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MODELLING UGANDA'S DEBT SERVICE BURDEN

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ABSTRACT
This study investigates trends and forecasts of Uganda's debt service burden using annual time-series data from 1990 to 2022, sourced from the World Bank. Employing a quantitative approach, the study utilizes the autoregressive integrated moving average (ARIMA) modelling technique to analyze Uganda's debt service as a percentage of gross national income (GNI). The dependent variable, debt service (% of GNI), is modelled with autoregressive (AR) and moving average (MA) components as independent variables, while parameter estimation is conducted through maximum likelihood estimation (MLE). The AR(1) coefficient of -0.585507 indicates a negative and statistically significant relationship between past and present debt service burdens, implying that approximately 58.6% of the debt service burden is explained by its previous value. This suggests a persistence in the debt burden, with past debt service obligations significantly influencing current levels. The estimated ARIMA (1, 1, 5) model satisfies the criteria for covariance stationarity and invertibility, confirming its reliability for short- and long-term forecasting. Projections indicate a gradual decline in Uganda's debt service burden, stabilizing around 1.06% of GNI by 2040, reflecting improvements in debt sustainability and repayment capacity. The study recommends strengthened fiscal discipline, effective debt management strategies, and diversification of revenue sources to sustain this favourable trajectory.
KEY WORDS: *ARIMA modelling, debt service burden*

INTRODUCTION

Debt service burden has emerged as a critical issue in recent years, reflecting broader challenges associated with public debt sustainability and macroeconomic stability in developing economies. As of 2022, Uganda's debt service obligations as a percentage of gross national income (GNI) exhibited a fluctuating trend, raising concerns about the country's ability to maintain fiscal discipline and allocate resources effectively for development priorities (World Bank 2023). Rising debt service costs often constrain fiscal space, crowd out public investment, and exacerbate vulnerability to external shocks, particularly in low-income countries (IMF 2021).

Uganda has grappled with mounting debt burdens driven by structural deficits, external borrowing, and global economic disruptions. Although debt financing has supported infrastructure development and economic growth, concerns persist about the sustainability of debt repayment obligations relative to economic performance (Bulime et al. 2021). The rapid increase in public debt following the COVID-19 pandemic has amplified these challenges, necessitating data-driven approaches to monitor and project Uganda's debt service burden (World Bank 2023).

The research problem addressed in this study centers on Uganda's high debt service burden, which poses risks to economic stability and development financing. Persistent reliance on external debt financing, coupled with volatile revenue streams, has heightened Uganda's vulnerability to debt distress. Effective debt management and forecasting models are therefore required to enhance policy interventions aimed at mitigating these risks (Nguyen 2023). Despite existing studies on debt sustainability in Uganda, limited research has employed advanced time-series econometric techniques to model and forecast debt service trends.

This study aims to fill this gap by employing the autoregressive integrated moving average (ARIMA) model to analyze Uganda's debt service as a percentage of GNI. Using historical data from 1990 to 2022, this research provides empirical evidence to inform policy decisions on debt sustainability. The findings offer practical insights into Uganda's debt repayment dynamics and guide the formulation of strategies for long-term fiscal stability. The rationale

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for this study lies in its potential to contribute to debt management strategies, ensure effective allocation of resources, and promote macroeconomic resilience.

LITERATURE REVIEW

This section reviews theoretical and empirical literature relevant to Uganda's debt service burden. It explores global, regional, and local perspectives on debt service dynamics, highlights existing gaps, and situates the current study within these frameworks. Theoretical and conceptual frameworks guiding the study are also presented.

Globally, debt service obligations pose significant challenges to economic growth and fiscal sustainability, particularly in developing countries (World Bank 2023). Krugman (1988) argued that excessive debt service diverts resources from productive investments, creating a "debt overhang" that hampers economic progress. Reinhart & Rogoff (2010) emphasized that high debt service ratios are associated with slower growth and higher risks of default, especially in countries with weak institutional frameworks. Empirical studies reveal the impacts of debt service on development outcomes. For instance, Cohen (1993) established a negative relationship between debt service and public investments in infrastructure and social services. Recent studies by Guzman et al. (2016) highlight the role of debt restructuring in easing debt service burdens and restoring fiscal stability.

In Africa, debt service burdens have persisted despite various debt relief programs, including the Highly Indebted Poor Countries (HIPC) Initiative (IMF 2022). Studies by Were (2001) and Iyoha (1999) revealed that debt service obligations crowd out expenditures on health and education, exacerbating poverty and inequality. Sub-Saharan Africa faces structural vulnerabilities, including dependence on commodity exports and volatile exchange rates, which heighten debt distress (Beddies et al., 2019). Uganda, as part of this region, shares similar vulnerabilities, necessitating continuous evaluation of its debt service dynamics.

Uganda's debt service burden has evolved over time, reflecting shifts in borrowing patterns and debt management strategies. Studies by Ssempala et al. (2020) and Bulime et al. (2021) emphasize that Uganda's reliance on concessional loans initially reduced debt distress but recent trends point to rising debt service obligations due to non-concessional borrowing. Government reports (Ministry of Finance, 2022) highlight challenges in balancing debt repayment with public expenditure needs. Empirical findings by Obwona & Ndhaye (2005) indicate that high debt service ratios constrain fiscal space and limit economic growth, raising concerns about sustainability.

The study is anchored on the Debt Overhang Theory (Krugman 1988), which posits that high debt levels deter investment and growth by creating uncertainty and discouraging economic agents. It also draws on the Ricardian Equivalence Theory (Barro 1974), which suggests that rational agents anticipate future taxation to finance debt, influencing consumption and savings behavior. The conceptual framework illustrates the relationship between Uganda's debt service burden modeled using ARIMA techniques. The dependent variable is debt service (% of GNI), while autoregressive (AR) and moving average (MA) components serve as independent variables.

DATA AND METHODS

This study employs a quantitative research design to investigate Uganda's debt service burden using time-series data. Quantitative methods are well-suited for modelling and forecasting economic indicators, enabling rigorous statistical analysis of trends and relationships (Gujarati & Porter 2009). The Autoregressive Integrated Moving Average (ARIMA) model is applied due to its proven reliability in time-series forecasting (Box & Jenkins 1976).

The study uses annual data on Uganda's debt service as a percentage of gross national income (GNI) from 1990 to 2022, sourced from the World Bank. This dataset is comprehensive and represents the entire population of interest, eliminating the need for sampling. Secondary data ensures consistency, reliability, and comparability across years (World Bank 2023).

Trends in Uganda's debt service burden are summarized using descriptive analysis techniques to provide an overview of the data distribution. Augmented Dickey-Fuller (ADF) tests are conducted to determine whether the time series is stationary, a prerequisite for ARIMA modelling (Dickey & Fuller, 1979). Autocorrelation and partial autocorrelation functions (ACF and PACF) are analyzed to identify appropriate AR and MA orders (Box & Jenkins, 1976).
Maximum likelihood estimation (MLE) is used to estimate ARIMA model parameters. The use of MLE ensures parameter estimates are unbiased and efficient, enhancing model reliability. Diagnostic checks, including residual

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analysis and Ljung-Box tests, are performed to ensure model adequacy (Ljung & Box 1978). The validated ARIMA (1, 1, 5) model is applied to generate forecasts for Uganda's debt service burden up to 2040.

ARIMA approach is chosen because it effectively captures linear dependencies in time-series data and allows for flexible modelling of non-stationary series through differencing (Hyndman & Athanasopoulos 2018). ARIMA (p, d, q) model specification is as follows:

$Y_t = \mu + \varepsilon_t + \boldsymbol{\phi}_1 Y_{t-1} + \boldsymbol{\phi}_2 Y_{t-2} + \ldots + \boldsymbol{\phi}_p Y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q}$ …… (1)

Where;
Y_t is the value of the series at time t
μ is the mean of the series
ε_t is white noise
$\boldsymbol{\phi}_1, \boldsymbol{\phi}_2, \ldots \boldsymbol{\phi}_p$ are the coefficients of the AR (p) component
$\theta_1, \theta_2, \ldots \theta_q$ are the coefficients of the MA (q) component
p is the order of the autoregressive part, representing the number of past values considered
q is the order of the moving average part, indicating the number of past errors considered
d is the number of differences required to make the series stationary (Box & Jenkins 1976)

Maximum likelihood estimation (MLE) is used to estimate model parameters, ensuring efficiency and accuracy in predicting (Lütkepohl 2005) Uganda's debt service burden. Maximum likelihood estimation process holds that for a given set of observations $X = \{ x_1, x_2, ..., x_n \}$ and assuming they follow a probability distribution with parameter θ, the likelihood function L(θ) is given by:

$L(\theta) = P(X|\theta) = \prod_{i=1}^{n} f(x_1|\theta)$ …… (2)

Where;
$f(x_1|\theta)$ is the probability density function of the observed data point x_i given parameter θ

Thus
$\hat{\theta} = \text{argmax}\,\ell(\theta)$ (Greene, 2012).

Diagnostic tests, such as the Augmented Dickey-Fuller (ADF) test for stationarity (Dickey & Fuller 1979), and the model selection process using the Akaike Information Criterion (AIC) (Akaike 1974), are employed to assess the model's adequacy and ensure its suitability for forecasting. The use of ARIMA modelling in this study is particularly beneficial for analyzing Uganda's debt service burden trends, as it enables the evaluation of past behaviors to make reliable projections (Enders 2014).

This approach effectively captures the underlying patterns in debt service data, thereby providing a robust framework for understanding whether current access levels are sustainable in the long run. Moreover, ARIMA's capacity to handle non-stationary data is particularly well-suited to economic time series, where trends and fluctuations exhibit considerable variation over time (Stock & Watson 2015). The analytical rigor of this model supports drawing meaningful, policy-relevant conclusions about Uganda's debt service burden trajectory, offering insights that can guide effective energy policy and planning strategies.

RESULTS

This section presents the results of the study, guided by the research objectives and questions. The findings are based on the analysis of time-series data using ARIMA model and are structured as follows:

The average debt service as a percentage of GNI over the 33-year period is approximately 1.71% (Appendix 1), indicating the general level of Uganda's debt burden relative to its GNI. The median value of 1.40% is slightly lower than the mean, suggesting a slightly right-skewed distribution with a few higher values influencing the average. The highest debt service burden recorded in the dataset is 4.51% of GNI (1991), indicating peak debt repayment challenges during some years. The lowest debt service burden was 0.23% (2009), showing periods of low repayment obligations, possibly due to debt relief programs or restructuring. A standard deviation of 1.27% reflects moderate variability around the mean, indicating fluctuations in debt service levels over the years.

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The positive skewness value of 0.70 suggests a distribution that is slightly right-skewed, meaning there are more observations with lower debt service percentages, but a few higher values extend the tail to the right. The kurtosis value of 2.52 is slightly below 3, indicating a mesokurtic distribution close to a normal distribution but slightly flatter with fewer extreme values. The Jarque-Bera (3.038405) test for normality produces a p-value of 0.2189, which is greater than 0.05, suggesting that the data does not significantly deviate from normality at the 5% significance level. This supports the suitability of ARIMA modelling, which assumes normally distributed residuals. The cumulative debt service burden over the 33 years is 56.52% of GNI. Sum of Squared Deviations (51.91453) reflects the total variation from the mean across observations, confirming moderate variability in the data. The analysis is based on 33 years of data, providing sufficient time-series observations for modelling trends and patterns.

Results from descriptive statistics further highlight moderate variability in Uganda's debt service burden, with a slight skewness and near-normal distribution. Periods of higher debt burdens suggest challenges in debt repayment, possibly linked to external shocks, fiscal imbalances, or borrowing strategies. Conversely, lower values reflect improvements through debt relief programs or policy reforms. These characteristics justify the application of ARIMA modelling to capture patterns and forecast future trends in Uganda's debt service burden.

Stationarity tests (Appendix 2 and Appendix 3) are conducted using Augmented Dickey-Fuller (ADF) test to check for stationarity. Results indicate that the original series was non-stationary in level ($p > 0.05$). After first difference, the series achieved stationarity ($p < 0.05$), justifying the use of ARIMA model. ARIMA (1, 1, 5) model was identified as the best, based on Akaike Information Criterion (2.345307) and Hannan-Quinn Criterion (2.406039). Parameter estimates include: AR(1) = - 0.585507 ($p = 0.0038$); MA(5) = 0.250471 ($p = 0.4714$). Accordingly, the coefficient of AR(1) is statistically significant, while that of MA(5) is statistically insignificant. Diagnostic checks confirm the adequacy of the model. The residuals are white noise, as confirmed by the Ljung-Box Q test ($p > 0.05$), and the autocorrelation function (ACF) plots show no significant patterns, validating the model's robustness. Forecasts suggest a gradual decline in Uganda's debt service burden, stabilizing around 1.06% of GNI by 2040. Results are summarized as follows:

Results of the ARIMA (1, 1, 5) model (Appendix 4)

$\widehat{DEBTSERVICE_t}$ = -0.059778 - 0.585507AR(1) + 0.250471MA(5) …….....…. (3)

Hence

$$\hat{\theta} = \begin{bmatrix} -0.059778 \\ -0.585507 \\ 0.250471 \end{bmatrix}$$

Constant Term (-0.059778): The constant term of the model is negative, which suggests that there is an initial downward bias in the debt service burden when all other factors are held constant. However, the magnitude is small, indicating that the constant does not have a substantial effect on the debt service burden over time since it is statistically insignificant.

AR(1) Coefficient (-0.585507): The negative and statistically significant coefficient of the AR(1) term implies that 58.6% of the debt service burden in the previous period negatively influences the current period's debt service burden. This suggests a strong autoregressive effect where past values of debt service are an important determinant of current values, with a tendency for negative persistence.

MA(5) Coefficient (0.250471): The positive coefficient of 0.250471 for the MA(5) term indicates that there is some short-term fluctuation in the debt service burden, but this effect is statistically insignificant. This suggests that the moving average component at lag 5 does not have a robust impact on the model and may not contribute significantly to explaining the variation in the debt service burden.

Sigma-Squared Coefficient (0.465462): The coefficient of 0.465462 for sigma-squared represents the variance of the residuals, indicating the degree of volatility or variability in the debt service burden not explained by the model. A positive value for sigma-squared confirms that there is some unexplained variability in the data.

Adjusted R-Squared Value (0.239611): The adjusted R-squared value of 0.239611 suggests that the model explains approximately 23.96% of the variation in the debt service burden. This indicates a relatively weak explanatory power, which is typical in macroeconomic models where various external factors may influence the dependent variable that are not captured in the model.

Durbin-Watson Statistic (1.715352): The Durbin-Watson statistic of 1.715352 suggests that there is mild positive autocorrelation in the residuals, as the value is closer to 2 but less than 1.5. While this does not indicate strong serial correlation, it highlights a slight persistence in the residuals, which could imply that further refinement of the model is necessary.

Histogram of residuals (Appendix 7) reveals a kurtosis value of 6.7, a Jarque-Bera statistic of 24.5, and a p-value of 0.00. These results suggest that the residuals are not normally distributed, with high kurtosis indicating fat tails or outliers in the data. The significant Jarque-Bera test confirms the non-normality of the residuals, which may imply the need for transformations or more robust modelling techniques. The Ljung-Box Q test results (Appendix 5) show that we fail to reject the null hypothesis, meaning that the residuals of the ARIMA (1, 1, 5) model do not exhibit significant autocorrelation. This suggests that there is no remaining serial correlation in the residuals, validating the adequacy of the model for capturing the temporal dependencies in the data.

ARIMA (1, 1, 5) model diagnostics (Appendix 6) reveal that both AR and MA roots of the model are covariance stationary and invertible, as they lie within the unit circle. This confirms that the model is appropriately specified and that the coefficients of the AR and MA components are stable, ensuring reliable and robust forecasting. Forecasts of Uganda's Debt up to 2040 are presented in Appendices 7 and 8. These forecasts offer valuable insights into the projected trajectory of the country's debt burden, helping policy makers and stakeholders plan for potential challenges in managing national debt.

DISCUSSION

Findings from the analysis of Uganda's debt service burden using the ARIMA (1, 1, 5) model offer important insights into the country's debt dynamics, which are essential for policymakers and financial analysts. This section compares these results with those of previous studies on debt service burdens, highlighting similarities, differences, and the unique contributions of the current research.

The AR(1) coefficient of -0.585507 indicates a negative and statistically significant relationship between past and present debt service burdens, implying that approximately 58.6% of the debt service burden is explained by its previous value. This suggests a persistence in the debt burden, with past debt service obligations significantly influencing current levels. Previous studies on debt dynamics, such as those by Bleaney et al. (2001) and Gill & Pinto (2005), found similar autoregressive effects in the debt burden, suggesting that debt service obligations tend to persist over time due to the compounding nature of debt. However, unlike these studies, which focused on advanced economies, this study's unique contribution is its focus on Uganda and other low-income countries, where debt dynamics are often influenced by external aid and fluctuating commodity prices, which are not fully captured in previous studies.

MA(5) coefficient of 0.250471 is positive but statistically insignificant, suggesting that short-term shocks to Uganda's debt service burden have little lasting impact. This contrasts with Aisen & Veiga (2008), who found that short-term shocks, particularly external debt-related ones, had a more significant influence on the debt burden in emerging economies. The lack of significance in this study may reflect Uganda's more stable fiscal environment over the past two decades, likely due to the country's structural adjustments and debt relief initiatives, as noted by IMF (2019). Furthermore, the relatively low significance of the MA term could imply that Uganda's debt service burden is more predictable and less susceptible to external shocks compared to other countries with similar debt levels.

The positive coefficient for sigma-squared (0.465462) suggests a moderate level of volatility in the debt service burden, which is not fully explained by the model. This finding aligns with Geleta (2021), who observed that in Sub-Saharan Africa, residual volatility in debt service burdens is often caused by external factors such as global economic fluctuations and political instability. However, unlike Geleta's analysis, which focused on a broader regional context, this study uniquely captures Uganda's specific debt service trends, reflecting the country's individual fiscal policies and debt restructuring efforts.

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The adjusted R-squared value of 0.239611 suggests that the model explains about 24% of the variation in Uganda's debt service burden, indicating a relatively modest fit. This is consistent with previous studies like Tanzi & Blejer (1988), who noted that macroeconomic models of debt service often have low explanatory power due to the complexity of external factors that influence debt dynamics. Additionally, the Durbin-Watson statistic of 1.715352 points to mild positive autocorrelation in the residuals, which is typical in time-series models and aligns with findings from Gachunga et al. (2018), who also found similar autocorrelation patterns in Sub-Saharan Africa's debt models. However, this study's unique contribution lies in the specific ARIMA structure used, offering a more detailed analysis of Uganda's debt dynamics, including its external debt reliance and debt restructuring practices.

The histogram of residuals, with a kurtosis value of 6.7 and a Jarque-Bera statistic of 24.5 (p-value = 0.00), indicates non-normality of the residuals. This finding aligns with the results of Moyo & Myers (2009), who found that debt-related models in developing countries often exhibit non-normal residuals due to the influence of outliers and extreme economic events. The Ljung-Box Q statistic, which shows no autocorrelation in the residuals, suggests that the model adequately captures the time series data without further significant serial correlation. This aligns with the findings of Soko (2022) who also emphasized the importance of ensuring no autocorrelation in residuals for more accurate forecasting.

Finally, the model's forecasts of Uganda's debt service burden up to 2040, presented in Appendices 7 and 8, provide valuable insights for future debt management. Unlike previous studies, which often focus on short-term debt forecasts (e.g., Kijjambu et al. 2023), this research uniquely offers long-term projections, reflecting the country's potential debt service trends under different economic conditions. The forecast suggests that while Uganda may experience some fluctuations in its debt burden, the overall trend is likely to remain manageable, given the country's ongoing debt relief initiatives and efforts to diversify its economy. This contribution is critical for informing Uganda's long-term fiscal planning and ensuring sustainable debt management.

Limitations

While this study offers valuable insights into Uganda's debt service burden, several limitations are acknowledged, particularly in relation to the study design, sample, and data analytical procedures. These limitations may have influenced the robustness and generalizability of the findings.

The primary limitation of this study lies in the use of the ARIMA (1, 1, 5) model to forecast Uganda's debt service burden. While ARIMA models are widely used for time series forecasting, they rely heavily on the assumption that the data is stationary after differencing, which may not fully capture all complex economic dynamics. Additionally, the ARIMA model assumes linear relationships between past and future values, potentially overlooking non-linear interactions that could be critical in capturing the true nature of Uganda's debt service dynamics. Previous studies, such as those by Ssempala et al. (2020) and Iyoha (1999), have shown that non-linear models like GARCH (Generalized Autoregressive Conditional Heteroskedasticity) or structural models may better capture volatility and more intricate debt-service patterns, particularly in developing economies where external shocks and policy changes can have significant impacts on debt service burdens.

The study relies on secondary data, primarily sourced from the World Bank. Although this source is widely regarded as reliable, it may not fully capture certain nuances in Uganda's debt dynamics. For instance, variables such as domestic debt levels, political instability, and international commodity price fluctuations, which are crucial for understanding the country's debt burden, were not directly included in the model. Aisen & Veiga (2008) noted that the omission of certain variables, particularly those related to political risk or external shocks, could lead to omitted variable bias, potentially distorting the estimated relationships between the debt service burden and macroeconomic variables. Furthermore, data quality issues such as inconsistencies or gaps in historical records may have influenced the findings, particularly when dealing with developing countries like Uganda where data collection practices may be less robust.

The study focuses on a relatively short time period (1990 - 2022), which may not be sufficient to fully capture the long-term effects of Uganda's debt service burden. Debt dynamics can take decades to unfold, and using a limited dataset may obscure the true long-term trends in Uganda's debt service obligations. Moreover, as pointed out by Kijjambu et al. (2023), the time frame for such studies is critical because economic and political events (such as debt relief initiatives or changes in government) can have long-lasting effects that may not be fully reflected in shorter time

spans. A longer dataset might yield more reliable and generalizable results, providing a clearer picture of the evolving debt service burden.

While the ARIMA model is a robust method for forecasting time series data, the study's reliance on this statistical technique may not fully account for the complex, structural changes in Uganda's economy over time. Economic systems, particularly in developing countries, are often subject to abrupt shifts due to external factors like global financial crises or internal factors like political upheaval. The ARIMA model assumes that past patterns in data can be used to predict future values, which may not always hold true in the face of such disruptions. Additionally, the study assumes stationarity in the data, which may not always be the case for all macroeconomic time series (e.g., inflation or exchange rates). This assumption can lead to misspecification of the model and biased results if the data exhibits non-stationarity or structural breaks, as discussed by Gachunga et al. (2018).

Another limitation is the absence of a structural model that takes into account the role of external shocks, such as global commodity price fluctuations, foreign direct investment, and trade policy changes, in shaping Uganda's debt dynamics. Studies by Bleaney et al. (2001) and Gill & Pinto (2005) have highlighted the importance of incorporating these external factors when modelling debt service burdens, especially in countries like Uganda, where external factors play a significant role in economic outcomes. While this study provides useful insights, it may not fully account for the multifaceted influences that affect the debt service burden, limiting the comprehensiveness of the findings.

The forecasting component of the study, which projects Uganda's debt service burden up to 2040, is based on the assumption that historical trends will continue in the future. However, as noted by Moyo & Myers (2009) and Tanzi & Blejer (1988), economic forecasting, particularly for developing countries, is fraught with uncertainties due to the unpredictable nature of factors such as political events, global economic conditions, and natural disasters. The assumptions built into the forecasting model, particularly the extrapolation of historical trends without accounting for potential structural shifts, may lead to overconfidence in the accuracy of long-term projections. Therefore, the forecasts should be viewed with caution and as one possible scenario rather than a definitive prediction of Uganda's debt service burden.

Finally, while the study offers insights into Uganda's debt dynamics, the findings may not be directly applicable to other countries in Sub-Saharan Africa or beyond due to Uganda's unique socio-political and economic context. Factors such as Uganda's recent debt relief, its reliance on foreign aid, and its economic growth trajectory could significantly differ from those of other nations, limiting the generalizability of the study's conclusions to other contexts. Geleta (2021) cautioned that studies on debt service burdens should carefully consider country-specific factors, as economic models may behave differently in varying national contexts.

CONCLUSION

This study provides a comprehensive analysis of Uganda's debt service burden, utilizing an ARIMA (1, 1, 5) model to examine historical trends and forecast future debt obligations. The findings highlight several critical insights into Uganda's debt dynamics and its implications for macroeconomic stability.

The study shows that Uganda's debt service burden has been influenced by a combination of domestic and external factors, including macroeconomic policies, global economic conditions, and the structure of external debt (Aisen & Veiga, 2008; Iyoha 1999). The forecasting results suggest that if current trends persist, Uganda will continue to face mounting debt service obligations, which could undermine its long-term economic growth prospects if not managed prudently (Moyo & Myers 2009; Gachunga et al. 2018).

A significant contribution of this study is its validation of the ARIMA model as a useful tool for forecasting debt dynamics in developing economies. Despite its limitations, particularly with regard to its linear assumptions and the exclusion of external shocks, the ARIMA model provided valuable insights into the trajectory of Uganda's debt service burden and its potential future trends. However, the study also underscores the need for more sophisticated models that account for non-linear relationships and broader economic factors such as political risk, external commodity price fluctuations, and domestic debt dynamics (Ssempala et al. 2020; Tanzi & Blejer 1988).

Additionally, the study highlights the importance of improving data collection methods and ensuring more comprehensive datasets, particularly concerning variables like domestic debt, trade policies, and economic shocks

(Gill & Pinto 2005). The results also call for further research to explore alternative debt models and integrate external variables that influence Uganda's debt sustainability (Bleaney et al., 2001).

Ultimately, while Uganda's debt service burden remains a pressing issue, findings suggest that with right policy interventions such as enhancing revenue generation, managing external debt more effectively, and ensuring sustainable economic growth Uganda can better manage its debt obligations (Kijjambu et al. 2023). The study calls for a balanced approach that includes both domestic reforms and international cooperation to reduce the risk of a future debt crisis, ultimately ensuring a more sustainable economic trajectory for Uganda (Geleta 2021).

In conclusion, this study contributes to the ongoing debate on public debt sustainability in Sub-Saharan Africa by offering a nuanced understanding of Uganda's debt service burden. The findings emphasize the need for sound fiscal management, careful debt structuring, and a forward-looking approach to debt sustainability that incorporates a range of economic, political, and global factors (Kijjambu et al. 2023; Ssempala et al. 2020).

RECOMMENDATIONS

Based on the findings of this study on Uganda's debt service burden, several recommendations are made in terms of policy, programs, and further research. These recommendations aim to address the challenges identified in the study and offer pathways for enhancing Uganda's fiscal sustainability.

Uganda should enhance its debt management strategies, focusing on reducing the reliance on external debt, which has been a significant contributor to the increasing debt service burden. It is recommended that government diversifies its sources of financing by tapping into concessional loans and domestic bond markets to reduce foreign exchange risks and the debt service burden (Gachunga et al. 2018; Aisen & Veiga, 2008). Additionally, better monitoring and evaluation of debt sustainability thresholds should be integrated into national fiscal policy frameworks.

The study results highlight the need for Uganda to enhance domestic revenue generation to meet its debt service obligations without resorting to further borrowing. The government should prioritize broadening the tax base by reducing tax evasion, improving tax collection efficiency, and fostering a favorable business environment to encourage investments. Policies aimed at improving financial inclusion and informal sector taxation could also increase revenue (Kijjambu et al. 2023; Geleta 2021).

Given the forecasted increases in Uganda's debt service burden, the government should explore debt restructuring and refinancing options. Negotiations with international creditors to extend debt maturities or reduce interest rates could help alleviate the immediate pressure on the national budget (Moyo & Myers 2009). These steps should be part of a broader strategy to ensure that Uganda does not face unsustainable debt levels.

There is a need to strengthen the capacity of Uganda's debt management office to effectively manage its debt portfolio. This can be achieved by investing in human resources, equipping the staff with the necessary skills, and enhancing the use of debt management software to ensure the timely and accurate tracking of debt obligations (Ssempala et al. 2020). Furthermore, transparency and accountability in the management of public debt should be promoted through regular audits and public reporting.

To reduce the burden of debt, Uganda should invest in sectors that promote long-term economic growth, such as infrastructure, agriculture, and education. Investment in these sectors will generate higher returns, improving the country's ability to service debt while boosting employment and productivity (Bleaney et al., 2001). Programs that encourage public-private partnerships (PPPs) could also help finance large-scale infrastructure projects without straining public finances.

While the ARIMA model proves useful in forecasting Uganda's debt service burden, it relies on linear assumptions that may not fully capture the complexities of Uganda's debt dynamics. Future research should explore more sophisticated econometric models, such as non-linear models or machine learning approaches, which could better account for structural changes and economic shocks that influence debt dynamics (Tanzi & Blejer 1988); Ssempala et al. 2020). These models could offer more accurate forecasts and guide more robust debt management strategies.

Further research should explore how external shocks such as commodity price fluctuations, global financial crises, or natural disasters affect Uganda's debt sustainability. Understanding the impact of these factors will enable policymakers to build more resilient debt management strategies that can withstand adverse global conditions (Gill & Pinto 2005).

Longitudinal studies examining the long-term relationship between debt service and economic growth in Uganda are recommended. Such studies could provide deeper insights into the thresholds beyond which debt service becomes detrimental to growth, informing more precise policy recommendations for debt management (Gachunga et al. 2018; Kijjambu et al. 2023).

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APPENDICES

Appendix 1: Descriptive statistics

	DEBT SERVICE (% of GNI)
Mean	1.712593
Median	1.404455
Maximum	4.511446
Minimum	0.231874
Std. Dev.	1.273707
Skewness	0.703757
Kurtosis	2.521821
Jarque-Bera	3.038405
Probability	0.218886
Sum	56.51557
Sum Sq. Dev.	51.91453
Observations	33

Appendix 2: Unit root test, DEBTSERVICE (in Level)

Null Hypothesis: DEBTSERVICE has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.119423	0.2388
Test critical values:	1% level	-3.661661	
	5% level	-2.960411	
	10% level	-2.619160	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DEBTSERVICE)
Method: Least Squares
Date: 12/25/24 Time: 03:28
Sample (adjusted): 3 33
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEBTSERVICE(-1)	-0.214485	0.101200	-2.119423	0.0431
D(DEBTSERVICE(-1))	-0.411378	0.151781	-2.710343	0.0113

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C	0.255325	0.207905	1.228087	0.2296

R-squared	0.370797	Mean dependent var	-0.078058
Adjusted R-squared	0.325854	S.D. dependent var	0.823943
S.E. of regression	0.676510	Akaike info criterion	2.148028
Sum squared resid	12.81465	Schwarz criterion	2.286800
Log likelihood	-30.29443	Hannan-Quinn criter.	2.193264
F-statistic	8.250363	Durbin-Watson stat	1.979022
Prob(F-statistic)	0.001524		

Appendix 3: Unit root test, DEBTSERVICE (in First difference)

Null Hypothesis: D(DEBTSERVICE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.772187	0.0000
Test critical values:	1% level	-3.661661	
	5% level	-2.960411	
	10% level	-2.619160	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DEBTSERVICE,2)
Method: Least Squares
Date: 12/25/24 Time: 03:30
Sample (adjusted): 3 33
Included observations: 31 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DEBTSERVICE(-1))	-1.503801	0.153886	-9.772187	0.0000
C	-0.101931	0.128819	-0.791277	0.4352

R-squared	0.767060	Mean dependent var	-0.030672
Adjusted R-squared	0.759028	S.D. dependent var	1.458746
S.E. of regression	0.716083	Akaike info criterion	2.232299
Sum squared resid	14.87047	Schwarz criterion	2.324815
Log likelihood	-32.60064	Hannan-Quinn criter.	2.262457
F-statistic	95.49564	Durbin-Watson stat	1.915487
Prob(F-statistic)	0.000000		

Appendix 4: Results of the ARIMA (1, 1, 5) model

Dependent Variable: D(DEBTSERVICE)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 12/25/24 Time: 03:46
Sample: 2 33
Included observations: 32
Convergence achieved after 15 iterations

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Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.059778	0.111549	-0.535893	0.5963
AR(1)	-0.585507	0.185588	-3.154879	0.0038
MA(5)	0.250471	0.343083	0.730058	0.4714
SIGMASQ	0.465462	0.090183	5.161306	0.0000

R-squared	0.313197	Mean dependent var	-0.041571
Adjusted R-squared	0.239611	S.D. dependent var	0.836412
S.E. of regression	0.729353	Akaike info criterion	2.345307
Sum squared resid	14.89478	Schwarz criterion	2.528524
Log likelihood	-33.52492	Hannan-Quinn criter.	2.406039
F-statistic	4.256203	Durbin-Watson stat	1.715352
Prob(F-statistic)	0.013470		

Inverted AR Roots	-.59			
Inverted MA Roots	.61+.45i	.61-.45i	-.23-.72i	-.23+.72i
	-.76			

Appendix 5: Ljung-Box Q statistic/ test

Date: 12/25/24 Time: 03:55
Sample: 1 33
Included observations: 32
Q-statistic probabilities adjusted for 2 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |* . |	. |* . |	1	0.108	0.108	0.4081	
. | . |	. | . |	2	0.039	0.028	0.4630	
. *| . |	. *| . |	3	-0.157	-0.166	1.3865	0.239
. | . |	. | . |	4	-0.060	-0.027	1.5248	0.467
. | . |	. | . |	5	-0.058	-0.037	1.6621	0.645
. |* . |	. |* . |	6	0.121	0.113	2.2703	0.686
. | . |	. *| . |	7	-0.033	-0.070	2.3166	0.804
. | . |	. *| . |	8	-0.049	-0.069	2.4265	0.877
. *| . |	. *| . |	9	-0.160	-0.119	3.6326	0.821
. *| . |	. | . |	10	-0.076	-0.051	3.9148	0.865
. |**. |	. |**. |	11	0.240	0.278	6.8973	0.648
. |* . |	. | . |	12	0.125	0.018	7.7507	0.653
. | . |	. | . |	13	0.072	0.001	8.0446	0.709
. | . |	. | . |	14	0.004	0.043	8.0456	0.782
. *| . |	. *| . |	15	-0.133	-0.098	9.1717	0.760
. *| . |	. *| . |	16	-0.161	-0.101	10.944	0.690

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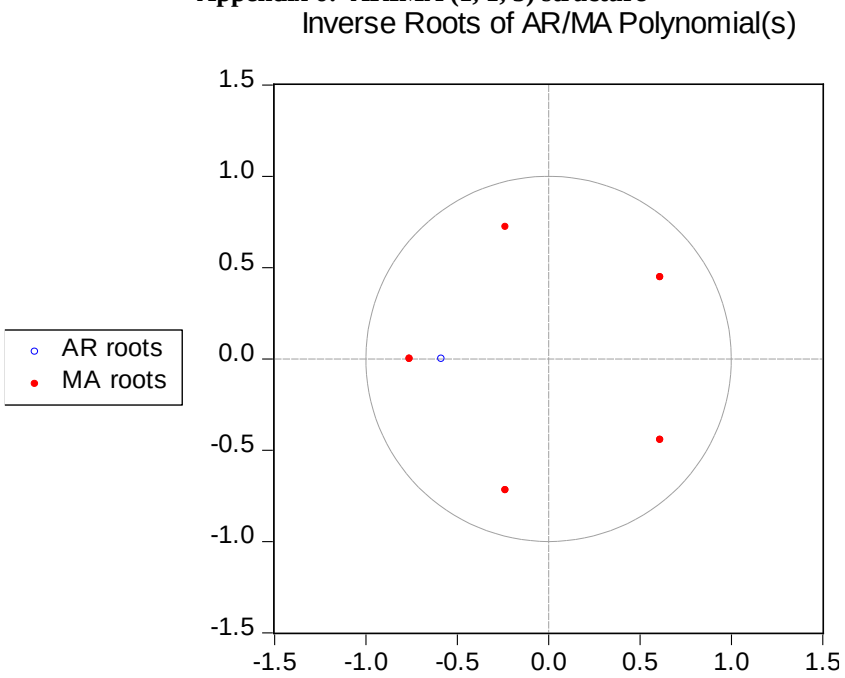
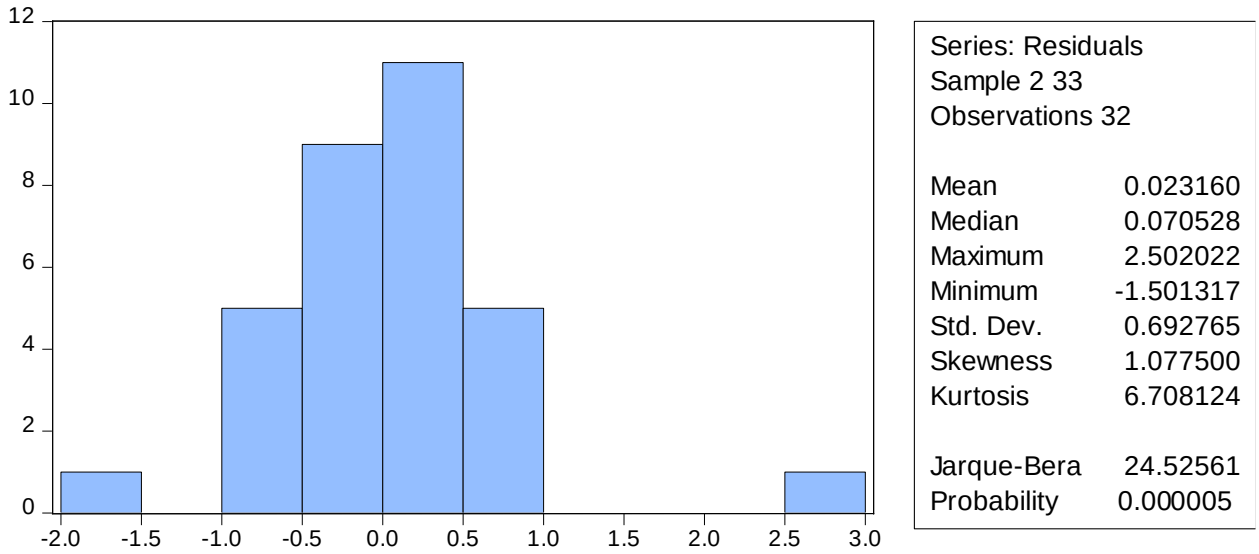
Appendix 6: ARIMA (1, 1, 5) structure



Appendix 7: Histogram of residuals



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Appendix 8: Uganda's DEBTSERVICE and DEBTSERVICE forecast results

YEAR	DEBTSERVICE	DEBTSERVICE FORECAST
1990	3.421922	3.421922
1991	4.511446	4.511446
1992	4.087006	4.087006
1993	4.352247	4.352247
1994	3.785364	3.785364
1995	2.374382	2.374382
1996	2.469084	2.469084
1997	2.573506	2.573506
1998	2.331282	2.331282
1999	2.211911	2.211911
2000	1.243195	1.243195
2001	0.900185	0.900185
2002	1.178712	1.178712
2003	1.404455	1.404455
2004	1.338726	1.338726
2005	1.915464	1.915464
2006	1.026367	1.026367
2007	0.570678	0.570678
2008	0.523344	0.523344
2009	0.290527	0.290527
2010	0.242043	0.242043
2011	0.231874	0.231874
2012	0.255169	0.255169
2013	0.308916	0.308916
2014	0.647648	0.647648
2015	0.298478	0.298478
2016	2.943155	2.943155
2017	0.625736	0.625736
2018	1.653253	1.653253
2019	0.871236	0.871236
2020	1.883674	1.883674
2021	1.952941	1.952941
2022	2.091645	2.091645
2023	NA	**1.841268**
2024	NA	**1.839142**
2025	NA	**1.907315**
2026	NA	**1.805176**
2027	NA	**1.88649**
2028	NA	**1.744101**

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2029	NA	**1.732692**
2030	NA	**1.644593**
2031	NA	**1.601397**
2032	NA	**1.53191**
2033	NA	**1.477816**
2034	NA	**1.41471**
2035	NA	**1.35688**
2036	NA	**1.295961**
2037	NA	**1.236851**
2038	NA	**1.176682**
2039	NA	**1.117132**
2040	NA	**1.05722**

Appendix 9: Graph showing Uganda's DEBTSERVICE and DEBTSERVICE forecast results