



COLLEGE OF BUSINESS AND MANAGEMENT SCIENCES

SCHOOL OF STATISTICS AND PLANNING

DEPARTMENT OF STATISTICS AND ACTUARIAL SCIENCES

**A TIME SERIES ANALYSIS OF THE UGANDA'S VALUE OF PETROL AND
PETROLEUM IMPORT PRODUCTS (1996-2025)**

BY

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**A DISSERTATION SUBMITTED TO THE SCHOOL OF STATISTICS AND PLANNING IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE
OF STATISTICS**

June, 2026

DECLARATION

I KAYONDO DERICK, hereby declare that this dissertation is my original work done under guidance of my supervisor and has not been submitted to any institution of higher learning for the award of any academic qualification. All sources of information used in this study have been duly acknowledged.

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APPROVAL

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DEDICATION

I also dedicate this work to my beloved parents and family for their unconditional love, encouragement, sacrifices, and unwavering support throughout my studies. Their belief in my abilities has been a constant source of motivation. Finally, I dedicate this dissertation to my supervisor, lecturers, friends, and colleagues whose guidance, encouragement, and support contributed to the successful completion of this study

ACKNOWLEDGEMENT

I would like to express my sincere appreciation to all those who helped me complete this dissertation. Firstly, I wish to express my sincere gratitude to Almighty God for His guidance, strength, and blessings throughout the course of this study.

I am deeply indebted to my supervisor, **Mr. Mutungi Gilbert** for the valuable guidance, constructive comments, and continuous support provided during the preparation of this dissertation. His professional advice greatly contributed to the successful completion of this work. I also wish to thank the staff and faculty of the Department of Statistics at Makerere University, especially the library team, for their support and advice during my studies. They provided me with access to the necessary resources and facilities, and shared their expertise and insights with me.

My sincere appreciation also goes to the Uganda Bureau of Statistics, for providing me with the data and information that formed the basis of my analysis. I appreciate their cooperation and willingness to collaborate with me on this research. I am also indebted to my colleagues and friends, who supported me emotionally and intellectually throughout this journey. They offered me constructive feedback, moral support, and companionship.

Lastly I would like to extend my appreciation to my family, who have always been my source of strength and motivation. I am forever grateful to my parents, for their unconditional love and sacrifice. They instilled in me the values of hard work and perseverance.

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LIST OF ACRONYMS

Acronym	Meaning	Acronym	Meaning
ACF	Autocorrelation Function	PACF	Partial Autocorrelation Function
ADF	Augmented Dickey–Fuller	R	R Statistical Software
AIC	Akaike Information Criterion	RMSE	Root Mean Square Error
AR	Autoregressive	UBOS	Uganda Bureau of Statistics
ARIMA	Autoregressive Integrated Moving Average	URA	Uganda Revenue Authority
COVID-19	Coronavirus Disease 2019	USD	United States Dollar
EAC	East African Community	MEMD	Ministry of Energy and Mineral Development
I(1)	Integrated of Order One	MA	Moving Average
IEA	International Energy Agency	MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error		

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ABSTRACT

This study analyzes the trends, seasonal patterns, and forecasting performance of Uganda's petroleum import values from January 1996 to December 2025 using time series techniques. Petroleum products are a part of the major import commodity in Uganda and play a key role in supporting transport, industrial, and economic activities. However, Uganda's heavy dependence on imported petroleum exposes the economy to external shocks such as global price fluctuations and supply disruptions, making reliable analysis and forecasting essential for planning and policy guidance.

The study uses monthly petroleum import values obtained from the Uganda Bureau of Statistics (UBOS) and applies descriptive statistics, seasonal decomposition, stationarity tests, and forecasting models. Specifically, the Autoregressive Integrated Moving Average (ARIMA), Random Walk, and Seasonal Naïve models are estimated and compared using forecast accuracy measures including MAPE, RMSE, and MAE.

Results indicate a strong and persistent upward trend in petroleum import values over the study period, with trend effects accounting for over 95% of the total variation in the series. Seasonal effects are present but relatively weak, suggesting that long-term growth dominates short-term seasonal fluctuations. Among the forecasting models, the ARIMA(2,1,3) with drift model outperforms both the Random Walk and Seasonal Naïve models in terms of overall predictive accuracy, making it the preferred model for forecasting Uganda's petroleum import values.

Forecasts from the ARIMA model suggest continued growth in petroleum import expenditure through 2027, implying increasing pressure on Uganda's foreign exchange reserves and trade balance. The study recommends that policymakers integrate these forecasts into planning processes and prioritize energy diversification strategies to reduce long-term dependence on imported petroleum products.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Petroleum products remain a critical source of energy in Uganda. As a landlocked country with no commercial petroleum refining capacity, Uganda has historically relied on imported petroleum products to meet the energy demands of the transport, industrial, agricultural, and household sectors. However, the demand for petroleum products has increased steadily over time due to population growth, urbanization, motorization, and expanding economic activity ((URA)., 2022)

Petroleum products, including petrol, diesel, kerosene, aviation fuel, and lubricants, are among the most valuable imports in Uganda's merchandise trade. According to the Uganda Bureau of Statistics (UBOS, 2024), Uganda imported approximately 2.47 million cubic metres of petroleum products in 2023, compared to 2.28 million cubic metres in 2022, representing an increase of 7.9 percent, reflecting growing energy demand across the economy (UBOS, 2024). Furthermore, petroleum products accounted for a substantial share of Uganda's import expenditure, contributing significantly to foreign exchange outflows and the country's trade deficit.

In recent decades, time series forecasting techniques have become essential tools for analyzing and predicting economic and energy related variables. Models such as the Autoregressive Integrated Moving Average (ARIMA), random walk, and seasonal naïve have been widely applied in forecasting energy demand and other variables in Uganda because of their ability to capture temporal patterns and generate reliable forecasts (Hyndman & Athanasopoulos, 2018) but there is limited applicability to petroleum imports. In such as cases studies focusing on the long-term trends, seasonal behavior, and forecasting of petroleum import values remain limited.

In particular, few studies have compared the forecasting performance of the above time series models using Ugandan petroleum import data. Therefore, this study seeks to analyze the trends and patterns of Uganda's petroleum import values from 1996 to 2025 and compare the forecasting performance using Arima, random walk and seasonal naïve.

1.2 Problem Statement

Despite the discovery of commercially viable oil reserves, Uganda remains heavily dependent on imported refined petroleum products to satisfy domestic demand. This dependence exposes the country to uncertainties especially during fluctuations in international oil prices, exchange rate increases, wars, and petroleum supply disruptions which can significantly affect import expenditure and economic stability of the country if they occur since the economy largely depends on petroleum imports.

Available statistics confirm that Uganda's reliance on petroleum imports has increased substantially over time. The Uganda Bureau of Statistics (UBOS, 2024) reported a 7.9 percent increase in petroleum import volumes between 2022 and 2023, while import values exceeded USD 1.6 billion in 2022 alone, making petroleum one of Uganda's most significant import commodities (Reuters, 2024). These figures highlight the growing pressure that petroleum imports exert on the country's foreign exchange reserves and trade balance.

Despite the significance of petroleum imports to Uganda's economy, the monetary value of these imports over time has not been comprehensively examined using time series methods to understand underlying trends, seasonality and irregular shocks. Most existing studies have focused on the effects of petroleum prices on household welfare and the broader economy, rather than on the historical patterns and long-term behavior of import values. Furthermore, while models such as ARIMA, random walk, and seasonal naïve have been applied in various forecasting contexts, comparative evidence on their performance for Uganda's petroleum import values remains absent. This study addresses these gaps by analyzing monthly petroleum import values from 1996 to 2025, identifying trends and seasonal patterns, and comparing the forecasting accuracy of the three models.

1.3 Main objective

To analyze the trends and patterns of Uganda's monthly monetary value of petroleum imports from 1996 to 2025 using time series analysis.

1.4 Specific objectives

1. To examine the trends of petroleum products, import value in Uganda from 1996 to 2025
2. To identify the seasonal patterns in Uganda's petroleum import values

3. To fit and compare different forecasting models such as ARIMA, random walk and seasonal naïve.

1.5 Research questions

1. Are there dominant trends characterizing Uganda's petroleum import values from 1996 to 2025?
2. What seasonal patterns are embedded in Uganda's monthly value of petroleum import value?
3. Which of the ARIMA, random walk, and seasonal naïve models provides the best fit and most accurate forecasts for Uganda's petroleum import value?
4. What are the projected petroleum import values for Uganda in 2027?

1.6 Scope of the Study

1.6.1 Geographical Scope

The study focuses on the Republic of Uganda as a whole. Petroleum import value data aggregated at the national level will be used, drawn from records of the Uganda Bureau of Statistics (UBOS) that were published.

1.6.2 Content Scope

The study concentrates on the value of Uganda's petroleum imports expressed in thousand United States Dollars (USD). The analysis covers major petroleum products, including petrol (gasoline), diesel, kerosene, aviation fuel, and other refined petroleum products imported into the country. The study specifically examines trends, seasonal patterns, and forecasting performance using Autoregressive Integrated Moving Average (ARIMA), random walk and seasonal naïve models.

1.6.3 Time Scope

The study covers petroleum import value data from January 1996 to December 2025. This period provides a sufficiently long time series data for analyzing trends, seasonality, and forecasting Uganda's petroleum import values.

CHAPTER TWO: LITERATURE REVIEW

2.1 Literature on Trends

Petroleum products remain a major source of energy in most developing countries despite increasing investment in renewable energy. The analysis of trends in petroleum imports is important because it helps reveal long term changes in energy demand and import dependence. Studies have shown that petroleum imports tend to increase with economic growth, urbanization, industrialization, and expansion of transportation systems.

According to (International Energy Agency, 2024), petroleum demand in developing economies has continued to rise due to rapid population growth and increased industrial activity. The report indicates that transportation remains the largest consumer of petroleum products globally, accounting for a substantial share of total fuel demand.

In East Africa, petroleum products constitute an important component of import expenditure. A study by the East African Community Secretariat (EAC, 2023) found that petroleum imports represented a consistent increase in petroleum demand resulting from growing vehicle ownership and expanding economic activity leading to increased imports expenditure.

The Uganda Bureau of Statistics (2024) reported that petroleum import volumes increased from 2.28 million cubic metres in 2022 to 2.47 million cubic metres in 2023 (UBOS, 2024) Similarly, the Ministry of Energy and Mineral Development (2023) observed that petroleum consumption has increased steadily over the last two decades due to economic growth, urbanization, and increased motorization. (Ministry of Energy & Mineral Development, 2023)

Although these reports provide useful information regarding petroleum imports and consumption, they mainly present descriptive statistics and do not examine long-term trends using advanced time series techniques. Therefore, this study contributes to the existing literature by conducting a comprehensive trend analysis of petroleum import values from 1996 to 2025.

2.2 Empirical Literature on Seasonal Patterns

Seasonality is a common feature of energy related time data and involves regular fluctuations that occur at specific periods within a year. At the micro level (Rosado & Guerra, and Ferreira, 2021) examine daily fuel sales at a gas station and find statistically significant seasonality in fuel consumption across weekdays, months, and operational shifts. Their findings confirm that petroleum product demand is not random but follows structured seasonal cycles driven by consumer behavior and operational activity. According to (Hyndman & Athanasopoulos, 2018), timeseries dataset usually exhibits seasonality given it happens periodically. Identifying seasonal patterns enables forecasters to decompose seasonality from long term trends and random components, leading to more reliable forecasts. Likewise, (Obukohwo Oba, Buzugbe, & Enoch Hilda, 2019) reported significant seasonal variations in fuel consumption in Nigeria, particularly during periods of increased transportation and commercial activities. The authors emphasized that accounting for seasonality improves the accuracy of energy demand forecasts.

In Southern Africa, petroleum demand typically increases during December and January due to end of year holidays and increased tourism-related travel. Similarly, April often records relatively high fuel consumption because of school holidays and major religious celebrations such as Easter, which stimulate long distance travel (moonstone, 2026). Petroleum demand may also rise during planting and harvesting seasons when agricultural machinery and transportation activities intensify (Inchauspe, Li, & Park, 2020)

Within East Africa, seasonal demand for petroleum products has been linked to agricultural production cycles, transport activities, and regional trade movements. The East African Community Secretariat (EAC, 2023) noted that fuel demand tends to increase during harvesting seasons and periods of intensified economic activity. Similarly, the (Ministry of Energy and Mineral Development, 2023) observed that petroleum consumption in Uganda rises during periods of increased transportation and commercial operations. Despite this evidence, limited studies have specifically investigated seasonal patterns in Uganda's petroleum import values. Therefore, this study seeks to identify and quantify seasonal effects in Uganda's petroleum import values using seasonal decomposition techniques

2.3 Forecasting Petroleum Imports

2.3.1 Autoregressive Integrated Moving Average (ARIMA) Models

The Autoregressive Integrated Moving Average (ARIMA) model is one of the most widely used statistical techniques for forecasting time series data. In Uganda, ARIMA and related time-series methods have been applied in forecasting energy demand and other economic indicators in other sectors and fields. For example, (Okoboi & Mawejje, 2016) employed ARIMA forecasting techniques to analyze Uganda's electricity usage patterns which demonstrated ability to utilise historical patterns to generate reliable forecasts for energy planning. Despite the usefulness of ARIMA models in forecasting, limited studies have applied the technique to Uganda's petroleum import values

2.3.2 Seasonal Naïve

The Seasonal Naïve model is an extension of the simple naïve forecasting approach that incorporates seasonality. It assumes that the value of a series in a given period will be equal to the value observed in the same period in the previous seasonal cycle. Empirical evidence from African energy and fuel markets shows that seasonal naïve models are often appropriate where demand follows predictable cyclical patterns. For instance (Obukohwo & Buzugbe Enoh, 2019) found clear seasonal variation in petroleum product consumption in Nigeria, driven by fluctuations in transport and commercial activity across the year. Studies on interest rates forecasting demonstrate that seasonal naïve models often provide strong forecasting accuracy for variables that do not change instantly overtime and are difficult to outperform in short-term prediction problems (Paulsen & Gürtler, 2017).

According to (Okoboi & Mawejje, 2016), Uganda's energy demand exhibits time dependent fluctuations influenced by structural and seasonal effects, making time series approaches appropriate for forecasting. Similarly, studies on Uganda's import expenditure show clear seasonal and cyclical variations driven by economic activity and population growth (Ssentamu, 2025) The seasonal naïve model is particularly relevant for petroleum import forecasting because import expenditure often follows recurring monthly or quarterly patterns linked to global supply contracts and domestic demand cycles but researchers rarely use them making this study necessary.

2.3.3. Random walk model

The Random Walk (RW) model assumes that the best forecast of a future value is the most recently observed value, plus some changes in the series that are random and unpredictable. Similarly, (Inchauspe, Li, & Park, 2020) observed that random walk forecasts often provide surprisingly accurate predictions and are frequently used as a benchmark against which more complex forecasting methods are evaluated. For instance, benchmark energy forecasting studies have shown that random walk models can perform competitively when forecasting variables characterized by high volatility and persistence (Welton, 2014). In Uganda, (Okoboi & Mawejje, 2016) found that energy-related variables exhibit substantial fluctuations over time due to economic and structural factors, suggesting that simple benchmark models such as the Random Walk may provide useful forecasts. These findings indicate that the Random Walk model has potential applicability in forecasting Uganda's petroleum import values. However, there is limited empirical evidence regarding the use of Random Walk models for petroleum import forecasting in Uganda

.2.4 Research Gap

The reviewed literature indicates that petroleum imports have generally increased over time due to increase in energy demand yet Uganda has limited capacity to produce petrol and petroleum products required by the masses. Previous studies have also shown that import related variables often exhibit seasonal patterns and that forecasting models such as ARIMA, seasonal naïve and random walk models can provide reliable forecasts. However, most studies have focused on petroleum consumption, import demand, and other energy-related variables, with limited attention given to Uganda's value of petroleum import expenditure. Furthermore, few studies have examined the long-term trends and seasonal patterns of petroleum import values in Uganda to understand underlying trends and seasonal patterns. Ugandan forecasting studies have largely utilised ARIMA and exponential smoothing models, leaving a gap in the application and comparison of random walk, ARIMA and seasonal naïve models for petroleum import forecasting. Therefore, this study seeks to fill this gap by analyzing the trends and seasonal patterns of Uganda's petroleum import values from 1996 to 2025 and comparing the forecasting performance of ARIMA, random walk and seasonal naïve models.

CHAPTER THREE: METHODOLOGY

3.1 Research Design

This study adopted a quantitative time series research design using monthly petroleum and petroleum products import data covering the period from January 1996 to December 2025. The design was appropriate because the study focused on a single variable observed repeatedly over time. Time series analysis enabled the examination of long-term trends, seasonal patterns, fluctuations, and future forecasts of petroleum and petroleum products imports data.

3.2 Data sources

The study utilized secondary data on monthly value of petroleum and petroleum import products measured in thousand United States dollars (US\$). The data was extracted from the composition of Uganda's imports covering a period from January 1996 to December 2025 produced monthly by Uganda Bureau of Statistics (UBOS). The composition of imports dataset provides detailed information on the value of Uganda's imports by commodity category over time. The data are compiled from customs declarations and international merchandise trade records and are published regularly by UBOS as part of the country's external trade statistics. The dataset used in this study was obtained from the UBOS External Trade Statistics database, which contains monthly import data from 1996 onwards.

3.3 Data Analysis plan.

Data analysis was conducted using R statistical software and Microsoft Excel. The analytical strategy was structured around five stages: descriptive statistics, seasonal decomposition and trend analysis, stationarity testing, model estimation and selection, and out-of-sample forecasting.

3.3.1 Descriptive Statistics

Descriptive statistics including the mean, minimum, maximum, range, and standard deviation were computed to summarize the characteristics of the petroleum import series over the study period. Additionally, the series was decomposed to assess the relative strength of its trend, seasonal, and irregular components, and a seasonal graph was produced to display the average monthly pattern across all months

3.3.2 Seasonal Decomposition and Trend Analysis

The time series was decomposed into trend, seasonal, and irregular components using a multiplicative decomposition model, which is appropriate when the seasonal variation increases proportionally with the level of the series. The 12-month centered moving average was used to estimate the trend component. Seasonal indices were computed for each calendar month by averaging the ratios of the observed values to the trend estimates across all years, and these were subsequently adjusted to ensure they summed to 12. A seasonal graph showing the average import value by month across the study period was produced to visualize recurring monthly patterns.

3.3.3 Stationarity Testing

The Augmented Dickey-Fuller (ADF) test was applied to the original series to assess the presence of a unit root (non-stationarity). The null hypothesis of the ADF test is that the series contains a unit root. If the p-value exceeds 0.05, the null is not rejected and differencing is applied. The ADF test was subsequently applied to the first-differenced series to confirm stationarity. In addition to testing for regular (non-seasonal) stationarity, the series was examined for seasonal unit roots using the seasonal pattern of the data, and the seasonal differencing requirement was assessed through ACF analysis at seasonal lags.

3.3.4 Model Estimation and Comparison

Three forecasting models were fitted: ARIMA, Seasonal Naïve, and Random Walk. The data were divided into a training set (January 1996 to December 2023, comprising 336 observations) and a test set (January 2024 to December 2025, comprising 24 observations). Models were estimated on the training data and evaluated on the test data using out-of-sample forecast accuracy metrics.

For the ARIMA model, the ACF and PACF plots of the differenced series were used to identify candidate model orders, and the `auto.arima()` function in R was used to select the optimal specification based on the Akaike Information Criterion (AIC). Residual diagnostics including the Ljung-Box test were used to assess model adequacy. Model performance was compared across the

3.3.1 Forecasting

The selected forecasting model was used to generate forecasts of monthly petroleum and petroleum products imports for the period January 2026 to December 2027. Forecast results were presented in tabular form and interpreted in relation to future import demand and planning requirements.

3.4 Ethical considerations

This study used secondary data obtained from official sources, specifically the Uganda Bureau of Statistics (UBOS). No personal or confidential information was collected or used in the analysis. The data were used solely for academic purposes, and all sources of information were properly acknowledged.

CHAPTER FOUR: RESULTS AND FINDINGS

4.1 Descriptive Statistics

The monthly import values of petroleum and petroleum products from January 1996 to December 2025 exhibited considerable variation over the 30-year study period. The average monthly import value was US\$ 73,964.64 thousand, while the minimum and maximum values recorded were US\$ 739.00 thousand (January 1997) and US\$ 234,249.90 thousand (June 2025), respectively. The range of US\$ 233,510.90 thousand reflects the enormous expansion in petroleum import expenditure over the study period. The standard deviation of US\$ 55,957.63 thousand indicates a high degree of dispersion around the mean, consistent with the strong upward trend characterizing the series.

Table 1 Descriptive Statistics of Monthly Petroleum and Petroleum Products Import Values (1996–2025)

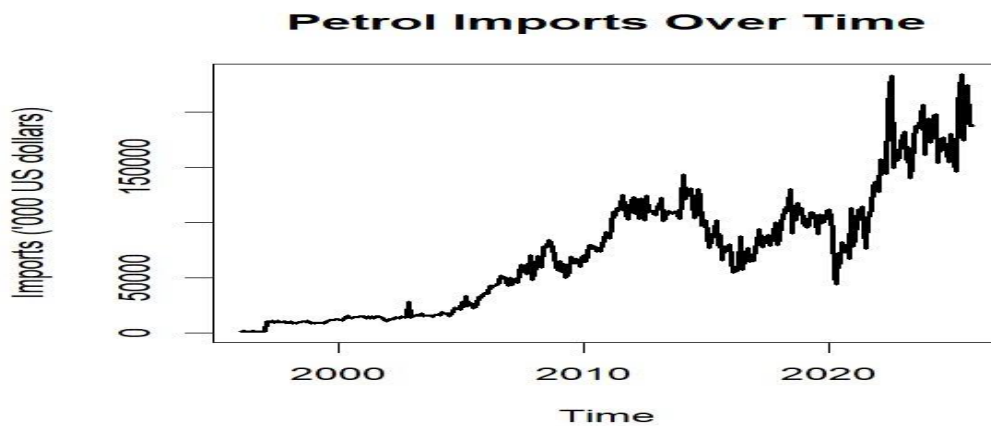
Statistic	Value (Thousand US\$)
Mean	73,964.64
Minimum	739.00
Maximum	234,249.90
Standard Deviation	55,957.63

These statistics highlight the dramatic growth in Uganda's petroleum import expenditure from the mid-1990s to the mid-2020s, driven by increasing energy demand, economic expansion, and rising global oil prices over the study period.

4.2 Trend Analysis and Decomposition

4.2.1 Time Series Plot

The line graph of monthly petroleum and petroleum products import values from January 1996 to December 2025 reveals a clear and pronounced long-term upward trend. Import values were relatively low and stable during the late 1990s and early 2000s, reflecting limited industrialization and lower petroleum demand. From approximately 2005 onwards, import expenditure began rising more steeply, accelerating significantly after 2015 in line with Uganda's expanding economy, rising vehicle ownership, and increasing industrial activity. A temporary decline is visible around 2015–2016, likely attributable to the global oil price collapse, and another dip is evident around 2020, which can be associated with the COVID-19 pandemic-induced economic slowdown and reduced transportation demand. Following each disruption, import values recovered rapidly and reached their highest levels during 2024 and 2025, with values exceeding US\$ 200,000 thousand in several months.



4.2.2 Decomposition Strength of Components

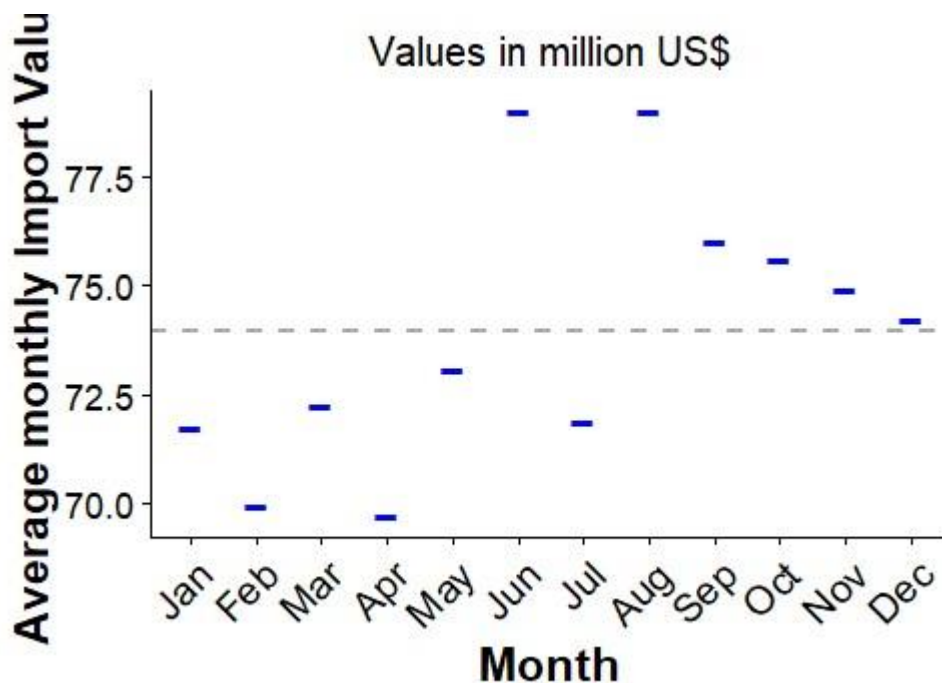
The time series was decomposed into trend, seasonal, and irregular components using multiplicative decomposition. The strength of each component was formally measured using the variance based approach. The results reveal that the trend component dominates the series almost entirely.

Table 2 Decomposition of components

Component	Strength (%)
Trend (F_t)	97.5
Seasonal (F_s)	3.7
Irregular (Remainder)	4.3

The trend strength of 97.5% confirms that petroleum import values in Uganda are overwhelmingly driven by a long-term upward trajectory, with the trend accounting for nearly all of the systematic variation in the series. The seasonal strength of 3.7% indicates that seasonal effects contribute only marginally to the variation in the data, after accounting for the dominant trend while the random component constitutes only 4.3%

4.2.3 Seasonal Graph



A seasonal graph displaying the average monthly petroleum import value across all 30 years of the study period was produced to visualize the recurring monthly pattern. The graph plots the mean

import value for each calendar month, allowing a direct visual comparison of which months consistently record higher or lower import expenditure.

The seasonal graph reveals that import values are slightly higher in June and August on average, with mean monthly values of approximately US\$ 79,009 thousand and US\$ 79,022 thousand respectively. April and February tend to record comparatively lower average import values of US\$ 69,717.5 thousand and US\$ 69,995 thousand respectively, which may reflect reduced activity at the start of the calendar year. However, the differences across months are modest, consistent with the low seasonal strength of 3.7% identified in the decomposition analysis.

Table 3 Average Monthly Petroleum Import Values Across All Years (US\$ Thousand)

Month	Average Import Value (US\$ Thousand)	Seasonal Index
January	71,776.1	1.045
February	69,994.6	0.978
March	72,249.5	1.035
April	69,717.5	0.978
May	73,089.6	1.006
June	79,008.9	1.047
July	71,903.8	0.995
August	79,022.4	1.009
September	76,031.2	0.997
October	75,631.3	0.986
November	74,908.5	0.979

December	74,242.4	0.945
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The seasonal indices presented above, derived from multiplicative decomposition, further confirm the subdued seasonal pattern. All indices lie close to 1.0, with June recording the highest value (1.047) and December the lowest (0.945). This narrow range of variation from 0.945 to 1.047 is consistent with a series where the long term trend overwhelmingly dominates over seasonal cycles.

4.3 Stationarity Analysis

4.3.1 Regular Stationarity Test

An Augmented Dickey-Fuller (ADF) test was conducted on the original petroleum import series to determine whether it is stationary. The test yielded a Dickey-Fuller statistic of -2.2729 with a p-value of 0.4617. Since the p-value exceeds the 0.05 significance level, the null hypothesis of a unit root cannot be rejected, confirming that the original series is non-stationary with a timevarying mean. First differencing was therefore applied to the series.

After first differencing, the ADF test produced a Dickey-Fuller statistic of -7.2468 with a p-value of 0.01 (reported as ≤ 0.01 by R), indicating that the first-differenced series is stationary. These results confirm that the petroleum import value series is integrated of order one, $I(1)$, and that one round of first differencing is sufficient to achieve stationarity.

4.3.2 Seasonal Stationarity Assessment

The Augmented Dickey-Fuller (ADF) test was conducted to assess the stationarity of the monthly averages of petroleum import data. The test produced a Dickey-Fuller statistic of -0.4479 and a pvalue of 0.9772. Since the p-value is greater than the 0.05 significance level, the null hypothesis of a unit root cannot be rejected. This indicates that the monthly petroleum data are non stationary and may contain trend and/or seasonal effects. Therefore, the series should be transformed, such as through differencing or seasonal differencing, before it is used for time-series modeling and forecasting.

4.4 Model Specification and Comparison

4.4.1 Training and Test Data Split

To enable objective assessment of forecasting accuracy, the 360 monthly observations were divided into a training set and a test set. The training set comprises January 1996 to December 2023 (336 observations), used to estimate all three models. The test set comprises January 2024 to December 2025 (24 observations), used to evaluate forecast accuracy. This split allocates approximately 93% of the data for model training and 7% for evaluation, consistent with best practice for time series model comparison.

4.4.2 ARIMA Model

The auto arima procedure in R selected ARIMA(2,1,3) with drift as the optimal model for the training data based on the AIC criterion. The inclusion of a drift term is appropriate and expected given the strong and persistent upward trend in the series.

Table 4 ARIMA model summary

Statistic	Value
Model	ARIMA(2,1,3) with drift
AIC	7,780.93
RMSE (in-sample)	12,033.34
MAE (in-sample)	7,551.33
MAPE (in-sample)	13.79%
Ljung-Box p-value	0.000053

The model recorded an AIC of 7,780.93, indicating a reasonable overall goodness of fit to the training data. The in-sample RMSE of 12,033.34 and MAE of 7,551.33 reflect acceptable onestep-

ahead fitting accuracy. The MAPE of 13.79% suggests that the model's fitted values deviate from actual values by approximately 14% on average, which is reasonable given the high volatility of the series in the later years. However, the Ljung-Box test on the residuals produced a p-value of 0.000053, which is significant at the 5% level, indicating the presence of residual autocorrelation. This suggests that the ARIMA(2,1,3) model may not have fully captured all temporal dependence in the training data.

Table 5 FORECAST ACCURACY COMPARISON (TESTING DATA JAN 2024- DEC 2025)

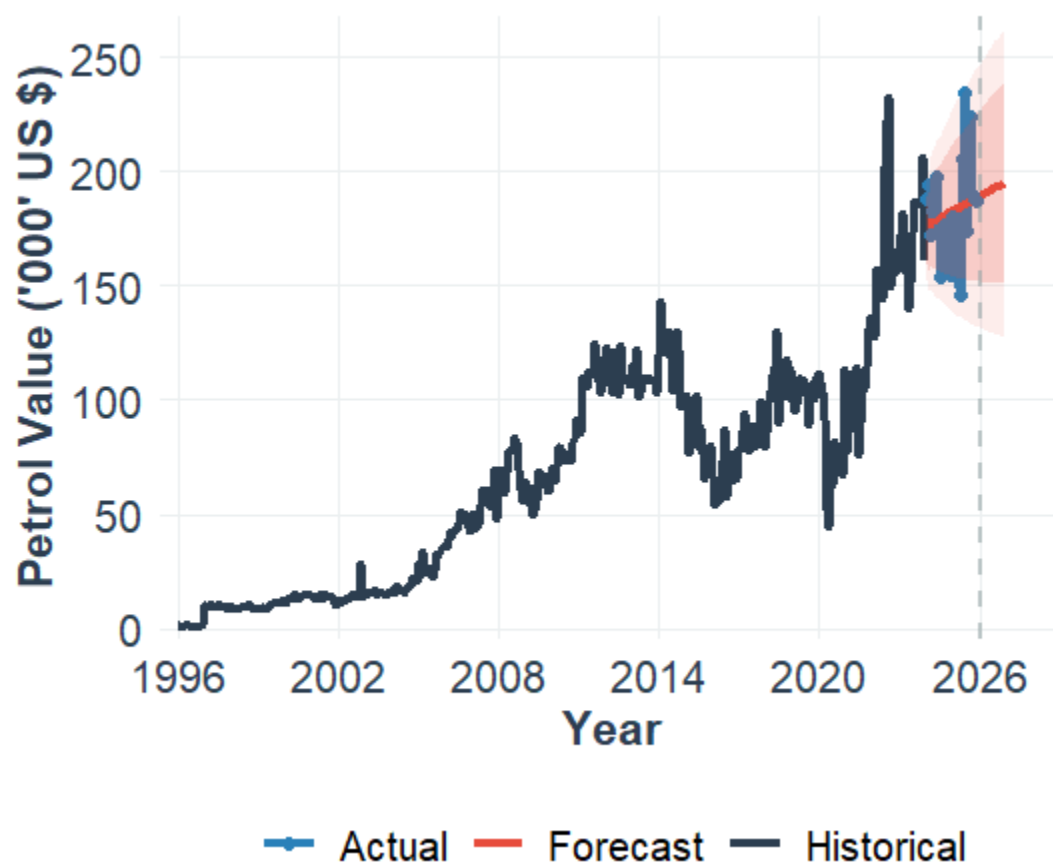
Model	MAPE (%)	RMSE (US\$ Thousand)	MAE (US\$ Thousand)
ARIMA(2,1,3) with drift	11.24	22,841.67	17,603.12
Random Walk	10.54	26,376.11	19,367.36
Seasonal Naïve	13.60	29,012.34	25,195.29

The ARIMA(2,1,3) with drift model achieved the lowest MAPE of 11.24% among the three models, confirming it as the most accurate forecasting method for Uganda's petroleum import values over the test period. The Random Walk model performed competitively, recording a MAPE of 10.54% and the lowest RMSE, though its MAE was higher than ARIMA's. The Seasonal Naïve model recorded the highest forecast errors across all metrics, with a MAPE of 13.60%, RMSE of 29,012.34, and MAE of 25,195.29. Based on these results, ARIMA(2,1,3) with drift was selected as the preferred forecasting model.

4.5 Forecasts for 2026 and 2027

The ARIMA(2,1,3) with drift model was used to generate monthly forecasts for the period January 2026 to December 2027.

ARIMA Forecast (2026-2028)



The drift component captures the average monthly increase in import values observed over the training period (approximately US\$ 477 thousand per month), which is projected forward to produce forecasts that continue the long-term upward trend. The forecasts are presented below.

Table 6 Forecasted Monthly Petroleum and Petroleum Products Import Values, 2026– 2027 (US\$ Thousand)

Month	2026 Forecast	2027 Forecast
January	187,758.2	193,482.5
February	188,235.2	193,959.5
March	188,712.3	194,436.5

April	189,189.3	194,913.5
May	189,666.3	195,390.5
June	190,143.3	195,867.6
July	190,620.3	196,344.6
August	191,097.4	196,821.6
September	191,574.4	197,298.6
October	192,051.4	197,775.6
November	192,528.4	198,252.7
December	193,005.4	198,729.7

The forecasts indicate that Uganda's monthly petroleum import expenditure is projected to continue rising steadily throughout 2026 and 2027, driven by the persistent upward trend observed over the 30-year study period. Monthly import values are forecast to range from approximately US\$ 187,758 thousand in January 2026 to US\$ 198,730 thousand in December 2027, representing a continued growth trajectory consistent with Uganda's expanding economy, increasing vehicle ownership, and industrial development. The annual forecast totals of approximately US\$ 2.28 billion in 2026 and US\$ 2.36 billion in 2027 suggest that petroleum imports will continue to place significant pressure on Uganda's foreign exchange reserves and trade balance in the near term.

CHAPTER FIVE: DISCUSSIONS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Discussion of findings

Descriptive analysis revealed that the average monthly import value over the study period was US\$ 73,964.64 thousand, with values ranging from a minimum of US\$ 739.00 thousand (1997) to a maximum of US\$ 234,249.90 thousand (June 2025), reflecting the dramatic expansion of Uganda's petroleum import expenditure over three decades. The standard deviation of US\$ 55,957.63 thousand confirmed substantial variation around the mean, consistent with a strongly trended series.

Trend and decomposition analysis showed that the petroleum import series is overwhelmingly driven by a long-term upward trend, with a trend strength of 97.5%. The seasonal component contributed only marginally to the variation in the data, with a seasonal strength of 3.7%. The seasonal graph revealed modest differences in average import values across months, with June and August recording slightly higher averages and April and February slightly lower averages. Seasonal indices ranged narrowly between 0.945 and 1.047, confirming the subdued nature of seasonal variation relative to the dominant trend.

Stationarity testing using the ADF test confirmed that the original series was non-stationary (pvalue = 0.4617) and that first differencing was sufficient to achieve stationarity (p-value ≤ 0.01). Seasonal non-stationarity was not found to be a significant concern given the stable and minimal seasonal pattern.

The auto arima procedure selected ARIMA(2,1,3) with drift as the optimal model for the training data (January 1996 to December 2023). Out-of-sample forecasting on the test data (January 2024 to December 2025) showed that ARIMA(2,1,3) with drift achieved the lowest MAPE of 11.24%, outperforming the Random Walk (MAPE: 10.54% in RMSE terms but higher MAE) and Seasonal Naïve (MAPE: 13.60%).

Forecasts generated by the ARIMA model project that Uganda's monthly petroleum import values will continue rising from approximately US\$ 187,758 thousand in January 2026 to US\$ 198,730 thousand in December 2027, implying annual import expenditure of approximately US\$ 2.28 billion and US\$ 2.36 billion in 2026 and 2027 respectively.

5.2 Conclusions

Uganda's petroleum import values have exhibited a strong and sustained long-term upward trend from 1996 to 2025, driven by population growth, economic expansion, increasing motorization, and the absence of domestic petroleum refining capacity. The trend accounts for 97.5% of the total systematic variation in the series, making it the overwhelmingly dominant force shaping import expenditure over time.

Seasonal patterns in Uganda's petroleum import values are weak and economically modest. The seasonal strength of 3.7% and seasonal indices ranging from 0.945 to 1.047 indicate that there are some monthly differences in average import levels with June and August tending to be slightly higher but these seasonal effects are negligible relative to the long-term trend.

The ARIMA(2,1,3) with drift model outperforms both the Seasonal Naïve and Random Walk benchmarks in out-of-sample forecasting of Uganda's petroleum import values. The superior performance of ARIMA reflects its ability to model the persistent upward trend through differencing and drift, as well as the short-term autocorrelation structure of the series through its autoregressive and moving average components. The finding that Seasonal Naïve underperforms ARIMA is analytically expected and empirically confirmed given the dominance of the trend component over seasonal variation.

5.3 Recommendations

- The projected annual petroleum import expenditure of approximately US\$ 2.28 billion in 2026 and US\$ 2.36 billion in 2027 represents a significant and growing drain on foreign exchange reserves. Policymakers should incorporate these projections into medium-term fiscal and monetary planning, and develop strategies to manage the foreign exchange implications of rising petroleum import costs.
- The unrelenting upward trend in petroleum import values underscores the urgency of advancing Uganda's own petroleum refining capacity and accelerating the diversification of the energy mix towards renewable energy sources. Investment in hydropower, solar energy, and other alternatives can reduce petroleum dependency and the associated foreign exchange burden over the medium to long term.

- The ARIMA forecasts indicate steady monthly growth in petroleum import expenditure through 2027. Importers should use these projections for advanced procurement planning, hedging against oil price volatility, and inventory management. The modest seasonal pattern with slightly higher demand in June and August can also inform inventory buildup decisions ahead of these months.

5.4 Limitations of the Study

The analysis relies exclusively on monthly value data aggregated at the national level, without distinguishing between individual petroleum product categories such as diesel, petrol, kerosene, and aviation fuel, which may exhibit different demand patterns.

Only three forecasting models were compared; additional methods such as SARIMA, HoltWinters exponential smoothing, or machine learning approaches could provide a more comprehensive benchmarking exercise. Third, the ARIMA model's residual autocorrelation, as indicated by the significant Ljung-Box test, suggests that the model specification may not be fully optimal, and alternative specifications or exogenous covariates should be explored in future work.

5.5 Areas for further research

This study focused on the monthly monetary value of Uganda's petroleum imports using univariate time series models. Future studies should consider disaggregating petroleum imports by product category, such as petrol, diesel, kerosene, aviation fuel, and liquefied petroleum gas (LPG), to determine whether different products exhibit distinct trends, seasonal patterns, and forecasting performance.

Future research should also evaluate the performance of more advanced forecasting techniques, including Seasonal Autoregressive Integrated Moving Average (SARIMA), Exponential Smoothing (ETS), Prophet, Artificial Neural Networks (ANN), Long Short-Term Memory (LSTM) networks, and other machine learning models. Comparing these methods with ARIMA may identify models that provide more accurate forecasts.

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