Analysis of the Trends in Domestic Prices of Petroleum Products in Sri Lanka

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***Abstract*—Crude oil plays a crucial role as a commodity with significant global economic implications. This research project aimed to identify predictive models for forecasting future oil prices in Sri Lanka, utilizing monthly data spanning over 32 years. The analysis involved examining monthly Domestic Prices for five petroleum products, Lanka Petrol 95 (LP95), Lanka Petrol 92 (LP92), Lanka Auto Diesel (LAD), Lanka Super Diesel (LSD), and Lanka Kerosene (LK) covering the period from 1990 to 2021. Three popular time series trend models, namely, Linear Trend Model (LTM), Quadratic Trend Model (QTM) and Exponential Growth Model (EGM), were used on the five petroleum product types. Furthermore, the fitted models were further assessed to find the best fitted models for each type of petroleum product using accuracy measures such as Mean Squared Deviation (MSD), Mean Absolute Deviation (MAD), and Mean Absolute Percentage Error (MAPE). According to the trend analysis results, the exponential growth model was the most suitable for LP95, LP92, LAD, LSD and LK. The results of the study offer practical implications for stakeholders in the Sri Lankan petroleum industry, enabling them to make informed decisions in a volatile global market.**

Keywords—Trend analysis, domestic prices, petroleum products, in Sri Lanka

I. Introduction

Crude oil, often referred to as 'black gold,' is a naturally occurring unrefined petroleum product consisting of hydro-carbon deposits found in underground reservoirs. This raw petroleum, known as crude oil, can be refined into various valuable petroleum products, including diesel, gasoline, and a variety of petrochemicals [1]. As countries around the world experience rapid growth and development, the corresponding surge in demand for crude oil is becoming increasingly evident. The forecast for crude oil prices is a frequent subject of analysis in the global market economy due to its substantial political and economic ramifications, more so than any other commodity. Nevertheless, even though it plays a crucial role in policymaking and economic progress, predicting its price remains difficult because of its intricate and unpredictable pricing patterns [2].

In Sri Lanka, the state-owned Ceylon Petroleum Corporation (Ceypetco) was the sole entity responsible for the importation of crude oil and refined oil, as well as storage, distribution, and retail trade until 2003 [3]. Currently, in addition to Ceypetco, private companies such as the Indian-owned Lanka India Oil (LIOC) and Sinopec, a Chinese oil and gas enterprise, operate numerous fuel stations around the island. These state-owned and private companies distribute petroleum products including petrol, diesel, kerosene and lubricants [3], [5].

The consumption of petroleum products in Sri Lanka has been used in various sectors over the years, including transport, electricity generation, and industrial purposes (such as agriculture, fisheries, and manufacturing) [3]. In Sri Lanka, major petroleum products include diesel, petrol, and kerosene, as well as additional products like LP gas and furnace oil [3]. The pricing of local petroleum is anticipated to be based on a formula considering global prices, currency exchange fluctuations, and additional cost elements [6]. Furthermore, fluctuations in the cost of petroleum exert substantial influence on the prices of commodities and services, given its crucial role as a fundamental intermediate resource in the production process [6]. Therefore, studying the trends and patterns of petroleum products is vital for a country's economic stability, energy security, environmental sustainability, and overall strategic planning. It provides valuable insights that inform policy decisions and prepare nations for potential challenges related to energy supply and pricing.

This study applies three-time series trend models: The Linear Trend Model (LTM), Quadratic Trend Model (QTM) and Exponential Growth Model (EGM), to five distinct petroleum products, namely Lanka Petrol 95 (LP95), Lanka Petrol 92 (LP92), Lanka Auto Diesel (LAD), Lanka Super Diesel (LSD), and Lanka Kerosene (LK). The aim is to identify the most suitable model that can provide more precise forecasts of petroleum prices in Sri Lanka.

II. Theory and Methodology

A. Data

This study utilized the domestic petroleum prices published by the Ceylon Petroleum Corporation in Sri Lanka. Monthly data spanning a 32-year period (1990 to 2021) was collected. Data from a 30-year period (1990 to 2019) was utilized for analysis, and the remaining price data from the years 2020 and 2021 (2 years) were reserved for validating the trend analysis. Furthermore, the results were obtained using the statistical software, Minitab 17, and a 5% level of statistical significance was considered.

B. *Trend Analysis*

Trend analysis is the initial phase of the study, employing a mathematical technique that utilizes historical data to predict future outcomes. Three popular time series trend models, LTM, QTM and EGM were applied in this research.

a) Linear Trend Model (LTM): A linear trend model in time series analysis is a mathematical representation used to illustrate how a variable relates to time. It operates on the assumption that the variable undergoes a consistent, steady change over time. In other words, when graphically representing the data, it would follow a straight-line pattern.

The equation for a linear trend model typically takes the form:

$$y_t = B_0 + B_1 t + \varepsilon_t \tag{1}$$

where y_t represents the value of the variable at time t, B_0 is the intercept term, which represents the starting value of the variable, $B_1$is the slope, indicating the rate of change per unit of time, t is time and ε_t represents the error term, accounting for random fluctuations or noise in the data [7].

b) Quadratic Trend Model (QTM): A quadratic trend model in time series analysis is a mathematical representation employed to depict how a variable relates to time in cases where the changes over time do not follow a straight-line pattern. Rather, the data displays a curved or parabolic trend.

The equation for a quadratic trend model typically takes the form:

$$y_t = B_0 + B_1 t + B_2 t^2 + \varepsilon_t \tag{2}$$

where y_t represents the value of the variable at time t, B_0, B_1 and B_2 are coefficients that need to be estimated from the data, t is time, t^2 represents the square of time, introducing the curved aspect of the model and ε_t represents the error term, accounting for random fluctuations or noise in the data [7].

c) Exponential Growth Model (EGM): The exponential growth model in time series analysis is a mathematical framework employed to depict a scenario in which a variable experiences an accelerating increase or decrease over time.

The equation for an exponential growth model typically takes the form:

$$y_t = B_0 B_1^t + \varepsilon_t \tag{3}$$

where y_t represents the value of the variable at time t, B_0 and B_1 are coefficients that need to be estimated from the data, t is time and ε_t represents the error term, accounting for random fluctuations or noise in the data [7].

When assessing the depiction of the time series, particularly the time series plot, the choice of model fitting is determined by its visual characteristics. Linearity, if observed in the representation, will lead to the application of the linear trend model. In cases where curvature or an exponential trend is demonstrated, the quadratic or exponential model will be employed, respectively [7].

Additionally, the fitted models were evaluated using various accuracy measures, including Mean Squared Deviation (MSD), Mean Absolute Deviation (MAD), and Mean Absolute Percentage Error (MAPE). Furthermore, the actual prices and forecasted prices were compared using the Pearson Correlation Coefficient to validate the fitted models [7], [8].

MSD is a commonly employed measure for assessing the fit of time series values. Smaller values indicate a better fit. MAD gauges accuracy in the same units as the data, providing a tangible sense of the error magnitude. MAD is less influenced by outliers compared to MSD. Smaller values indicate a better fit. MAPE measures accuracy as a percentage of the error, making it easy to understand. For example, a MAPE of 5 implies that, on average, the forecast deviates by 5%. Lower values signify a more accurate fit. When a single model doesn't yield the lowest values for all three accuracy measures, MAPE is typically the preferred metric [9].

III. Results and Discussion

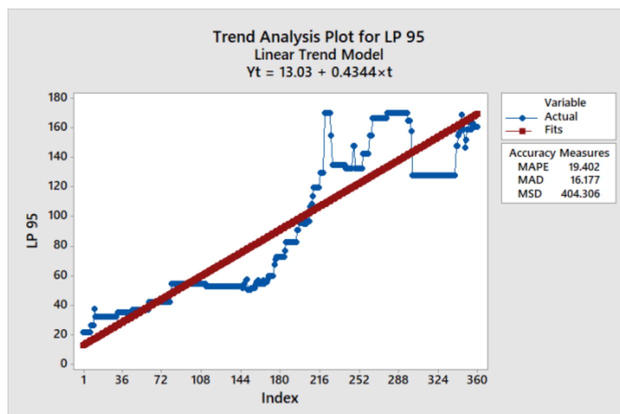

Fig. 1. Trend analysis plot (LP95, LTM)

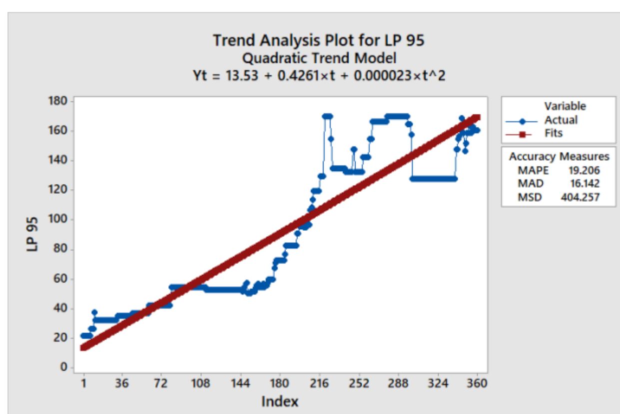

Fig. 2. Trend analysis plot (LP95, QTM)

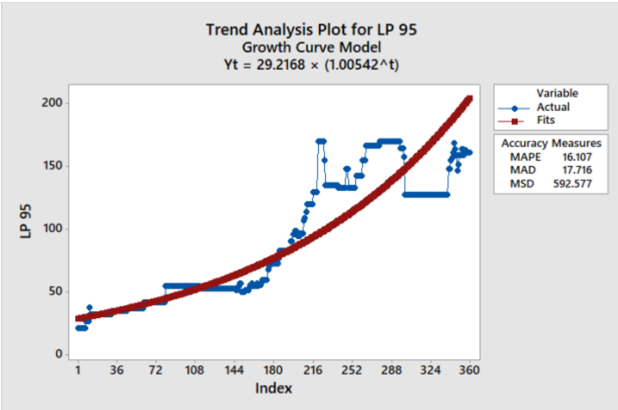

Fig. 3. Trend analysis plot (LP95, EGM)

TABLE I
ACCURACY MEASURES FOR LP95

Accuracy Measure	LTM	QTM	EGM
MAPE	19.402	19.206	16.107
MAD	16.177	16.142	17.716
MSD	404.306	404.257	592.577

Fig 1, 2 and 3 illustrates the fitted trend models, namely LTM, QTM, and EGM, for LP 95. A comparison of the accuracy measures for LP 95, in Table I revealed that both LTM and QTM exhibit lower values for MAD and MSD in comparison to the accuracy measures of EGM model. However, the EGM model showed a lower MAPE of 16.107 when compared to MAPE values of LTM and QTM. Therefore, the EGM model stands out as the best fit due to its superior accuracy measures. The mathematical expressions for the fitted models are as follows:

LTM:

$$y_t = 13.03 + 0.4344t \tag{4}$$

QTM:

$$y_t = 13.53 + 0.4261t + 0.000023t^2 \tag{5}$$

EGM:

$$y_t = 29.2168 \times 1.00542^t \tag{6}$$

TABLE II
ACCURACY MEASURES FOR LP92

Accuracy Measure	LTM	QTM	EGM
MAPE	18.171	19.263	16.164
MAD	14.739	14.891	16.599
MSD	353.590	352.132	537.526

Fig 4, 5 and 6 illustrates the fitted trend models for LP 92. The results presented in Table II shows the accuracy measures for LTM, QTM, and EGM for LP 92. Among these models, the EGM stands out with the lowest MAPE value of 16.164, while both LTM and QTM exhibit lower values for MAD and MSD when compared to measurable values of EGM. Therefore, the

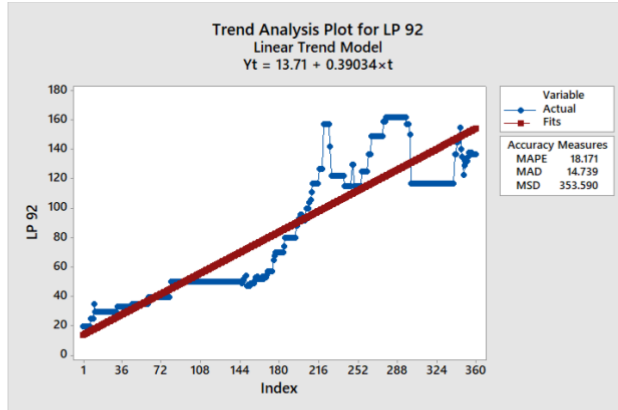

Fig. 4. Trend analysis plot (LP92, LTM)

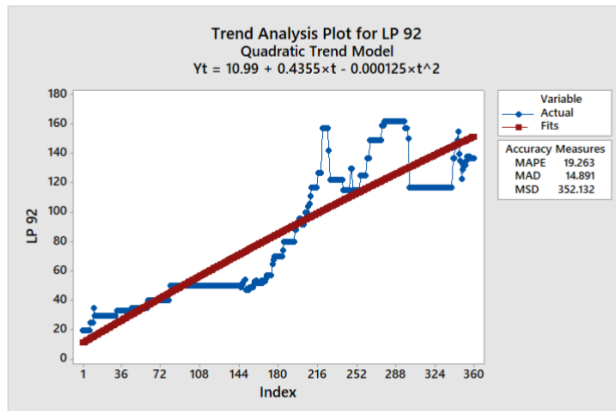

Fig. 5. Trend analysis plot (LP92, QTM)

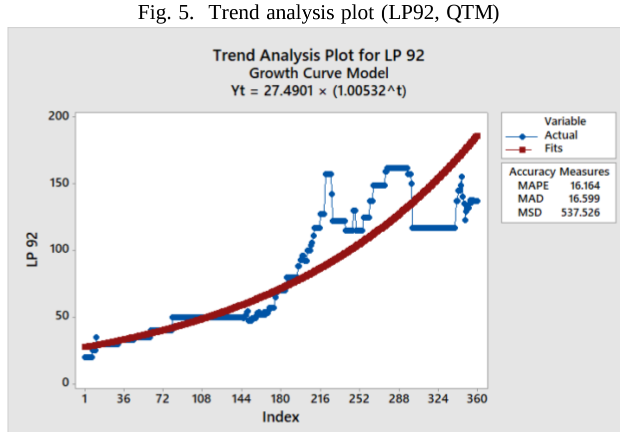

Fig. 6. Trend analysis plot (LP92, EGM)

best fitted model is EGM. The corresponding trend models are as follows.

LTM:

$$y_t = 13.71 + 0.39034t \tag{7}$$

QTM:

$$y_t = 10.99 + 0.4355t + 0.000125t^2 \tag{8}$$

EGM:

$$y_t = 27.4901 \times 1.00532^t \tag{9}$$

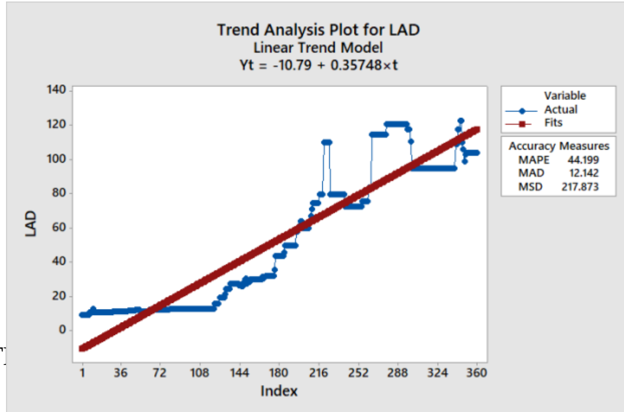

Fig. 7. Trend analysis plot (LAD, LTM)

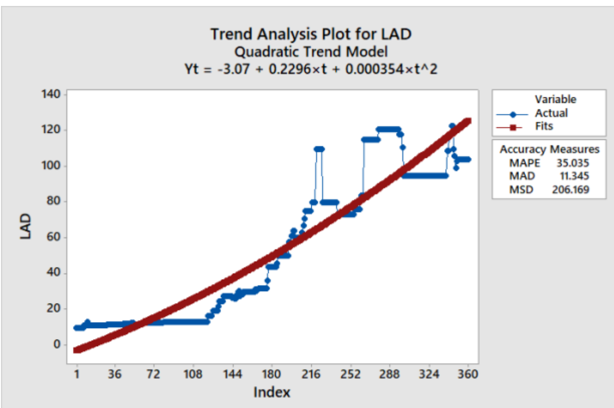

Fig. 8. Trend analysis plot (LAD, QTM)

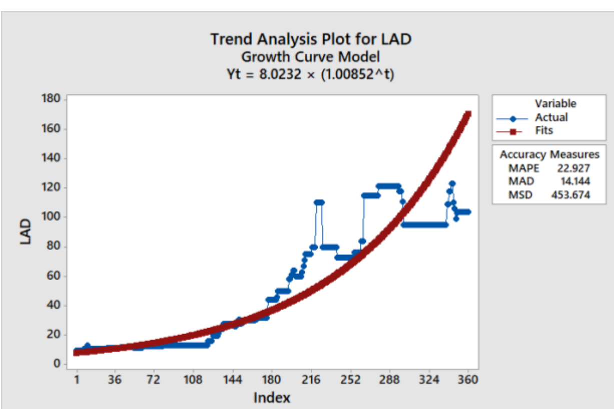

Fig. 9. Trend analysis plot (LAD, EGM)

Fig 7, 8 and 9 illustrates the fitted trend models for LAD. Accuracy measures for the product LAD are represented in Table III. Both MAPE and MAD values, 22.927 and 14.144

TABLE III
ACCURACY MEASURES FOR LAD

Accuracy Measure	**LTM**	**QTM**	**EGM**
MAPE	44.199	35.035	22.927
MAD	12.142	11.345	14.144
MSD	217.873	206.169	453.674

respectively, are lower in the EGM model compared to LTM and QTM. According to that EGM is the best fitted model. The corresponding trend models for LTM, QTM, and EGM are as follows:

LTM:

$$y_t = -10.79 + 0.35748t \tag{10}$$

QT

$$y_t = -3.07 + 0.2296t + 0.000354t^2 \tag{11}$$

EGM:

$$y_t = 8.0232 \times 1.00852^t \tag{12}$$

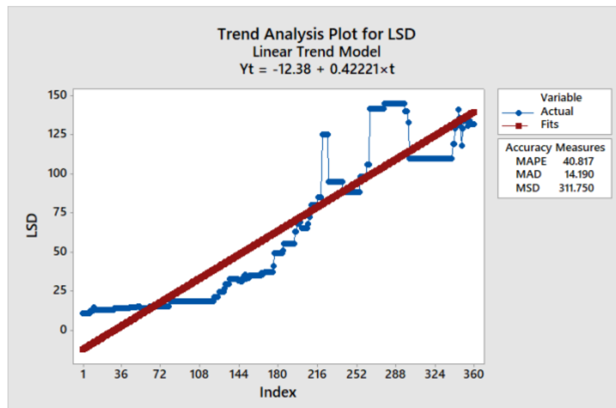

Fig. 10. Trend analysis plot (LSD, LTM)

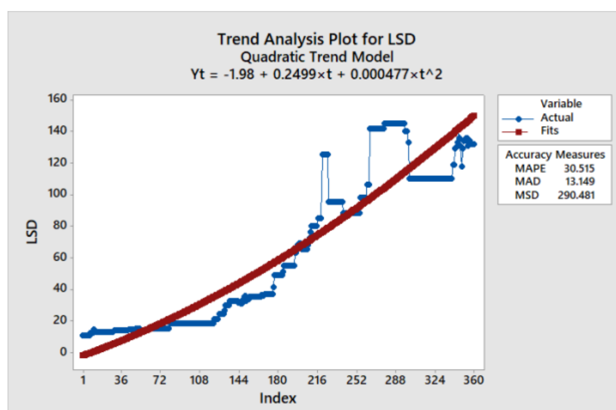

Fig. 11. Trend analysis plot (LSD, QTM)

Fig 10, 11 and 12 illustrates the fitted trend models for LSD. The lowest MAPE value (19.755) was associated with the EGM in Table IV for the product LSD, and QTM exhibits the

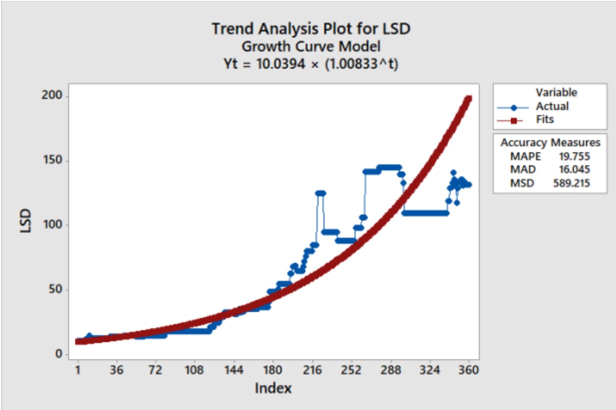

Fig. 12. Trend analysis plot (LSD, EGM)

TABLE IV
ACCURACY MEASURES FOR LSD

Accuracy Measure	LTM	QTM	EGM
MAPE	40.817	30.515	19.755
MAD	14.190	13.149	16.045
MSD	311.750	290.481	589.215

lowest MAD value (13.149) when compared with measured values of other models. Then, EGM emerges as the preferred model for forecasting the price of LSD. The fitted trend models for LSD are as follows:

LTM:

$$y_t = -12.38 + 0.42221t \quad (13)$$

QTM:

$$y_t = -1.98 + 0.2499t + 0.000477t^2 \quad (14)$$

EGM:

$$y_t = 10.0394 \times 1.00833^t \quad (15)$$

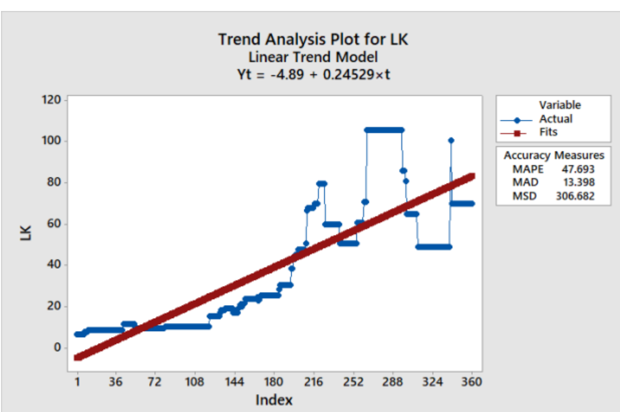

Fig. 13. Trend analysis plot (LK, LTM)

Fig 13, 14 and 15 illustrates the fitted trend models for LK. Table V represents the details of accuracy measures of LK and the MAD values for all the models are nearly equal. EGM has the least MAPE value (27.692) and MSD is less in both LTM and QTM than in the EGM. Most suitable model to forecast the prices of LK is the EGM. Fitted tend models LTM, QTM and EGM are given below.

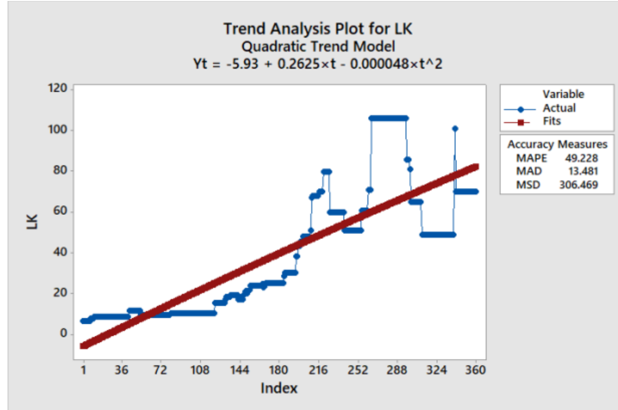

Fig. 14. Trend analysis plot (LK, QTM)

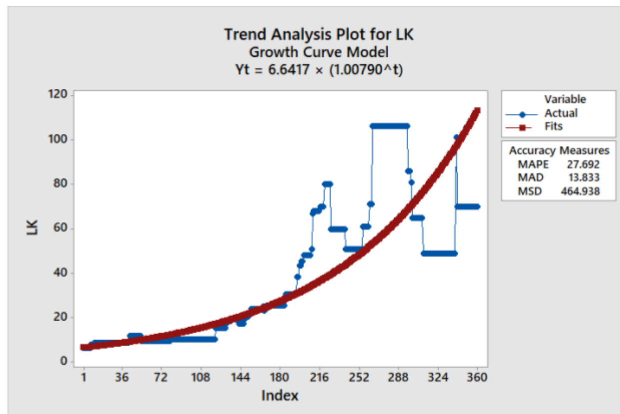

Fig. 15. Trend analysis plot (LK, EGM)

TABLE V
ACCURACY MEASURES FOR LK

Accuracy Measure	LTM	QTM	EGM
MAPE	47.693	49.228	27.692
MAD	13.398	13.481	13.833
MSD	306.682	306.469	464.938

$$y_t = -4.89 + 0.24529t \quad (16)$$

QTM:

$$y_t = -5.93 + 0.2625t + 0.00048t^2 \quad (17)$$

EGM:

$$y_t = 6.6417 \times 1.00790^t \quad (18)$$

Table VI shows the correlation analysis between the actual prices of all petroleum products for the years 2020 and 2021, based on 24 monthly prices, and the forecasted prices by each model. The results exhibit a high correlation between the forecasted prices by the fitted models LTM, QTM, and EGM and the actual monthly prices of petroleum products of LP 95, LP 92, LAD, LSD, and LK.

TABLE VI
CORRELATION BETWEEN ACTUAL PRICES AND THE FORECASTED PRICES OF LP92, LAD, LSD AND LK

Petroleum Product	LTM	QTM	EGM
LP95	0.775	0.775	0.783
LP92	0.775	0.773	0.783
LAD	0.751	0.753	0.765
LSD	0.761	0.764	0.775
LK	0.751	0.750	0.764

Since the current global economy depends mostly on fuels, the global oil market is more complicated than it appears, and the price of oil is dependent upon many different factors. Present study analyzed the domestic petroleum price in Sri Lanka, and there are many factors that affect it, such as the inflation rate, economic growth rate, gross domestic growth rate, dollar exchange rate, OPEC (The Organization of Petroleum Exporting Countries), supply and demand, restrictive legislation, political unrest, financial markets, weather, etc. [10, 11].

IV. CONCLUSION

This study has performed the trend analysis for domestic prices of petroleum products in Sri Lanka using monthly data through the years 1990 to 2021. The results concluded the best models which can be used to predict future oil prices. The results of the study revealed that the best fitted model for LP95, LP92, LAD, LSD and LK was EGM. These outcomes not only contribute valuable insights to the domain of energy economics but also offer practical implications for stakeholders in the Sri Lankan petroleum industry, enabling them to make informed decisions in a volatile global market.

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