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Modeling Consumer Price Index of Malaysia: Application of Exponential Smoothers

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ABSTRACT

The Consumer Price Index (CPI) indicates whether the economy of a country is experiencing inflation, deflation, or stagflation. The variation of the CPI are used to assess price changes associated with the cost of living. Malaysia holds the 35th highest Gross Domestic Product (GDP) in world ranking and the 3rd in Southeast Asian ranking in the year 2022. At present the CPI of Malaysia shows an increasing trend. Therefore, the study design to predict the CPI of Malaysia. Monthly CPI data of Malaysia for the period of January 2012 to March 2022 were obtained from the International Monitory Fund (IMF) database. Double Exponential Smoothing (DES), and Holt's Winter's three parameter additive and multiplicative models were tested to forecast the CPI of Malaysia. Auto Correlation Function (ACF), Anderson Darling test and Ljung-Box Q (LBQ) test were applied to test the model assumptions to validate the model. Both relative and absolute measurements of errors were applied to assess the forecasting ability of the model. Results of the study revealed that the DES is the most suitable model to forecast the CPI of Malaysia. According to the DES model, there is an increasing trend of the CPI of Malaysia.

Keywords: Consumer Price Index, Inflation, DES, Holt's Winters', Trend

1. INTRODUCTION

1.1 Background of the Study

The prices of goods and services are often changed due to the effectiveness of economic policies, changes in government, national policies and various other factors, including natural disasters. The average change in the prices over time that consumers pay for a basket of goods and services of a specific country or a province is measured by the Consumer Price Index (CPI) (Fernando, 2021).The CPI indicates whether the economy of a country is experiencing inflation, deflation, or stagflation (Fernando, 2021). The changes in the CPI are used to assess price changes associated with the cost of living (Fernando, 2021). The Gross Domestic Products (GDP) highly influences the CPI under any circumstances and they are closely related to each other. The cost of production and the price of the goods and services has strong relationship. The cost of the strategic resources highly influence to the CPI and GDP. The CPI is used to adjust wages, retirement benefits, tax and other important indicators in the economy. According to the IMF statistics, Malaysia holds the 35^{th} highest GDP in world ranking and the 3^{rd} in Southeast Asian ranking in the year 2022. There are three main contributors to the Malaysian GDP (Al-Amin et al, 2007). They are the service sector, industry sector, and agriculture sector (Al-Amin et al, 2007).The service sector is the leading one followed by industry and agriculture (Al-Amin et al, 2007).Broad money, export goods and services, household final consumption expenditure and GDP were few identified determinants (Venkadasalam,2015). The CPI of Malaysia shows a minor increasing trend. It means the price of the selected goods and services in the consumer basket is increasing gradually. It is a minor inflation situation in the country. This situation can be a symptom of a healthy economy (Floyd, 2022). But the future behavior of the CPI is unpredictable. There could be many reasons influence to increase the price of the goods and services in Malaysia.

Forecasting the behavior of CPI is very important to minimize the risk of the economy. It is road mapped to overcome the inflation of any country. To achieve the objective of forecasting, global researches have applied many stochastic models. According to the literature, Exponential smoothers are one of the successful stochastic approach applied by global researchers for the purpose.

1.2 Research Problem

The increasing CPI shows an increasing price of the goods and services in Malaysia. It may lead to an inflation situation in the country in the future. This would lead to reducing the purchasing power of consumers. Besides, lower-income consumers have to spend a higher proportion of their income to purchase day-to-day needs. Further, there could be negative effects on the trade-off between inflation and unemployment in both public and private sectors (Floyd, 2022). To overcome these consequences it is essential to predict the CPI of Malaysia.

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1.3 Objective of the Study

To forecast the Consumer Price Index of Malaysia.

1.4 Significance of the Study

The results of the study can be used to predict the behavior of the CPI of Malaysia. It gives insight into the effectiveness of the monitory and fiscal policies of the country. Besides, effective prediction would guide to revise or impose economic and price controlling policies of Malaysia. Prediction of future behavior is another guide for investment decisions for investors. For example, the stock prices of the energy sector will increase due to the rise of energy prices (The Investopedia Team, 2021). The share prices of the energy companies will increase due to inflation (The Investopedia Team, 2021). Real-estate sector is another example for favorable investment in such situations. Further, it is a guide to increase the production, including the substitutes, and create new demand of the consumers (Konarasinghe 2022). It is another guide for financial budget planning for both public and private sector industries in Malaysia. The results of the study can be used to work out the potential needs in wage shifts and necessary adjustments in human capital and resource, downsizing, outsourcing to increase the profit margins of all sectors contribute to the Malaysian GDP.

2. LITERATURE REVIEW

The review of the study focused on CPI modeling research papers. Stochastic models and Soft computing techniques have been applied for the aim. Stochastic modeling was the main concern of many researchers.

2.1 Studies Based on Modeling CPI

Konarasinghe (2022) has used Auto-Regressive Distributed Lag Model (ARDLM), Double Exponential Smoothing (DES), and Auto-Regressive Integrated Moving Average (ARIMA) to forecast CPI of Thailand. ARDLM is the most suitable model for the purpose. Konarasinghe (2021-a) has used Sama Circular Model (SCM), Holt-Winters' additive and multiplicative models, and Seasonal Auto-Regressive Integrated Moving Average (SARIMA) to forecast CPI of the USA. Holt-Winters' additive model is the most suitable for forecasting. Djami et al (2021) have used ARIMA model to forecast the CPI of Ambon city of Indonesia. Shinkarenko et al (2021) have used ARIMA and Holt-Winters' to forecast the CPI of Ukraine. Konarasinghe (2021-b) has used DES to forecast the CPI of the USA. Purbasari et al (2020) have used ARIMA and Artificial Neural Network (ANN) to predict the Indonesian CPI. The results of the study revealed that the ANN performed better than ARIMA. Khamis, et al (2020) have used ARIMA and Simple Linear Regression for modeling CPI of Malaysia. ARIMA performed better than Simple Linear Regression in their study. Konarasinghe (2020) has used ARDLM to forecast the CPI of Thailand. Aabeyir (2019) has used Simple Exponential Smoothing (SES), DES, and Winters' additive and multiplicative models to forecast the CPI of Ghana.

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The Winters' multiplicative model performed better than other models in this study. Jere et al (2019) have used Error Correction Model (ECM) and ARIMA to forecast the CPI of Zambia. The results of the study revealed that ECM is the most suitable for this purpose. Nyoni (2019-a) has used ARIMA to predict the CPI of Mauritius. Konarasinghe, W.G.S. (2019-a) has applied the SCM and ARIMA on the forecasting CPI of India and found that SCM performed better than ARIMA. Nyoni (2019-b) has used ARIMA to forecast the CPI of Germany. Singla et al (2019) have used Holt-Winters' additive and SARIMA model to forecast the CPI of India. The performances of both models were extremely good. Sinha et al (2018) have used Neural Network Models to forecast the CPI of India. Gjika et al (2018) have used SARIMA and Multiple Regression model to forecast the CPI of Albania.

The results revealed that SARIMA performed better than Multiple Regression. Ambukege, et al (2017) have used Neuro-Fuzzy modeling for forecasting the CPI of Tanzania. Norbert et al (2016) have used ARIMA to model the CPI of Rwanda. Kharimah et al (2015) has used ARIMA to forecast CPI of Bandar Lampung City, Indonesia from 2009-2013. Adams et al (2014) have used ARIMA to model CPI of Nigeria. Alibuhtto (2014) has used the Vector Auto-Regressive (VAR) model to predict the Colombo Consumer Price Index (CCPI) of Sri Lanka. Zhang et al (2013) have used ARMA to forecast the CPI of China.

The ARIMA was highly applied to model CPI. Besides, SARIMA, ARDLM, ECM, DES, SCM, SES, VAR, Holt-Winters', Multiple Regression and Simple Linear Regression were other stochastic models applied for the aim. Some researchers have applied soft computing approaches. ANN and the combination of ANN and fuzzy logic were a few of them. They were highly successful in forecasting CPI. The review of the study revealed that SCM, ECM, Holt-Winters', ARDLM and ANN outperformed ARIMA on a few occasions. Testing the model assumptions and the verification part was not specified clearly in a few studies. The ARIMA model shows straight line in forecasting. It doesn't capture the actual behavior of the series. The similar situation has observed during the applications of DES too.

3. METHODOLOGY

Monthly data of CPI of Malaysia for the period of January 2012 to March 2022 were obtained from the International Monitory Fund (IMF) database. The pattern of the CPI paves the path for the model selection (Konarasinghe, 2016-a; 2016-b); and (Konarasinghe, W.G.S., & Abeynayake, 2014). The data series could be included seasonal, cyclical, trends, heavy and minor volatility, irregular wave-like pattern with; constant amplitude, increasing amplitude, decreasing amplitude , or a mix within the period (Konarasinghe & Konarasinghe, 2021):(Konarasinghe, W.G.S. & Abeynayake, 2014). Such behaviors recognized by the Auto Correlation Function and the time series plots (Konarasinghe, W.G.S., & Abeynayake, 2014). As per the behavior of the data series, DES and Holt's Winter's three parameter additive and multiplicative models were selected to forecast the CPI of Malaysia. ACF, Anderson Darling test, and Ljung-Box Q (LBQ) test were applied to test the assumptions of the selected models (Konarasinghe, W.G.S., et al, 2015). Three measurements of errors were used to assess the forecasting ability Konarasinghe, (2018; 2016-c; 2015-a; 2015-b).They are; Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE), and Mean Absolute Deviation (MAD) Konarasinghe, (2018; 2016-c; 2015-a; 2015-b).

3.1 Double Exponential Smoothing Model

Double Exponential Smoothing (DES) provides short-term forecasts (DeLurgio, 1998). This model uses a second smoothing constant β to separately smooth the trend (DeLurgio, 1998). Holt's model further adjusts each smoothed value for the trend of the previous period before calculating the new smoothed value (DeLurgio, 1998). This model includes two dynamic estimates. They are, α and β; with values between 0 and 1 (Konarasinghe, 2016-d). They represent level and trend respectively. Formulae of DES technique (Holt's method) are;

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

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

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

$$F_{t+m} = L_t + mT_t \qquad (1\text{-}4)$$

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.

3.2 Holt's Winters' Three Parameter Models

Winters' Method smoothers data by Holt-Winters exponential smoothing and provides short to medium-range forecasting (Konarasinghe, 2016-d). This model can be applied when both trend and seasonality are present (Holt, 1957). These two components are 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 Winters' multiplicative model are;

$$L_t = \alpha (Y_t / S_{t-p}) + (1-\alpha) [L_{t-1} + T_{t-1}] \qquad (2\text{-}1)$$

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

$$S_t = \gamma (Y_t / L_t) + (1-\gamma) S_{t-p} \qquad (2\text{-}3)$$

$$\hat{Y}_t = (L_{t-1} + T_{t-1}) S_{t-p} \qquad (2\text{-}4)$$

Where,

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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 Winters' additive 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.

4. RESULTS

The analysis contains two main parts:

4.1 Pattern recognition of CPI of Malaysia.
4.2 Forecasting CPI of Malaysia.

4.1 Pattern Recognition of CPI of Malaysia

Figure 1 is the time series plot of CPI of Malaysia for the period of January 2012 to March 2022. The pattern of the CPI of Malaysia shows an increasing trend up to November 2014. There was decay observed from November 2014 to February 2015. After February it shows an increasing trend with minor fluctuations till February 2017. Once again there was a decay till July 2018.

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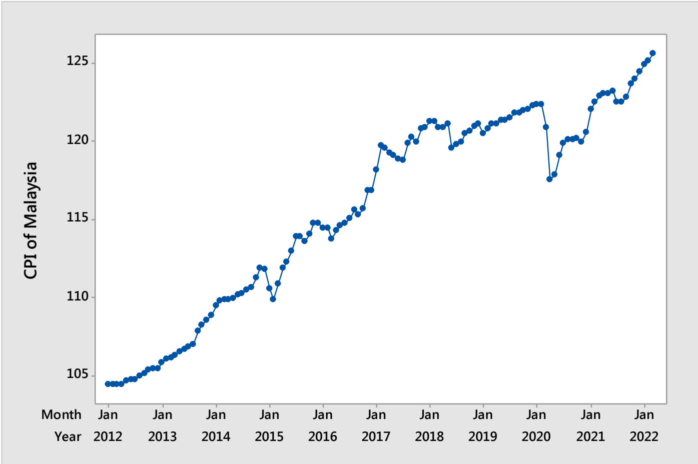
Figure 1: Time Series Plot of CPI of Malaysia



After July the CPI shows an increasing trend till February 2020 and it declined from February to April 2020. After April 2020 it shows an increasing trend with minor fluctuations.

Figure 2 is the ACF of the CPI of Malaysia. The behavior of the CPI shows a trend with a decay. There are two seasonal changes with 3-4 months observed in the ACF. Besides, the series of CPI confirmed the weak stationary.

Figure 2: ACF of CPI

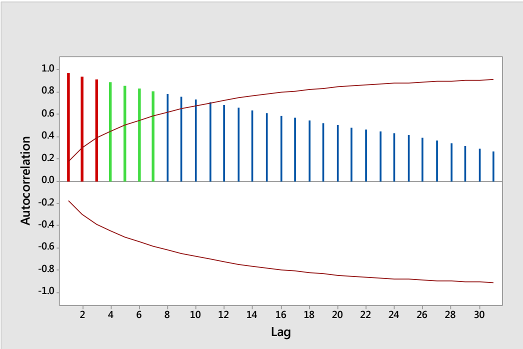


Figure 3: Plot of 1st Difference of CPI

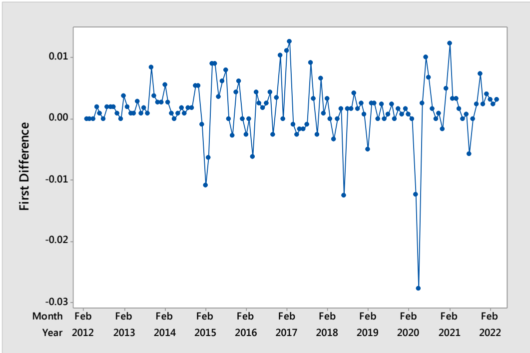


Figure 3 has shown the first difference series of the CPI. The wave-liked pattern of the CPI is high for the period December 2014 to March 2019. A similar behavior shows after March 2020.The pattern of the CPI of Malaysia paves the path to select the DES and Holt's Winters' three parameter additive and multiplicative models to forecast the CPI of Malaysia.

4.2 Forecasting CPI of Malaysia

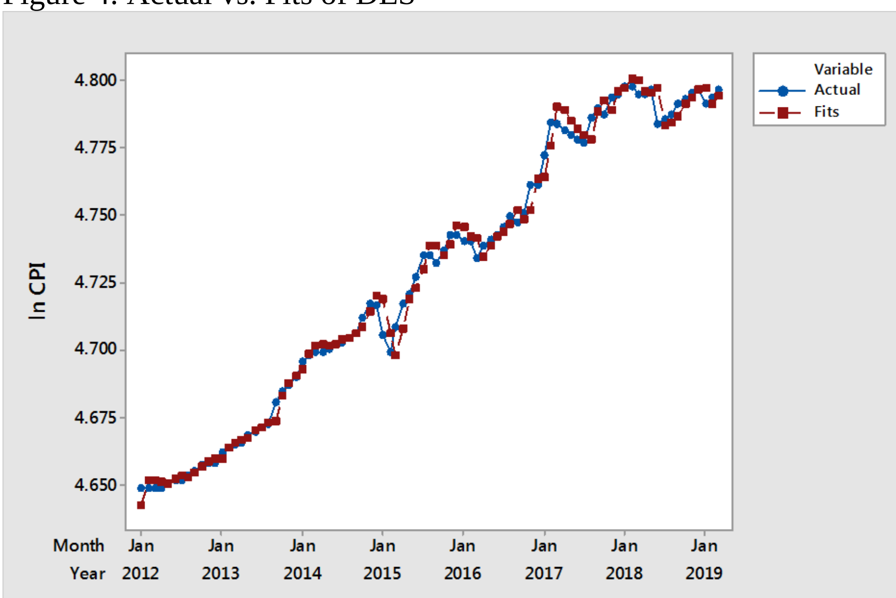
The DES model was tested at the beginning with different weights bases on trial and error method. The results given in Table 1.

Table 1: Model Summary of DES

Model	Model Fitting		Model Verification	
α (Level) 0.94 γ (Trend) 0.20	MAPE	0.068877	MAPE	0.201498
	MSE	0.000019	MSE	0.000207
	MAD	0.003265	MAD	0.009652
	Normality	P = 0.114		
	Independence of Residuals	Yes		

DES α:0.94, γ: 0.20 satisfied all model validation criteria of the normality and the independence of the residuals. The forecasting ability of the DES model is extremely high. It is below 1% under the fitting and the verification. Figure 4 shows the actual vs fits of the fitted DES model. The behavior of fits follows an analogous pattern of the actual series with the least deviation.

Figure 4: Actual vs. Fits of DES



Holts' Winters' multiplicative and additive models were tested after the DES model. Weights of parameters based on trial and error method. The seasonal length of 3 and 4 months has been observed from ACF in Figure 2. Therefore, Holts' Winters' multiplicative and additive models were tested for 3 and 4 months consecutively. The model summary is in Table 2.

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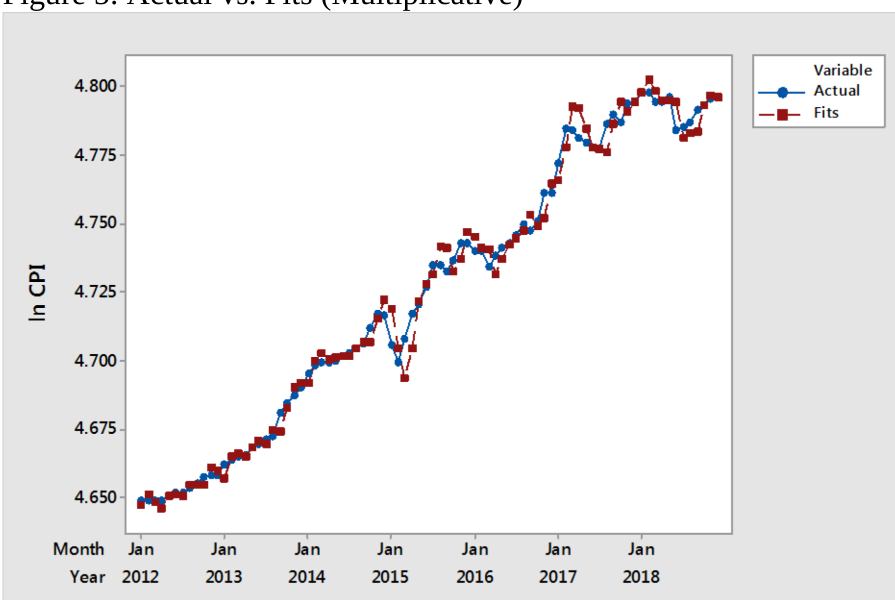
Table 2: Model Summary of Holts' Winters' (Multiplicative)

Model	Model Fitting		Model Verification	
Multiplicative (3) α (Level) 0.8 γ (Trend) 0.6 δ (Seasonal) 0.3	MAPE	0.07575	MAPE	0.59076
	MSE	0.00002	MSE	0.00105
	MAD	0.00359	MAD	0.02836
	Normality	P= 0.061		
	Independence of Residuals	Yes		

The fitted Holts' Winters' multiplicative model of α: 0.8, γ:0.6, and δ:0.3 with seasonal length 3 was tested at the beginning. The model satisfied the model validation criterion shown in Table 2. The measurements of errors are extremely low under the fitting and verification. It has confirmed that the forecasting ability of the model is highly satisfactory. Actual vs fits of fitted Holts' Winters' multiplicative model are shown in Figure 5. The pattern of both actual and fits are similar with the least deviation.

Figure 5: Actual vs. Fits (Multiplicative)



Holts' Winters' additive model was tested afterward with the same seasonal length. The model summary is in Table 3.

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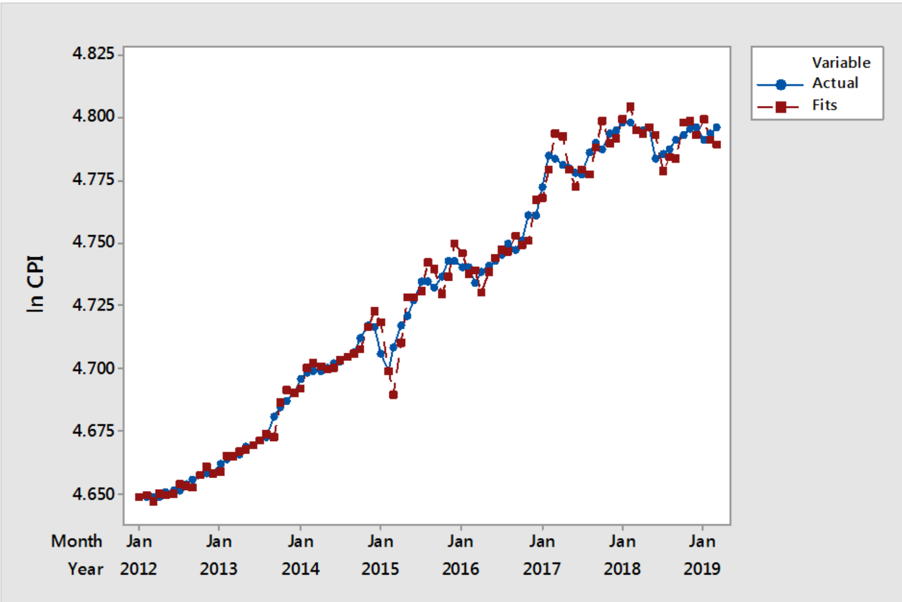
Table 3: Model Summary of Holts' Winters' (Additive)

Model	Model Fitting		Model Verification	
Additive (3) α (Level) 0.8 γ (Trend) 0.999 δ (Seasonal) 0.3	MAPE	0.08088	MAPE	1.55165
	MSE	0.00002	MSE	0.00691
	MAD	0.00383	MAD	0.07455
	Normality	P= 0.072		
	Independence of Residuals	Yes		

The results of the Holts' Winters' additive model were similar to the multiplicative model. The fitted additive model of α: 0.8, γ: 0.999, and δ:0.3 satisfied the model validation criterion. Both relative and absolute measurements of errors are extremely low under the fitting. But it is little bit higher in the verification. Actual Vs fits of fitted Holts' Winters' additive model are shown in Figure 6. The behavior of fits almost followed the pattern of the actual series.

Figure 6: Actual vs. Fits (Additive)



This behavior is identical to the multiplicative model. Finally, the Holts' Winters' multiplicative and additive models were tested for the seasonal length of 4 months. The model summary is in Table 4.

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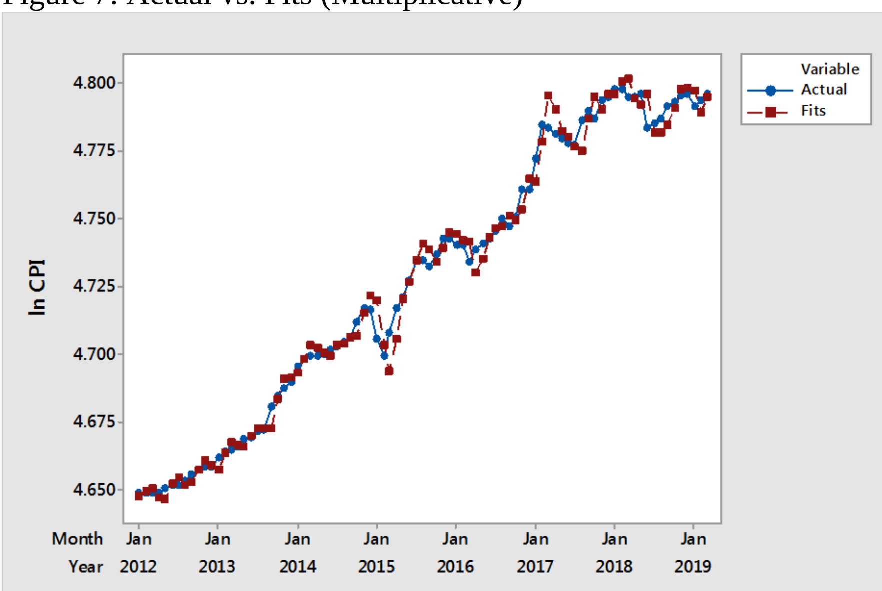
Table 4: Model Summary of Holts' Winters' (Multiplicative)

Model	Model Fitting		Model Verification	
Multiplicative (4) α (Level) 0.8 γ (Trend) 0.6 δ (Seasonal) 0.3	MAPE	0.07658	MAPE	0.29301
	MSE	0.00002	MSE	0.00035
	MAD	0.00363	MAD	0.01404
	Normality	P= 0.085		
	Independence of Residuals	Yes		

The fitted Holts' Winters' multiplicative model of $\alpha : 0.8$ and $\gamma : 0.6$, $\delta : 0.3$ satisfied the model validation criterion shown in Table 4. The forecasting ability of the model is highly satisfactory under the fitting and verification. Actual vs fits of fitted Holts' Winters' multiplicative model are shown in Figure 7. The pattern of both actual and fits are similar with the least deviation.

Figure 7: Actual vs. Fits (Multiplicative)



Holts' Winters' additive model was tested afterwards with same seasonal length. The model summary is given in Table 5.

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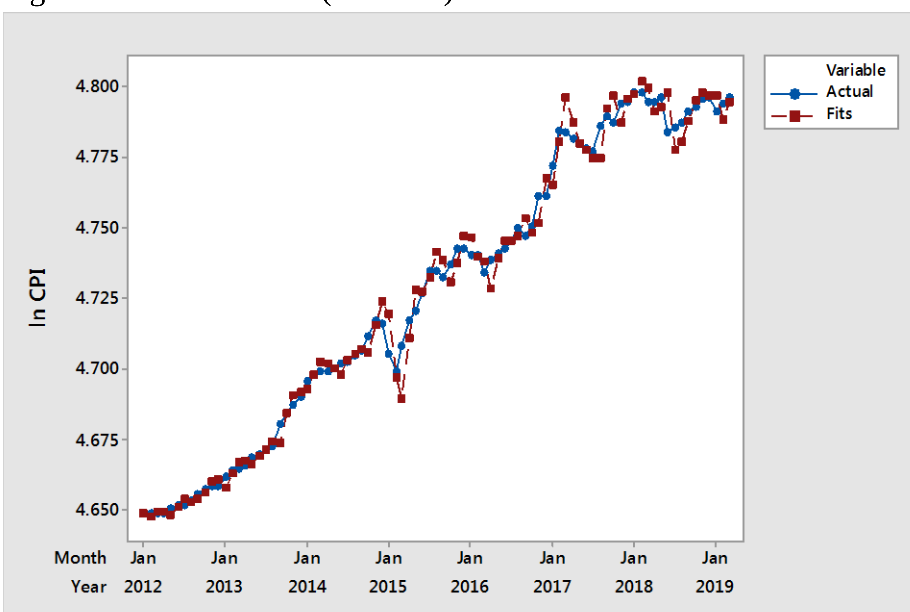
Table 5: Model Summary of Holts' Winters' (Additive)

Model	Model Fitting		Model Verification	
Additive (4) α (Level) 0.8 γ (Trend) 0.999 δ (Seasonal) 0.2	MAPE	0.080641	MAPE	0.663060
	MSE	0.000027	MSE	0.001315
	MAD	0.003825	MAD	0.031838
	Normality	P= 0.059		
	Independence of Residuals	Yes		

The performances of the Holts' Winters' additive model was similar with the multiplicative model with same seasonal length. The fitted additive model of α :0.8 and γ :0.999, δ : 0.2 satisfied the model validation criterion. Both relative and absolute measurements of errors are extremely low under the fitting and verification. Actual Vs fits of fitted Holts' Winters' additive model are shown in Figure 8.

Figure 8: Actual vs. Fits (Additive)



This behavior also identical with multiplicative model. According to the model summaries of Tables 1, 2, 3, 4 and 5, the best fitted model is DES. The DES model has the least measurements of errors than Holts' Winters' multiplicative and additive models. Model comparison of Holts'Winters' multiplicative additive and DES is shown in Figure 9.

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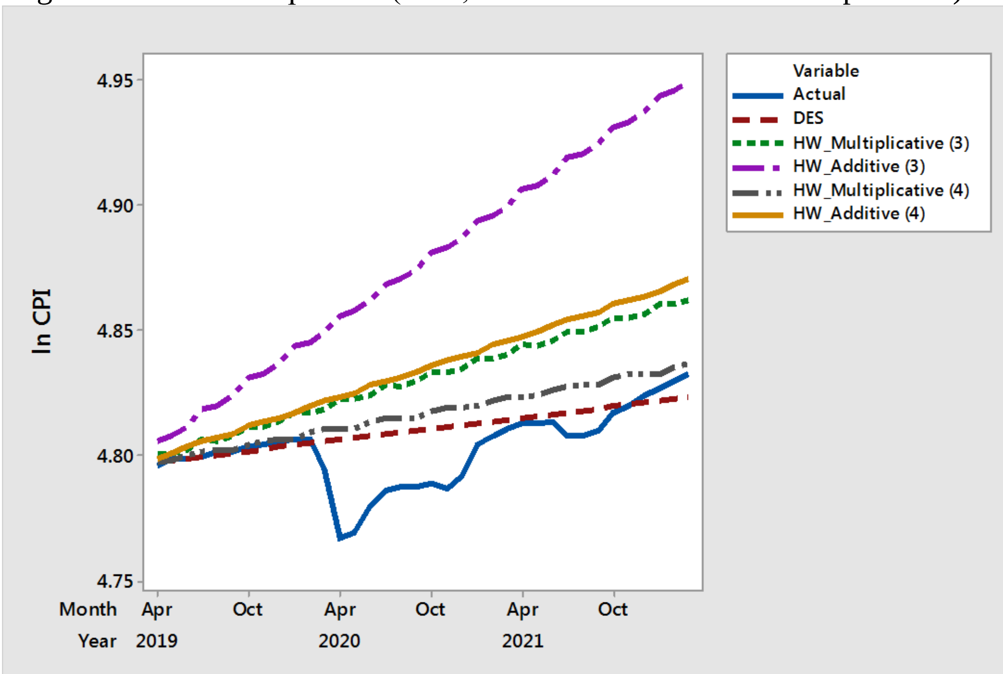
Figure 9: Model Comparison (DES, Winters' Additive and Multiplicative)



The forecasting behavior of DES was closer to the actual with the least deviation than other models. All other models had shown overestimated behavior of CPI of Malaysia. The model comparison is another solid evidence to select DES is the most suitable model for forecasting CPI of Malaysia. Table 6 is the forecasted results of CPI. This table presents the CPI forecast by DES.

Table 6: Forecasted Results of CPI (DES Model)

Year	Month	CPI	Year	Month	CPI
2022	April	126.263	2023	April	130.469
	May	126.608		May	130.826
	June	126.954		June	131.184
	July	127.302		July	131.543
	August	127.650		August	131.903
	September	127.999		September	132.263
	October	128.349		October	132.625
	November	128.700		November	132.988

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	December	129.052		December	133.351
2023	January	129.405	2024	January	133.716
	February	129.759		February	134.082
	March	130.114		March	134.449

Table 6 shows the forecasted results of CPI of Malaysia for the period of April 2022 to March 2024. The DES forecasted 24 months (2years) ahead. There was a minor increasing trend of the selected prices of goods and services overtime. The volatility of the price changes would be very less in Malaysia. This would be a symptom of a healthy economy in Malaysia.

5. CONCLUSION AND RECOMMANDATIONS

The study has tested DES, and Holts' Winters' multiplicative and additive models to achieve the objective. The past pattern of the CPI considered for model selection. The forecasting ability of the DES, and Holts' Winters' multiplicative model with seasonal length 4 were high. But the performance of the DES is extremely higher than other models. Hence, the study concluded that the DES is the most suitable model to forecast the CPI of Malaysia.

The fitted DES was applied to forecast CPI for 24 months. There is a minor increasing trend. But it is recommended to explore the causes of increasing the prices of the goods and services and take measures to control it. There could be some external factors such as; rise of raw material and other equipment prices, labor cost, supply issues and economic conditions etc. In addition there would some external factors namely; scope creep of various projects, labor productivity etc. Besides, modeling CPI of their import countries is more useful to identify the causes. The results of the study could be a guide to increase the production of goods and services in Malaysia. Further, more efforts should be made to increase domestic supplies and encourage domestic manufacturing and extractive companies to invest overseas. The share prices of the Real Estate and Energy sectors may be increasing in the future. This would be an advantage for international and domestic investors.

The present behavior of the data series is supporting to capture the seasonal behavior. It is recommended to conduct another study to capture any seasonal behaviors of the CPI of Malaysia. According to the literature, Exponential Smoothers (ES) are not popular in forecasting CPI. But this study is another evidence to recommends ES are one of the suitable approach for the purpose. But, forecasting DES provides a straight line that is not capable to capture the wave-like pattern of the actual series.

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Hence, it is recommended to test many Exponential Smoothing techniques and check the possibility to achieve the aim. Finally, it is strongly recommended to design more studies on modeling the CPI of other countries furthermore.

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