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PREDICTION OF PETROL AND DIESEL PRICES IN DAR ES SALAAM USING ARIMA MODELS

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ABSTRACT

Purpose: The study aims to address the importance of predicting fuel prices due to their impact on the economy and welfare of people in Dar es Salaam city and regions in Tanzania.
Design/Methodology/Approach: This study follows the quantitative research design by utilizing secondary data. The sample data consists of monthly petrol and diesel prices in Dar es Salaam from January 2015 to May 2023. The ARIMA model was employed to analyze the time series data with model identification, estimation, and verification steps performed using statistical techniques such as the ADF test, ACF, PACF, and AIC.
Findings: The findings indicated that the ARIMA (0,1,1) model was the best-fitted model for forecasting both petrol and diesel prices in Dar es Salaam. The forecasted values for the next six months show that models demonstrated good performance in predicting petrol and diesel prices.
Research Limitation/Implication: Some of the potential limitations of this study include the reliance on secondary data, the assumptions of stationarity and linearity in the ARIMA model, and the sensitivity of the forecast to future data. Also, the study focuses specifically on Dar es Salaam which may limit the generalizability of the findings in other regions.
Social Implications: This study has significant social implications for residents of Dar es Salaam, offering insights for household budgeting, transportation planning, and predicting fuel price changes. It also informs social programs and subsidies, contributing to equitable and sustainable community development.
Practical Implications: The study has practical implications for the stakeholders in the fuel industry, policymakers, and consumers in Dar es Salaam. The accurate prediction of petrol and diesel prices can assist consumers in making informed decisions regarding pricing, budgeting, and fuel consumption which helps to reduce the risk of fuel loss and optimize their fuel-related choices.
Originality/Value: The novelty of this study is analyzing historical fuel price data in Dar es Salaam using ARIMA models. Through this approach, we identify trends, seasonality, and cyclical patterns unique to the region. This knowledge adds to the existing understanding of fuel price determinants in the local context.

Keywords: *ARIMA models. diesel. petrol. price forecasting. Tanzania.*

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1. INTRODUCTION

The recent increase in the price of fuel has had a widespread impact throughout the world. The majority of developed and developing countries in the world are net importers of petroleum and diesel products. The rise in the price of fuel has a big effect on the overall economic well-being of people all over the world. Fuel price fluctuations have an impact on the stock market, daily commodity prices, and all major parts of the country's economy (Lahari et al., 2018). Energy demand is determined by the demand for energy services (Malleo, 2020). Demand for petrol and diesel varies according to consumer type. Household demand is based on subsistence consumption, whereas businesses and investors rely on petrol and diesel as inputs in production processes. Due to the high demand for petrol and diesel, the prediction of their future price has become important.

Based on prior and current research highlighting both standard and sophisticated price forecasting methodologies, there are three types of fuel price forecast models which include the parametric, non-parametric, and hybrid models. The parametric models have a fixed number of parameters that must be estimated from the data to fit the model. Some of the studies which used the parametric models include Zhao et al., (2018), Xiang & Zhuang, (2013), Baumeister & Kilian, (2012), and Miao et al., (2017). The non-parametric models are frequently used to estimate fuel prices because they do not require the assessment of critical parameters to create the prediction equation (Yu et al., 2021). Some of the studies that employed the non-parametric models are Ding, (2018), Shin et al.,(2013), Polanco-Martínez and Abadie, (2016), and Godarzi et al., (2014). The hybrid models are mostly used to integrate parametric and non-parametric prediction methodologies. These models can overcome the limitations of both parametric and non-parametric techniques effectively (Yu et al., 2021). Some of the studies that employed the hybrid models include Li et al., (2017), X. Li et al., (2019), Zhang et al., (2014), and Wang et al., (2018).

Like many developing countries, petrol and diesel have remained critical fuel inputs for Tanzania's socio-economic development. Petrol and diesel in Tanzania are used in motorcycles, automobiles, boats, trains, ships, and any other machine that uses a powerful engine. Since the turn of the twenty-first century, considerable and sustained increases in fuel prices have occurred (Arndt, 2012). Tanzania's commodity prices have remained high. Predicting petrol and diesel prices in Tanzania is critical for evaluating the welfare and poverty implications of the country's economic progress, as it encompasses all key real-world impact channels.

The fuel price in Tanzania has been regulated by the government over time. Steel, on the other hand, has seen a fluctuation in fuel prices throughout the years. There could be several reasons for this price increase, some of which can be traced and controlled and others that cannot be traced and controlled. It is more necessary for the public to have a well-thought-out plan to limit the impact of sudden fluctuations in fuel prices on their financial well-being. Proper planning in this regard necessitates making a simple forecast of future fuel price changes. The current body of existing research in Tanzania lacks a focused analysis on the regional partens of fuel pricing in Dar es Salaam. This study aims to fill research this gap

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by providing an in-depth analyzing of fuel prices by using an ARIMA model to predict the petrol and diesel prices in Dar es Salaam.

2. MATERIAL AND METHOD

2.1 Sample and Data Collection

This study was based on secondary data. The sample data considered were the petrol and diesel prices in Dar es Salaam starting in January 2015 and ending in May 2023. There was a monthly base, which was obtained from the Energy and Water Utilities Regulatory Authority (EWURA).

2.2 Data Analysis and ARIMA Model

The data analysis in this study was conducted using the statistical software environment R (R core Team, 2021). We expected to have the time-series data (Y_t) with the component such as trend(T), cyclic (C), seasonality (S) and irregularity (I). To understanding the occurrence possibility of fuel monthly price, we used the ARIMA models. This model is written as ARIMA(p,d,q) with p,d, and q stands for Autoregressive process, integrating part and Moving Averages process respectively. ARIMA model is used to model non-stationary time series by differencing. The differencing technique applied to transform the non-stationary time series data into a stationary form is denoted by 'd'. The differenced series is represented in Equation 1

$$\Delta^d X_t = (1 - L)^d X_t \quad (1)$$

Once the series is stationary, the model can be defined as a combination of the Autoregressive (AR) and Moving Average (MA) models operating on the differenced series as indicated in Equation 2.

$$\Delta^d X_t = c + \sum_{i=1}^{p} (\phi_i \cdot \Delta^d X_{t-i}) + \varepsilon_t + \sum_{j=1}^{q} (\theta_j \cdot \varepsilon_{t-j}) \quad (2)$$

Then, the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots can be analyzed to determine the optimal values for the ARIMA model. The optimal value for 'd' can be determined using statistical the Augmented Dickey-Fuller (ADF) test. Also, we the Akaike Information Criterion (AIC) identify the best combination of p, d, and q parameters.

Then we fitted the selected ARIMA(p, d, q) model to the stationary (differenced) time series data, estimating the model parameters (ϕ_i and θ_j) using methods like the Maximum Likelihood Estimation (MLE). Then, we evaluated the model's performance by checking the residuals' behavior, ensuring they are normally distributed, uncorrelated, and have zero means. Use diagnostic tests like the Ljung-Box test to assess the model's adequacy, If the model diagnostics indicate a satisfactory fit, we employed the generated model to forecast the price and validate the model's accuracy by comparing the forecasted value with the test data.

3. RESULT AND DISCUSSION

3.1 Data

The summary statistics and time series plots for petrol and diesel prices (TSh) in Dar es Salaam are presented in Table 1 and Figure 2.

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Table 1: Statistical Summary of Petrol and Diesel Prices (TSh) in Dar es Salaam, Tanzania

Variable	Observations	Minimum	Maximum	Mean	Standard deviation
Petrol	100	1520	3410	2212	378.4485
Diesel	100	1486	3322	2129	455.8155

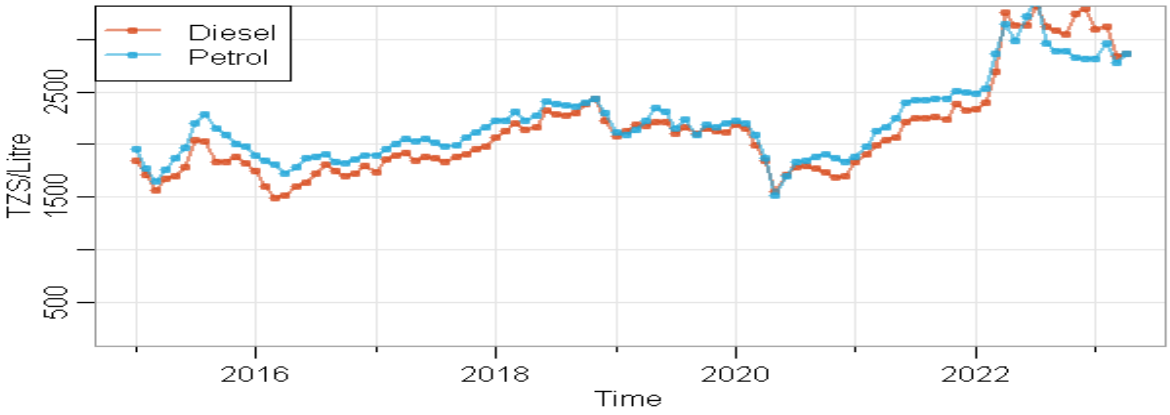

Figure 2: Time series Plot for Petrol and Diesel Prices in Dar es Salaam

The graph shown in Figure 2 is based on the monthly price of Diesel and Petrol in Dar es Salaam from January 2015 until May 2023. The rising trend in both series of petrol and diesel prices provides support for the price change hypothesis. The finding agrees with the study of Xiuzhen, Zheng, and Umair (2022) who concluded that rising oil prices will raise production costs and better price fluctuations for other commodities. We can see that neither price trend was linear, as there were periods of stability followed by gradual increases and decreases. Fitting the linear regression trend does not provide a precise description of the trend. We can also see that the two series are related as both prices increased and decreased simultaneously.

3.2 Model Identification, Estimation, and Verification

The stationarity of the training datasets was tested using the ADF test. The p-value for the Petrol and Diesel training dataset was 0.6744. and 0.8642 respectively. Since both p-values were greater than the significance level of 0.05, this indicated that both training data sets were not stationary. The p-value for both differenced Petrol and Diesel training datasets was 0.01 which was less than the statistical significance level of 0.05 and confirmed the stationarity. The results are illustrated in Figures 3 and 4. We found that ARIMA (0,1,1) had the minimum AIC and was selected as the best-fitted model for forecasting the price of both petrol and diesel. To ensure that there is no more information left for extraction, we checked the ACF and PACF plots for the residuals of our best-fit model and the results showed that residuals were random and did not contain any information. This indicated that the ARIMA (0,1,1) model that we formulated performs exceptionally well for both the petrol and diesel price datasets.

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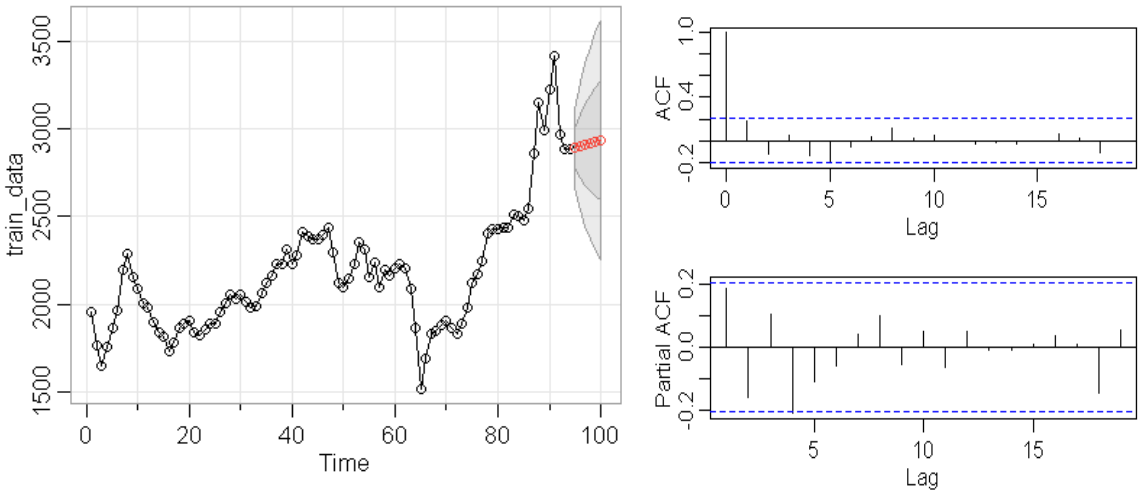

Figure 3: Correlogram and forecast plots of ARIMA (0,1,1,) for the petrol price.

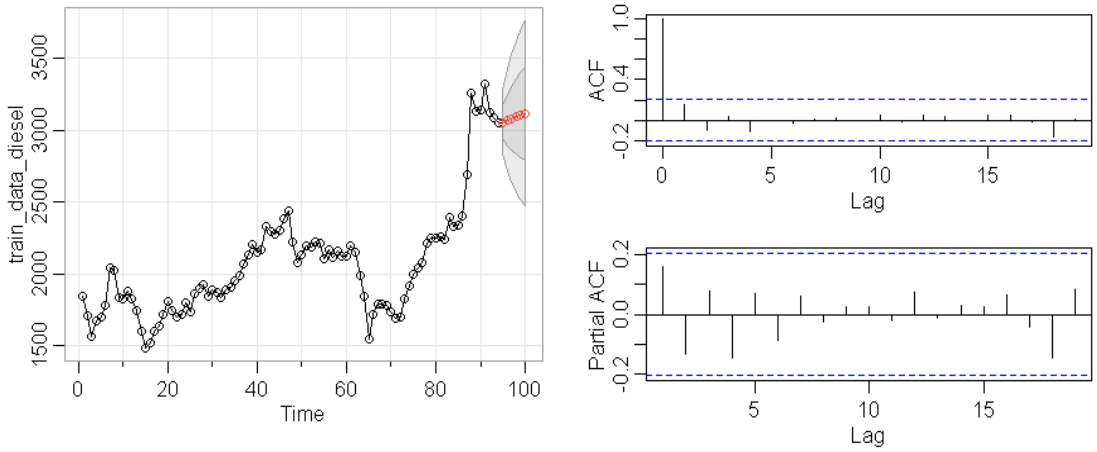

Figure 4: Correlogram and forecast plots of ARIMA (0,1,1,) for the diesel price.

3.3 Forecasting

Table 2: Forecast value for the six months (December 2022 to May 2023) after the analysis of petrol prices (TSh) in Dar es Salaam

Months	Petrol Test Data	Predicted Value	95% Lower Bound	95% Upper Bound.
December	2827	2888.765	2669.49	3108.04
January	2819	2898.223	2678.947	3117.498
February	2819	2907.68	2688.405	3126.955
March	2968	2917.137	2697.862	3136.412
April	2781	2926.594	2707.319	3145.869
May	2871	2936.052	2716.776	3155.327

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Table 3: Forecast value for the six months (December 2022 to May 2023) after the analysis of diesel prices (TSh) in Dar es Salaam

Months	Diesel Test Data	Predicted Value	95% Lower Bound	95% Upper Bound.
December	3247	3054.869	2835.602	3274.137
January	3295	3067.467	2848.2	3286.735
February	3105	3080.065	2860.798	3299.333
March	3130	3092.663	2873.396	3311.931
April	2847	3105.261	2885.994	3324.529
May	2871	3117.859	2898.592	3337.127

After determining the most relevant price model for our circumstance, the next step was to conduct forecasting. To accomplish this and to identify trends and produce predictions, we utilized the R package titled Forecasting. Tables 2 and 3 show the outcomes of the six-month price forecasts derived from the ARIMA (0, 1, 1) model. These findings show the prediction for the next six months to come (December 2022 to May 2023). It is abundantly evident that the selected model may be utilized for modeling and forecasting the future prices of diesel and petrol in Dar es Salaam. Diesel and petrol pricing decisions in Dar es Salaam were made with greater ease as a result of the predictions obtained through modeling. Smith, Tarui, and Yamagata (2021) claimed that fuel consumption in the emerging economies rises much faster When the pricing forecast is obtained, it will be significantly easier and clearer than ever before to determine the right fuel costs. This will help fuel users make the right decisions regarding their daily fuel consumption. In addition, this affects the entire process of fuel consumption by eliminating the chance of fuel loss for customers who purchase petrol and diesel in Dar es Salaam.

4. CONCLUSION

This study was modeling-based, and its outcome gives individuals, economists, government, and other natural resource stakeholders a better look at the petrol and diesel price management and provides an early warning on fuel price fluctuation for better planning. Predicting the price of fuel is a key component of managing fuel prices. Due to its integration with several other business functions, it is one of the most important planning processes that individuals and firms may employ in the future. Using the Box-Jenkins time series method, we constructed an ARIMA model to model and predict the price in Dar es Salaam. Several ARIMA models were developed utilizing historical data on fuel costs, and the best appropriate model was selected based on AIC performance criteria. We decided to employ the ARIMA (0,1,1) model because it has the lowest AIC values. The fact that these results were obtained suggests that this model is suitable for modeling and predicting future petrol and diesel prices in Dar es Salaam. Customers who purchase petrol and diesel in Dar es Salaam and throughout Tanzania will have access to reliable purchasing guidelines as a result of these findings.

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