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Projection and assessment of COVID-19 contagion and its dynamics: Bangladesh perspective

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Abstract
The aim of the study is to assess the dynamics and projection of the COVID-19 contagion in Bangladesh in order to implement appropriate policy to prevent the spreading as well as smoothing the economic growth. The number of COVID-19 epidemic cases (infected, death and recovered) of Bangladesh between 03/08/2020 and 07/14/2020 has been estimated and used for forecasting by using Box-Jenkins (ARIMA) method and Brown and Holt linear exponential smoothing method in this study. The ARIMA method suggests that, at the mid of August, Coronavirus infected, dead and recovered (cumulative) number of people would be approximately 300831, 3830 and 221357 respectively. The Holts linear and browns linear trend method implies that number would be slightly less for infected and death cases. With developing economy and inadequate healthcare system Bangladesh is already cobwebbed by this virus. To palliate the hamper of the economy as well as healthcare system a strong, fitting policy is very much needed. This study will shed some light in designing appropriate policy as it projected some future prospects of the corona virus situation.

Keywords*: COVID-19, Coronavirus, forecast, Exponential smoothing model, ARIMA Models.*

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I. INTRODUCTION

The whole world is devastated by the unprecedented attack of COVID-19.Total of 13.5 million people are Coronavirus positive and 583,293 people are dead globally till date .[1]Originated from Wuhan, China this virus has traversed almost the entire world. Bangladesh confirmed this virus's existence in March 8, 2020. Initially the rate at which virus spread was relatively low but nowadays the rate is increasing in a mounting approach. The virus has confounded Bangladesh from all the way. Almost every day new record is happening for both the number of affected and dead from corona virus. Bangladesh reached its 100 cases in 6th April, 1000 cases in 14th April and 100000 cases in 18th June[2]. Whereas many affected countries in the world are now showing declining trend in affected rate and death rate, Bangladesh is still showing upward trend in affected and death rate. In this situation social and moral decay as well as economic growth is hampered. As Bangladesh is still showing upward trend in corona virus contagion situation, appropriate projection is needed to design any policymaking. In order to minimize loss appropriate rules and regulations should be accepted and implemented.

Although several policies had been accepted and implemented including full lockdown and partial lockdown, shutdown of internal and international flight, intercity transport, all these doesn't seem to incorporate the actual goal. It could both be the shortsighted decision of the authority or the carelessness of the community, the goal of minimizing the contagion is just not working.

This paper is designed to give communities and also the government a sense of how fast this pandemic is successive and to notify them of necessary safety measures. For this purpose, the number of the COVID-19 epidemic cases of the country between 03/08/2020 and 07/14/2020 has been scrutinize and used fo forecasting by using Box-Jenkins (ARIMA) and Brown and Holt linear exponential smoothing methods in this study. The study depends on secondary data based on cumulative number of infected cases, death and recovery obtained from the website of IEDCR [3]. The estimates show how the track of the epidemic in the following days, taking into account increase rates of the current cases.

This paper closely follows Moghadami M et al, 2020 [4] and Yonar, Harun.Yonar et al , 2020 [5] and made suitable change in order to evaluate Bangladesh's perspective. The rest of the paper is organized as follows. Section 2 introduces the methods and describes it in a general sense, while Section 3 consists of results and discussion. Section 3.1 concludes by sketching various graphical presentations from ARIMA and exponential smoothing methods. Section 3.2 concludes by presenting model statistics derived by operating those methods.

II. METHODOLOGY

The datasets in this study involve cumulative number of infected, death and recovery cases of COVID-19 pandemic belonging to the between 03/08/2020 and 07/14/2020 in the selected country. In this study, data source is secondary and obtained from the website of IEDCR. The forecasts of the COVID-19 infected, death and recovery cases are made by using the Box-Jenkins and Brown and Holt linear exponential smoothing methods which are the linear exponential smoothing method. IBM SPSS Statistics for Windows, Version 22.0 is used to carry out the analysis.

Time Series is a series derived from the observations made at periodical time intervals. This series enables to improve a proper model and to make prospective estimations by using statistical methods. However, stationary series are required for estimating the values which they will take prospectively by using the past values for any series. Since non-stationary series contain up-and-down values exhibiting variance at high level, margin of error in the possible estimates is quite high. Stationarity may be defined as "a probabilistic process whose average and variance do not vary over time and covariance between two periods is based on distance only between two periods, not period for which this covariance is calculated" methods are used for searching the stationary. Those that are most common among these methods are ACF (Autoregressive Correlation Function) and PACF (Partial Autoregressive Correlation Function) graphics and Augmented Dickey Fuller (ADF) unit root test. [5]

2.1 ARIMA

Popularly known as the Box-Jenkins (BJ) methodology, but technically known as the ARIMA methodology, the emphasis of these methods is not on constructing single-equation or simultaneous-equation models but on analyzing the probabilistic, or stochastic, properties of economic time series on their own under the philosophy *let the data speak for themselves*. Unlike the regression models, in which $\mathrm{Y_t}$ is explained by k regressors $\mathrm{X_1, X_2, X_3, \ldots, X_K}$, the BJ-type time series models allow $\mathrm{Y_t}$ to be explained by past, or lagged, values of Y itself and stochastic error terms.[6]

ARIMA (p, d,q) models are obtained by taking the difference of series from d degree and adding to ARMA (p, q) model for the stabilizing process. In the ARIMA (p, d, q) models, p is the degree of the Autoregressive (AR) model, q is the degree of the moving average (MA) model and d stands how many differences are required to make the series stationary. ARIMA model becomes AR (p), MA(q) or ARMA (p, q) if the time series is stationary

ARMA (p, q) model is shown as follows

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \beta_i \varepsilon_{t-i} + \varepsilon_t \ldots\ldots..(1)$$

First difference of the non-stationary Y_t

$$\nabla^1 Y_t = Y_t - Y_{t-1} = Y_t^{'} \ldots\ldots(2)$$

If $Y_t^{'}$ series is not still stationary, difference taking process is repeated for the d times until being stationary. The general form for the difference taking process is given as follows:

$$\nabla^d Y_t = \nabla^{d-1} Y_t - \nabla^{d-1} Y_{t-1} \ldots.(3)$$

The expression of ARIMA (p, d, q) model can be defined as follows:

$$Y_t = \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \cdots + \varphi_p Y_{t-p} + \alpha_1 - \theta_1 \alpha_{t-1} \text{-} \alpha_2 - \theta_2 \alpha_{t-2} \text{-....-} \alpha_q - \theta_q \alpha_{t-q} \ldots.(4)$$

Here: φ_p are the parameter values for autoregressive operator, α_q are the error term coefficient, θ_q are the parameter values for moving average operator, Y_t is the time series of the original series differenced at the degree d. [5]

2.2 Holt's linear trend method

Holt (1957) extended simple exponential smoothing to allow the forecasting of data with a trend. This method involves a forecast equation and two smoothing equations (one for the level and one for the trend):

Forecast equation: $\widehat{y_{t+h|t}} = l_t + hb_t$

Level equation: $l_t = \alpha y_t + (1-\alpha)(l_{t-1} + b_{t-1})$

Trend equation: $b_t = \beta^*(l_t - l_{t-1}) + (1-\beta^*) b_{t-1}$

Where l_t denotes an estimate of the level of the series at time t, b_t denotes an estimate of the trend (slope) of the series at time t, α is the smoothing parameter for the level, $0 \le \alpha \le 1$, and β^* is the smoothing parameter for the trend, $0 \le \beta * \le 1$.

As with simple exponential smoothing, the level equation here shows that l_t is a weighted average of observation y_t and the one-step-ahead training forecast for time t, here given by $l_{t-1}+b_{t-1}$. The trend equation shows that b_t is a weighted average of the estimated trend at time t based on $l_t - l_{t-1}$ and b_{t-1}, the previous estimate of the trend.

The forecast function is no longer flat but trending. The h-step-ahead forecast is equal to the last estimated level plus h times the last estimated trend value. Hence the forecasts are a linear function of h.[7]

2.3 Brown's Linear Exponential Smoothing Method

The simplest time-varying trend model is Brown's linear exponential smoothing model, which uses *two* different smoothed series that are centered at different points in time. The forecasting formula is based on an extrapolation of a line through the two centers.

The algebraic form of Brown's linear exponential smoothing model, like that of the simple exponential smoothing model, can be expressed in a number of different but equivalent forms. The "standard" form of this model is usually expressed as follows: Let S' denote the *singly-smoothed* series obtained by applying simple exponential smoothing to series Y. That is, the value of S' at period t is given by:

$$S'_t = \alpha Y_t + (1-\alpha)S'_{t-1}$$

(Under simple exponential smoothing, this would be the forecast for Y at period $t+1$) Then let S'' denote the *doubly-smoothed* series obtained by applying simple exponential smoothing (using the same α to series S':

$$S''_t = \alpha S'_t + (1-\alpha)S''_{t-1}$$

Finally, the forecast for Y_{t+k}, for any $k > 1$, is given by:

$$\widehat{Y_{t+k}} = L_t + kT_t$$

where:

$L_t = 2S'_t - S''_{t-1}$...is the estimated *level* at period t, and

$T_t = (\alpha/(1-\alpha))(S'_t - S''_{t-1})$ ...is the estimated *trend* at period t.

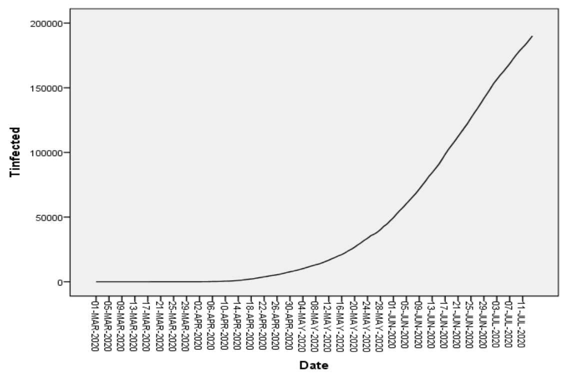
For purposes of model-fitting (i.e., calculating forecasts, residuals, and residual statistics over the estimation period), the model can be started up by setting $S'_1 = S''_1 = Y_1$, i.e., set both smoothed series equal to the observed value at $t = 1$.[8]

III. RESULT AND DISCUSSION

3.1 Result

ARIMA: Initially the infection rate was slow, but later on the virus infected people at an increasing rate. The figure attached showed in cooperation, the three cases (confirmed, death and recovered) are steeper form (Figure: 1) time to time. 'Tinfected' , 'Tdeath' and 'Trecovered' are denoted for total infected , total death and total recovered in the diagram respectively throughout this paper.

In March 8, Bangladesh first confirmed the virus's existence. 10 days later, 18 March, first death registered due to corona virus. Two people were registered recovered as they became well again from the virus at 11 March, 2020



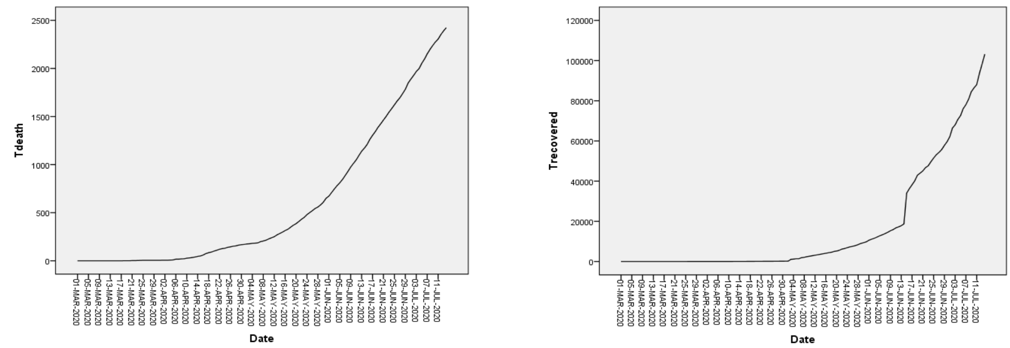


Figure1: Sequence chart of total infected, death and recovered

Available data is not suitable for identify seasonal pattern, although the three datasets shows upward trend. To conduct ARIMA approach, dataset ought to be stationary. So as to achieve stationary, three parameters of which our study is based on had to differentiate in order find them stationary in mean. The dataset becomes stationary in mean at 2^{nd} order of differentiation. (Figure 2)

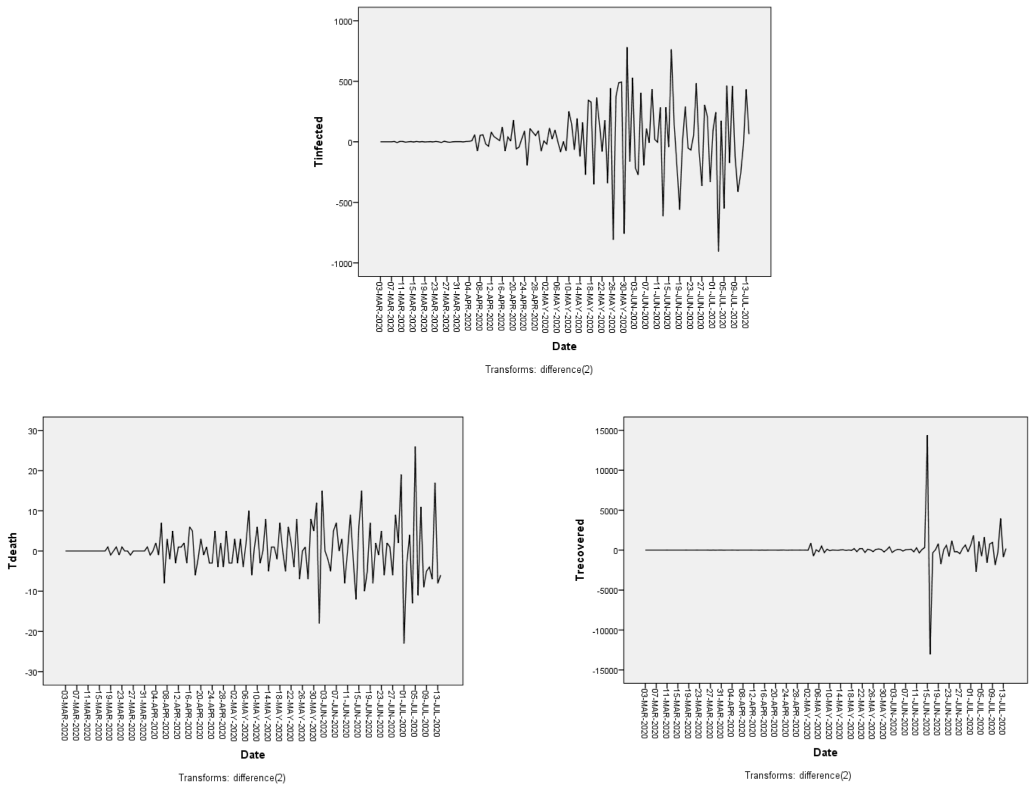


Figure 2: 2^{nd} difference of time series datasets

After differentiating and finding them at stationary in mean, we need to figure out the order of autoregressive and moving average. From autocorrelation function and partial autocorrelation function, the possible order of auto regression and moving average for three datasets are determined.

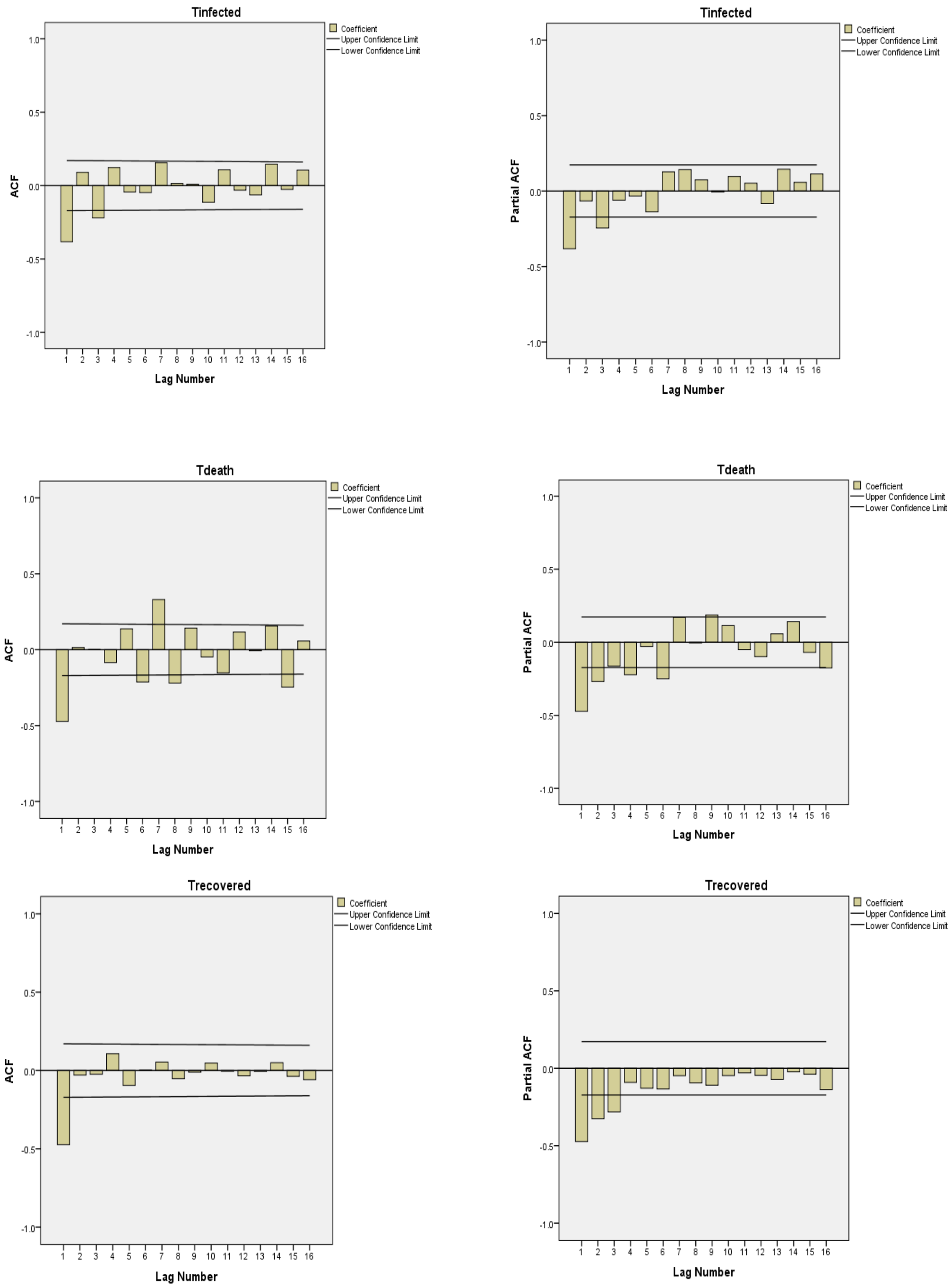


Figure 3: ACF and PACF of three time series datasets

Forecast according to ARIMA approaches are presented in figure 4.Total infected in mid August will be approximately 300831 ranging from 273740 to 327921 .Total number of death is projected to be is 3830 ranging from 3463 to 4197. And total number of recovered is forecasted to be 221357 ranging from 179511 to 263204.All the forecast is based on 95% confidence interval.

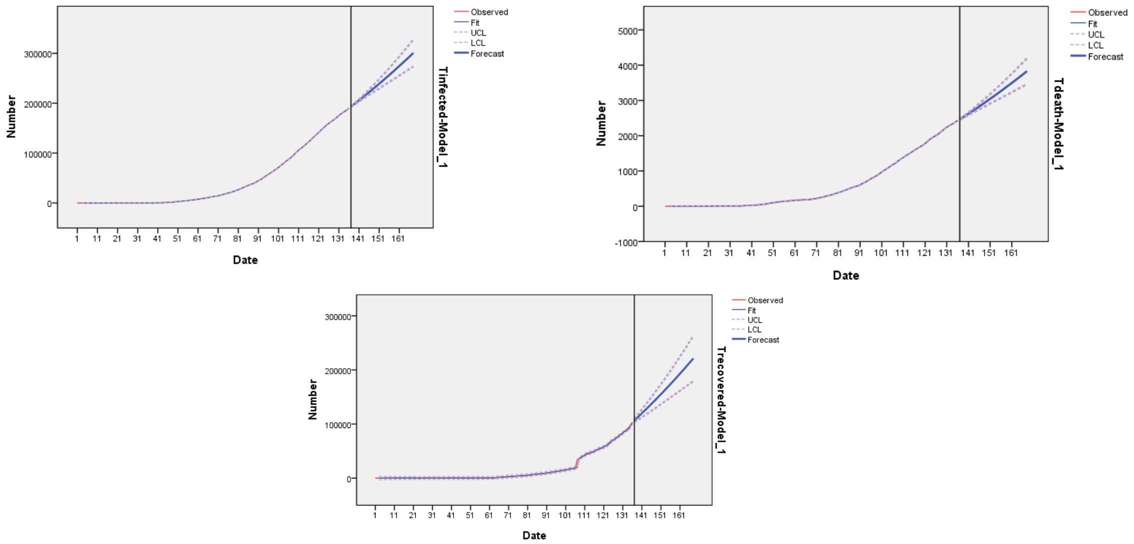
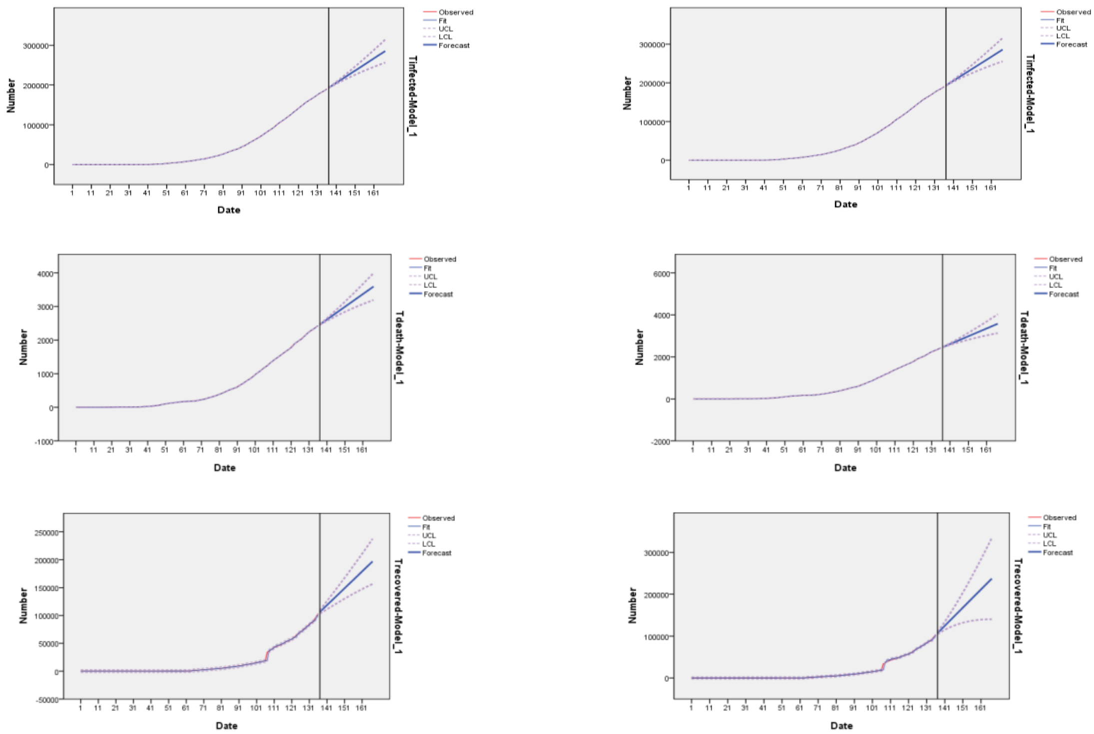


Figure 4: Forecast according to ARIMA

Holt's and Brown's Linear Trend Method

The prediction of confirmed, death and recovery of COVID-19 according to Holts and Brown's are presented in the figure 5. On the report of Holts Linear method Total infected in mid August will be approximately 285383 ranging from 256489 to 314278.Total number of dead is projected to be is 3595 ranging from 3195 to 3996 and total number of recovered is forecasted to be 197024 ranging from 156503 to 237545. In accordance with Browns Linear method Total infected in mid August will be approximately 285869 ranging from 255534 to 316203.Total number of dead is projected to be is 3580 ranging from 3132 to 4029. And total number of recovered is forecasted to be 237343 ranging from 140224 to 334462.



Holt's Linear Trend Brown's Linear trend

Figure 5: Forecast in relation to Holt's and Brown's Linear Trend

3.2 Discussion

Model statistics for ARIMA and Holt's linear trend and Brown's linear trend are presented in table 1 and 2. All three models have high R^2 values. MAPE values are less than 10% for most of the models accept for ARIMA designed for infected and recovered.

Table 1: Model Fit Statistics

Model Fit Statistics									
	Model Type	Stationary R^2	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Total Infected	HOLTs Linear Trend	.145	1.000	237.813	5.412	145.120	114.160	802.482	11.015
Total Infected	Brown's Linear Trend	.141	1.000	237.519	5.455	145.389	119.241	797.714	10.977
Total Infected	ARIMA(0,2,1)	.172	1.000	235.742	86.894	150.670	1525.392	832.669	10.999
Total Death	HOLTs Linear Trend	.318	1.000	5.276	4.607	3.342	100.000	28.818	3.399
Total Death	Brown's Linear Trend	.308	1.000	5.294	4.526	3.353	100.000	23.057	3.369
Total Death	ARIMA(0,2,1)	.337	1.000	5.240	6.531	3.540	128.832	21.917	3.386
Total Recovered	HOLTs Linear Trend	.402	.997	1380.491	7.200	326.563	83.744	14706.577	14.533
Total Recovered	Brown's Linear Trend	.358	.997	1424.270	7.251	373.616	99.999	14646.833	14.559
Total Recovered	ARIMA(0,2,1)	.420	.997	1369.585	890.900	439.871	8837.916	14447.984	14.518

Table 2: Ljung-Box (18)

		Ljung-Box Q(18)		
		Statistics	DF	Sig
Total Infected	HOLTs Linear Trend	28.061	16	.031
Total Infected	Brown's Linear Trend	28.877	17	.036
Total Infected	ARIMA(0,2,1)	26.991	17	.058
Total Death	HOLTs Linear Trend	31.249	16	.013
Total Death	Brown's Linear Trend	35.168	17	.006
Total Death	ARIMA(0,2,1)	29.170	17	.033
Total Recovered	HOLTs Linear Trend	6.279	16	.985
Total Recovered	Brown's Linear Trend	13.645	17	.692
Total Recovered	ARIMA(0,2,1)	6.315	17	.991

IV. CONCLUSION

Initially the contagion rate was slow. However with careless attitude of the community as well as questionable decision imposed by authority now Bangladesh is cobwebbed by the virus. Bangladesh reached its 100 cases in 6th April, 1000 cases in 14th April and 100000 cases in 18th June. As Bangladesh was on the verge of become a developing nation, because of this disastrous pandemic this will be very troublesome. Bangladesh is without doubt a great densely populated country. With more people being infected, the circumstances become highly inhumane. Keeping in mind, the life as well as living, Bangladesh is now longed for rational, genuine, germane measures to fight back with this warlike state of affairs. The health care facility is not commensurate to the infectivity rate.

In this study, from 03/08/2020 to 07/14/2020 of data had been incorporated to analyze the trajectory of the infectivity of Coronavirus. The ARIMA method suggests that, at the mid of August, Coronavirus infected, dead and recovered (cumulative) number of people would be approximately 300831, 3830 and 221357 respectively. The Holts linear and browns linear trend method implies that number would be slightly less for infected and death cases. From the beginning to present, many parameters affected to dampen the current position. Bangladesh should have been more successful as we are one of the many countries which are lately affected by community transmission. Unfortunately we couldn't make that knowledge help us.

So, this is high time that a highly fitted, longsighted policy should be taken and implemented on the basis of policymakers. This research had used two popular approaches to forecast namely ARIMA and exponential smoothing. Our finding varies little amongst the models we used, but able to give some idea. And model statistics had been operated in such a way so that minimal error occurs/ to find the best result. As this research was based on current data, the projection that has been made may be at variance.

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