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Forecasting COVID -19 Outbreak in the Philippines and Indonesia

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ABSTRACT

The COVID -19 is the worst pandemic in the world after Swine Flu (2009-2010). Indonesia and the Philippines have reported the highest amount of infected cases among Southeast Asian countries. The behavior of the daily infected cases in Indonesia and the Philippines in the future might be doubtful. The patterns of the outbreak show trend and seasonal behaviors in both countries. The authorities have to study the future behavior of the outbreak and prepare to avoid the outbreak of the pandemic to protect the humans in Indonesia and the Philippines. Hence, the study has designed to forecast the daily infected cases of COVID -19 in Indonesia and the Philippines. The daily infected cases of COVID-19 of Indonesia and the Philippines for the period of 22nd January 2020 to 24th May 2021 were obtained from the World Health Organization (WHO) database. The pattern recognition of the series done by Time series plots and Auto Correlation Function (ACF).The Quadratic Trend Model, Double Exponential Smoothing (DES) techniques, and Holt's Winters three-parameter additive and multiplicative models were selected to forecast infected cases. The ACF, and Ljung-Box Q (LBQ)-test and Anderson Darling test, were applied to test the validation criterion and fit the model. The forecasting ability of the models was assessed by both relative and absolute measurements of errors in both model fitting and verification processes. The results of the study revealed that the Quadratic trend model, DES, and Holt's Winters three-parameter additive and multiplicative models were satisfied with all criteria and the performance of the models were extremely high. Both relative and absolute measurements of errors were very low under the model fitting and verification process. It had been concluded that the Quadratic trend model, DES, and Holt's Winters three-parameter additive and multiplicative models are most suitable to forecast the infected cases in Indonesia and the Philippines. It is recommended to capture the seasonal behaviors in both countries furthermore.

Keywords: COVID -19, Seasonal, Trend.

1. INTRODUCTION

1.1 Background of the Study

The COVID 19 stands for Corona (CO), Virus (VI), Disease (D) and year 2019 (19), which is COVID-19 first appeared in 2019 (Sugiyanto & Muchammad, 2020). Novel corona virus can cause pneumonia (Pan et al, 2020). Pneumonia is an inflammatory lung disease which is characterized by coughing, chest pain, fever, and difficulty breathing (Pan et al., 2020).An outbreak of COVID -19 worse than the Swine Flu (2009-2010) exceeds the total loss of human lives. It became very clear that the illness was severe and that it was spreading quickly over a wide area. This situation has made a huge impact on people's life and their work since 2019. Indonesia and the Philippines have reported the highest amount of infected cases among Southeast Asian countries. These two countries exceed more than 2,462,309 infected cases since 2nd March and 30th January 2020 consecutively. The first infected case reported from Indonesia on 2nd March and 30th January 2020 from the Philippines. According to the World Health Organization (WHO) statistics, both countries still reporting a higher volume of infected cases and suffered from 42,782 and 15,286 death total consecutively. At present daily infected cases are declining in Indonesia. But the situation is different in the Philippines. The future of the outbreak of these countries could be doubtful.

1.2 Research Problem

An increasing or decreasing number of infected cases generates outnumbered and surplus of health care facilities and other medical supplies (Konarasinghe, 2020). On the other hand, increasing infected cases could be highly affected sustainable development in long run. Forecasting infected cases is a lighthouse to control the outbreak of these countries. There is a heap of research papers published by researchers focusing on forecasting infected cases of these countries. Nevertheless, the dynamic changes of the behavior should be captured more often to control the outbreak. Hence, forecasting the outbreak in these countries is extremely important to defeat the pandemic.

1.3 Objective of the Study

The objective of the study is to forecast the number of infected cases of COVID -19 in the Philippines and Indonesia.

1.4 Significance of the Study

The results of this study could be a tool to be proactive and protect Indonesia and the Philippines from the outbreak of the pandemic. It could be useful to develop various strategies and policies to control the spread of the pandemic. The results of this study would be useful to work out the health care and medical resources with minimum waste. Base on the results the authorities can decide the lockdown schedules and impose the supply delivery systems to attenuate the movement of the general public (Konarasinghe, 2020). The results of this study could be another guide for business. They can decide how

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to improve their business functions to gain maximum benefits and retain their external stakeholders. The results can be used to predict how long this pandemic situation will exist. It could be useful to impose a new mandate to control COVID- 19 outbreak in the Philippines and Indonesia.

2. LITERATURE REVIEW

The review of the study was focused on model-based analysis on outbreak of the pandemic situations in the Philippines and Indonesia. The mathematical and statistical models were used by many researchers.

Annas et al (2020) have applied Suspected, Exposed, Infected, and Recovered SEIR mathematical model to analyze the pandemic spread in Indonesia. The same mathematical model SEIR used by Ndii, et al (2020): Rustan & Handayani (2020): Wirawan & Januraga (2020): Anwar & Sukardi (2020): Rayo et al (2020) and Udomsamuthirun et al (2020). They have applied this to model the outbreak of pandemic in Indonesia, Bali in Indonesia, West Nusa Tenggara (NTB) Province in Indonesia, Philippine and within the ASEAN region consecutively. The studies of David et al (2020): Chavez (2020) and Sulaiman (2020) have used an epidemiologic-based (susceptible, infected, recovered) SIR model to forecast active, death, and total cases of COVID 19 within the Philippines, forecast COVID-19 epidemic in Davao Region, Philippines and analyze the dynamic behavior of pandemic in Indonesia. Richards's model is another technique applied to predict the infected cases in Indonesia and forecast the pandemic in South Sulawesi in Indonesia by Rayungsari et al (2020) and Zuhairo & Rosadi (2020). Nuraini et al (2020) have applied a model based on Richard's Curve that represents a modified logistic equation to predict the pandemic situation in Indonesia. The study of Sugiyanto & Muchammad (2020) was to estimate infected cases in Indonesia. They have applied the susceptible, infected, recovery, and virus (SIRV) model to estimate infected cases in Indonesia. Toharudin et al (2020) have used Bayesian Poisson Model with Markov Chain Monte Carlo (MCMC) to analyze the COVID- 19 incidence in West Java Province, Indonesia. The Gaussian equation used for modeling the Covid-19 case in Indonesia by Yufajjiru & Dharma (2020). Egwolf & Austriaco (2020) model infected cases in Metro Manila, Philippines by using DELPHI model. The generalized logistic model (GLM) have used to predict the outbreak of the pandemic in China, Iran, the Philippines, and Taiwan by Sharon & Aharoni (2020). Konarasinghe (2020) have used Double Exponential Smoothing (DES) model to forecast the COVID - 19 Outbreak in the Philippines

The SEIR and SIR were the commonly applied mathematical models to predict the outbreak in Indonesia and the Philippines. Besides, Richards's model, SIRV model, Bayesian Poisson Model, Gaussian equation, DELPHI model, GLM, and DES also used for the purpose. The researcher's concern on model verification was less. An applications of time series forecasting was very less too. Assessment of the forecasting ability was doubtful in several models. The number of studies focused on the Philippines was less

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than Indonesia. More attention should be paid to predicting the outbreak of the Philippines.

3. METHODOLOGY

The daily infected cases of COVID-19 of the Indonesia and Philippines for the period of 22nd January 2020 to 24th May 2021 were obtained from the World Health Organization (WHO) database. Pattern recognition of a data series paves the path for the selection of the most suitable model (Konarasinghe, 2016; 2016). It gives an insight into the various patterns of trends, seasonal variations, cyclical variations, and volatility within the precise period of time (Konarasinghe & Abeynayake, 2014). Hence, time series plot and Auto Correlation Function (ACF), were used for the aim, as done by Konarasinghe & Abeynayake (2014). Supported by the pattern recognition, Quadratic trend model, Double Exponential Smoothing (DES) techniques, and Holt's Winters Three Parameter additive and multiplicative models were tested to forecast the daily infected cases of Indonesia and the Philippines. The model validation is done by using the Anderson Darling test, ACF, and Ljung-Box Q (LBQ)-test (Konarasinghe et al,2015). The forecasting ability of the models was assessed by both relative and absolute measurements of errors; Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE), and Mean Absolute Deviation (MAD) in both model fitting and verification process, as per Konarasinghe et al (2015).

3.1 Trend analysis

Trend analysis fits a general trend model to time series data and provides forecasts (Konarasinghe , 2015). Trend models has been applied to forecast daily infected cases in India and Malaysia by Konarasinghe (2020: 2020). This study followed the procedure of Konarasinghe (2015) to choose the Quadratic trend model. A formula of Quadratic trend model is;

$$Y_t = \alpha + \beta_1 \mathrm{t} + \beta_2 \mathrm{t}^2 + \varepsilon \qquad (1)$$

3.2 Double Exponential Smoothing Model

Double Exponential Smoothing (DES) provides short-term forecasts. DES was applied to forecast daily infected cases of COVID-19 in the UK, Russia, India, Brazil, Malaysia, Thailand, Singapore, Philippines (Konarasinghe,2020; 2020;2020).This technique works well when a trend is present, but it also is a general smoothing method (Konarasinghe, 2016). This model includes two dynamic estimates. They are, α and β; with values between 0 and 1 (Konarasinghe, 2016).

They represent level and trend respectively. Formulae of DES technique (Holt' method) are;

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$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (2\text{-}1)$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \quad (2\text{-}2)$$

$$\hat{Y}_t = L_{t-1} + T_{t-1} \quad (2\text{-}3)$$

$$F_{t+m} = L_t + mT_t \quad (2\text{-}4)$$

Where,

L_t : is the level at the end of period t , α is the weight of level, T_t = is the estimated trend at the end of period t, β is the weight of trend, m = is the forecast horizon.

3.3 Holt's Winters Three Parameter Models

Winters' Method smoothers data by Holt-Winters exponential smoothing and provides short to medium-range forecasting (Konarasinghe, 2016). This model can be applied when both trend and seasonality are present, with these two components being either additive or multiplicative (Holt, 1957). Winters' Method calculates dynamic estimates for three components; level, trend and seasonal which denotes α, β, and γ (with values between 0 and 1) (Holt, 1957). Formulae of Winter's multiplicative model is;

$$L_t = \alpha\,(Y_t / S_{t-p}) + (1-\alpha)\,[L_{t-1} + T_{t-1}] \quad (3\text{-}1)$$

$$T_t = \beta\,[L_t - L_{t-1}] + (1-\beta)T_{t-1} \quad (3\text{-}2)$$

$$S_t = \gamma\,(Y_t / L_t) + (1-\gamma)\,S_{t-p} \quad (3\text{-}3)$$

$$\hat{Y}_t = (L_{t-1} + T_{t-1})\,S_{t-p} \quad (3\text{-}4)$$

Where,

L_t = is the level at time t, α is the weight for the level, T_t = is the trend at time t, β is the weight for the trend, S_t = is the seasonal component at time t, γ is the weight for the seasonal component, p = is the seasonal period, Y_t = is the data value at time t, $\hat{Y}_t$ = is the fitted value, or one-period-ahead forecast, at time t.

Formulae of Winter's additive model is;

$$L_t = \alpha\,(Y_t - S_{t-p}) + (1-\alpha)\,[L_{t-1} + T_{t-1}] \quad (4\text{-}1)$$

$$T_t = \beta[L_t - L_{t-1}] + (1-\beta)T_{t-1} \quad (4\text{-}2)$$

$$S_t = \gamma\,(Y_t - L_t) + (1-\gamma)\,S_{t-p} \quad (4\text{-}3)$$

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$$\hat{Y}_t = L_{t-1} + T_{t-1} + S_{t-p} \quad (4\text{-}4)$$

Where,

L_t = is the level at time t, α is the weight for the level, T_t is the trend at time t, β is the weight for the trend, S_t = is the seasonal component at time t, γ is the weight for the seasonal component, p = is the seasonal period, Y_t = is the data value at time t, $\hat{Y}_t$ = is the fitted value, or one-period-ahead forecast, at time t.

4. RESULTS

The analysis contains two main parts:

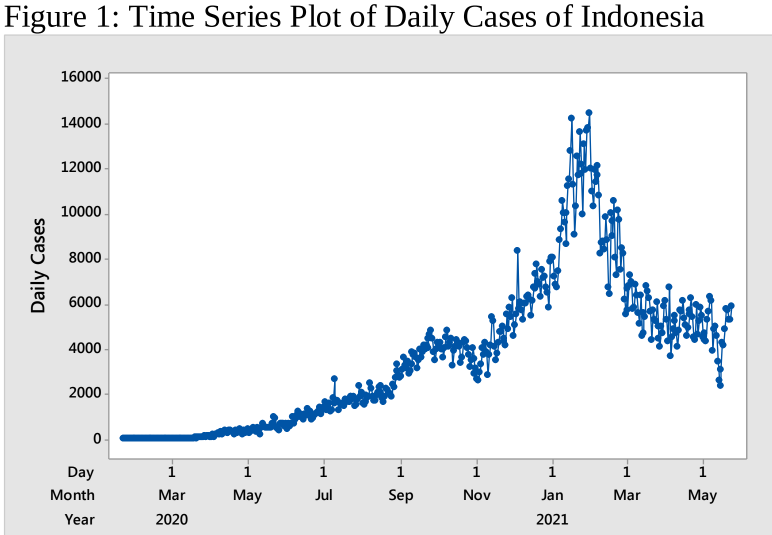
4.1 Pattern recognition and forecasting daily infected cases of Indonesia.
4.2 Pattern recognition and forecasting daily infected cases of the Philippines.

Initially, pattern recognition of the data series of Indonesia and the Philippines was done, then DES, Holt's Winters Three Parameter additive and multiplicative models, and Quadratic trend models tested for forecasting. Log transformed data were used for the analysis.

4.1 Pattern Recognition and Forecasting Daily Infected Cases in Indonesia

Time series plot of daily infected cases of Indonesia for the period of 22nd January 2020 to 24th May 2021 (Figure 1). The first confirmed case reported from Indonesia on 2nd March 2020. There was an exponential growth of daily infected cases for the period of 2nd March 2020 to 30th January 2021. After 30th January 2021, there was a declining trend of daily cases (Figure 1).

Figure 1: Time Series Plot of Daily Cases of Indonesia



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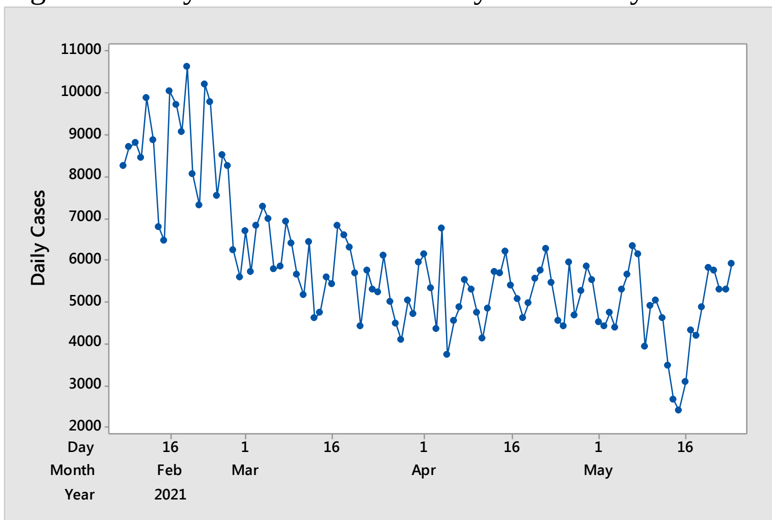
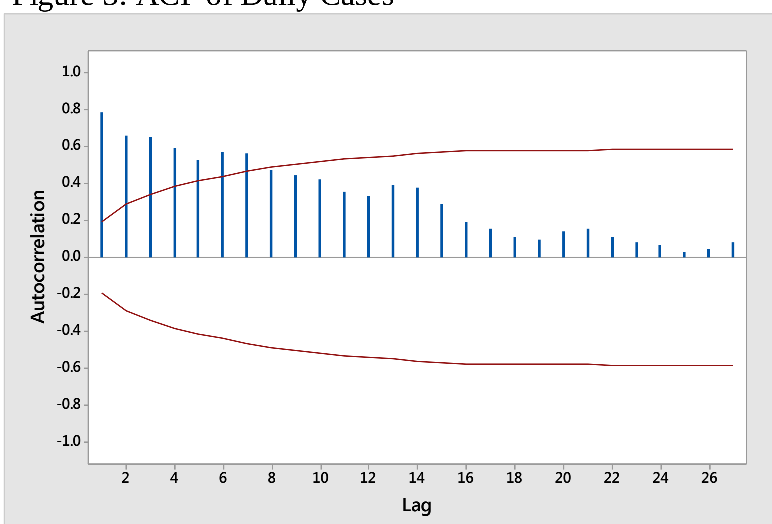
Hence, the data set for the period of 8th February 2021 to 24th May 2021 was used to forecast daily infected cases in Indonesia.

Figure 2: Daily Cases of 8th February to 24th May 2021.



The pattern of the daily infected cases for the chosen period was further examined. Figure 2 is that the time series plot of confirmed cases for the period of 8th February to 24th May 2021. There is a decline of daily infected cases with fluctuations. It began to decline after 26th February 2021. In the meantime, there was a sudden drop for the period of 11th to 15th May 2021. The behavior of Figure 2 suggested the quadratic trend of the series. The ACF of the series is shown in Figure 3.

Figure 3: ACF of Daily Cases



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The ACF shows a decline with many significant lags. Many seasonal behaviors observed within the daily infected cases in Indonesia. Based on the observed pattern of the series and the evidence provided by the literature, the study selected the Quadratic trend model and DES to forecast daily infected cases in Indonesia. The summaries of the Quadratic trend model and DES models are given in Table 1;

Table 1: Summary of Model Fittings and Verifications of Quadratic Model and DES

Model	Model Fitting		Model Verification	
$\ln Y_t = 9.1336 - 0.01973t + 0.000165t^2$	MAPE	1.2026	MAPE	3.4976
	MAD	0.1042	MAD	0.2890
	MSE	0.0160	MSE	0.1428
	Normality	P= 0.642		
	Independence of Residuals	Yes		
α (level) 0.78 γ (trend) 0.20	MAPE	1.4677	MAPE	3.7324
	MAD	0.1269	MAD	0.3085
	MSE	0.0267	MSE	0.1554
	Normality	P=0.550		
	Independence of Residuals	Yes		

Both models were satisfied with the model validation criterion. The Anderson Darling test confirmed the normality of residuals of both the Quadratic trend model and DES. The LBQ test and ACF confirmed the independence of residuals of both models. The relative and absolute measurements of errors are very low under the fitting and verifications of both the Quadratic trend model and DES. The actual fits, and forecast of the Quadratic trend model and actual, fits, and forecast of DES are in Figures 4 and 5. Actual vs. Fits of DES are closer to each other and the trend of Actual vs. Fits of Quadratic trend model follows the same.

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Figure 4: Actual, Fits & Forecast of Quadratic Trend Model

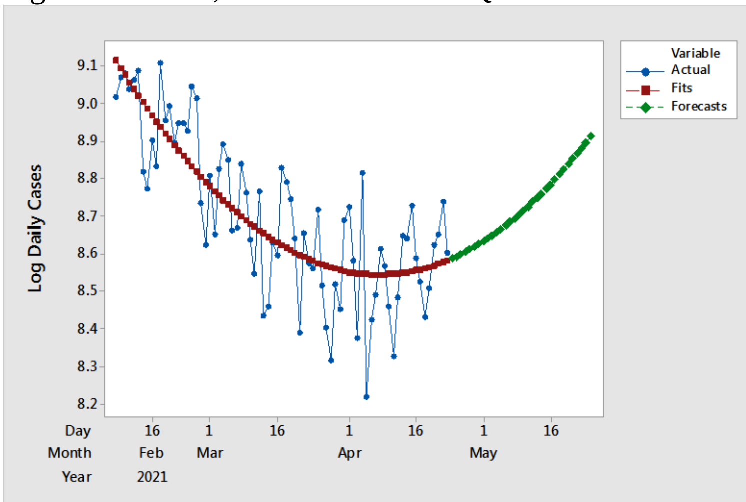
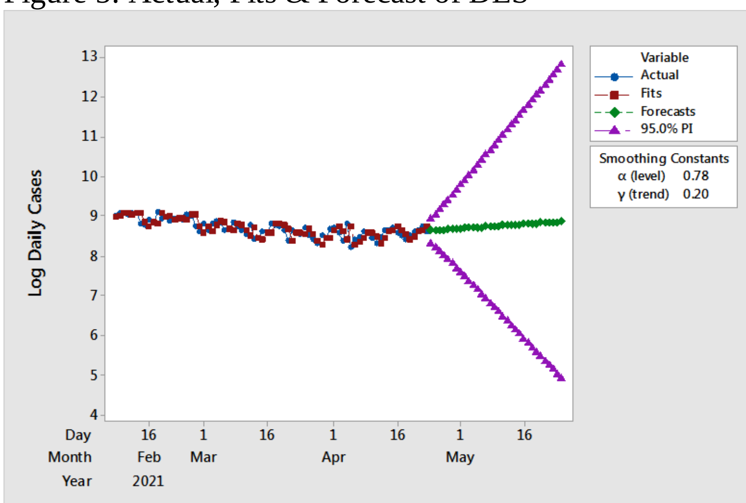


Figure 5: Actual, Fits & Forecast of DES



Hence, both DES and Quadratic trend models are the most suitable models to forecast daily infected cases of COVID -19 in Indonesia.

4.2 Pattern Recognition and Forecasting Daily Infected Cases in the Philippines

The pattern recognition of daily infected cases of the Philippines was examined. The time series plot of daily infected cases was obtained for the period of 22nd January 2020 to 24th May 2021. Figure 6 is the time series plot of daily infected cases.

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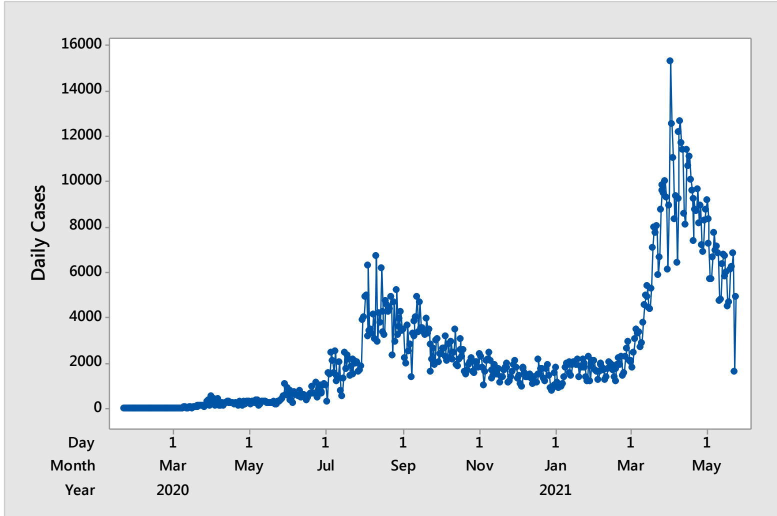
Figure 6: Time Series Plot of Daily Cases of Philippines



The first confirmed case was reported on 30th January 2020. The number of cases was low up to 27th March and climb afterward. Rapid growth is observed for the period of 3rd July to 10th August 2020. Once again, the same growth is observed by the series for the period of 6th January to 2nd April 2021. Thereafter a declining behavior is observed. Hence, the data set for the period of 3rd April to 24th May 2021 used to forecast daily infected cases of COVID -19 in the Philippines.

Figure 7: Daily Cases of 3rd April to 24th May 2021

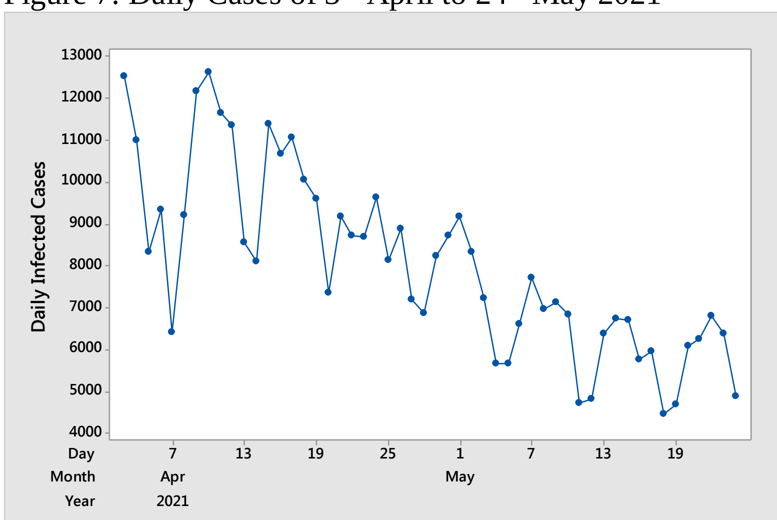


Figure 7 is the time series plot of daily confirmed cases of the Philippines for the period of 3rd April to 24th May 2021. There is a declining trend with irregular fluctuations of daily cases has observed after 3rd April 2021. The ACF of the series is shown in Figure 8.

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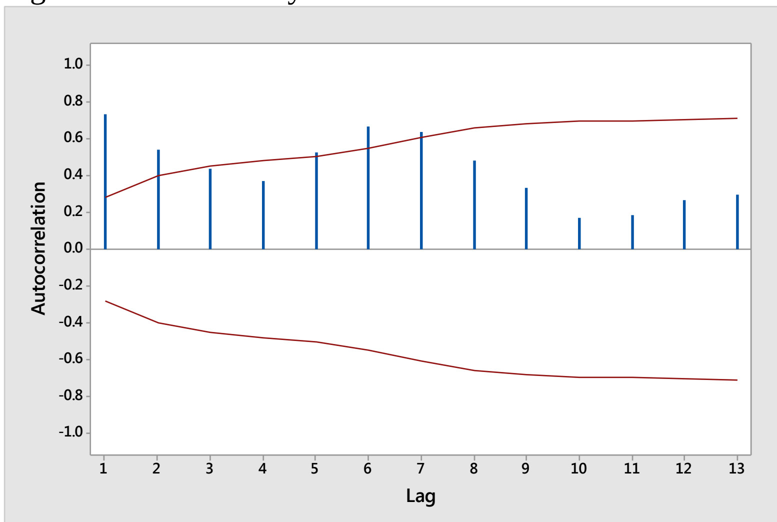
Figure 8: ACF of Daily Cases



Two seasonal behaviors with a declining trend is observed from the ACF of Figure 8. There could be 6 and 7 seasonal lengths. The series does not confirm the stationary criteria. Hence, DES and Holt's Winters additive and multiplicative models were tested. Initially, the DES was tested with log-transformed data for different α and γ values. Model Summary in Table 2 shows the outputs at the best levels.

Table 2: Summary of Model Fittings and Verifications of DES

Model	Model Fitting		Model Verification	
α (level) 0.988 γ (trend) 0.200	MAPE	1.6519	MAPE	1.8045
	MAD	0.1484	MAD	0.1549
	MSE	0.0356	MSE	0.0286
	Normality	P= 0.878		
	Independence of Residuals	Yes		

According to Table 2, the DES with α = 0.988 and γ = 0.200 had the least relative and absolute measurement of errors during the model fitting and verifications. The residuals were normally distributed and independent. The actual vs fits and forecast of the series are shown in Figure 9. The fits and the forecast followed a similar pattern of actual daily infected cases in the Philippines. The deviation between actual values fits, and the forecast is less. Hence, the DES (α = 0.988 and γ = 0.200) is a suitable model for forecasting daily infected cases in the Philippines.

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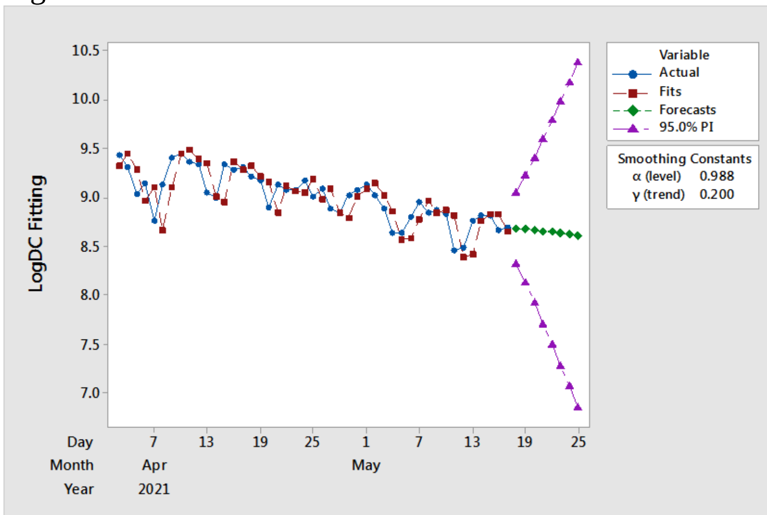
Figure 9: Actual Vs. Fits and Forecast of DES



The Holt's Winters additive and multiplicative models were tested after the DES with log-transformed data for different α, γ, and δ values and two seasonal lengths of 6 and 7 consecutively. Model Summary in Table 3 shows the outputs at the best levels of Holt's Winters additive and multiplicative with 6 seasonal lengths.

Table 3: Model Summary

Model		Model Fitting		Model Verification	
Additive (6)		MAPE	1.4986	MAPE	1.7252
		MAD	0.1345	MAD	0.1476
α (level)	0.999	MSE	0.0292	MSE	0.0293
γ (trend)	0.100	Normality	P= 0.763		
δ(seasonal)	0.100	Independence of Residuals	Yes		
Multiplicative (6)		MAPE	1.5133	MAPE	1.7449
		MAD	0.1359	MAD	0.1492
α (level)	0.999	MSE	0.0294	MSE	0.0309
γ (trend)	0.100	Normality	P= 0.688		
δ(seasonal)	0.100	Independence of Residuals	Yes		

According to Table 3, Holt's Winters additive and multiplicative with α = 0.999, γ = 0.100, and δ = 0.100 had the least relative and absolute measurement of errors during the model fitting and verifications. The residuals were normally distributed and

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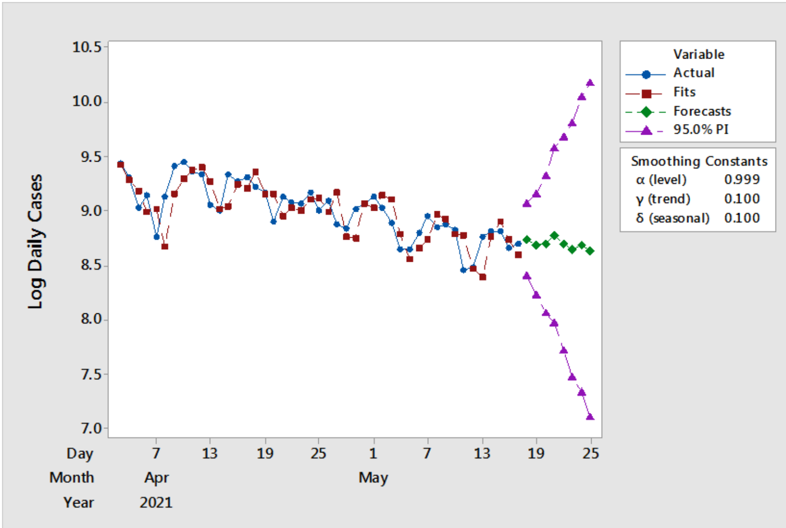
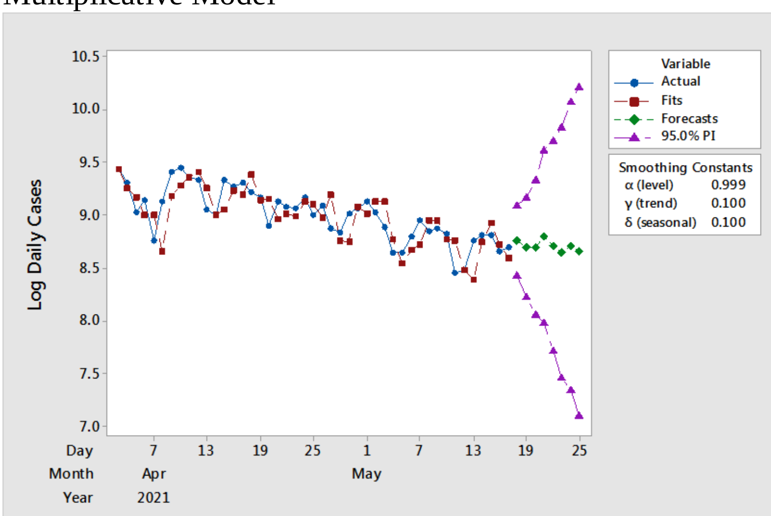
independent. The actual vs. fits and forecast of the additive model are shown in Figure 10.

Figure 10: Actual Vs. Fits and Forecast of Holt's Winters Additive Model



According to Figure 10, fits and the forecast of Holt's Winters additive model followed a similar pattern of the actual daily infected cases in the Philippines. The deviation between actual values of fits, and the forecast is less. Hence, the Holt's Winters additive model ($\alpha = 0.999$, $\gamma = 0.100$ and $\delta = 0.100$) is the suitable model for forecasting daily infected cases in the Philippines. The actual vs. fits and forecast of the multiplicative model are shown in Figure 11.

Figure 11: Actual Vs. Fits and Forecast of Holt's Winters Multiplicative Model



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The output of the model followed a similar pattern to the actual daily infected cases. The behavior is almost similar to the additive model. The deviation between actuals fits and the forecast is less. The Holt's Winters multiplicative model (α = 0.999, γ = 0.100 and δ = 0.100) also suitable to forecasting daily infected cases in the Philippines. The forecasting ability of Holt's Winters additive and multiplicative models was extremely high. Hence, both additive and multiplicative models equally well in forecasting daily infected cases in the Philippines.

Table 4: Model Summary

Model	Model Fitting		Model Verification	
Additive (7) α (level) 0.6 γ (trend) 0.2 δ (seasonal) 0.4	MAPE	0.9858	MAPE	1.3494
	MAD	0.0890	MAD	0.1167
	MSE	0.0143	MSE	0.0203
	Normality	P= 0.126		
	Independence of Residuals	Yes		
Multiplicative (7) α (level) 0.6 γ (trend) 0.2 δ (seasonal) 0.4	MAPE	0.9857	MAPE	1.3393
	MAD	0.0889	MAD	0.1157
	MSE	0.0142	MSE	0.0191
	Normality	P= 0.169		
	Independence of Residuals	Yes		

The summary of Table 3 shows that Holt's Winters additive and multiplicative with α = 0.6, γ = 0.2, and δ = 0.4 had the least relative and absolute measurement of errors during the model fitting and verifications. The residuals were normally distributed and independent. The actual vs. fits and forecast of the additive model are shown in Figure 12.

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Figure 12: Actual Vs. Fits and Forecast of Holt's Winters Additive Model

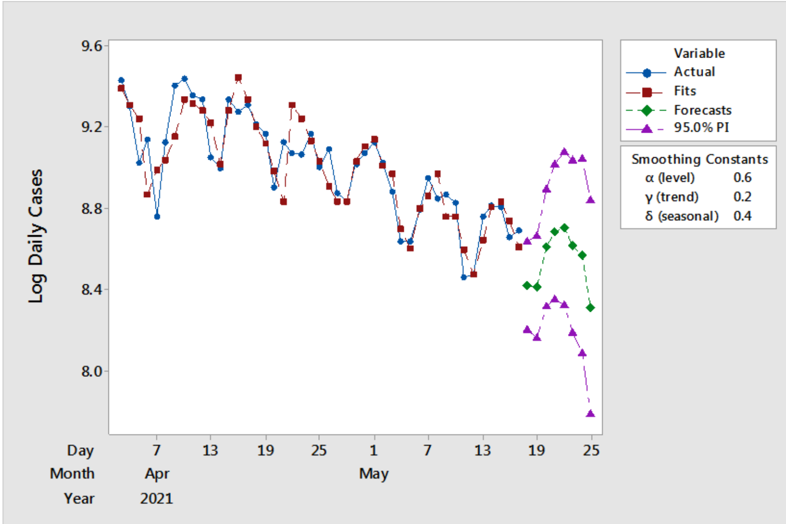

Figure 12, shows the actuals almost follow a similar pattern of fits and forecast of the daily infected cases in the Philippines. Besides, the deviation between actual and fits also very less. Hence, the Holt's Winters additive model ($\alpha = 0.6$, $\gamma = 0.2$ and $\delta = 0.4$) is the suitable model for forecasting daily infected cases in the Philippines. Figure 13 is the actual vs. fits and forecast of the multiplicative model.

Figure 13: Actual Vs. Fits and Forecast of Holt's Winters Multiplicative

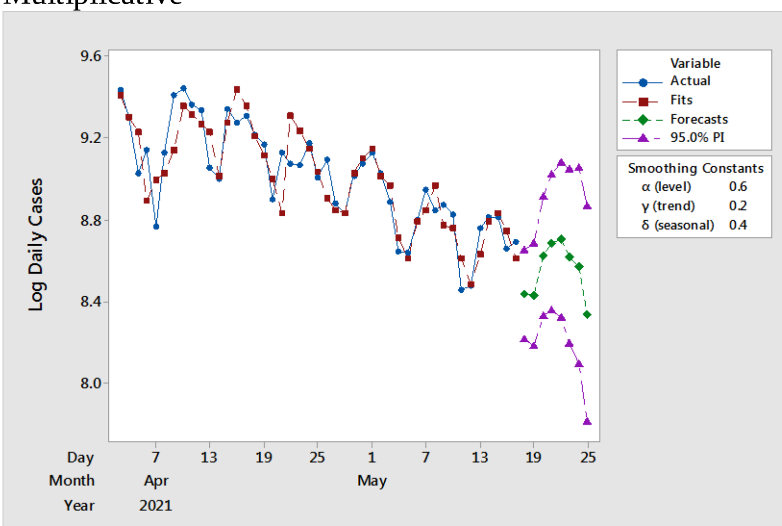

Figure 13 shows the performance of the fitted model of Holt's Winters multiplicative model ($\alpha = 0.6$, $\gamma = 0.2$, and $\delta = 0.4$) with 7 seasonal lengths. The performance is almost

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similar to the additive models and it's extremely good for forecasting daily infected cases in the Philippines.

5. CONCLUSION AND RECOMMANDATION

It is concluded that DES is the best-suited model in forecasting daily infected cases in Indonesia and the Philippines. Besides, the Quadratic trend model suited for Indonesia and Holt's Winters three-parameter model suited for the Philippines.

The behaviors of the daily infected cases in Indonesia and the Philippines have an upward trend initially, but downward trends later. It is a good sign of the control the outbreak of COVID-19 in both countries. It shows that they have the potential to control the outbreak. The behaviors of the data series suggested seasonal patterns of both countries. This study captured only the seasonal behaviors of the Philippines. There were two seasonal patterns with 6 and 7 days. It means the changes of the daily infected cases occurred after every 6 and 7 days. This movement could be another guideline to control the outbreak.

The authorities of both countries should impose non-pharmaceutical practices, including personal protection, social distancing, and restrict movements of the overall public, and monitor them strictly with prompt actions against the violations of those practices. The public should follow the rules and other control measures imposed by the authorities. The self-discipline of the general public is of utmost importance to control the outbreak and they have to think that is their responsibility to the future. Proper hand hygiene, respiratory etiquette, and other personal hygiene are a few of the self-discipline practices. All media sources of both countries need to play a key role to educate the general public on non-pharmaceutical and improve the immunity of their bodies.

There were few vaccines introduce recently to protect from COVID-19 as medical care. But that is not the only solution for prevention. Besides, medical care constitutes only 10% – 20% of health outcomes approximately (AIM, 2019). That is not sufficient for complete prevention. The remaining 80% to 90% incorporates with social factors namely; work, play, etc., behaviors namely; smoking, consuming too much alcohol, consuming unhealthy food (short eats) etc. Healthcare systems such as non-pharmaceutical practices are used to control them (AIM, 2019). It is important to pay more attention on healthcare systems to prevent and avoid the spread of the pandemic of both countries.

Improving immunity is another factor to prevent the COVID 19. There were indigenous food habits available in most of the Asian countries. It is one of the best solutions to improve the immunity of the people. It is important to increase the capacity and developing the potential for rapid viral diagnosis systems and medical staff, health care officers, security providers, and other essential service providers need to use, proper protective equipment (Konarasinghe, 2020).

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The pattern recognition of the study showed many seasonal behaviors of both data sets. This study captured only two seasonal behaviors in the Philippines, but there could be many more patterns in the daily infected cases of Philippines and Indonesia. Hence it is strongly recommended to identify the hidden seasonal behaviors by applying Seasonal Auto Regressive Integrated Moving Average (SARIMA) and the Sama Circular Model (SCM).

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