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Forecasting COVID -19 Spread in Malaysia, Thailand, and Singapore

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ABSTRACT

Singapore, Thailand, and Malaysia have reported a considerable amount of infected cases compared with other Southeast Asian countries and still reporting the infected cases. These countries located geographically as a belt. They are preparing to reopen and confirm the sleek function as usual but in doubts about the future behavior of the pandemic. Hence the study aimed to forecast the number of infected cases of COVID -19 in Malaysia, Thailand, and Singapore. The daily confirmed cases of COVID-19 of Malaysia, Thailand, and Singapore for the period of 22nd January 2020 to 29th June 2020 were obtained from the World Health Organization (WHO) database. Time series plots and Auto Correlation Functions (ACF) were used to examine the pattern of the series. The linear trend model and Double Exponential Smoothing (DES) techniques were tested to forecast the pandemic. The Anderson Darling test, ACF, and Ljung-Box Q (LBQ)-test were used to test the validation criterion and fit the model. The forecasting ability of the models was assessed by two measurements of errors; Route Mean Square Error (RMSE), and Mean Absolute Deviation (MAD) in both model fitting and verification process. It is concluded that the linear trend model is suitable to forecast the pandemic of Malaysia and DES has successfully fitted for all three countries.

Keywords: Infected Cases, Linear Trend, DES, COVID-19

1. INTRODUCTION

1.1 Background of the Study

Southeast Asia is another region that found it grappling with the COVID 19 pandemic. Singapore, Thailand, and Malaysia still reporting infected cases daily. These countries have reported a substantial amount of infected cases compared with other Southeast Asian countries. The geographical site and movements between the countries considered for selection to model the pandemic. As per the World Health Organization (WHO) reports, Singapore has 43,661 infected cases, over 37,000 recoveries, and 26 deaths. Thailand has reported 3,169 infected cases, 3,053 recoveries, and 58 deaths. Besides, 8,637 infected cases, 8,334 recoveries, and 121 deaths have reported from Malaysia. Their death toll was above within the other two countries. The recovery rates were extremely high in all three countries. The recovery rates of Thailand and Malaysia were 96% each, whereas, Singapore has 85%. The infection rate of the pandemic was 0.004% in Thailand. This is the lowest compared to the other two countries. The infected rate in Malaysia was 0.026%. Whereas Singapore has 0.74% which was the highest infection rate among all three countries. These three countries were preparing to reopen and make sure the sleek function as usual. But they have doubts about on future behavior of the pandemic.

1.2 Research Problem

An exploring the longer-term behavior of infected cases plays a vital role in deciding for future activities to combat the pandemic and convey backs a country to a normal. The behavior of the pandemic has already changed with time. Besides, authorities of those countries want to understand the longer-term behavior of the infected cases. Hence, this study was designed to fill the knowledge gap.

1.3 Objective of the Study

The objective of the study was to forecast the number of infected cases of COVID -19 in Malaysia, Thailand, and Singapore.

1.4 Significance of the Study

The results of this study would be a guide for the decision making of combat the pandemic. Authorities can decide the way of lifting the bands for various activities. They could use the results of this study to strengthen preventive measures to avoid the spread of the pandemic. Workout the necessities of equipment and personal protective kits, working schedules within the public and private sector, public transport schedules, changes of business processes within the respective countries could be decided by observing the results of the study.

2. LITERATURE REVIEW

The study reviewed research papers associated with the modeling and analysis of COVID -19 pandemic in Malaysia, Singapore, and Thailand.

Mahmud, A. & Lim, P.Y.(2020) have applied Susceptible, Exposed, Infectious, and Removed (SEIR) mathematical models to forecast pandemic in Malaysia. Three mathematical models namely: Curve Fitting Model with Probability Density Function and Skewness Effect, SIR (S -susceptible, I- infectious, and R – recovered) and System Dynamic models have applied by Salim, et al.,(2020) to predict outbreak cases in Malaysia. The study of Alsayed, et. al., (2020) has aimed to predict the epidemic peak, the infection rate, and short-time forecasting of the number of infected cases in Malaysia. They have applied Susceptible–Exposed–Infectious–Recovered (SEIR) model, estimated using the Genetic Algorithm (GA) and Adaptive Neuro-Fuzzy Inference System (ANFIS) model for their purpose. Ahmad, et al.,(2020) have applied mathematical techniques namely Fuzzy Autocatalytic Set to analyze the COVID- 19 outbreak in Malaysia. Labadin, J., & Hong, B.H.(2020) have applied the SEIR model to predict infected cases in Malaysia. The prediction of infected cases of Malaysia was the objective of Ariffin, et.al.,(2020). They have applied the SIR model. Ankaral, et. al (2020) was aimed to model active cases, death, and recovery of the pandemic for 25 countries including Thailand. They have applied Auto-Regressive Integrated Moving Average (ARIMA) (p,d,q), Simple Exponential Smoothing, Holt's Two Parameter, Brown's Double Exponential Smoothing Models for the purpose. ARIMA models employed by Dehesh, et.al.,(2020) to forecast the amount of daily confirmed COVID -19 cases in Italy, China, South Korea, Iran, and Thailand. Yan, et.al.,(2020) have applied Fudan-CCDC (China Center for Disease Control and Prevention) model to analyze things of COVID- 19 in East Asia followed by Singapore. The SEIR model has applied by Udomsamuthirun, et.al (2020) to predict the spread of the pandemic within the ASEAN region.

The literature has emphasized that the researches applied mathematical models, statistical models, and soft computing techniques to forecast and analyzed the pandemics in Malaysia, Singapore, and Thailand. Some of the models are; SEIR, Curve Fitting Model with Probability Density Function and Skewness Effect, SIR, System Dynamic model, Fudan-CCDC model, ARIMA, Simple Exponential Smoothing, Holt's Two Parameter model, Brown's Double Exponential Smoothing models. Besides, soft computing techniques like GA and ANFIS model and mathematical techniques like the Fuzzy Autocatalytic Set have applied for the purpose. The researches concentrations in Malaysia were very high but had been very low in Thailand and Singapore.

3. METHODOLOGY

The daily confirmed cases of COVID-19 of Malaysia, Thailand, and Singapore for the period of 22nd January 2020 to 29th June 2020 were obtained from the WHO database. The pattern recognition of a data series paves the path for model selections (Konarasinghe, 2016). It gives an insight into the trends, seasonal variations, cyclical variations, and volatility within a precise period (Konarasinghe, 2016). Hence, time series plots and Auto Correlation Functions (ACF) were used for the aim, as done by Konarasinghe & Abeynayake (2014). Supported by pattern recognition, the linear trend model, and Double Exponential Smoothing (DES) techniques were tested to forecast the

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pandemic.The Anderson Darling test, ACF, and Ljung-Box Q (LBQ)-test were used to test the validation criterion and fit the model. The forecasting ability of the models was assessed by two measurements of errors; Route Mean Square Error (RMSE), and Mean Absolute Deviation (MAD) in both model fitting and verification process, as per Konarasinghe, et al. (2015).

3.1 Trend Models

Trend analysis fits a general trend model to time series data and provides forecasts (Konarasinghe, 2015). This study has applied linear and quadratic trend models and the models follow:

Linear Trend Model $Y_t = \alpha + \beta t + \varepsilon$ (1)

Quadratic Trend Model $Y_t = \alpha + \beta_1 \mathrm{t} + \beta_2 \mathrm{t}^2 + \varepsilon$ (2)

3.2 Double Exponential Smoothing Model

This technique works well when a trend is present, but it also is a general smoothing method (Konarasinghe, 2016). This method is found using two dynamic estimates, α and β; with values between 0 and 1 (Konarasinghe, 2016). They represent level and trend respectively. Formulae of DES technique (Holt' method) are;

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

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

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

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

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.

4. RESULTS

The analysis contains two main parts:

4.1 Pattern recognition.
4.2 Forecasting pandemics.

The pattern recognition of the pandemics for Malaysia, Thailand, and Singapore was the initial step.

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4.1 Pattern Recognition

The pattern recognition was done to examine the behavior of pandemic. It's useful to identify an appropriate model to forecast the spread (Konarasighe, 2016).

4.1.1 Pattern Recognition of Malaysia

The time series plot of daily infected cases in Malaysia for the period of 22nd January to 29th June 2020 in Figure 1. The first confirmed case reported from Malaysia on 25th January 2020. The number of daily cases was very low up to 12th March 2020 and shows an enormous jump commenced on 15th March and moved with big fluctuations till 14th April. Afterward, there was a decline with a fluctuation till 29th June 2020. Then, the infected cases reported very low. The Auto Correlation Function (ACF) as in Figure 2. It shows the non- stationary behavior of the daily infected cases. 15th April 2020, is the beginning of the jump of daily infected cases.

Figure 1: Time Series Plot of Daily Infected Cases in Malaysia

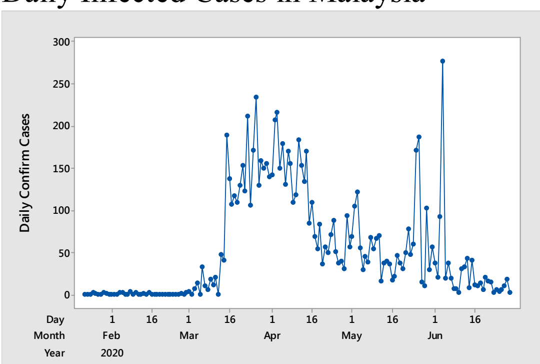
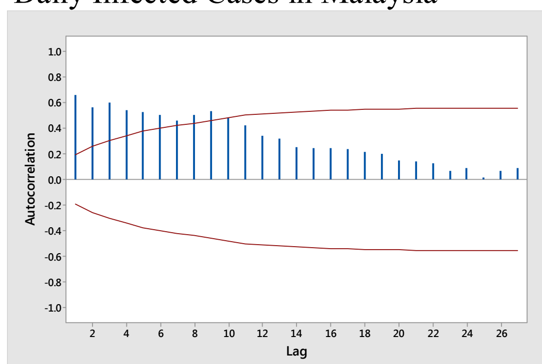


Figure 2: ACF of Daily Infected Cases in Malaysia



Hence, the pattern after 15th April 2020 in Malaysia was re-examined. Figure 3, time series plot shows fluctuations of daily infected cases. Two unusual jumps observed from 24th to 27th of May and 2nd to 5th of June 2020. Afterward, the reported cases were very low. The ACF (Figure 4) confirms the non-stationary of the infected cases after 15th April 2020.

Figure 3: Time Series Plot of Daily Cases after 15th April 2020

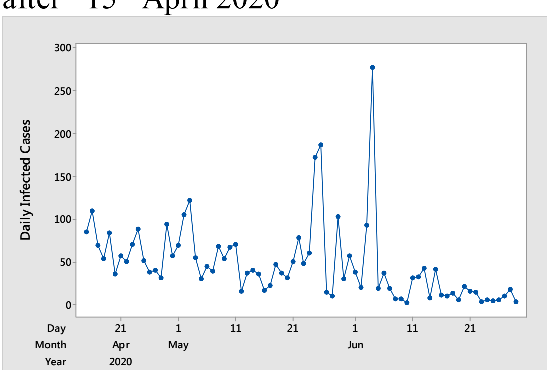
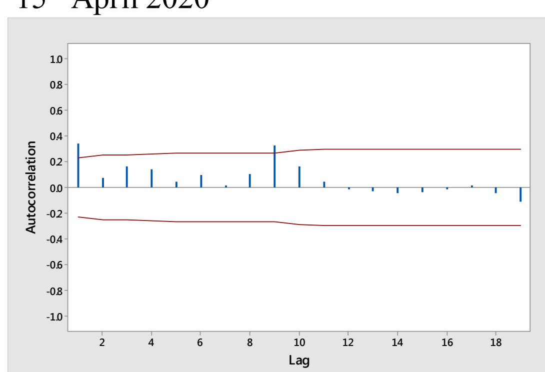


Figure 4: ACF of Daily Cases after 15th April 2020



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4.1.2 Pattern Recognition of Thailand

Time series plot of daily infected cases in Thailand for the period of 22nd January to 29th June 2020 in Figure 5.

Figure 5: Time Series Plot of Daily Infected Cases in Thailand

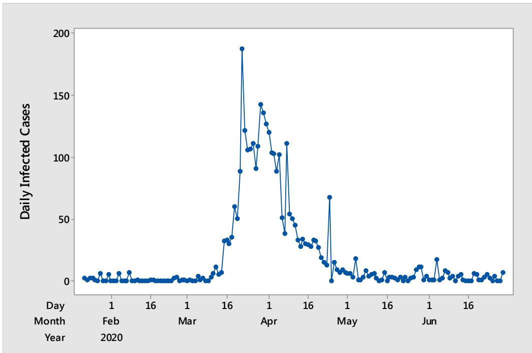
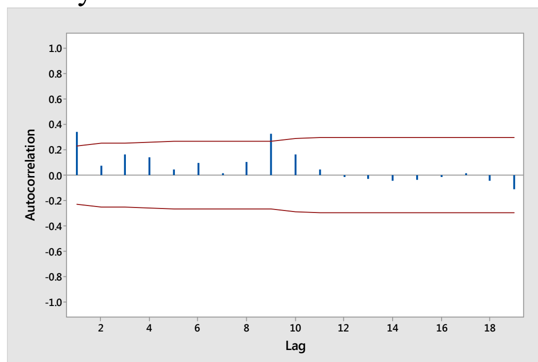


Figure 6: ACF of Daily Infected Cases in Thailand



The first confirmed case reported from Thailand on 22nd January 2020. The number of daily cases was very low up to 14th March and shows rapid growth and a drop with a fluctuation till 25th April 2020. Afterward, there's a downward trend up to 29th June 2020. The ACF in Figure 6 confirmed the non- stationary behavior of the daily infected cases. The pattern after 25th April 2020 in Thailand was re-examined. Figure 7, time series plot shows fluctuations of daily infected cases. The reported cases were low after the 28th April. But there have been four jumps detected from 25th to 28th of April, 3rd to 5th of May, 24th to 30th of May, and 3rd to 5th of June 2020. Afterward, the reported cases were very low. The ACF (Figure 8) confirmed the stationary of the infected cases after 25th April to 29th June 2020.

Figure 7: Time Series Plot of Daily Cases after 25th April 2020

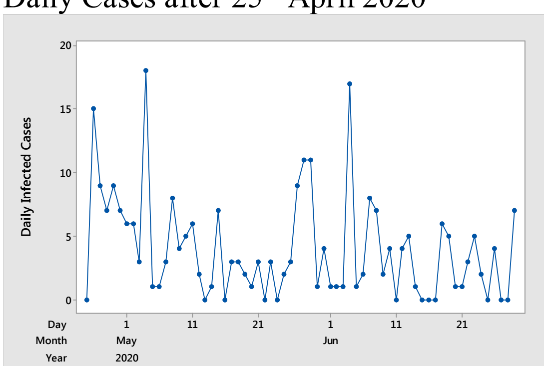
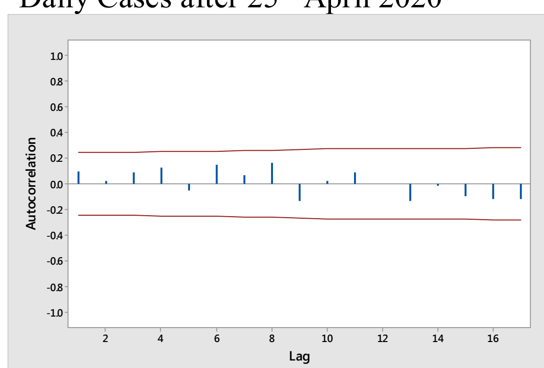


Figure 8: ACF of Daily Cases after 25th April 2020



4.1.3 Pattern Recognition of Singapore

Time series plot of daily infected cases in Singapore for the period of 22nd January to 29th June 2020 in Figure 9.

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Figure 9: Time Series Plot of
Daily Infected Cases in Singapore

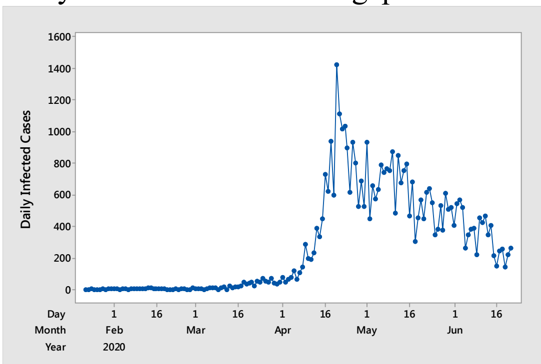
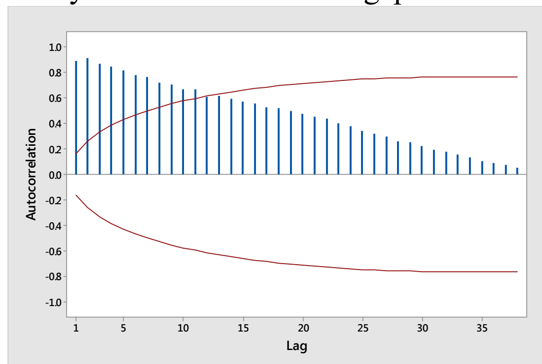


Figure 10: ACF of
Daily Infected Cases in Singapore



The first confirmed case reported from Singapore on 23rd January 2020. The number of daily cases was low up to 8th April and shows a rapid climb till 20th April 2020. The decline of daily cases commenced after 22nd April. Afterward, there was a downward trend until 29th June 2020. The ACF in Figure 10 confirmed the non- stationary behavior of the daily infected cases. The pattern after 22nd April 2020 in Singapore was re-examined. Figure 11, time series plot shows fluctuations of daily infected cases after 22nd April. The reported cases have shown a declining trend with big fluctuations. The ACF (Figure 12) confirm the non- stationary of the infected cases after 22nd April to 29th June 2020.

Figure 11: Time Series Plot of
Daily Cases after 22nd April 2020

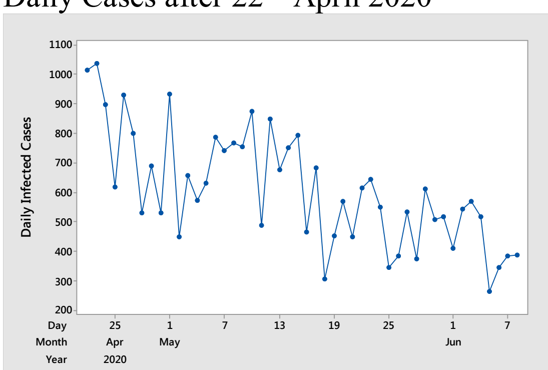
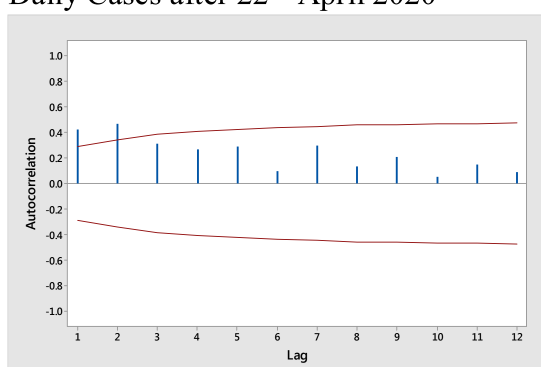


Figure 12: ACF of
Daily Cases after 22nd April 2020



4.2 Forecasting Pandemics

The patterns of daily infected cases of Malaysia, Thailand, and Singapore were examined under paragraph 4.1. All three countries reported daily infected cases and their patterns were supported to suit various trend models, ARIMA and DES, etc. Hence, the forecast of daily infected cases in Malaysia, Thailand, and Singapore was meaningful.

4.2.1 Forecasting Pandemic in Malaysia

The series suggests the non- stationary criteria and shows a trend. Initially, all trend models (Linear, Quadratic, Growth Curve, and S-Curve) were tested. Only the linear trend and DES model were successful. DES was tested after trend models. Log transformed data were used for the analysis. The summaries of the linear trend and DES models are given in Table 1;

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

Model	Model Fitting		Model Verification	
$\ln Y_t = 4.228 - 0.01270t$	MAD	0.4947	MAD	1.0966
	RMSE	0.6673	RMSE	1.3337
	Normality	P = 0.179		
	Independence of Residuals	Yes		
α (level) 0.1 γ (trend) 0.1	MAD	0.5421	MAD	1.0608
	RMSE	0.7118	RMSE	1.3015
	Normality	P = 0.440		
	Independence of Residuals	Yes		

The Anderson Darling test confirmed the normality of residuals. The ACF of the residuals and LBQ test confirmed the independence of residuals of both models. The measurements of errors were low under the fitting and verifications of linear and DES models. Both models were satisfied with the model validation criterion.

Figure 13: Actual, Fits and Forecast (Lin)

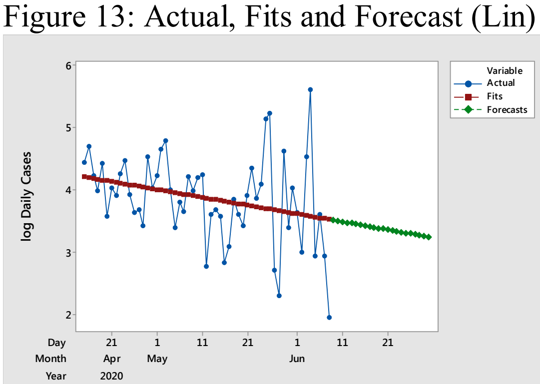
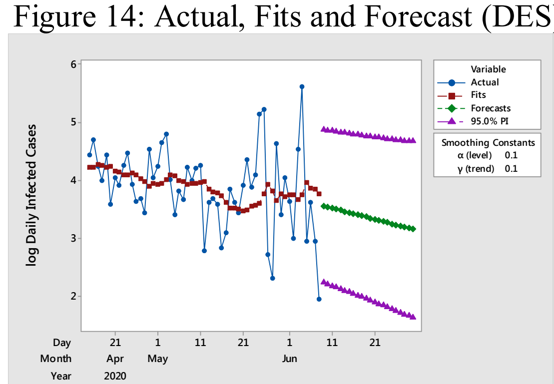


Figure 14: Actual, Fits and Forecast (DES)



Actual, fits, and forecast of a linear trend and DES models in Figures 13 and 14. Both linear and DES models show the downward trend of daily infected cases in Malaysia. The deviation of both models was very low. Therefore a number of infected cases would be zero from 219 days from 15th April 2020. In other words, the number of infected cases would be zero by 19th November 2020 in Malaysia.

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4.2.2 Forecasting Pandemic in Thailand

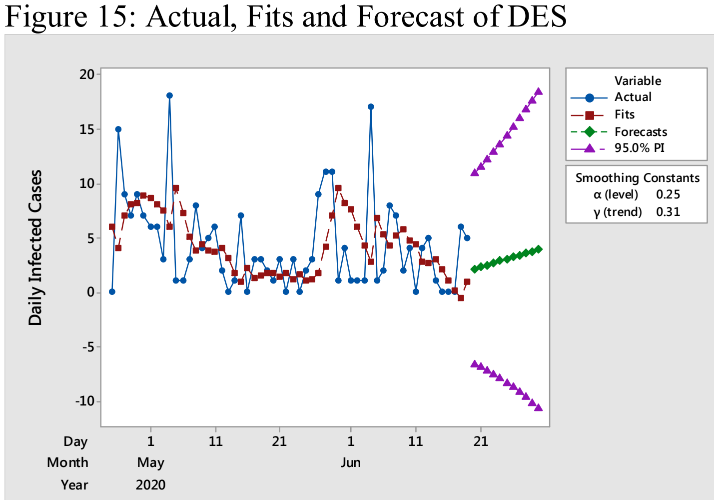
The series suggests stationary criteria. A clear trend wasn't visible. Considering the pattern of the series ARIMA model was tested. But it had not been fitted. Hence, DES was tested. The summary of the DES models are given in Table 2;

Table 2: Summary of Model Fittings and Verifications of DES

Model	Model Fitting		Model Verification	
α (level) 0.25 γ (trend) 0.31	MAD	3.568	MAD	2.051
	RMSE	4.666	RMSE	2.376
	Normality	P = 0.066		
	Independence of Residuals	Yes		

The Anderson Darling test confirmed the normality of residuals. The ACF of the residuals and LBQ test confirmed the independence of residuals of the DES model. The measurements of errors were low under the fitting and verifications. DES $\alpha = 0.25$, $\gamma = 0.31$ was satisfied with the model validation criterion. Figure 15 is the actual, fits, and forecast of the DES model. The deviations between actual, forecast and fits were very low. According to the results of DES $\alpha = 0.25$, $\gamma = 0.31$, the number of infected cases would be zero from 219 days from 25th April 2020. In other words, the number of infected cases would be zero by 29th November 2020 in Thailand.

Figure 15: Actual, Fits and Forecast of DES



4.2.3 Forecasting Pandemic in Singapore

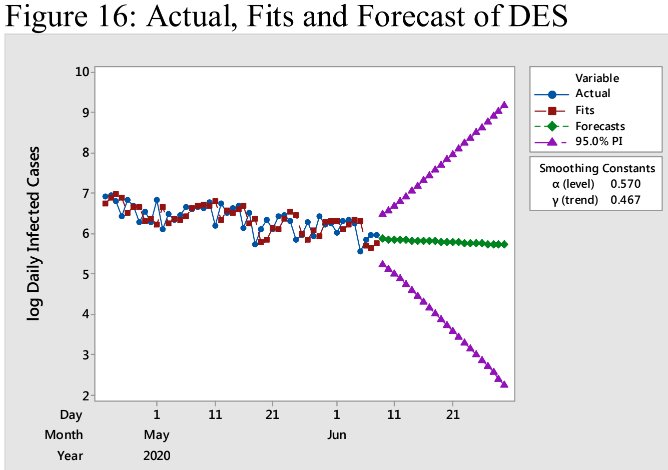
The series suggests non-stationary criteria. There was a visible trend. Considering the pattern of the series all trend models were tested initially. But, the attempts for trend models were failed. Hence, DES was tested. The summary of the DES models are given in Table 3;

Table 3: Summary of Model Fittings and Verifications of DES

Model	Model Fitting		Model Verification	
α (level) 0.570 γ (trend) 0.467	MAD	0.25133	MAD	0.41577
	RMSE	0.32039	RMSE	0.49542
	Normality	P = 0.063		
	Independence of Residuals	Yes		

The Anderson Darling test confirmed the normality of residuals. The ACF of the residuals and LBQ test confirmed the independence of residuals of the DES model. The measurements of errors were low under the fitting and verifications. DES α = 0.570, γ = 0.467 was satisfied with the model validation criterion. Figure 16 is the actual, fits, and forecast of the DES model. The forecasted infected cases show a declining trend. The deviations between actual, forecast and fits were very low. According to the results of DES α = 0.570, γ = 0.467, number of infected cases would be zero from 961 days from 22th April 2020. In other words, the number of infected cases would be zero by 8th December 2022 in Singapore.

Figure 16: Actual, Fits and Forecast of DES



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5. CONCLUSION AND RECOMMANDATIONS

It was concluded that the linear trend and DES models are suitable models in forecasting daily infected cases of the pandemic in Malaysia, whilst the DES is suitable for Thailand, and Singapore. Consistent with the fitted models of this study, the number of infected cases would be zero by 29th November 2020 in Thailand, 19th November 2020 in Malaysia, and 8th December 2022 in Singapore. The study was focused on adjoining countries of Southeast Asia; Thailand, Malaysia, and Singapore geographically located as a belt. The results of this study emphasize the future and present status of the pandemic. How long that the people might be accepting the pandemic. When is going to be the day that they will defeat the pandemic? How can they achieve their dreams? What kind of precautions to be taken? Many answers and guidance have given by global researches. This study is one of them. The results of the study revealed that the times of the infected cases become zero in Thailand, Malaysia, and Singapore. Thailand and Malaysia would be recovered very soon but Singapore would take a very long period. However correct adaptation of non-pharmaceutical and immunization practices and the morals of the general public may change the trends.

Due to the absence of antiviral drugs for COVID-19, the effective implementation of immunization practices such as; consume suitable food and beverages (Natural and Medicinal Food), avoid bad habits like smoking and alcohol consumption, use warm water, steaming, etc. are important to guard against the pandemic (Konarasinghe, 2020). Besides, non-pharmaceutical interventions like hand hygiene and respiratory etiquette, surveillance and case reporting, and rapid viral diagnosis altogether settings might be another remedy to avoid the spread of pandemic (Aledort,et. al., 2007). Besides, social distancing, avoid gatherings, safety arrangements in public transport like fresh air to circulate through the A/C filters, temperature checking, and masks, cleaning process are some practices for avoiding spreading and defeat pandemic. Proper identifications and screenings clusters were other important factors to avoid community spread. This might be achieved by gathering and processing information of infected, suspected, and associated people of a neighborhood. Military intelligence people are the foremost suitable for this task. Authorities need to deploy them to collect information and assist the medical and healthcare officers to avoid pandemic spread.

It is a well-known fact that the indigenous treatments and control systems are useful of avoid spreading and enhance the immunization of individuals. These practices were originated from their histories and cultures. Hence, this can be the time to look and adopt those methods to combat the pandemic. Media should play the vital role of educating general public sharing remedies to avoid spread and other preventive measures. The policies for travel restrictions and other movements of the overall public may be imposed and monitored by the authorities. However, the morals of the overall public, government policies, and monitoring and commitment of the medical personal may be the base of combat the pandemic and gain wealth to the people of those countries.

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