

STUDY ON COVID-19 PANDEMIC USING TIMESERIES ANALYSIS

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Science degree in Mathematics (B.Sc. Mathematics)

by

R. HARIHARAN (38060004)



**DEPARTMENT OF MATHEMATICS
SCHOOL OF SCIENCE AND TECHNOLOGY**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

JEPPIAARNAGAR, RAJIV GANDHI SALAI, CHENNAI - 600119

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Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai-600119

www.sathyabama.ac.in

DEPARTMENT OF MATHEMATICS

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **R. HARIHARAN (38060004)** who carried out the project entitled "**STUDY ON COVID-19 PANDEMIC USING TIME SERIES ANALYSIS**" under our supervision from **January 2021 to APRIL 2020**.

Internal Guide

External Guide

(Dr. M. NIRMALA)

Head of the Department

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

IR.HARIHARAN hereby declare that the Project Report entitled “**STUDY ON COVID-19 PANDEMIC USING TIME SERIES ANALYSIS**” done by me under the guidance of **Dr.M.NIRMALA** (Internal) at **Sathyabama Institute Of Science And Technology** is submitted in partial fulfillment of the requirements for the award of Bachelor of Science degree in Mathematics.

DATE:

A handwritten signature in blue ink, appearing to read 'R. Hariharan'.

PLACE: SIGNATURE OF THE CANDIDATE

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ABSTRACT

A virus named severe acute respiratory syndrome coronavirus 2 (or) COVID-19 becomes the most aggressive disease. It was impacting more than 90% countries over the world. The virus started from a single human in China, is now increasing globally at a rate of 3% to 5%. India being the second most populous country of the world. And the virus is spreading as a community level transmitter. The virus, which migrated from Bats to human, originating from Wuhan, the capital of Hubei in China, has influenced more than 180 countries of the world. The virus affected more than 85,000 of Chinese population. On 30 January 2020 the first case of India was reported and it tends to loss of life and economy. The first case of Tamil Nadu was reported on 7 March 2020 and Tamil Nadu becomes the fifth highest number of confirmed cases in India after Maharashtra, Kerala, Karnataka and Andhra Pradesh. So, it becomes important to take a study on COVID-19 to predict future facts and figures Corona cases in Tamil Nadu. Using time series analysis we analyse that the cases either increase or decrease.

The objective of the project is to analyse the collected data of Corona disease in Tamil Nadu by using time series analysis techniques, forecasting using Moving Average Method and identifying the better model for forecasting using the error measure, MAPE. Time series analysis also known as one of the most popular statistical method which used to forecast the future factors.

Keywords

- ◆ COVID-19
- ◆ Time series
- ◆ Time series analysis
- ◆ Moving Average
- ◆ Mean Percentage Error Measure (MAPE)
- ◆ Forecast

CHAPTER-1

1.1. Introduction

Time series data and its analysis are increasingly important due to the massive production of such data through, for example, the internet of things, the digitalization of healthcare, and the rise of smart cities. In the coming years one can expect the quantity, quality, and importance of time series data to grow rapidly.

As continuous monitoring and data collection become more common, the need for competent time series analysis with both statistical and machine learning techniques will increase. Indeed, the most promising new models combine both of these methodologies. A broad range of time series techniques are useful for analyzing and predicting human behavior, scientific phenomena, and private sector data, as all these areas offer rich arrays of time series data.

1.2. Time series

A time series is a sequence of observations taken sequentially in time. Many sets of data appear as time series such as a monthly sequence of the quantity of goods shipped from a factory, a weekly series of the number of road accidents, daily rainfall amounts, hourly observations made on the yield of a chemical process, and so on. Examples of time series abound in such fields as economics, business, engineering, the natural sciences especially geophysics and meteorology, and the social sciences.

1.3. Timeseries data

Time series data is a collection of observations obtained through repeated measurements over time. Time series data is everywhere, since time is a constituent of everything that is observable. As the world gets increasingly instrumented, sensors and systems are constantly emitting a relentless stream of time series data. Such data has numerous applications across various industries.

Tab.1.1.Example of dataset for their respective fields

Feild	Topic	Data
Economics	Gross Domestic Product (GDP), Consumer Price Index (CPI)	India GDP from the Federal Reserve Economic Data
Social sciences	Birth rates, population, migration data, political indicators	Population without citizenship from Eurostat
Epidemiology	Disease rates, mortality rates, mosquito populations	U.S. CancerIncidence rates from the Center for Disease Control
Medicine	Blood pressure tracking, weight tracking, cholesterol measurements, heart rate monitoring	MRI scanning and behavioral test dataset
Physical sciences	Global temperatures, monthly sunspot observations, pollution levels.	Global air pollution from the Our World in Data

1.4. Timeseries Analysis

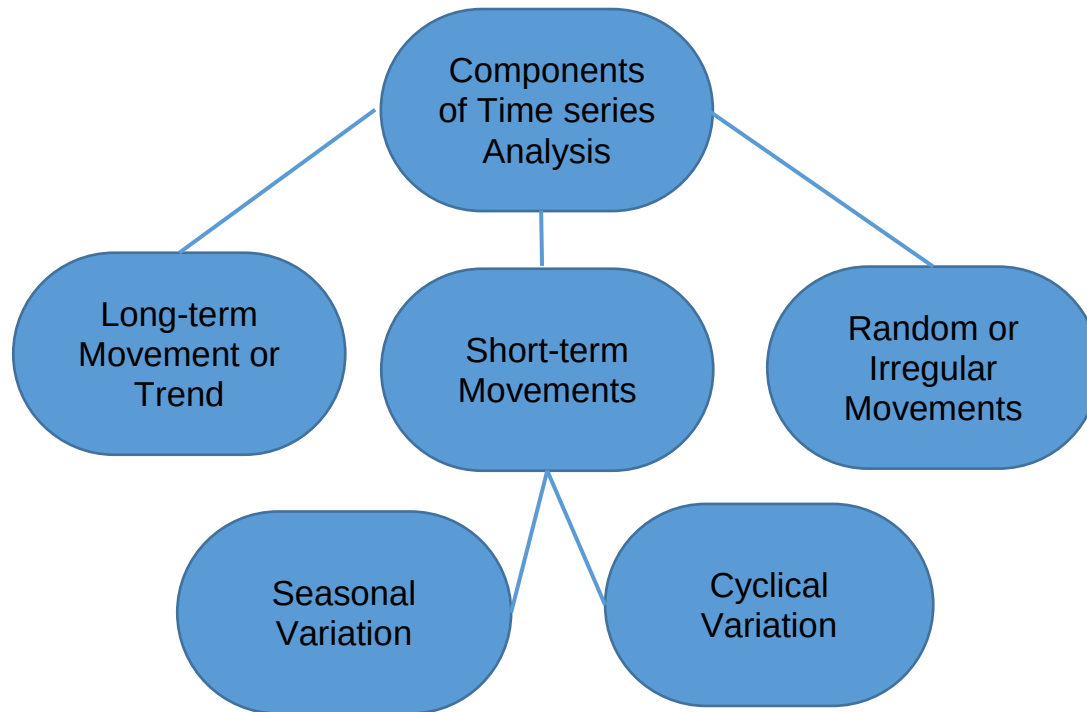
Time series analysis is a statistical technique that deals with time series data or trend analysis. Time series analysis can be useful to see how a given asset, security, or economic variable changes over time. It can also be used to examine how the changes associated with the chosen data point compare to shifts in other variables over the same time period .

1.5. Components of Time series Analysis

The various reasons which affects the values of an observation in a time series are the components of time series and the components are

- Trend-T
- Seasonal Variation-S
- Cyclical Variation-C
- Irregular Variation-I

Seasonal and Cyclic variations are periodic changes or short-term fluctuations.



Trend-T

The trend component is the gradual shifting of the time series to relatively higher or lower values over long period of time. The result of long term factors are such as changes in population, demographics, technologies or consumer preference.

Seasonal Variation-S

The seasonal component is the regular patterns of variability within a certain time periods, such as a year. The variability does not always correspond with seasons of year. (i.e. Winter, Spring, Summer, Falls)

Cyclical Variation-C

Cyclical variations are due to the ups and downs recurring after a period from time to time. These are due to the business cycle and every organization has to phase all the four phases of a business cycle some time or the other. Prosperity or boom, recession, depression, and recovery are the four phases of a business cycle.

Irregular Variation-I

They are not regular variations and are purely random or irregular. These fluctuations are unforeseen, uncontrollable, unpredictable, and are erratic. These occur due to wartime mobilization, disasters in a nation's economy and ecology of a nation, strikes and lockouts in industry which affects the economic climate of the corporate sector.

1.6. Study on Corona Virus

Corona viruses are a group of related RNA viruses that cause diseases in mammals and birds. In humans and birds, they cause respiratory tract infections that can range from mild to lethal. Mild illnesses in humans include some cases of the common cold while more lethal varieties can cause SARS, MERS, and COVID-19. In cows and pigs they cause diarrhea, while in mice they cause hepatitis and encephalomyelitis.

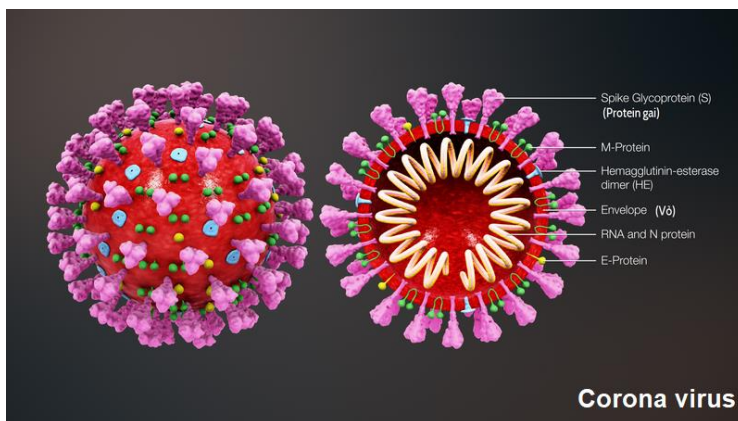


Fig.1.1.Illustration of Corona virus

COVID-19 declared as a global pandemic by WHO, has emerged as the most aggressive disease, impacting more than 90% countries of the world. The virus started from a single human being in China, is now increasing globally at a rate of 3% to 5%

daily and has become a never-ending process. Some studies even predict that the virus will stay with us forever. India being the second most populous country of the world, is also not saved, and the virus is spreading as a community level transmitter. The virus, which migrated from bats to human, originating from Wuhan, the capital of Hubei in China, has influenced more than 180 countries of the world. The first patient was reported on 8 December 2019, in Wuhan by the Chinese administration. A month later, the first death from the virus was reported on 9 January 2020. Then world health organization (WHO) declared that a novel corona virus diseases has been identified and is expanding everyday.

WHO declared the disease as an emergency situation for the whole world on 31 January 2020 and by 11 March 2020, it was declared as a new threatening global pandemic. As of 12 May 2020, almost 40,06,257 have been reported across the globe with a total death count (DC) of 2,78,892. The worst affected country being USA, the second most affected country is Russian Federation, followed by United Kingdom, Spain, Italy, Germany, France and Turkey. The first case was reported on 30 January 2020 and it was expected that India will not be able to survive the heat and due to lack of essential services, life of millions of people will be at stake. Later it leads to many loss of life and economy.

CHAPTER-2

2.1. Literature Survey

Domenico Benvenuto et.al(2020),has discussed “Application of ARIMA model on the Covid-19 epidemic data set”.In this paper,they performed Auto Regressive Integrated Moving Average (ARIMA) model prediction on the Johns Hopkins epidemiological data to predict the epidemiological trend of the prevalence and incidence of COVID-2019.

Neha K Gadhvi et.al(2020),has described “Statistical Analyses of COVID-19 Cases in India”.In this paper they have tried to analyse such data for India and made different kinds of prediction regarding affected rate, daily new cases, daily total finished cases of corona disease.Using statistical models results have been produced.

Muthusami R et.al(2020),has presented “Statistical analysis and visualization of the potential cases of pandemic corona virus”. This study done a statistical analysis and visualized reported cases of corona virus disease 2019 (COVID-19) based on the open data collection provided by Johns Hopkins University. Where the location and number of confirmed infected cases have been shown, there have also been deaths, recovered cases and comparisons of the growth rates between the Globe countries.

Vikas Chaurasia et.al(2020),has modeled “Application of machine learning time series analysis for prediction COVID-19 pandemic”.A study was carried out on coronavirus to observe the number of cases, deaths, and recovery cases worldwide within a specific time period of 5 months. Based on this data, this research paper will predict the future spread of this infectious disease in human society. They used many models such as simple average, moving average, single exponential smoothing, Holt linear trend method,Holt-Winters method and ARIMA to conclude the results

Tabsum Mirza et.al(2020),has proposed “Prediction of COVID-19 trend in India using time series forecasting”.In this paperMainly using ARIMA Model and PROPHET to forecast the COVID-19 trend in India and forecast the trend of outbreak in near future.

Yunting He et.al(2020),has given “Moving Average based index for judging the peak of COVID-19 epidemic”.In this paper they have establish a new index named the “epidemic evaluation index” (EEI) using seven-day moving average of log-transformed variables.

A.M.C.H.Attanayake et.al(2020),has designed “Forecasting COVID-19 cases using Alpha-sutte indicator-a comparison with autoregressive integrated moving average (ARIMA) method”.This study aims to model and predict COVID-19 cases of eight countries such Italy, New Zealand, the USA, Brazil, India, Pakistan, Spain, and South Africa which are in different geographical characteristics and here Alpha-Sutte indicator was utilized as modelling strategy.

Andrea Kolkova et.al(2020),has modeled “Indicators of technical analysis on the basis of moving averages as prognostic methods in the food industry”.The aim of this paper is to show the possibility of using technical analysis indicators in forecasting prices in the food industry in comparison with classical methods,namely exponential smoothing, to find accuracy MAPE and RMSE were selected and resulted.

Muhammad Aslam et.al(2020),has proposed “Monitoring the temperature through moving average control under uncertainty environment”.The study shows the superiority of the proposed chart over the moving average control chart under classical statistics(neutrosophic statistics).

Zoicaú-Ienciu Adrian et.al(2015),has described “.The sensitivity of moving average trading rules performance with respect to methodological assumptions”.In this paper, the objective is to test the sensitivity of the returns generated through the use of the dual moving average crossover rule with respect to the dimension of the investment decision space and the moment in which the investors do the actual trading suggested by the rule.

In this 21-st century many researchers have shown their attention and interest towards analyzing the epidemic of Corona disease. Many methods were found and used to get the solution of the problems. These methods are categorized as models, solving tools and solutions. In this project the epidemic of COVID-19 disease were analysed using Moving Average model has been constructed and formulation has been done.

CHAPTER-3

3.1. Objective of the Project work

- To collect Covid 19 data of Chennai city with various parameters
- To tabulate the data in a time series format
- To analyse time series data using time series analysis techniques
- To plot the variables with time factor, called timeseries plot
- To identify better forecasting model using Moving Average (MA) method and error measure, MAPE

3.2. Scope of the Project work

The results of the project work may be helpful to Health and Welfare department of the state for understanding the characteristics of the disease, Covid–19. Also, the preventive measures can be initiated with rapid manner to control the disease using the forecasting results obtained in the project work.

CHAPTER-4

4. 1. Material and Methods

Tamil Nadu covers an area of 1,30,058 km sq (50,216 sq mi) with the population of 6.79 Cr. The first case of the COVID-19 pandemic in the Indian state of Tamil Nadu was reported on 7 March 2020. The largest single-day spike (6,993 cases) was reported on 27 July and Tamil Nadu now has the fifth highest number of confirmed cases in India after Maharashtra, Kerala, Karnataka and Andhra Pradesh. All 37 districts of the state are affected by the pandemic, with capital district Chennai being the worst affected. As per the Health Department, 88% of the patients are asymptomatic while 84% of deaths were among those with co-morbidities. In June, the state saw a surge in deaths with 209 deaths occurring between 11 and 16 June. The initial surge in cases in the state was due to a cluster in Delhi, which caused a spike in early April. Another large local cluster in Koyambedu of Chennai was identified in May. The state government has responded to the outbreak by following a contact-tracing, testing and surveillance model. The state has 85 laboratories approved by Indian Council of Medical Research (ICMR), capable of conducting tests.



Fig.4.1.Tamil Nadu highlighted India outline

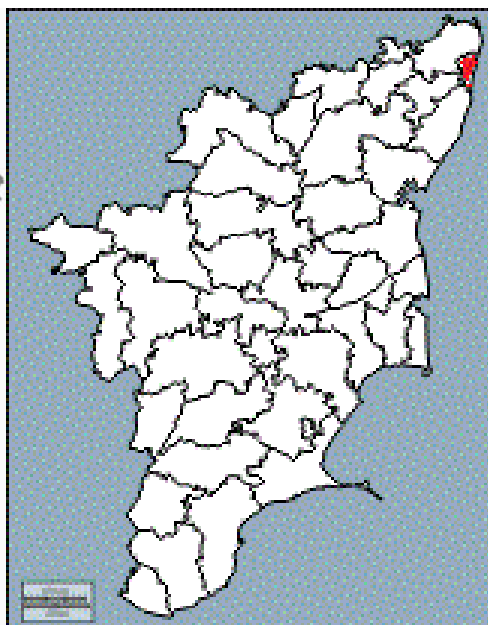


Fig.4.2.Chennai highlighted Tamil Nadu outline

First the state has been under a lockdown since 25 March which was relaxed to an extent from 4 May onwards. Then the lockdown was further extended until 30 June with significant relaxations from 1st June. The state has enforced a stricter lockdown in four majorly-affected districts which includes Chennai and its three neighbouring districts of Chengalpattu, Thiruvallur and Kancheepuram from 19 to 30 June. Tamil Nadu reached its peak number of active cases on 31 July with 57,968 and started to show a decline.

Data set consist of daily Affected, Recovered and death rate of people in Tamil Nadu during the period of 23 March 2020 to 16 June 2020 were collected from Tamil Nadu Health and Welfare Ministry website and reformulated in excel sheet.

4.2.Methodology

4.2.1. Central Tendencies

A central tendency (or measure of central tendency) is a central or typical value for a probability distribution. It may also be called a center or location of the distribution. The most common measures of central tendency are Mean, Mode, Median and Standard deviation.

Mean

The sum of all measurements divided by the number of observations in the data set.

$$\bar{x} = \frac{1}{n} (\sum_{i=1}^n (x_i)) = \frac{x_1 + x_2 + \dots + x_i}{n}$$

$\bar{x}$ - Mean

n - Number of elements in the data set

x_i - Elements in the data set

Mode

The most frequent value in the data set. This is the only central tendency measure that can be used with nominal data, which have purely qualitative category assignments.

$$\text{Mode} = M_0 = l + \left(\frac{f_1 - f_0}{2f_1 - f_0 - f_2} \right) \times h$$

l - lower limit of the modal class

h - size of the class interval

f_0 - frequency of the class preceding the modal class

f_1 - frequency of the modal class

f_2 - frequency of the class succeeding the modal class

Median

The median is the value separating the higher half from the lower half of a data sample, a population, or a probability distribution.

$$\text{Median} = \left(\frac{n+1}{2} \right) \text{th Observation} \quad ; \text{if } n \text{ is odd}$$

$$\text{Median} = \left(\frac{\left(\frac{n}{2} \right) \text{th Observation} + \left(\frac{n+1}{2} \right) \text{th Observation}}{2} \right) ; \text{if } n \text{ is even}$$

n - Number of elements in data set

Standard deviation

The standard deviation is a measure of the amount of variation or dispersion of a set of values. A low standard deviation indicates that the values tend to be close to the mean of the set, while a high standard deviation indicates that the values are spread out over a wider range.

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}}$$

σ - Population Standard deviation

x_i - Each value from population

μ - Population Mean

N - The size of the population

4.2.2. Time Series plot

A time series plot is a graph where some measure of time makes up the units on the x-axis. This is now called the time-axis, and the y-axis contains the data regarding what is being measured. Time series graphs can be used to visualize trends in counts or numerical values over time. Because date and time information is continuous categorical data (expressed as a range of values), points are plotted along the x-axis and connected by a continuous line. Missing data is displayed with a dashed line.

From the graph generated by the plotted points, we can see any trends in the data. A trend is a change that occurs in a general direction. For example, if we see a car at a red light and then the light turns green, we could plot the distance the car moves versus the time it takes to get to its current position. We would notice the trend of an increasing distance from the starting point.

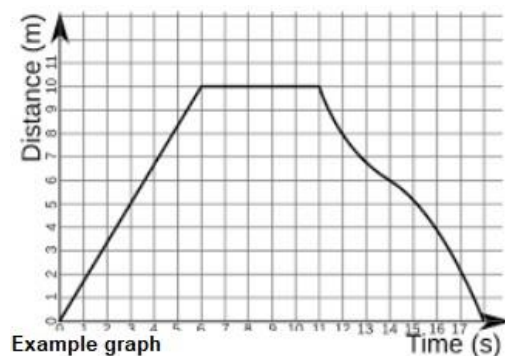


Fig.4.3. Time versus Distance plot(Graph)

We can see from the distance versus time graph that there are a couple of trends. From 0 to 6 seconds we can see the distance from the starting point is increasing. From 6 to 11 seconds the trend is that the object came to a stop and isn't moving because it remains at the distance of 10 meters for 5 seconds. Then, the object starts moving back to the location where it started.

Another type of time series plot is a bar graph. A bar graph uses horizontal or vertical rectangles to represent an amount. Data surrounding the cases of Lyme disease in the United States from 1992 through 2004 is represented by month on a time series plot.

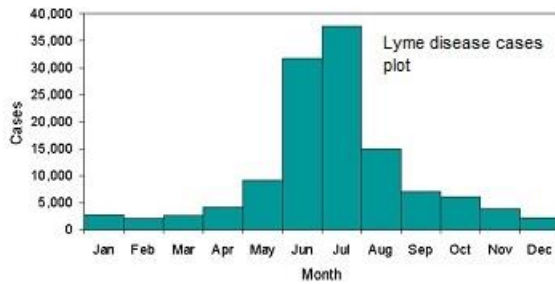


Fig.4.4.Lyme disease over time represented by bar graph

4.2.3.Moving Average(MA) method:

A moving average is a calculation to analyze data points by creating a series of averages of different subsets of the full data set. It is also called a moving mean (MM) or rolling mean and is a type of finite impulse response filter. Given a series of numbers and a fixed subset size, the first element of the moving average is obtained by taking the average of the initial fixed subset of the number series. Then the subset is modified by shifting forward; that is, excluding the first number of the series and including the next value in the subset. A moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles. The threshold between short-term and long-term depends on the application, and the parameters of the moving average will be set accordingly. For example, it is often used in technical analysis of financial data, like stock prices, returns or trading volumes. It is also used in economics to examine gross domestic product, employment or other macroeconomic time series. Mathematically, a moving average is a type of convolution and so it can be viewed as an example of a low-pass filter used in signal processing. When used with non-time series data, moving average filters higher frequency components without any specific connection to time, although typically some kind of ordering is implied. Viewed simplistically it can be regarded as smoothing the data.

4.3.Error Measure

Error is defined as actual or observed value minus the forecasted value. The Mean Absolute Percentage Error (MAPE) is the mean or average of the absolute percentage

errors of forecasts. Consequently, MAPE has managerial appeal and is a measure commonly used in forecasting. The smaller the MAPE the better the forecast.

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

Here, M - Mean Absolute Percentage Error,

n - Number of elements in the data set,

A_t - observed value,

F_t - Forecasted value.

CHAPTER-5

5.1. Result and Discussion

5.2.Descriptive statistics

The values of various descriptive statistics for each parameter of

Covid-19 dataset is tabulated in the following table.

Tab.5.2.Descriptive statistics of Covid-19 data

Central tendency	Confirmed cases	Death cases	Recovered cases
Mean	10551.635	87.506	5189.2
Mode	571	1	0
Median	3550	31	1409
Standard deviation	12766.913	113.4438	7088.6867

5.3.Time series plot of the Parameters

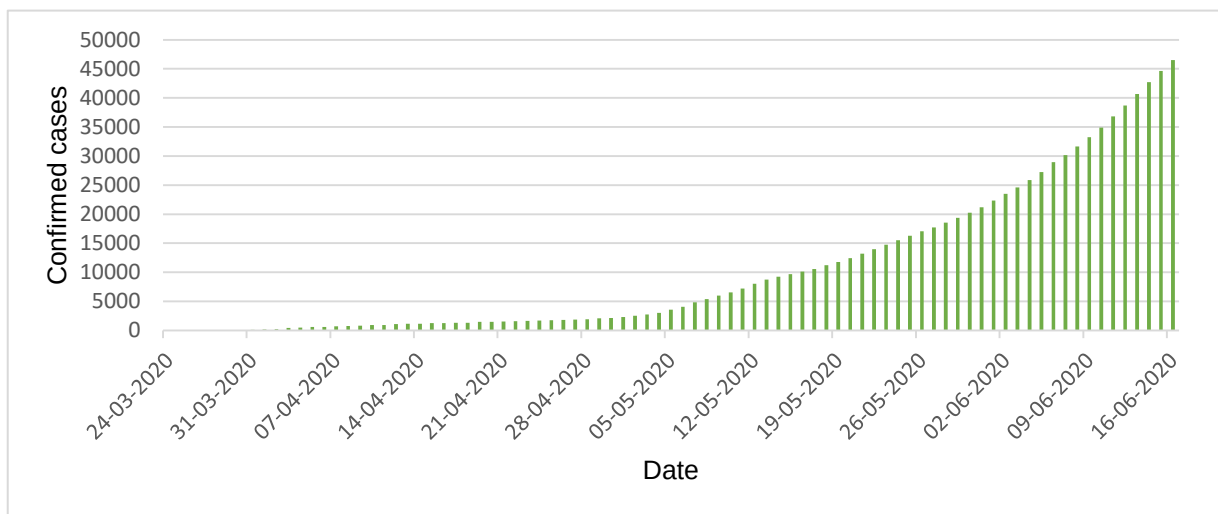


Fig.5.1.Time series plot For Tamil Nadu state confirmed cases during 23rd March 2020 to 16th June 2020

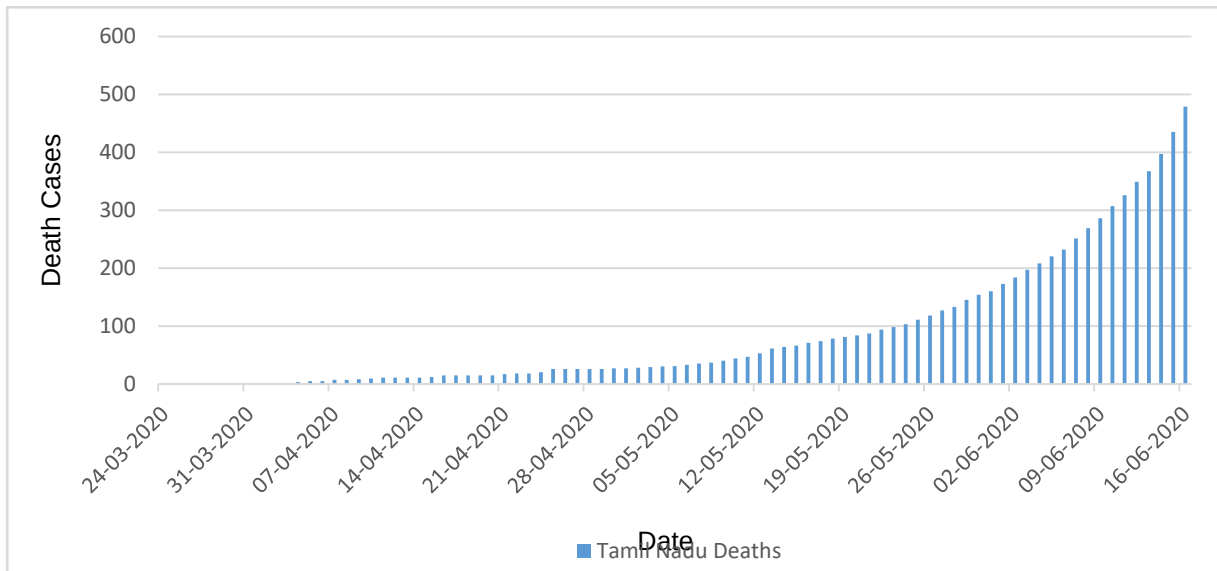


Fig.5.2.Time series plot For Tamil Nadu state death cases during 23rd March 2020 to 16th June 2020

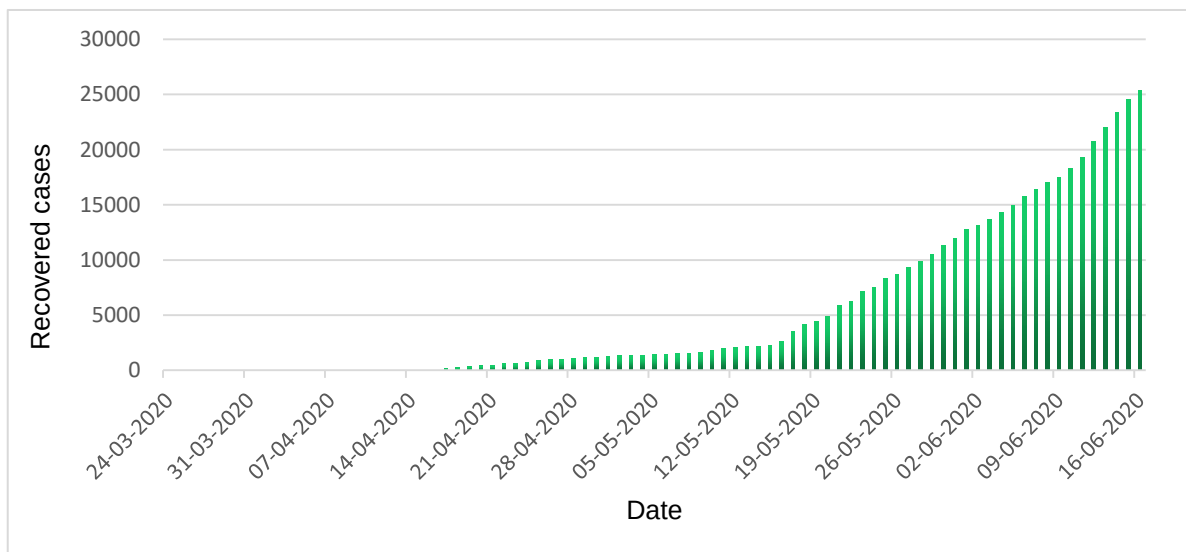


Fig.5.3.Time series plot For Tamil Nadu state recovered cases during 23rd March 2020 to 16th June 2020

5.4. Forecasting

The forecasting of Covid -19 was made by using the parameters like, affected cases, recovered cases and number of deaths during the period 23rd March 2020 to 16th June 2020 using Moving Average method with order 2 for each parameter.

5.5.Forecasting accuracy

The following table gives us the error measure value for the various parameters considered in this study. Based on the MAPE value, it can be concluded that the chosen forecasting model, Moving Average, gives better results with less error

Tab.5.1.Error measure values

Error measure	Confirmed cases	Death cases	Recovered cases
MAPE	4.230029697	3.792521404	3.330501694

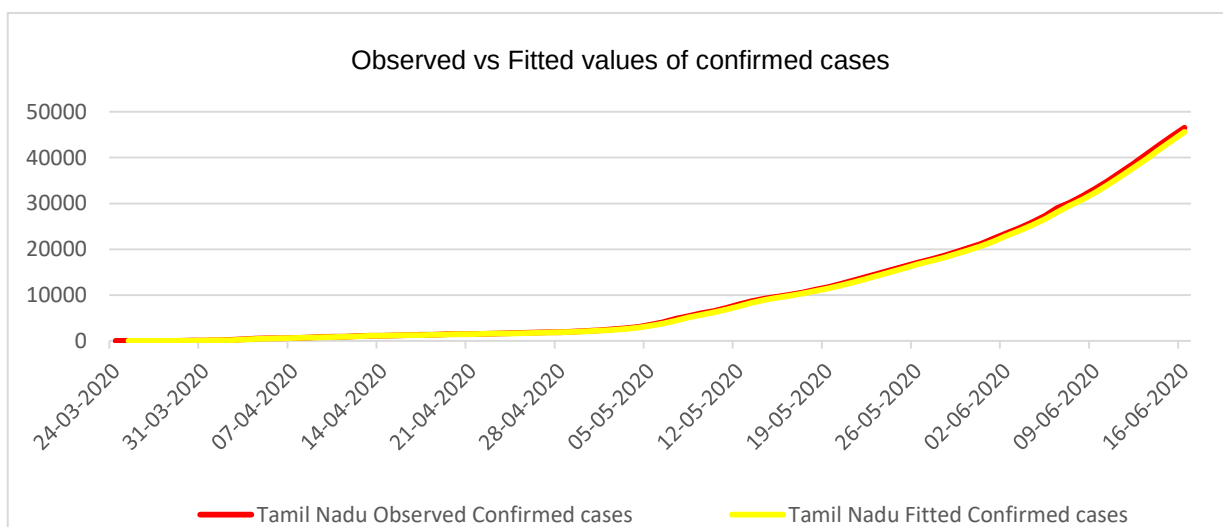


Fig.5.4.Plot for observed vs fitted values of confirmed cases

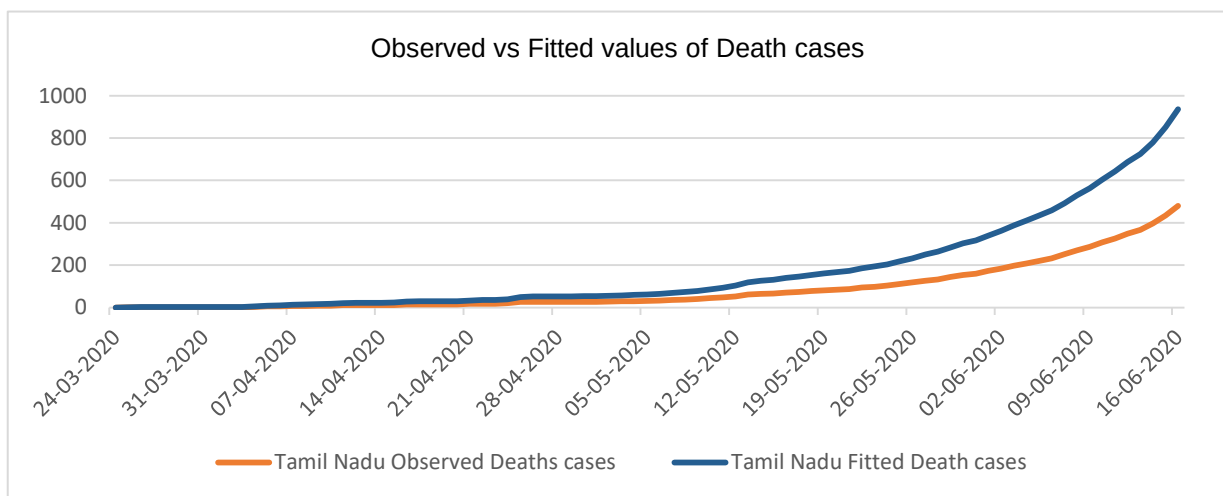


Fig.5.5.Plot for observed vs fitted values of death cases

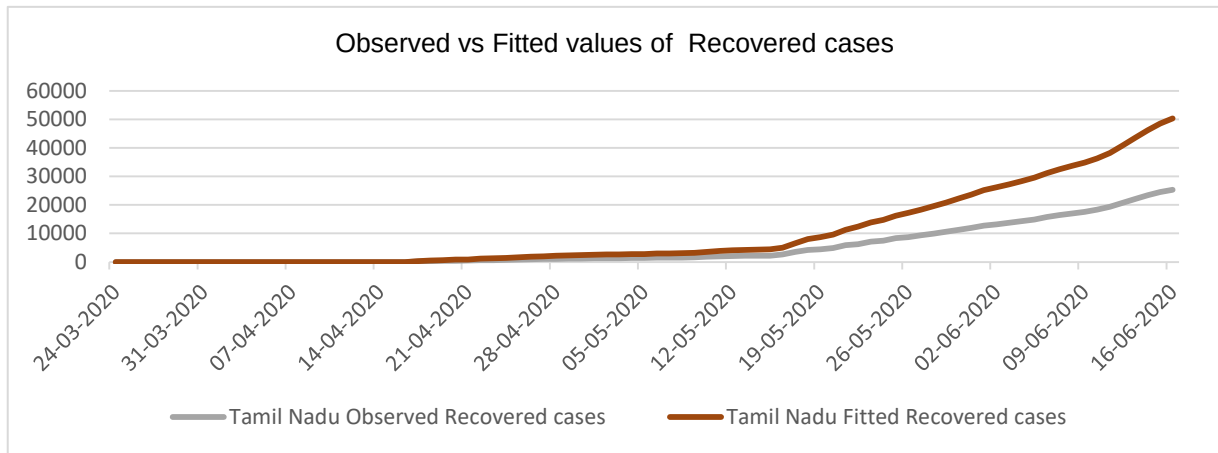


Fig.5.6. Plot for observed vs fitted values of recovered cases

From the above plots, it is identified that the observed data set merges with the forecasted values through moving average method. This concludes that the model applied is better model for forecasting Covid-19.

CHAPTER-6

6.1. Conclusion:

In this research work, COVID-19 data with parameters like affected, recovered and death of Tamil Nadu state were collected. To identify the underlying pattern of the data set, descriptive statistical analysis were made for the parameters such as confirmed cases, recovered cases and death. Also, time series plot were made for all parameters. To forecast, Moving Average (MA) method was applied for each parameter and at order 2 the MA method gives better results. MAPE is the error measure applied here to identify the better model. The results of this project work may be helpful for the Health and Welfare department of a state in monitoring and controlling the disease. More accuracy may be arrived if more number of parameters are included, which can be analysed as a future work

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