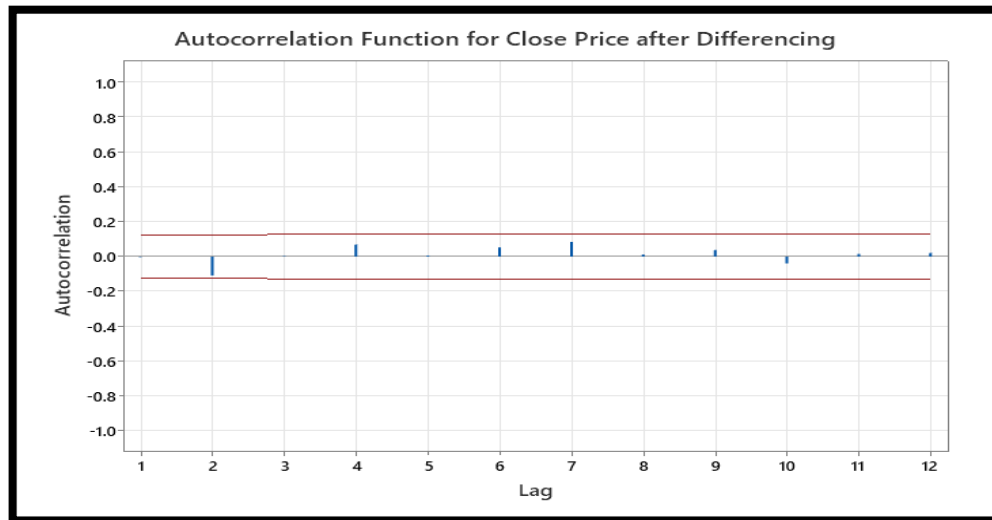


Fig 5.5: Autocorrelation Function for close Price after 1st differencing

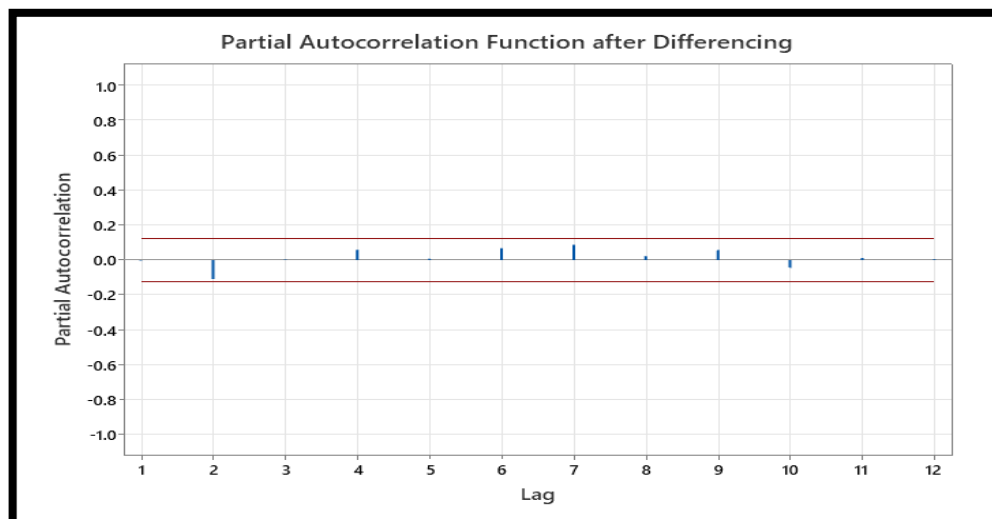


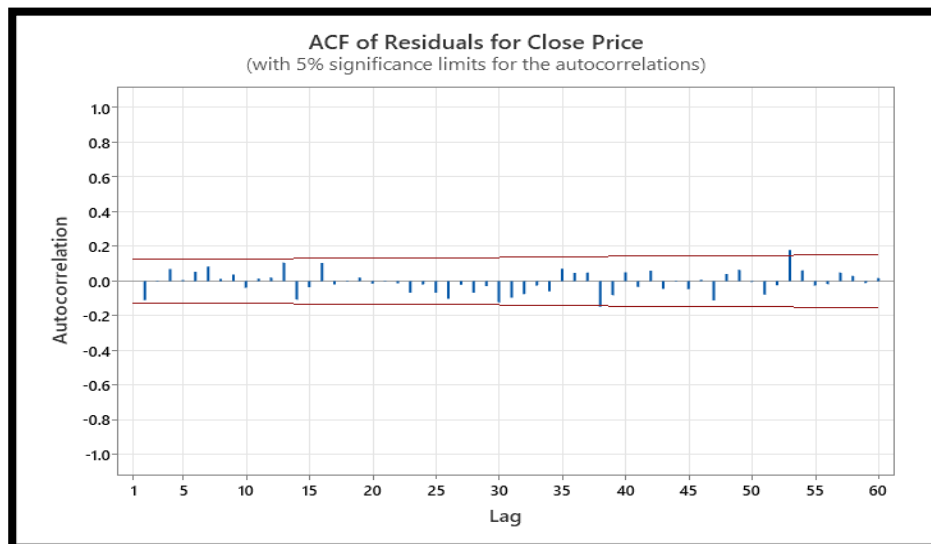
Fig 5.6: Partial Autocorrelation Function for close Price after 1st differencing

Table 5.3: MAPE values of ARIMA model for TCS close price

ARIMA	MAPE
(1,1,0)	0.098397
(0,1,1)	0.098392
(1,1,1)	0.098757
(0,1,2)	0.128793
(2,1,0)	0.140387
(2,1,2)	0.146982

Table 5.3 shows the error measure (MAPE) for different parameters of autoregressive (p), differencing (d) and moving average (q) among several ARIMA models. It is clearly seen that among various ARIMA models performed,

ARIMA (0, 1, 1) is considered to be the best model for TCS. This model contains relatively smallest error measure (MAPE) compared with other models.



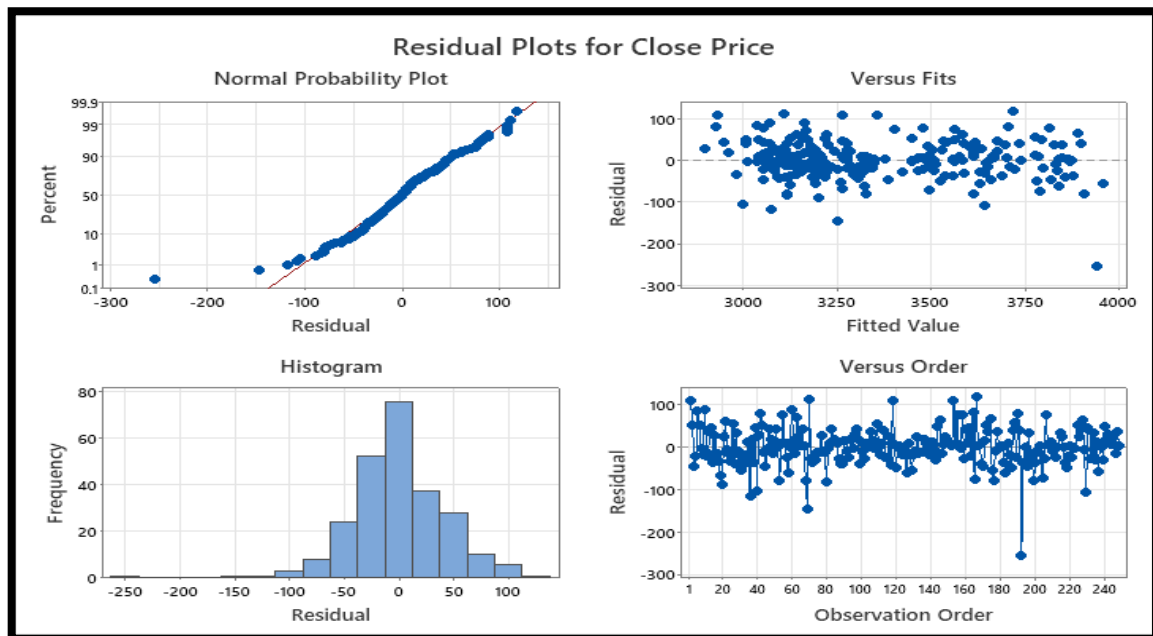
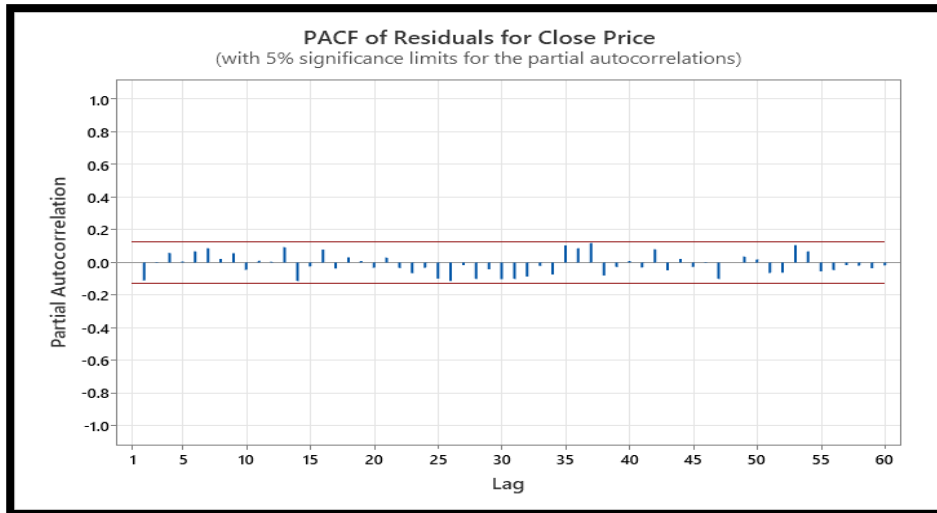


Fig 5.7: Correlogram of Residuals

5.4 HYBRID MODEL:

5.4.1 MA-ARIMA Model:

In this model length of moving average 3, is taken as the input and various ARIMA models have been performed. This model is referred as MA-ARIMA. First step is to check whether the time series is stationary or not. Since, the time series is not stationary as shown in fig 5.8 it can be converted into stationary by differencing.

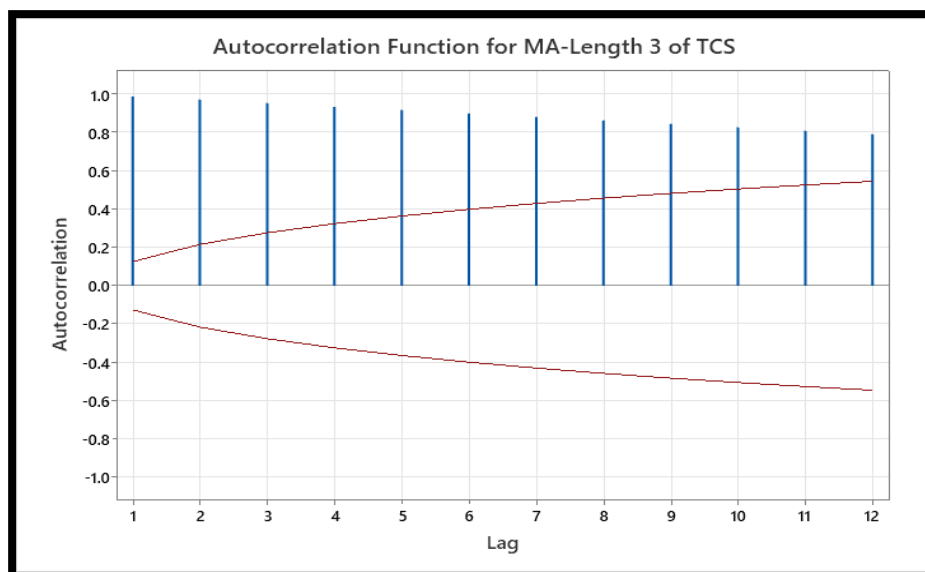


Fig 5.8: Correlogram of MA -Length 3 of TCS

After the first differencing, the time series becomes stationary as shown in fig 5.9 & 5.10.

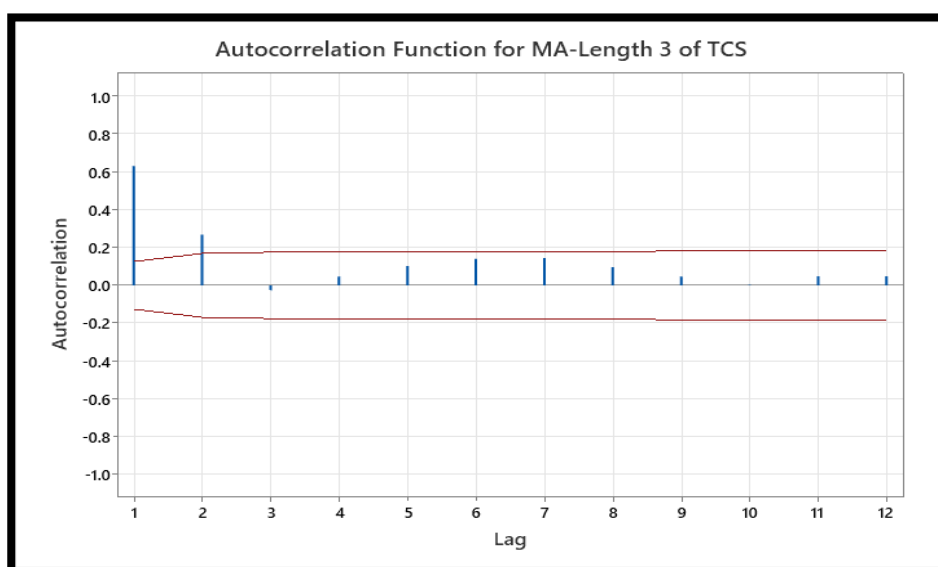


Fig 5.9: Autocorrelation Function for MA-Length 3 after 1st differencing

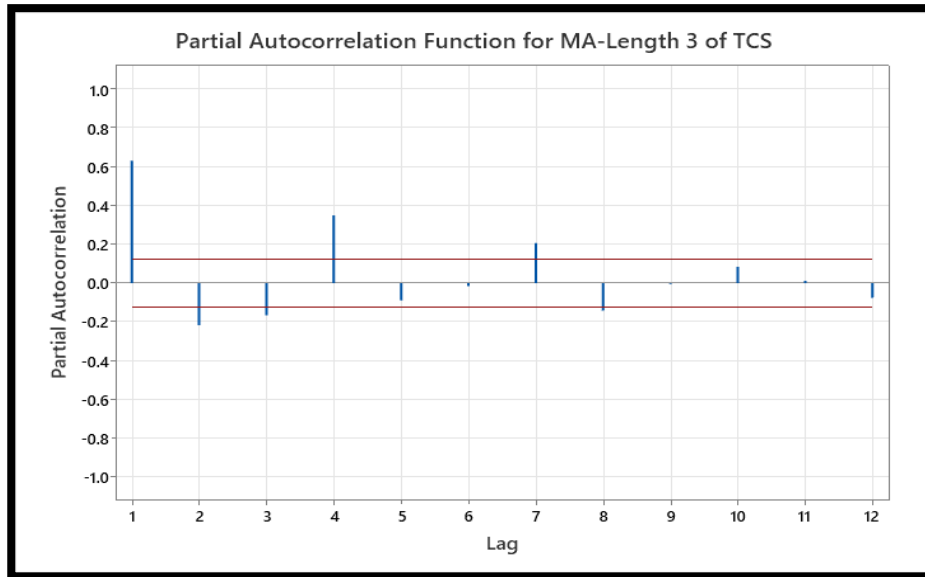


Fig 5.10: Partial Autocorrelation Function for MA-Length 3 after 1st differencing

Table 5.4: MAPE values of MA-ARIMA model for TCS

MA - ARIMA	MAPE
(1,1,0)	0.377018
(0,1,1)	0.245539
(1,1,1)	0.384486
(0,1,2)	0.481344
(2,1,0)	0.388336
(2,1,2)	0.462164

Table 5.4 shows the error measure (MAPE) for different parameters of autoregressive (p), differencing (d) and moving average (q) among several ARIMA models. It is clearly seen that among various ARIMA models performed,

ARIMA (0, 1, 1) is considered to be the best MA - ARIMA model for TCS. This model contains relatively smallest error measure (MAPE) compared with other models.

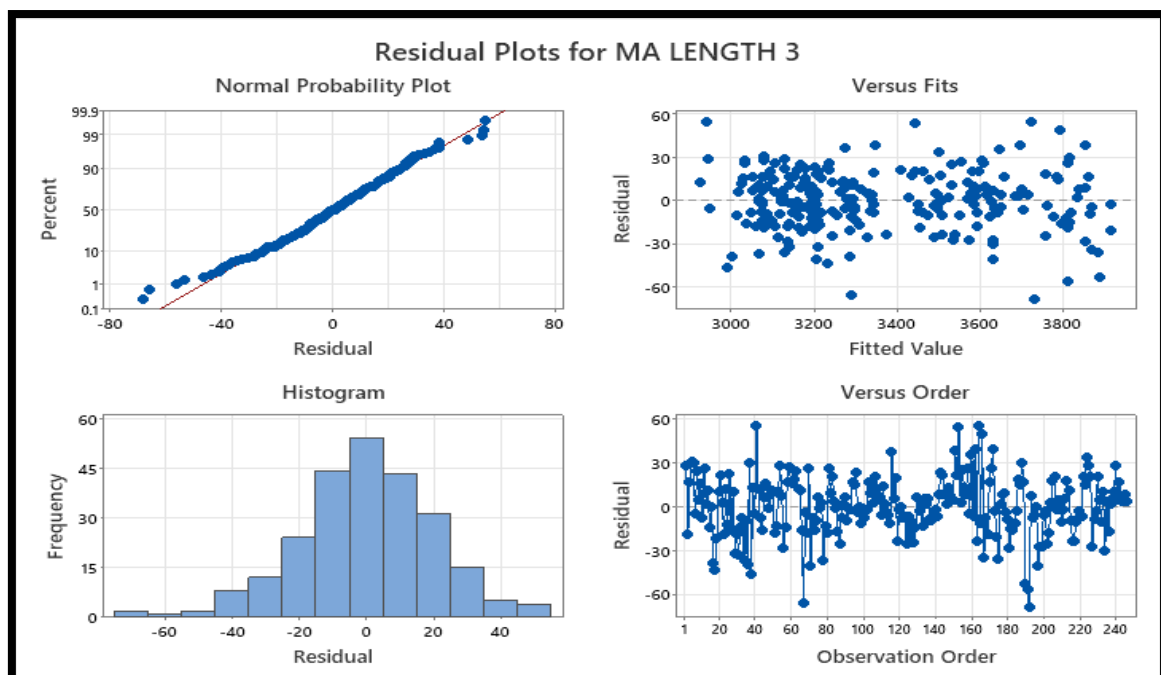
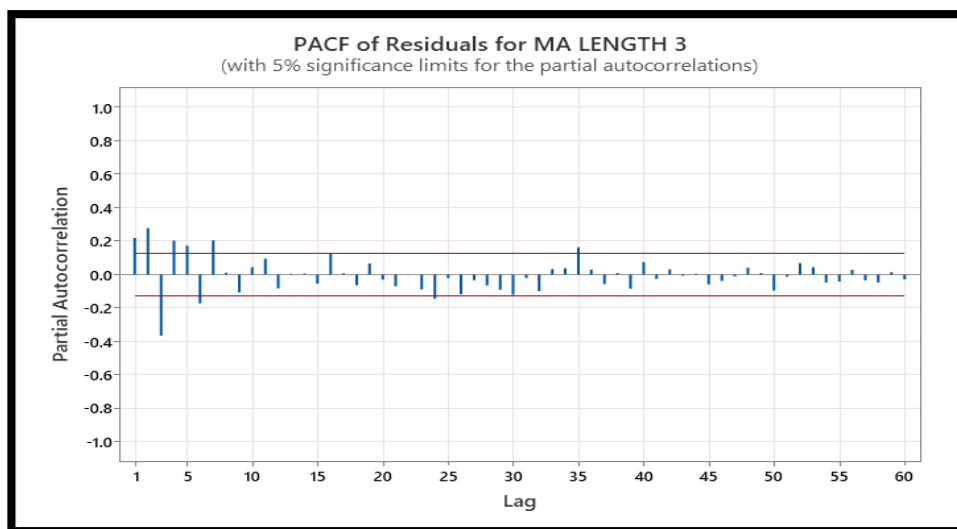
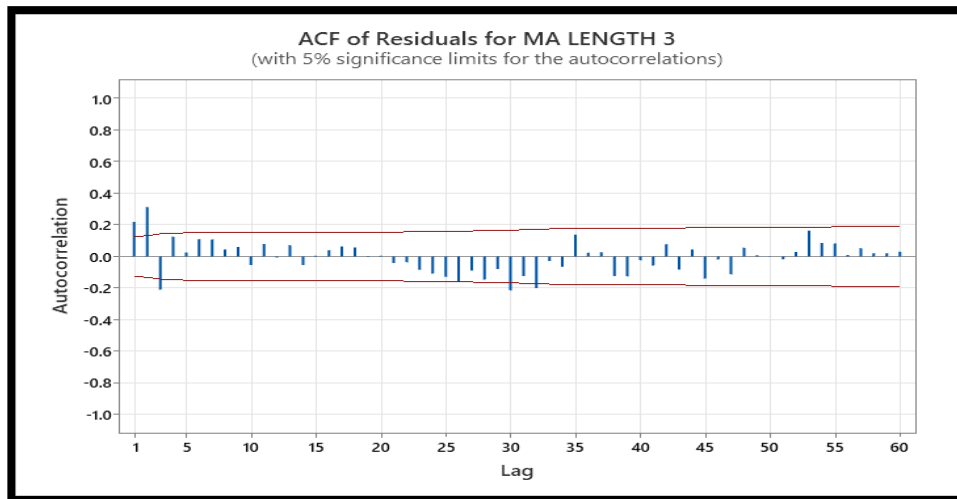


Fig 5.11: Correlogram of Residuals for MA-ARIMA

5.4.2 SINGLE EXPONENTIAL – ARIMA:

In this model, smoothing factor $\alpha = 0.9$ is taken as the input and various ARIMA model have been performed. This model is referred as single exponential – ARIMA. From fig 5.12, the time series seems to be non-stationary, since Autocorrelation function dies down slowly. If the time series is not stationary, it can be converted into stationary series by differencing.

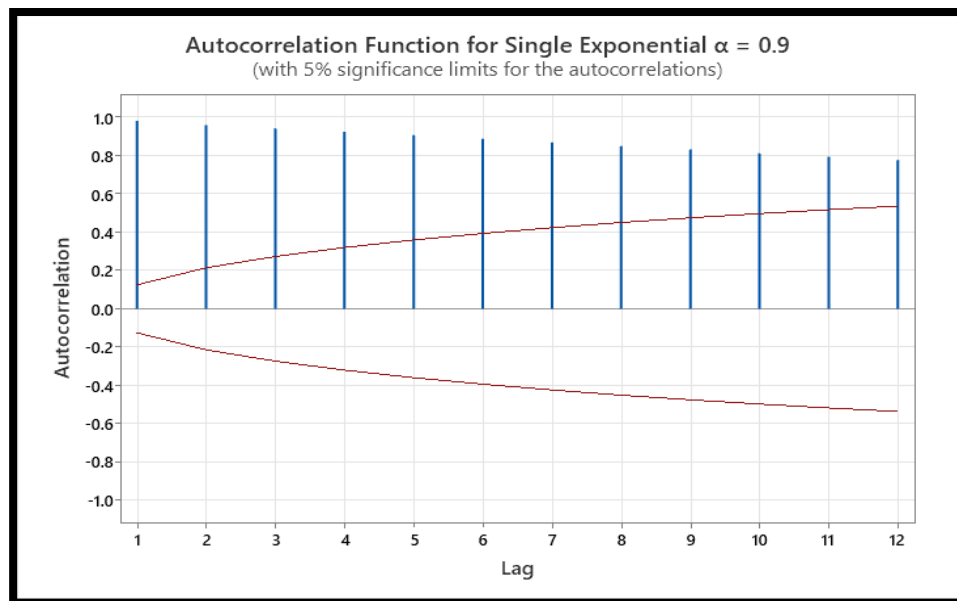


Fig 5.12: Correlogram of single exponential $\alpha = 0.9$ of TCS

After first differencing, the time series of TCS becomes **stationary** as shown in Fig 5.13 & 5.14.

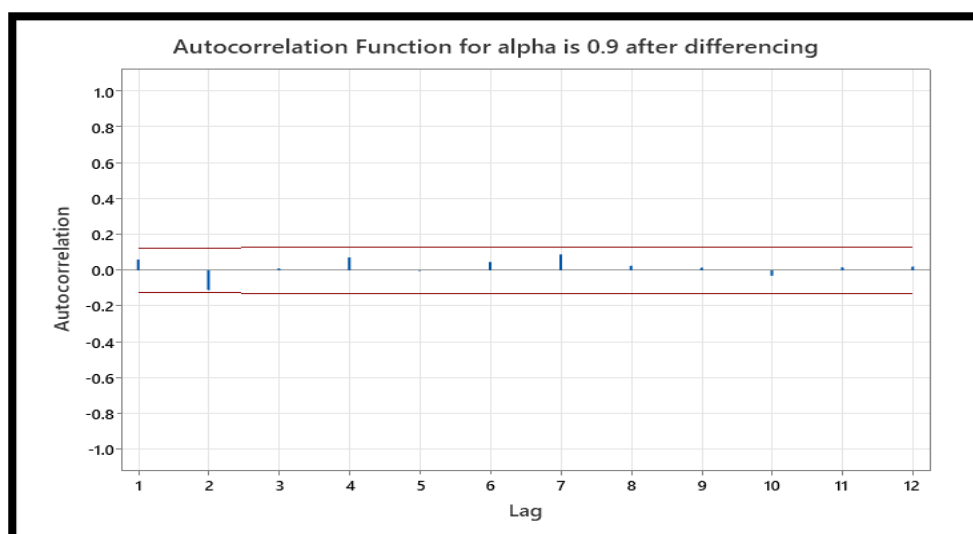


Fig5.13: Autocorrelation Function for $\alpha = 0.9$ after 1st differencing

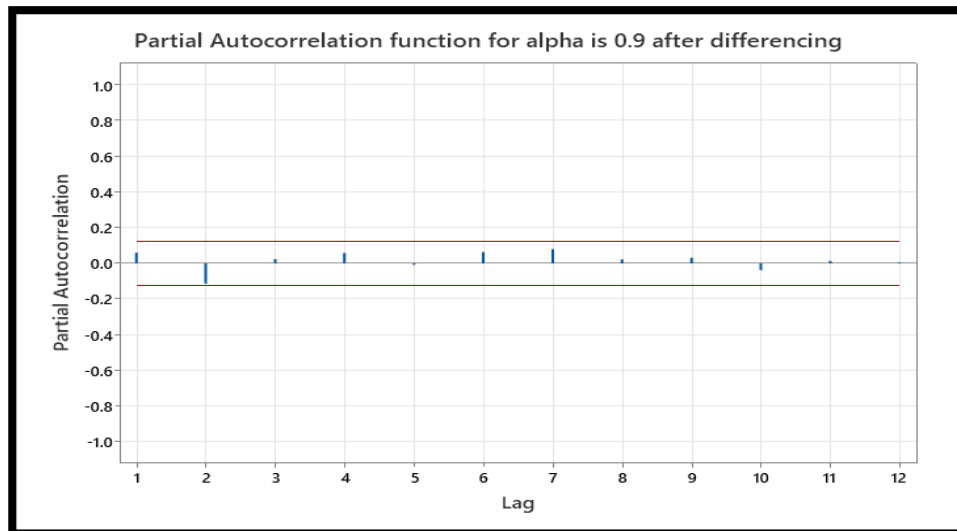


Fig5.14: Partial Autocorrelation Function for $\alpha = 0.9$ after 1st differencing

Table 5.5: MAPE values of single exponential -ARIMA model for TCS

Single Exponential-ARIMA	MAPE
(1,1,0)	0.09383
(0,1,1)	0.102489
(1,1,1)	0.115704
(0,1,2)	0.128983
(2,1,0)	0.138366
(2,1,2)	0.220022

Table 5.5 shows the error measure (MAPE) for different parameters of autoregressive (p), differencing (d) and moving average (q) among several ARIMA models. It is clearly seen that among various ARIMA models performed,

ARIMA (1, 1, 0) is considered to be the best single exponential - ARIMA model for TCS. This model contains relatively smallest error measure (MAPE) compared with other models.

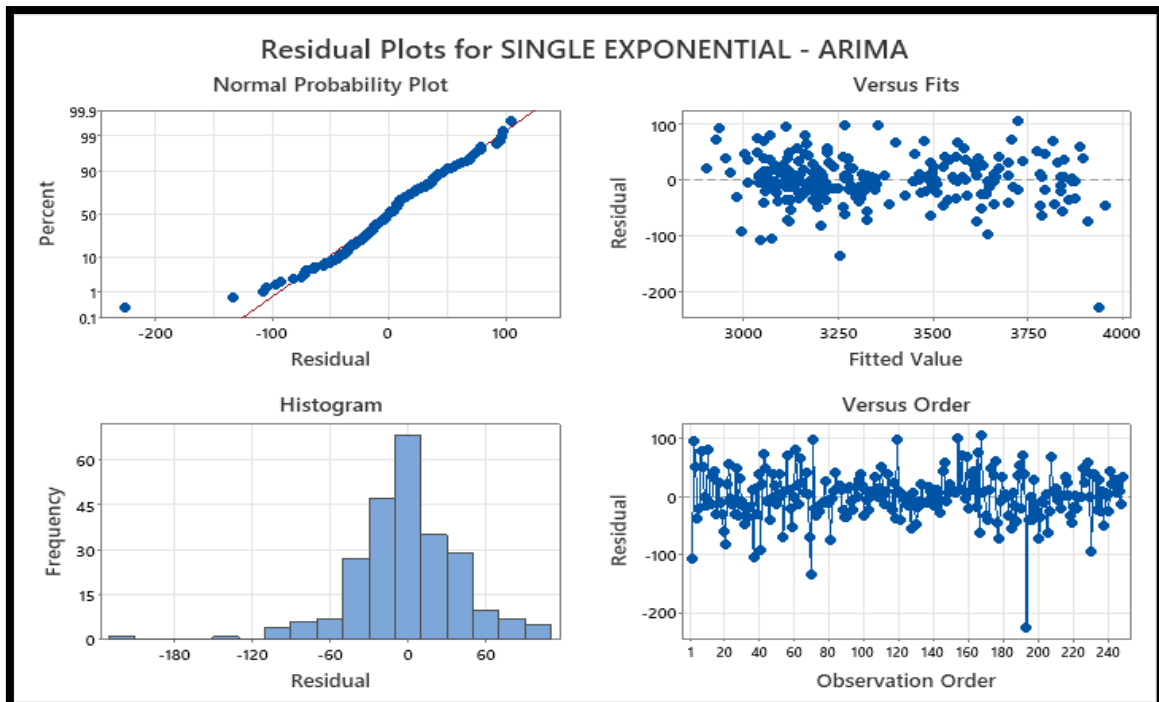
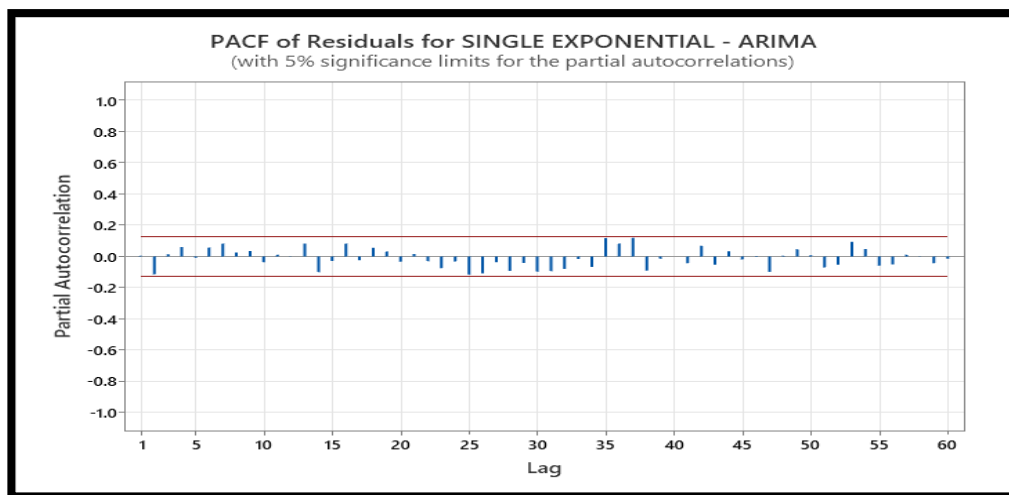
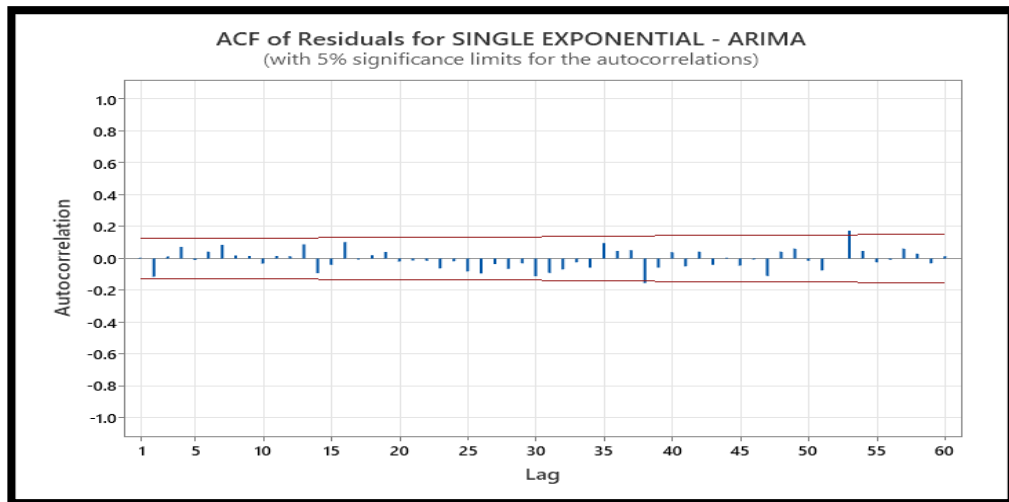


Fig 5.15: Correlogram of Residuals for single exponential-ARIMA

CHAPTER – 6

6.1 SUMMARY AND CONCLUSION:

This study considered daily closing price for stock market returns for the period 2021 to compare the forecast techniques and to find the most suitable forecasting model. Here, moving average and single exponential model are coupled with ARIMA. As a result, two new hybrid forecasting model MA-ARIMA and single exponential-ARIMA were proposed to forecast the stock market returns of TCS close price. The moving average length 3 and exponential smoothing $\alpha = 0.9$ forecasted values were calculated for applying these models. From the error measure, MAPE it is concluded that original forecasted values when compared to the coupled models gave accurate less forecasted values. But among the coupled models, **single exponential-ARIMA model is more accurate.**

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