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Forecasting End of COVID – 19 in India Based on Time Series Analysis

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Abstract:- In this paper, the Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) models for active and exponential smoothing HOLT for removed rates has been estimated using daily time series data from 1st April to 14thSeptember 2020.The active and removed rates are computed from cumulative confirmed, active, recovered and deceased cases. It has been found that ARIMA (0, 1, 1) and Holt exponential smoothing Models are best fit for active and removed rates respectively. Normalized BIC is 0.577and 0.898 for active and removed rates respectively and is minimum among all the six models considered. Lack of fit of models is tested by Ljung-BoX Q statistic. The p-value is 0.925 and 0.840 for active and removed rates respectively Since for both the rates p-value is greater than 0.05, hence conclude that our model does not show a lack of fit. On the basis of our analysis, active rate will be nullified latest by 5th January 2020, if everything goes best, as P M of India has assured on eve of Independence Day that vaccine for corona will be available very soon. Otherwise by 9th February 2021 if the past trend continued and in worst situation it will tends to zero on 26th March 2021. We expect the removed rates will reach 100 percent by 20TH October 2020 if everything goes best and by 5th January 2021 if the past trend continued. On the assumptions that Pandemic will come to an end when removed rate in the population tends to 100 percent and active rate to zero percent. Thus on the basis our analysis we expect that COVID – 19 Pandemic may come to end latest either by 9th February 2021 or 26th March 2021 subject to condition that the social distance and safely measures remains vigilance to stabilize and control the pandemic and in achieving India's recovery from COVID-19.

Keywords:- *Epidemic; COVID-19; ARIMA; Forecast; Pandemich.*

I. INTRODUCTION

The paper aims to develop a model to find the likely date of end of Pandemic of Novel Corona virus COVID19 in India. Global warning was sparked by the outbreak of contagious person-to-person pneumonia caused by the excessive acute respiratory corona virus 2 syndrome (SARS-COV-2, also known as COVID-19). Droplets of saliva or nose discharge while an infected person is coughing or sneezing causes the spreads of The COVID- 19 virus. On March 11, 2020, COVID-19 has been declared as an infectious disease by World Health Organization (WHO) and its outbreak is a pandemic that is has extend over the more than 209 countries. The most affected countries by this virus are Italy, China, Australia, the USA Brazil and India are. The source of the virus is still not established, but the first person found to positive is from Wuhan, China. In India, the first case of COVID-19 was tested as positive on January 30 2020, in Kerala. Milan Batista (2020) predicted the total number of cases and peak time of the corona virus epidemic in China, South Korea, and the rest of the World by fitting Logistic.Throughout the world 32.1 million people world have been diagnosed with COVID – 19 while more than 23.7 million have recovered and 0.98 million had died (Worldometer, September 24th 2020). On September 24th, 2020 the total no. of confirmed, active, recovered and deceased cases in our county are 5730184, 966342, 4671850 and 91173 respectively. Though the number of confirmed cases of Covid 19 are accelerating but recovery rate (81.56 %) which almost 10 percent higher than that of world recovery rate (73.8 %).On other hand death rate (1.6 %) which is almost half that of world (3.1 %).In this paper, We, in this paper, attempted to find (i) the trends of active and removed rates for next six months (ii) and attempts to predict the likely dates when pandemic will come to an end. The paper is planned as follows; (I) Introduction, (II) Review of literature, (III) Methodology & Modeling, (IV) Sources of data, (V) Empirical Results and lastly (VI) the Conclusions. Auto-Regressive Integrated Moving Average (ARIMA) model has been used to forecast the trend of COVID-19 cases using SPSS. The finding will be helpful in proper planning health services.

II. REVIEW OF LITERATURE

Jinming Cao et.al (2020) established the dynamic models of the six chambers .Their study revealed that the cumulative diagnosis of pneumonia of COVID-19 in mainland China can reach 36,343 (February 8, 2020), and the number of basic regenerations can reach 4.01.Tania et al. (2020) published the research paper on Forecasting of COVID-19 to predict confirmed cases using ARIMA models in order to have more readiness in healthcare systems. Ribeiro et al. (2020) developed efficient short-term forecasting models for forecasting the number of future cases by using an autoregressive integrated moving average (ARIMA), cubist regression (CUBIST), random forest (RF), ridge regression (RIDGE), support vector regression (SVR) and stacking-ensemble learning models for evaluating in the task of time series forecasting with one, three, and six-days ahead the COVID-19 cumulative confirmed cases in ten Brazilian states with a high daily

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incidence. Chakraborty (2020) also used a hybrid approach based on ARIMA and Wavelet-based forecasting model to generate short-term (ten days ahead) forecasts of the number of daily confirmed cases for Canada, France, India, South Korea, and the UK. Tyagi et.al (2020) predicted that the no of confirmed cases at all India level will be 75391, 100052 and 124712 by end of May 20, middle of June and end of June 2020 respectively but the corresponding actual no of confirmed were observed to be 190648, 343070 and 585792 respectively .Thus their prediction does not seem to fit in the current situation. Tiwari et al. (2020) predicted that the peak of the cases for India would be attained between the third and fourth weeks of April 2020. This outbreak is predicted to be controlled around the end of May 2020. The total number of predicted confirmed cases of COVID-19 might reach around 68,978, and the number of deaths due to COVID-19 are predicted to be 1557 around April 25, 2020, in India. However, this prediction does not seem to fit in the current situation as we have observed around 26283 confirmed cases and 825 deaths by 25th April 2020. Khan Farhan Mohammad et.al (2020) have selected an ARIMA (1, 1, 0) model on the data collected from 31st January 2020 to 25th March 2020. Their results showed an increasing trend in the actual and forecasted numbers of COVID-19 cases with approximately 1500 cases per day, based on available data as on 04th April 2020.Tinani et.al (June 2020) used ARIMA model to forecast the trend of COVID-19 cases in R programming. Kumar et.al. (2020) used BAILEY'S MODEL to described that COVID- 19 epidemic would end in mid September 2020 but paper does not support conclusion.

III. METHODOLOGY

There are several methods dealing with time series forecasting, the most relevant is Box-Jenkins (1976) methodology which is used in this study. It is discussed in several publications viz. Chatfild C (1996); Montgomery, D.C. (1976); Pankratz, A (1983); Salas, J.D et.al (1980) and Vandaele, W (1983).ARIMA, short for 'Auto-Regressive Integrated Moving Average' is a class of models explaining a given time series based on its past values, i.e., its own lags and the lagged forecast errors, so that equation can be used to forecast future values. An ARIMA model is characterized by 3 terms: p, d, q.

Where, p is the order of the AR term.
q is the order of the MA term.
d is the number of differencing required to make the time series stationary.

- Box and Jenkins give a methodology (Fig. 1) in time series analysis to find the best fit of time series to past values in order to make future forecasts.The methodology consists of four steps: 1) Model identification. 2) Estimation of model parameters. 3) Diagnostic checking for the identified model appropriateness for modeling and 4) Application of the model (i.e. forecasting). Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF) are two important diagnostic tools used with time series analysis and forecasting.These functions calculate the statistical relationships between observations in a single data series with lag. The plot of ACF helps to take a decision as to many moving average terms are to be included in the model. The PACF plot is used to decide how many auto regressive terms are necessary to expose one or more of the time lags where high correlations appear, seasonality of the series, trend either in the mean level or in the variance of the series Al-Ansari et.al (2006).

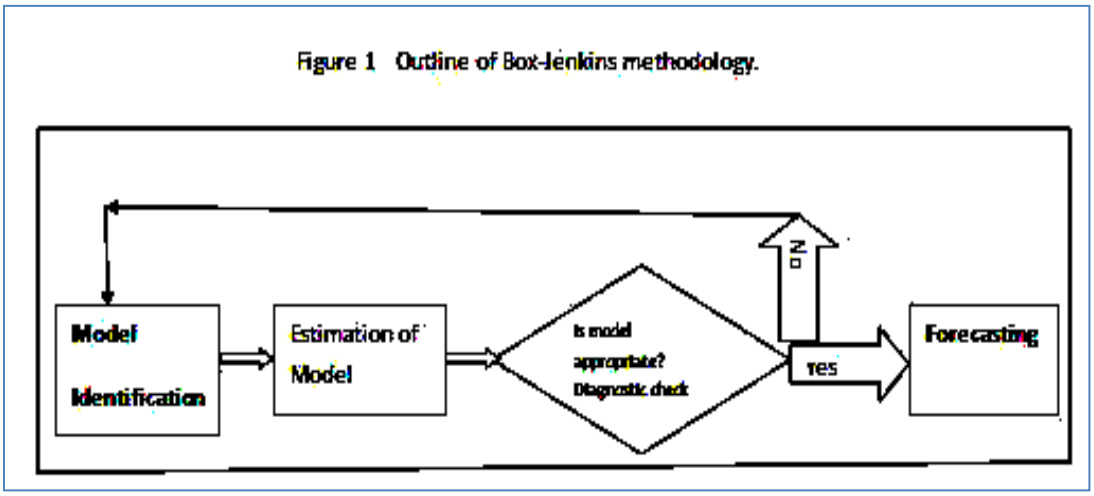

Fig 1

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ACF and PACF helps to identify provisional model (step 1). They are used not only to guess the form of the model, but also to obtain approximate estimates of the parameters Box G.E.P (1976).Method of Maximum likelihood that maximize the probability of observations is used to estimate the parameters in the model (step 2). The next, is checking on the adequacy of the model for the series (step 3). The assumption is that residual is a white noise process and that the process is stationary and independent. Model diagnostic checking is accomplished, in this work, through careful analysis of the residual series, the histogram of the residual, sample correlation and a diagnosis test Ljung (1978). Assumptions of model residuals are checked by Ljung-Box, Q-test. The best model among the class of models considered is one which has lowest BIC. Etebong. P (2014).

- Holt's Trend Corrected Exponential smoothing

Holt exponential smoothing method is the most popular double exponential smoothing method, proposed by Holt (1957) with extending simple exponential smoothing to allow forecasting of data with a trend. Holt method is to concentrate on the series of increments X_t-X_{t-1} and then estimate the slop parameter to a linear trend by exponential smoothing of these differences. The Holt method can be expressed as following formulas:

$$\hat{X}_t = \alpha X_t + (1-\alpha)(\hat{X}_{t-1} + b_{t-1}) \quad \text{and}$$

$$b_t = \gamma(\hat{X}_t - \hat{X}_{t-1}) + (1-\gamma)b_{t-1}.$$

The formula for prediction is

$$\hat{X}_{T+i} = \hat{X}_T + ib_T.$$

In this formulation, two weighting parameter (α and γ) are used for the two updating equations.

- In this study, daily Cumulative removed cases are computed as the sum of the cumulative of recovered and cumulative deceased cases. Active rate is computed as the percentage of cumulative active cases to the cumulative confirmed cases.Removed rate is computed as the percentage of cumulative removed cases to the cumulative confirmed cases. We are assuming that the pandemic will come to end when the active rate tends zero and the removed rate to approaching to 100 %. We explore suitable best fit ARIMA model to find the projection of active and removed rate.

IV. SOURCE OF DATA

The daily data on Cumulative Confirmed, Active , Deceased and recovered cases from 1st April 2020 to 6th September 2020 was used in this study, and extracted from the Websites: www.covid19india.org . This Data is available in the public Domain.

V. EMPIRICAL RESULTS

We first checked whether the time series of Cumulative active and Cumulative removed rates of COVID – 19 cases are stationary or not. Figure 2 clearly revealed that non stationary is inherent in data as active and removed rate are showing downward and upward trends respectively.

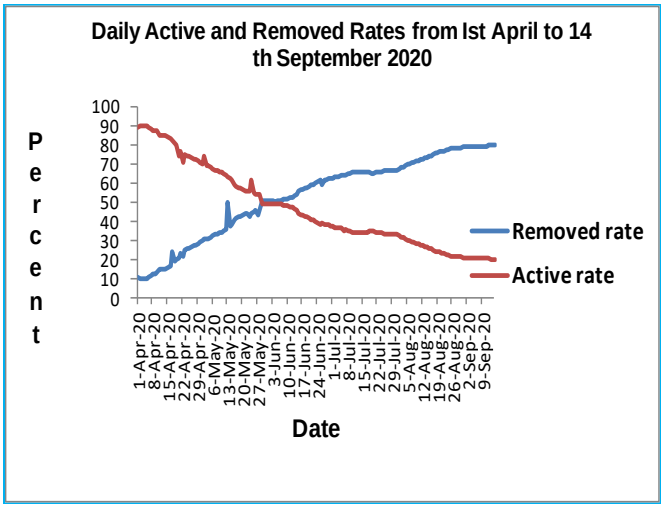

Fig 2

The times series of active and removed rates are transformed by taking non seasonal differences one and plots Autocorrelation Function (ACF) and Partially Autocorrelation Function (PAFC) of the transformed series figure 3 which clearly shows that the time series is stationary.

For the identification of the model, the task is to find out the appropriate values of p and q with the help of ACF and PACF graph values. The initial number of the ARIMA model was guessed through the ACF and PACF graphs. From a close examination of the ACF and PACF of active rate Fig 3(a) and Removed rate 3(b) of the first differenced series , we noticed that the ACF show significant peak at low lag 1 implying thereby that there may be at the most one non-seasonal moving average (MA) terms i.e. q=0 or, 1, and the corresponding PACF plot shows significant peak at low lag (1) indicating that there may be at the most one non seasonal autoregressive (AR) terms therefore p can takes the value either 0 or 1.

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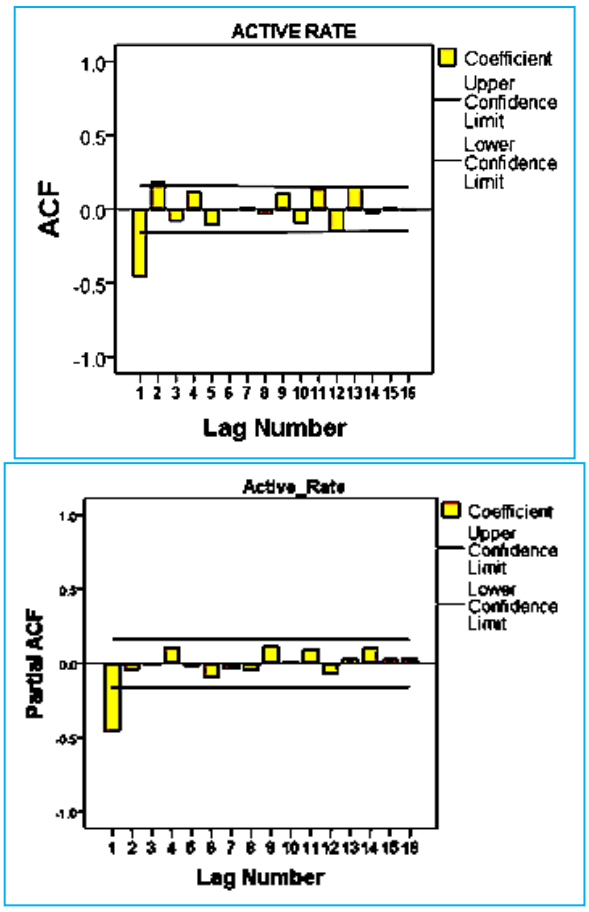

Fig 3(a):- Correlogram for the Active Rate of COVID-19 in India

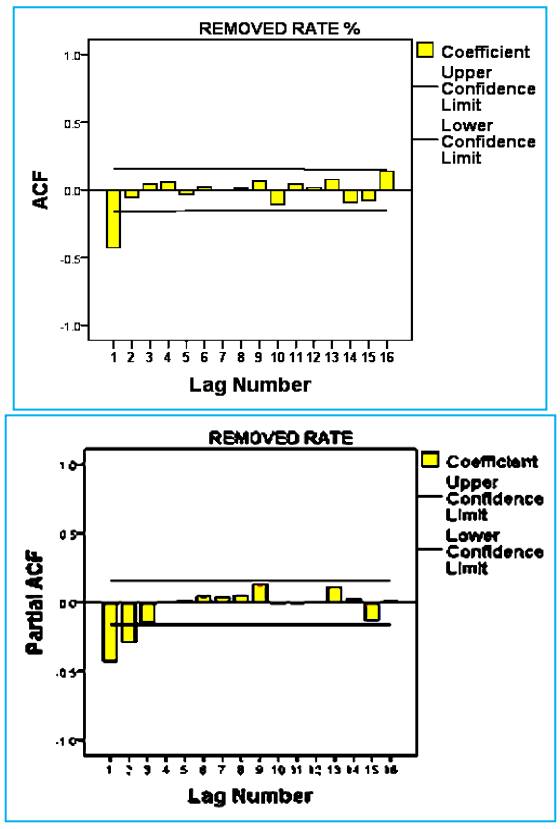

Fig 3(b):- Correlogram for the Removed Rate of COVID-19 in India

This implies that the stochastic process can generate the modeling for active and removed rates with the following successful Models.

Table 1 ARIMA MODELS WITH POSSIBLE VALUES OF BIC

ACTIVE RATE	BIC	REMOVED RATE	BIC
ARIMA (0 ,1 ,1)	0.577	Simple exponential smoothing	1.104
ARIMA (1 ,1 , 0)	1.363	Simple exponential smoothing with square root transformation	1.108
ARIMA (1, 1 , 1)	1.102	Holt with no transformation	0.898
ARIMA (1, 1 , 2)	1.137	Brown	0.909
ARIMA (0 , 2 ,1)	1.203	Brown with squqre root transformation	0.921
ARIMA (1 ,2 , 0)	1.554	Damped trend	0,925

The most important measure of goodness of fit of model are statistics viz. R^2 , likelihood function (for maximum likelihood estimation), standard error of estimate and the Q statistic has been summarized in Table 2.For a well-fitted model, the Q statistic is expected to be statistically insignificant. Another important criterion for checking the adequacy of a fitted model is the Normalized Bayesian Information Criteria (BIC).When considering several ARIMA models we choose the one with the lowest BIC (TABLE 1).Based on these our important statistics and BIC. ARIMA (1, 1 0) and HOLT exponential smoothing were found to be best fit for active and removed rates respectively.The R^2 is an estimate of the proportion of the total variation in the series explained by the model. It has been found (Table 2) that the applied model for active and removed rates explains 99 % of variation in data.

Table 2 Model Statistic ARIMA

Model Statistics

Rate	Model	Model Fit statistics					Ljung-Box Q(18)			Number of Outliers
		Stationary R^2	R^2	RMSE	MaxAE	Normalized BIC	Statistics	DF	Sig.	
Active Rate	ARIMA(0, 1 , 1)	0.196	0.996	1.294	7.003	.577	8.641	17	0.925	0
Removed Rate	Holt	0.748	0.995	1.519	13.287	.898	13.438	16	0.840	0

Root Mean Square Error (RMSE) measure of how much a dependent series varies from its model-predicted level, expressed in the same units as the dependent series. Thus the variation of the original active and removed rates time series data from model-predicted level is 1.294 and1.51 respectively.The normalized BIC (Bayesian Information Criterion) measures the overall fit of a model that attempts to account for model complexity. Normalized BIC is 0.577 and 0.898 for active and removed rates respectively. The test the lack of fit of models is tested by Ljung-BoX Q statistic The null hypothesis, H0: The model does not show a lack of fit, Against the alternative hypothesis, H1: The model does show a lack of fit. Here,

for active rates p-value is 0.925, for removed rate p-value is 0.840 since for both the rates p-value is greater than 0.05, hence we do not reject the null hypothesis and conclude that our model does not show a lack of fit. The estimated coefficient of ARIMA (1, 1, 0) and HOLT models are shown in the table 3.The parameter estimates of these Model are all significant ($p<0.01$).

Again, the models are adequate in the sense that the plots of the residual ACF and PACF for active and removed rates in figures 4 show a random variation, thus, from the origin zero (0), the points below and above are all uneven, hence the model fitted is adequate.

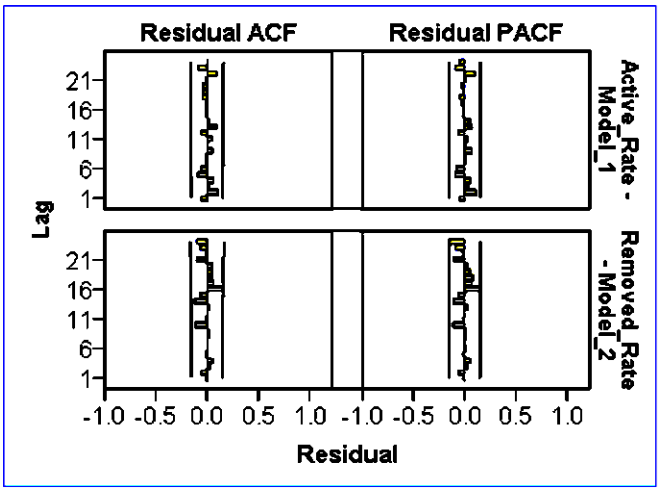

Fig 4:- Graph of the residual ACF and PACF for Active and Removed rates

The location parameter (mean) of the Noise residual for active rate is approximately zero 0.0004 with constant variance 0.0899 and the corresponding parameter (mean) of the Noise residual value for removed rate is -0.1278 with constant variance 1.5091 The normality test of the error (Noise Residual) conducted by drawing histogram of the residuals shown in figure Figures 5(a) and 5(b) suggests that the error distribution is approximately normal.

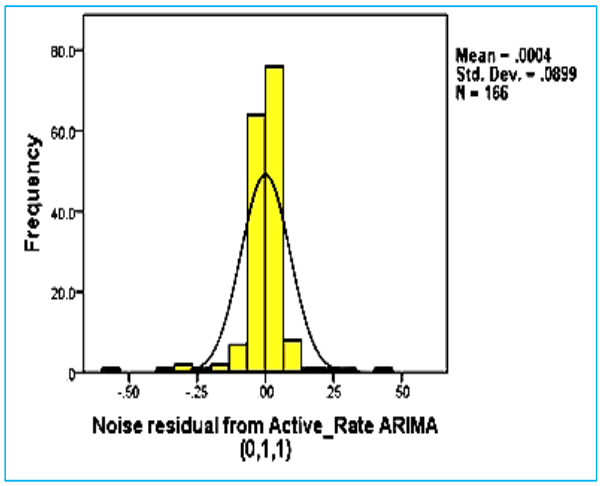

Fig 5(a):- Histogram of Noise Residual of Active Rate

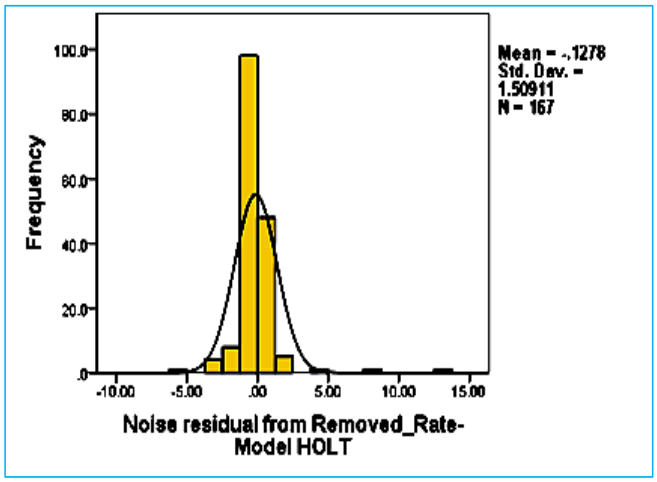

Fig 5(b):- Histogram of Noise Residual of Removed Rate

Therefore the assumptions of the error component in the ARIMA (0, 1, 1) and HOLT Models are fulfilled and thus these model can forecast the future trend of the active and removed rates.

It has been found that date-wise estimated active and removed rates from 1st April 2020 to 14th September 2020 are very close to actual rates Figures 6 clearly indicates that Models are good fit to the data.

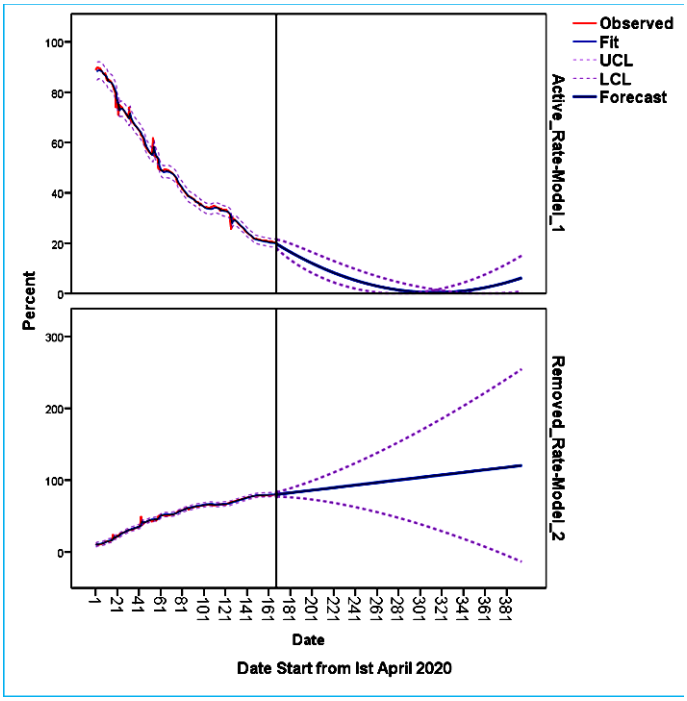

Fig 6:- Observed, Fit and Forecasted Active and Removed Rate

Following India's tireless fight against the swiftly sprouting COVID-19 pandemic since the past six months, the country finally sees signs of green shoots with the faster recoveries and sharp decline of active cases. The researchers around the world are making rigorous efforts to find effective vaccine and/or therapeutics against corona virus or SARS-CoV-2 diseases and the existence of such pharmaceutical interventions will extraordinarily change

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the results .Our analysis shows that following India's peak, daily active rate are projected to decline very steadily (0.4) percent per day) from 88.33 % from Ist April 2020 to 20.08 % in mid of 14h September 2020 Figure 6 and Table 6 appendix.

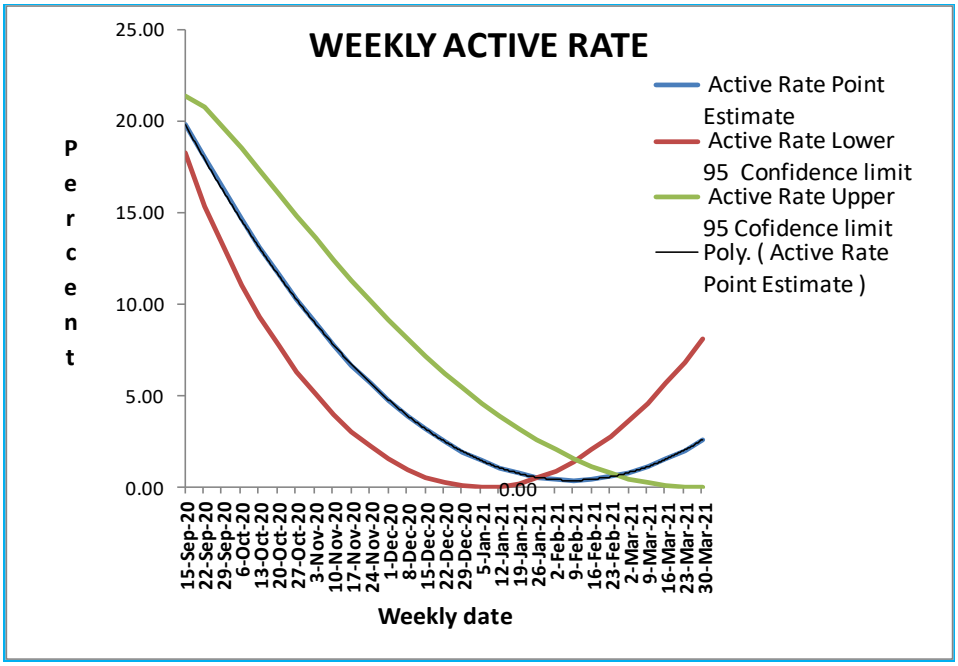

Fig 7 (a)

Date	Active Rate		
	Point Estimate	Lower 95 Confidence limit	Upper 95 Cofidence limit
15-Sep-20	19.77	18.21	21.37
22-Sep-20	17.96	15.35	20.72
6-Oct-20	14.61	11.06	18.51
13-Oct-20	13.06	9.29	17.29
20-Oct-20	11.61	7.72	16.05
27-Oct-20	10.24	6.32	14.82
3-Nov-20	8.96	5.08	13.61
10-Nov-20	7.77	3.99	12.43
17-Nov-20	6.67	3.04	11.28
24-Nov-20	5.66	2.22	10.18
1-Dec-20	4.74	1.54	9.12
8-Dec-20	3.90	0.98	8.10
15-Dec-20	3.16	0.55	7.14
22-Dec-20	2.50	0.25	6.24
29-Dec-20	1.93	0.06	5.39
5-Jan-21	1.45	0.00	4.59
12-Jan-21	1.06	0.05	3.86
19-Jan-21	0.76	0.22	3.19
26-Jan-21	0.54	0.51	2.58
2-Feb-21	0.42	0.91	2.03
9-Feb-21	0.38	1.42	1.54
16-Feb-21	0.43	2.05	1.12
23-Feb-21	0.57	2.79	0.77
2-Mar-21	0.80	3.64	0.48
9-Mar-21	1.12	4.59	0.26
16-Mar-21	1.53	5.66	0.10
23-Mar-21	2.02	6.84	0.02
30-Mar-21	2.60	8.13	0.00

Table 3:- Weekly Predicted Active Rates from 15th September 2020 to 30 March 2021

It has been observed from Table 4 and figure 7(a) that the point estimate of active rate will further decline to 6.67 percent on 17th November 2020 from 19.77 on 15th September 2020. Our estimates are matching with the Times Fact-India Outbreak Report (August 21) who projected daily active case counts are projected to decline by November 17. It expected to further falls rapidly to 1.45 percent on 5th January 2021 in a period of next one and half months. They are approaching to 0.38 percent on 9th February 2021 thereafter it again start rising. However the lower and upper limits of the 95 percent confidence interval of active rates approaches to zero and zero percent respectively on 5th January 2020 and 26th March 2021 .Thus we conclude on the basis of our analysis that active cases will be nullified latest by 5th January 2020, if everything goes best, as P M of India has assured on eve of independence day that vaccine for corona will be available very soon,otherwise by 9th February 2021 if the past trend continued and in worst situation an active cases will tends to zero on 26th March 202.

Our analysis shows that removed rates are accelerating steadily (0.42 percent per day) from 11 percent in 1st April 2020 to 79.91 percent on 14th September 2020 (Figure 6 and Table 7 in the appendix) It has been found (Table 5 & figure 7(b)) that the point estimate of removed rates will inclined to 91 percent on 17th November 2020 from 80 on 15th September 2020. It increased by 11percentile point in a period of period of two months. Removed rates are expected to tend to 100 percent on 5th January 2021 in a period of next one and a half months.

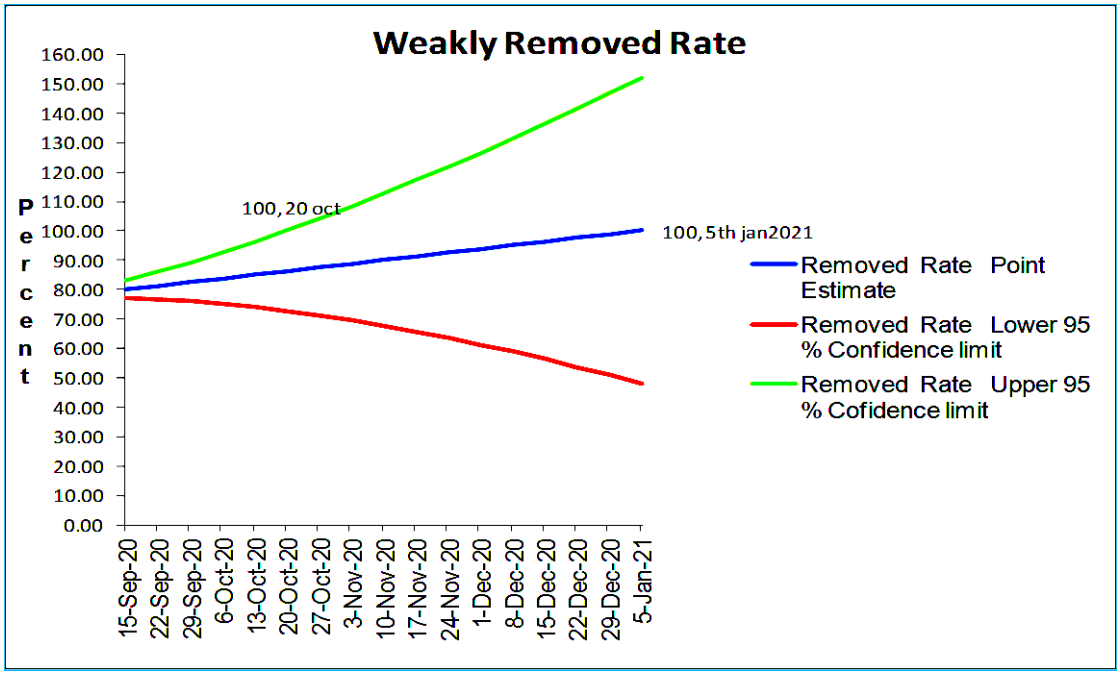

Fig 7 (b)

Date	Removed Rate		
	Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit
15-Sep-20	80.15	77.15	83.15
22-Sep-20	81.39	76.75	86.04
29-Sep-20	82.64	76.06	89.22
6-Oct-20	83.88	75.12	92.64
13-Oct-20	85.13	73.98	96.28
20-Oct-20	86.37	72.65	100.10
27-Oct-20	87.62	71.13	104.10
3-Nov-20	88.86	69.45	108.27
3-Nov-20	88.86	69.45	108.27
10-Nov-20	90.11	67.62	112.60
17-Nov-20	91.35	65.63	117.07
24-Nov-20	92.60	63.50	121.69
1-Dec-20	93.84	61.24	126.44
8-Dec-20	95.09	58.85	131.32
15-Dec-20	96.33	56.32	136.34
22-Dec-20	97.57	53.68	141.47
29-Dec-20	98.82	50.92	146.72
5-Jan-21	100.06	48.04	152.09

Table 4:- Weekly Predicted Removed Rate from 7th September to 9th November 2020

Thus we expect that removed rates will be 100 by 5th January 2021 if the past trend continued.

VI. CONCLUSION

The world is going through a pandemic, and almost every country is affected by it. A country needs to know how much burden of active and confirmed cases it will have to bear in the coming time. We used ARIMA model on the time series data of COVID-19 cases in India for forecasting the active and removed rates till end of 31 March 2021. The future is always unpredictable and we must keep this in mind when we read any kind of predictions. Our model forecasts give the following two estimates of end dates: On the basis of our assumptions that Pandemic will come to an end when removed rate in the population tends to 100 percent and active rate approaches to zero.

Thus on the basis our analysis we expect that COVID – 19 Pandemic may come to end latest either by 9th February 2021 or 26th March 2021 subject to condition that the social distance and safely measures remains vigilance to stabilize and control the pandemic and in achieving India's recovery from COVID-19. The finding will be helpful in proper planning health services

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Table 5 **Predicted Active Rates Rates with 95 percent confidence interval from 15th September 2020 t0 31st March 2021** **Appendix**

Date	Active Rates %			Date	Active Rates %			Date	Active Rates %			Date	Active Rates %		
	Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit		Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit		Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit		Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit
1-Sep-20				1-Nov-20	9.32	5.42	13.95	1-Jan-21	1.72	0.02	5.04	1-Mar-21	0.76	3.51	0.52
2-Sep-20				2-Nov-20	9.14	5.25	13.78	2-Jan-21	1.65	0.01	4.93	2-Mar-21	0.80	3.64	0.48
3-Sep-20				3-Nov-20	8.96	5.08	13.61	3-Jan-21	1.58	0.01	4.81	3-Mar-21	0.84	3.77	0.44
4-Sep-20				4-Nov-20	8.79	4.92	13.44	4-Jan-21	1.51	0.01	4.70	4-Mar-21	0.88	3.90	0.41
5-Sep-20				5-Nov-20	8.61	4.75	13.27	5-Jan-21	1.45	0.00	4.59	5-Mar-21	0.93	4.03	0.38
6-Sep-20				6-Nov-20	8.44	4.59	13.10	6-Jan-21	1.39	0.00	4.48	6-Mar-21	0.97	4.17	0.35
7-Sep-20				7-Nov-20	8.27	4.44	12.93	7-Jan-21	1.33	0.00	4.38	7-Mar-21	1.02	4.31	0.31
8-Sep-20				8-Nov-20	8.10	4.28	12.76	8-Jan-21	1.27	0.01	4.27	8-Mar-21	1.07	4.45	0.29
9-Sep-20				9-Nov-20	7.94	4.13	12.60	9-Jan-21	1.22	0.02	4.17	9-Mar-21	1.12	4.59	0.26
10-Sep-20				10-Nov-20	7.77	3.99	12.43	10-Jan-21	1.16	0.03	4.06	10-Mar-21	1.17	4.74	0.23
11-Sep-20				11-Nov-20	7.61	3.84	12.26	11-Jan-21	1.11	0.04	3.96	11-Mar-21	1.23	4.89	0.21
12-Sep-20				12-Nov-20	7.45	3.70	12.10	12-Jan-21	1.06	0.05	3.86	12-Mar-21	1.28	5.04	0.18
13-Sep-20				13-Nov-20	7.29	3.56	11.93	13-Jan-21	1.01	0.07	3.76	13-Mar-21	1.34	5.19	0.16
14-Sep-20				14-Nov-20	7.13	3.43	11.77	14-Jan-21	0.96	0.09	3.66	14-Mar-21	1.40	5.35	0.14
15-Sep-20	19.77	18.21	21.37	15-Nov-20	6.98	3.29	11.61	15-Jan-21	0.92	0.11	3.56	15-Mar-21	1.46	5.50	0.12
16-Sep-20	19.50	17.74	21.34	16-Nov-20	6.83	3.16	11.44	16-Jan-21	0.88	0.14	3.47	16-Mar-21	1.53	5.66	0.10
17-Sep-20	19.24	17.29	21.27	17-Nov-20	6.67	3.04	11.28	17-Jan-21	0.83	0.16	3.37	17-Mar-21	1.59	5.83	0.09
18-Sep-20	18.98	16.87	21.18	18-Nov-20	6.52	2.91	11.12	18-Jan-21	0.80	0.19	3.28	18-Mar-21	1.66	5.99	0.07
19-Sep-20	18.72	16.47	21.08	19-Nov-20	6.38	2.79	10.96	19-Jan-21	0.76	0.22	3.19	19-Mar-21	1.73	6.16	0.06
20-Sep-20	18.47	16.08	20.97	20-Nov-20	6.23	2.67	10.80	20-Jan-21	0.72	0.26	3.10	20-Mar-21	1.80	6.32	0.05
21-Sep-20	18.21	15.71	20.85	21-Nov-20	6.08	2.55	10.64	21-Jan-21	0.69	0.29	3.01	21-Mar-21	1.87	6.49	0.04
22-Sep-20	17.96	15.35	20.72	22-Nov-20	5.94	2.44	10.49	22-Jan-21	0.65	0.33	2.92	22-Mar-21	1.94	6.67	0.03
23-Sep-20	17.71	14.99	20.59	23-Nov-20	5.80	2.33	10.33	23-Jan-21	0.62	0.37	2.83	23-Mar-21	2.02	6.84	0.02
24-Sep-20	17.46	14.65	20.45	24-Nov-20	5.66	2.22	10.18	24-Jan-21	0.60	0.42	2.74	24-Mar-21	2.10	7.02	0.01
25-Sep-20	17.21	14.32	20.30	25-Nov-20	5.52	2.12	10.02	25-Jan-21	0.57	0.46	2.66	25-Mar-21	2.18	7.20	0.01
26-Sep-20	16.96	13.99	20.15	26-Nov-20	5.39	2.01	9.87	26-Jan-21	0.54	0.51	2.58	26-Mar-21	2.26	7.38	0.00
27-Sep-20	16.72	13.67	20.00	27-Nov-20	5.25	1.91	9.72	27-Jan-21	0.52	0.56	2.49	27-Mar-21	2.34	7.56	0.00
28-Sep-20	16.48	13.35	19.84	28-Nov-20	5.12	1.81	9.56	28-Jan-21	0.50	0.61	2.41	28-Mar-21	2.43	7.75	0.00
29-Sep-20	16.24	13.05	19.68	29-Nov-20	4.99	1.72	9.41	29-Jan-21	0.48	0.67	2.33	29-Mar-21	2.52	7.94	0.00
30-Sep-20	16.00	12.75	19.52	30-Nov-20	4.86	1.63	9.26	30-Jan-21	0.46	0.72	2.25	30-Mar-21	2.60	8.13	0.00
1-Oct-20	15.76	12.45	19.36	1-Dec-20	4.74	1.54	9.12	31-Jan-21	0.44	0.78	2.18	31-Mar-21	2.69	8.32	0.01
2-Oct-20	15.53	12.16	19.19	2-Dec-20	4.61	1.45	8.97	1-Feb-21	0.43	0.85	2.10				
3-Oct-20	15.29	11.88	19.02	3-Dec-20	4.49	1.37	8.82	2-Feb-21	0.42	0.91	2.03				
4-Oct-20	15.06	11.60	18.85	4-Dec-20	4.37	1.28	8.68	3-Feb-21	0.41	0.98	1.95				
5-Oct-20	14.83	11.33	18.68	5-Dec-20	4.25	1.21	8.53	4-Feb-21	0.40	1.04	1.88				
6-Oct-20	14.61	11.06	6.00	6-Dec-20	4.13	1.13	8.39	5-Feb-21	0.39	1.12	1.81				
7-Oct-20	14.38	10.79	18.34	7-Dec-20	4.02	1.05	8.24	6-Feb-21	0.39	1.19	1.74				
8-Oct-20	14.16	10.53	18.17	8-Dec-20	3.90	0.98	8.10	7-Feb-21	0.39	1.26	1.67				
9-Oct-20	13.93	10.27	17.99	9-Dec-20	3.79	0.91	7.96	8-Feb-21	0.39	1.34	1.61				
10-Oct-20	13.71	10.02	17.82	10-Dec-20	3.68	0.85	7.82	9-Feb-21	0.38	1.42	1.54				
11-Oct-20	13.49	9.78	17.64	11-Dec-20	3.57	0.78	7.69	10-Feb-21	0.38	1.51	1.48				
12-Oct-20	13.28	9.53	17.47	12-Dec-20	3.47	0.72	7.55	11-Feb-21	0.39	1.59	1.42				
13-Oct-20	13.06	9.29	17.29	13-Dec-20	3.36	0.66	7.41	12-Feb-21	0.39	1.68	1.35				
14-Oct-20	12.85	9.06	17.11	14-Dec-20	3.26	0.61	7.28	13-Feb-21	0.40	1.77	1.29				
15-Oct-20	12.64	8.82	16.94	15-Dec-20	3.16	0.55	7.14	14-Feb-21	0.41	1.86	1.24				
16-Oct-20	12.43	8.60	16.76	16-Dec-20	3.06	0.50	7.01	15-Feb-21	0.42	1.95	1.18				
17-Oct-20	12.22	8.37	16.58	17-Dec-20	2.96	0.45	6.88	16-Feb-21	0.43	2.05	1.12				
18-Oct-20	12.01	8.15	16.41	18-Dec-20	2.87	0.41	6.75	17-Feb-21	0.45	2.15	1.07				
19-Oct-20	11.81	7.93	16.23	19-Dec-20	2.77	0.36	6.62	18-Feb-21	0.46	2.25	1.01				
20-Oct-20	11.61	7.72	16.05	20-Dec-20	2.68	0.32	6.49	19-Feb-21	0.48	2.35	0.96				
21-Oct-20	11.41	7.51	15.88	21-Dec-20	2.59	0.28	6.36	20-Feb-21	0.50	2.46	0.91				
22-Oct-20	11.21	7.30	15.70	22-Dec-20	2.50	0.25	6.24	21-Feb-21	0.52	2.56	0.86				
23-Oct-20	11.01	7.10	15.52	23-Dec-20	2.41	0.22	6.11	22-Feb-21	0.55	2.67	0.81				
24-Oct-20	10.82	6.90	15.35	24-Dec-20	2.33	0.18	5.99	23-Feb-21	0.57	2.79	0.77				
25-Oct-20	10.62	6.71	15.17	25-Dec-20	2.25	0.16	5.87	24-Feb-21	0.60	2.90	0.72				
26-Oct-20	10.43	6.51	15.00	26-Dec-20	2.16	0.13	5.74	25-Feb-21	0.63	3.02	0.68				
27-Oct-20	10.24	6.32	14.82	27-Dec-20	2.09	0.11	5.62	26-Feb-21	0.66	3.14	0.64				
28-Oct-20	10.05	6.14	14.65	28-Dec-20	2.01	0.08	5.50	27-Feb-21	0.69	3.26	0.60				
29-Oct-20	9.87	5.95	14.47	29-Dec-20	1.93	0.06	5.39	28-Feb-21	0.73	3.38	0.56				
30-Oct-20	9.68	5.77	14.30	30-Dec-20	1.86	0.05	5.27								
31-Oct-20	9.50	5.59	14.13	31-Dec-20	1.79	0.03	5.15								

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Table 6 **Predicted Removed Rates Rates with 95 percent confidence interval from 15th September 2020 to 31st January 2021** **Appendix**

Date	Active Rates %			Date	Active Rates %			Date	Active Rates %		
	Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit		Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit		Point Estimate	Lower 95 % Confidence limit	Upper 95 % Cofidence limit
1-Sep-20				1-Nov-20	88.51	69.95	107.06	1-Jan-21	99.35	49.70	149.01
2-Sep-20				2-Nov-20	88.68	69.70	107.67	2-Jan-21	99.53	49.29	149.77
3-Sep-20				3-Nov-20	88.86	69.45	108.27	3-Jan-21	99.71	48.87	150.54
4-Sep-20				4-Nov-20	89.04	69.20	108.88	4-Jan-21	99.89	48.46	151.32
5-Sep-20				5-Nov-20	89.22	68.94	109.49	5-Jan-21	100.06	48.04	152.09
6-Sep-20				6-Nov-20	89.40	68.68	110.11	6-Jan-21	100.24	47.62	152.86
7-Sep-20				7-Nov-20	89.57	68.42	110.72	7-Jan-21	100.42	47.19	153.64
8-Sep-20				8-Nov-20	89.75	68.16	111.35	8-Jan-21	100.60	46.77	154.42
9-Sep-20				9-Nov-20	89.93	67.89	111.97	9-Jan-21	100.77	46.34	155.21
10-Sep-20				10-Nov-20	90.11	67.62	112.60	10-Jan-21	100.95	45.91	155.99
11-Sep-20				11-Nov-20	90.28	67.34	113.23	11-Jan-21	101.13	45.48	156.78
12-Sep-20				12-Nov-20	90.46	67.06	113.86	12-Jan-21	101.31	45.05	157.57
13-Sep-20				13-Nov-20	90.64	66.78	114.50	13-Jan-21	101.49	44.61	158.36
14-Sep-20				14-Nov-20	90.82	66.50	115.14	14-Jan-21	101.66	44.17	159.15
15-Sep-20	80.15	77.15	83.15	15-Nov-20	91.00	66.21	115.78	15-Jan-21	101.84	43.73	159.95
16-Sep-20	80.33	77.11	83.54	16-Nov-20	91.17	65.92	116.42	16-Jan-21	102.02	43.29	160.75
17-Sep-20	80.51	77.07	83.94	17-Nov-20	91.35	65.63	117.07	17-Jan-21	102.20	42.84	161.55
18-Sep-20	80.68	77.02	84.35	18-Nov-20	91.53	65.34	117.72	18-Jan-21	102.37	42.40	162.35
19-Sep-20	80.86	76.96	84.76	19-Nov-20	91.71	65.04	118.38	19-Jan-21	102.55	41.95	163.16
20-Sep-20	81.04	76.90	85.18	20-Nov-20	91.88	64.74	119.03	20-Jan-21	102.73	41.50	163.96
21-Sep-20	81.22	76.82	85.61	21-Nov-20	92.06	64.43	119.69	21-Jan-21	102.91	41.04	164.77
22-Sep-20	81.39	76.75	86.04	22-Nov-20	92.24	64.13	120.35	22-Jan-21	103.09	40.59	165.59
23-Sep-20	81.57	76.66	86.48	23-Nov-20	92.42	63.82	121.02	23-Jan-21	103.26	40.13	166.40
24-Sep-20	81.75	76.58	86.92	24-Nov-20	92.60	63.50	121.69	24-Jan-21	103.44	39.67	167.21
25-Sep-20	81.93	76.48	87.37	25-Nov-20	92.77	63.19	122.36	25-Jan-21	103.62	39.21	168.03
26-Sep-20	82.11	76.38	87.83	26-Nov-20	92.95	62.87	123.03	26-Jan-21	103.80	38.74	168.85
27-Sep-20	82.28	76.28	88.29	27-Nov-20	93.13	62.55	123.71	27-Jan-21	103.97	38.27	169.68
28-Sep-20	82.46	76.17	88.75	28-Nov-20	93.31	62.23	124.39	28-Jan-21	104.15	37.81	170.50
29-Sep-20	82.64	76.06	89.22	29-Nov-20	93.48	61.90	125.07	29-Jan-21	104.33	37.34	171.33
30-Sep-20	82.82	75.94	89.70	30-Nov-20	93.66	61.57	125.75	30-Jan-21	104.51	36.86	172.15
1-Oct-20	82.99	75.81	90.18	1-Dec-20	93.84	61.24	126.44	31-Jan-21	104.69	36.39	172.98
2-Oct-20	83.17	75.68	90.66	2-Dec-20	94.02	60.91	127.13				
3-Oct-20	83.35	75.55	91.15	3-Dec-20	94.20	60.57	127.82				
4-Oct-20	83.53	75.41	91.64	4-Dec-20	94.37	60.23	128.52				
5-Oct-20	83.71	75.27	92.14	5-Dec-20	94.55	59.89	129.22				
6-Oct-20	83.88	75.12	92.64	6-Dec-20	94.73	59.54	129.92				
7-Oct-20	84.06	74.97	93.15	7-Dec-20	94.91	59.20	130.62				
8-Oct-20	84.24	74.82	93.66	8-Dec-20	95.09	58.85	131.32				
9-Oct-20	84.42	74.66	94.18	9-Dec-20	95.26	58.49	132.03				
10-Oct-20	84.59	74.49	94.70	10-Dec-20	95.44	58.14	132.74				
11-Oct-20	84.77	74.33	95.22	11-Dec-20	95.62	57.78	133.46				
12-Oct-20	84.95	74.16	95.75	12-Dec-20	95.80	57.42	134.17				
13-Oct-20	85.13	73.98	96.28	13-Dec-20	95.97	57.06	134.89				
14-Oct-20	85.31	73.80	96.81	14-Dec-20	96.15	56.69	135.61				
15-Oct-20	85.48	73.62	97.35	15-Dec-20	96.33	56.32	136.34				
16-Oct-20	85.66	73.43	97.89	16-Dec-20	96.51	55.95	137.06				
17-Oct-20	85.84	73.24	98.44	17-Dec-20	96.69	55.58	137.79				
18-Oct-20	86.02	73.05	98.99	18-Dec-20	96.86	55.20	138.52				
19-Oct-20	86.20	72.85	99.54	19-Dec-20	97.04	54.83	139.25				
20-Oct-20	86.37	72.65	100.10	20-Dec-20	97.22	54.45	139.99				
21-Oct-20	86.55	72.44	100.66	21-Dec-20	97.40	54.06	140.73				
22-Oct-20	86.73	72.23	101.23	22-Dec-20	97.57	53.68	141.47				
23-Oct-20	86.91	72.02	101.79	23-Dec-20	97.75	53.29	142.21				
24-Oct-20	87.08	71.80	102.37	24-Dec-20	97.93	52.90	142.96				
25-Oct-20	87.26	71.58	102.94	25-Dec-20	98.11	52.51	143.71				
26-Oct-20	87.44	71.36	103.52	26-Dec-20	98.29	52.11	144.46				
27-Oct-20	87.62	71.13	104.10	27-Dec-20	98.46	51.72	145.21				
28-Oct-20	87.80	70.90	104.69	28-Dec-20	98.64	51.32	145.96				
29-Oct-20	87.97	70.67	105.28	29-Dec-20	98.82	50.92	146.72				
30-Oct-20	88.15	70.43	105.87	30-Dec-20	99.00	50.51	147.48				
31-Oct-20	88.33	70.19	106.47	31-Dec-20	99.17	50.11	148.24				