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ABSTRACT

The rapid rise of the national borrowings level around the world Due to the financial crisis of 2007/2008 has led to several governments' fiscal issues. In Rwanda alone, the level of borrowed funds rose from19.4% in 2010 to 59.7% in 2019; thus, more studies to understand how different economic indicators affect the public borrowings are needed. The current study has analyzed the economic indicators related to government debt accumulation in Rwanda by applying a multivariate time series analysis. The goals of the research were; to check for stationarity of the variables, to perform co-integration analysis and to forecast the external government borrowings level in the next five years. In this study, stationarity, co-integration and forecasting methods were executed. Historical data was covering the period from 1973 to 2022. Data collection involved secondary data obtained documentation on information from World Bank (W.B) and National Institute of Statistics of Rwanda (N.I.S.R.). The research conducted Augmented Dickey-Fuller test (ADF) for unit root to check for stationarity but also Johansen co-integration technique was utilized before applying Vector Autoregressive model (VAR) for forecasting the state borrowings. This study aimed to ascertain the influence of each selected variable on the state borrowings accumulation. This research found all the variable under the consideration to be stationary after first differentiation and there was no long-term association found between them. The forecasting techniques expect the foreign national borrowings to rise up to 74.20027 % in 2027 of the gross national income.

Key words: *External Debt, Internal Debt, Inflation and GDP*

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BACKGROUND

A group of Sub-Saharan countries including Rwanda have been struggling in managing their heavy external debt (Ndikumana & Boyce, 2010). Sub-Saharan Africa's public debt has been persistent with many countries facing difficulties to manage their hanging debt. However, historically, African economies have been characterized by high level debt accumulation from external creditors like African Bank for economic development, International Monetary Fund and other worldwide financial institution (Reinhart & Rogoff, 2011).

The recent financial crisis has caused an increased public debt for many countries around the world (Nautet & Van Meensel, 2011). The rapidly increasing U.S government debt has currently become a public issue. The United States also borrow from foreigners to fill the gap between U.S domestic investment and U.S savings. The U.S public debt ratio to GDP has shifted from 36.2% in 2007 to 62.2%. at the end of 2010. However, the corona virus pandemic projected the U.S public debt to highest levels from World War II. The United States debt to GDP is among the highest compared to developed countries as it comes only after Portugal, Italy, Greece and Japan. On the other hand, some economists consider the debt issue as exaggerated that U.S still has many years to resolve the problem (Bohn., 2011).

Today, public debt is a major concern in most of the countries around the world mostly in developing countries as they more depend on external debts than domestic borrowings (Egbetunde, 2012). Public debt can also be considered as the result of government spending more than what it produces. Economic experts have identified many factors (internal and external) which led to public debt accumulation (Panizza & Presbitero, 2013). Indeed, increasing public debt which is considered as both domestic and external debts remains a major concern in developing African countries since their independence (Kasidi & Said, 2013).

Throughout the years, the public debt has been a major source of capital for the growth and development endeavor in multiple nations around the World (Bua et al., 2014). Particularly, the public debt of Sub-Saharan countries has peaked in recent times. However, due to the global crisis public debt has become also a concern in developed countries. Over the years the process of borrowing has left many governments with heavy outstanding debts. On the other hand, reasonable borrowing is essential to the development of a national economy. But in countries with poor economic performance, public debt is serious matter since it can create low economic development. (Megersa, 2015).

Most of the Asian countries are facing the issue of debt expansion. India's ranking indicates that it has advanced from moderately to lower debt levels in low-income categories. Meanwhile, Pakistan transitioned from moderate level of debt to heavily burdened by debt (Raheem et al., 2022).

East African countries have been depending on government debt to cover budget deficits. There have been notable shifts in Uganda's debt to GDP ratio. The ratio was at its highest level in 2003 at 72%. Measures were taken to reduce it and it reached its lowest in 2009 at 20%. But from 2009 to 2018 it increased again to 40%. Tanzanian debt to GDP ratio reached its highest level in 2000 when it was 50% and it was reduced to 22% in 2008. However, from 2008 to 2018, debt to GDP have been continuously rising to the level of 37.5%. it is crucial to remember that public debt become dangerous when governments fail to repay. Although, public debts are considered as last option and it is also the best strategy than money creation or sales of national assets (Orinda et al., 2022). Research carried out determined an inverse correlation between the growth in national debt and corporate investment in Kenya. Large public debt has been the most critical crisis in many developing countries since their independence (Musa et al., 2023).

Problem Statement

In accordance with World Bank, public debt has been a great consideration for researchers and

authorities as it is continuously rising since the world financial crisis of 2007/2008. Public debt as a proportion of GDP has been increasing among the EAC members. Developing countries always face the problem of budget deficit which has left them with no other option than borrowing. Over the decades, the Rwandan government like many other African countries has experienced the failure in collecting enough revenues to meet their expenditure which causes continuous budget deficit. The Rwandan debt to GDP was 59.7% in 2019 from19.4% in 2010 which indicates a significant rise. Many economists consider this increase in level of public debt ratio as a threat to the economy of the concerned countries. In this study, stationarity, co-integration and prediction techniques were employed to highlight the problem of continuous rise in public debt level.

Research Objectives

The core focus of this study was to analyze the economic indicators related to external public debt accumulation in Rwanda by applying a multivariate time series analysis. The specific objectives of this study were: a) To test for stationarity among the variables, b) to perform co-integration analysis to determine the relationship between the variables (PD, INFL and Trade), c) to estimate the model parameters and d) to forecast external public debt for the republic of Rwanda up to the year 2027.

LITERATURE REVIEW

The concept of public debt

National debt is defined as the total of the administration borrowing from the public sector within the country or from abroad. The scholarly works already published on public determinants states that macroeconomic, political, institutional, and structural issues all have an impact on governmental debt (Presbitero, 2012). Titus (2013) analyzed the causal nexus connection between debt and financial growth in Nigeria using vector autoregressive (VAR) and the data from 1970 to 2010. The finding of the VAR model showed the presence of a bi-directional causality between borrowings and financial advancement in Nigeria.

Pirtea and NICOLESCU (2013) studied the elements that affect debt compared to GDP in Romania. The result showed the real interest rate, real GDP growth rate, exchange rate, and primary fiscal balance are significant components of the debt. Numerous economic indicators can affect the trend of the national debt such as; borrowing costs, economic advancement, price increases or decreases, budget deficit, regime spending and openness (Teles & Mussolini, 2014). The previous studies conducted on the determinants of public debt are scarce and limited (Čeh Časni et al., 2014). A study conducted in Romania used data from 2008 to 2012 and Johansen co-integration test was used to determine how many cointegration that exist between variables (imports, exports, labor, GDP and FDI). The results found that the maximum eigen value statistic suggested the presence of only one cointegrating equation in the four indicators of the Romanian economy at 5% level (Andrei & Andrei, 2015).

In accordance with Chiminya and Nicolaidou (2015) who analyzed the key elements of foreign debt in Sub-Saharan African nations by applying pooled OLS and fixed effect; the nations that benefited from debt relief appears to decrease debt accumulation. Their research has also found how economic activity is crucial in reducing the regional debt. More opened businesses to global trade result in decreasing their debt liabilities. The studies conducted by Gargouri and Keantini (2016) aimed at identifying the factors influencing government debt in Europe using correlated panel correction found a reverse GDP's impact on bank liquidity assets on public debt. Researchers studied the macroeconomic determinants of the Tunisian public debt. The findings proved the negative effect of inflation and investment on debt while the existence of a strong influence of budget deficit, borrowing costs and trade openness on debt was also found (Brini et al., 2016).

Using the Autoregressive-Distributive Lag (ARDL) technique, the main indicators of South Africa's national debt from 1994 to 2017 were identified. As administration expenditure, real GDP, and real interest rate were found to be the main indicators of South African national debt, the research revealed the existence of a long-term relationship between national debt and national expenditure, real GDP, inflation, and real interest rate (Mothibi & Mncayi, 2019). A study carried out in Ethiopia used times series data from 1990 to 2020 and Johansen cointegration test was employed to investigate if there is cointegration among the variables under consideration (economic growth, inflation, exchange rate and remittance). ADF and Phillips-Person were used to investigate if the series were stationary. The results noted that at least there exist one co-integrating vector and that for economic growth, In the long-term perspective, the system adjusts its previous period disequilibrium by 27.34% annually. Economic growth suffered from the adverse effects of inflation while benefiting positively from remittance inflows in the short-term. (Mohammed & Ahmed, 2021).

A study was carried out in Djibouti using an autoregressive distributed lag model approach and data from the period of 2000 to 2020. After applying the model, the result proved that In the long run, when GDP and government expenditure each rise by 1%, national debt also increases. Yet, inflation does not exhibit a similar pattern as according to the model an increase of 1% in inflation brings down the national debt (Dirir, 2022). Another study was conducted in East African Countries used longitudinal panel data from 2000 to 2021 to analyze the national debt. The outcomes demonstrated a significant correlation between GDP, inflation, government expenditure, imports, exports, and the national debt (Dirir, 2022).

A study conducted in Bangladesh aiming to analyze the consequences of debt for economic growth. This research utilized historical data covering the period from 1961 up to 2021 and they were secondary data from World Bank. This study also used ECM to investigate the short–term association between variables and autoregressive distributed lag for the presence of the long-term relationship. The findings found that external public debt negatively affect economic growth by 8.81% when it increases by 1% in the short-run. The outcomes found that there was also a long-term association among the variables (Nath et al., 2023).

Public debt administration

Public debt administration involves the government conducting self-financed activities in financial markets, conducted by the administration of a nation with a purpose of revising the configuration of the outstanding public debt (Aldrich, 1949). There are many reasons for nation to borrow. Borrowing helps government to control taxes collection (Bell, 2000). In addition, public debt helps the governments to enhance the flexibility of the non-government sector in solving the issue of variations in income and spending opportunities (Schick, 2003). Others studies conducted across Africa have also noticed that debt in African countries have risen during the past years (Ndikumana & Boyce, 2003). However, high public debt accumulation can result in fiscal policy to become ineffective and it is associated with risks and debt need to be sustained in the long run (Bohn, 2008). Researchers Investigating the impact of overseas national borrowings on Tanzania's economic advancement using longitudinal data provided by the Tanzanian Bank. The outcome indicated that foreign debt had a favorable influence on the GDP in short term. The results also showed that the debt service payment had a reversing effect on GDP in the long-term (Kasidi & Said, 2013).

Since 2014, many African countries have faced the problem of increasing public debt (Bua et al., 2014). High indebtedness causes multiple challenges for monetary policy. The first one involves the changes in monetary transmission mechanism making the borrower no more credible and leads to an interest rate increment. Secondly, high and rising public are expected to cause inflation. Understanding the

main drivers of the evolution of the debt is the pillar of debt management (Billi, & Vredin, 2014). This means that to contain the rising government debt; policy makers have to know the outstanding situation of the debt (Brian Hager, 2016). The sectors of the economy where the debts are invested affect the payment ability of these countries; if these debts are not used in the fruitful area of the economy; the country's ability to repay the debt become doubtful, thus causing rising debt accumulation which is believed to be a challenge to the reduction of poverty therefore, to economic advancement (Jawaid & Saleem, 2017).

A survey carried out in Nigeria with the main purpose to explore the existence of the short-run and extended-term relation between overseas borrowings and financial expansion. They used data covering the period from 1980 to 2013 sourced from Central Bank of Nigeria Statistical Bulletin, 2013. ADF unit root test, Co-integration and Error Correction Model were performed. GDP was the independent variable, while foreign debt stock, exchange rate and foreign borrowing service payment were dependent variable. The findings indicated that foreign debt had a positive relationship on GDP on the short-term but an inverse one on the long-term (Udeh et al., 2016).

Another study was also conducted aiming to evaluate the impact of foreign borrowing in completing the missing resources for economic development in Nigeria. They also used auto regressive lag bound and the information sourced from Nigeria Central Bank covering the period from 1981 to 2014. The outcomes found a long-term association between foreign debt and that in the short-term, foreign debt had a non-positive impact on economic growth (Onakoya & Ogunade, 2017). The International Monetary Fund (IMF)'Ss October 2018 World Economic Outlook expected a decrease in the borrowing levels over the next 3 years for African countries (Agbo & Nwadialor, 2020). Contrary, other researchers warned against an increment in debt levels and connected servicing burden but also on the other hand he assured the improvement in economic growth (Cramer et al.,2020). Ndung'u et al. (2021) noted that the debt growth rate in the 5 years to 2018 was fast at an average of 9.3% across Africa. They also indicated that monitoring of debt through speed of debt and then determining indicators properly, can improve debt sustainability for African countries. However, they clarified that nations follow different debts paths, therefore, decisions for debt management should be different from one nation to another.

A study carried out in Rwanda on how economic growth is influenced by public borrowings used the data sourced from National Bank of Rwanda and the debt office in Rwanda covering the period from 1980 to 2018 had employed multiple regression and the output revealed the presence of a clear relationship between IMF loan and gross domestic product, while a negative association exists between domestic debt and gross domestic product.

Models used to forecast the public debt.

Time series analysis using ARIMA in particular, is mostly used to predict macroeconomic variables in many scientific researches. It is an approach used to predict upcoming trends by analyzing past data sequences which was inaugurated and applied during the middle phase by J. Box and D. Jenkins (Makridakis & Wheelwright, 1977). Historically, one of the most used methodologies for forecasting times series data was the utilization of autoregressive models. The autoregressive model was introduced for the first time by Slutsky and Yule (De Gooijer & Hyndman, 2006).

Many researchers have used various macroeconomic determinants to obtain different models needed in public debt prediction and its trend (Presbitero, 2012). There are a number of different estimation techniques that are used to predict the levels of public debt. Some of these models include OLS, Instrumental Variables, and vector auto regressive (VAR) framework (Afonso & Jalles, 2013). According to the type of data available some of these forecasting techniques are most used compared to others. Another important

determinant to be considered when choosing the type of estimation to use is the limitations and the strengths of each estimation technique (Barbosa de Alencar et al., 2017) One of the surveys conducted in Sri-Lanka decided to focus on the elaboration of the debt-crisis forecasting model and a model was created to be used when analyzing the situation in developing nations between 1975 and 2010. According to this analysis, it was found that the main factors to use when predicting long time crises are; the liquidity of economy, growth in gross domestic product, currency devaluation, bonds interest and public policy in the nation (Joy et al., 2017).

A study tried to forecast the scale of the Egyptian foreign debt using various hypothesis of growth and fiscal policy. The outcome confirmed the public debt sustainability until 2020 and how the economic growth contributes in lowering public debt (El Husseiny, 2018). For example, when analyzing time series data, particularly macroeconomic data, Johansen (1988) supports that using VAR framework is more advantageous compared to other alternative estimators. VAR framework is preferred because it has the ability to cater for trending of data, to provide feedback impacts that exist between the past and present value, and also the presence of stochastic behavior of data as the main guide. Therefore, VAR is the most popular model used in forecasting because it is based on the observed outcomes of the past to predict the possible or expected future values (Lartey et al., 2018).

A study carried out in Slovakia with the main goal of determining indicators in macroeconomics influencing public borrowing, elaborating and verifying a Simplified model for projecting governmental borrowing. Authors made use of various research-based techniques, such as content-causal analysis, making comparisons, and using mathematical and statistical methodologies. They also elaborated a model of the government borrowings accumulation in Slovakia using simple linear regression and the regression model was formulated based on the information from 1995 to 2016. Researchers approved the exactness of the model was confirmed using information for 2017 (Knapkova et al., 2019).

The goal of a survey carried out in Rwanda was to find out how foreign borrowing affected the country's economic growth. Three econometric models and historical data from 1991 to 2016 from BNR, NISR, and MINECOFIN were utilized in this work to examine the relationship between economic expansion, governmental investment, private investment, and external debt. The results showed that foreign debt had a favorable impact on Rwanda's economic development. OLS has also been employed in many empirical studies to analyze the association between borrowings and economic performance (Fetai et al., 2020). On the other hand, Engle and Granger (1987) indicated that the application of OLS when studying times series data and especially public debt and economic growth variables which are extremely endogenous could make the results biased even though consistent with the theory (Heimberger, 2023).

METHODOLOGY

The steps and stages that were taken to finish the study were outlined in this chapter. Most decisions on the execution of the research, including the methodology and procedures employed, were discussed at this stage. This study used historical data in a sequence, quantitative and secondary data covering the period from 1973 to 2022 for Rwanda. Data were obtained and sourced from World Development Indicators (W.D.I).

Data type, collection, screening, cleaning and analysis

This study considered secondary and quantitative economic time series data. It used secondary data. In this regard, National Institute of Statistics of Rwanda and World Bank databases were used. It will utilize data covering the period from 1973 to 2022 on annual basis. About screening, the study used the generalized method for screening time series data. Utilization of basic methods for

prediction and adaptation was investigated. The statistical screening method was applied to calculate statistical indicator of data quality. Data screening employed the examination of encoded data to ensure that all data have been entered and computed.

Data cleaning is a useful strategy for enhancing data quality and has assisted in resolving problematic data quality issues. It is necessary to detect and identify low-quality data and determine the best strategies to alter them in order to generate valid and accurate clean data. The initial stage of the data cleaning procedure was error detection. Abnormal values are a common feature of quantitative data. Depending on how frequently they occur, quantitative mistakes with time series data can be separated into minor and large errors. Error data repair was the second step in the data cleaning process. By estimating the data distribution using probabilistic indicators, the maximum likelihood method was employed to solve statistics-based repair problems.

These variables were analyzed via the functional form;

$$\gamma = f(\alpha_1,\ \alpha_2,\ \alpha_3). \qquad (1)$$

This study performed stationarity, co-integration and forecasting by using R software packages. This particular software was used because of its user-friendliness. Data were presented in figures and tables.

Stationarity Test

Usually, most economic indicators are non-stationary. Thus, it was very important to test for stationarity before generalizing any relationship. The stationarity test helped to determine if the properties of time series process change over the time. Because so many practical analytical and statistical tests depend on stationarity, it was crucial. Thus, the Augmented Dickey Fuller (ADF) unit root test was used to test the stationarity test:

$$\Delta X_t = \beta_0 + \beta_1 t + \beta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-1} + y_t \qquad (2)$$

H_0: There is no unit root test

Where: ΔX_t: is the first variable difference which capture serial correlation

$\beta_0 + \beta_1 t$: is the linear trend component, y_t is this is the error term, and α_i is the lag order of the autoregressive process.

Johansen's cointegration test and long run relationship

Co-integration test was employed to test the potential presence of the long-term association between variable.

H_0: There is no cointegration

This study used Johansen's co-integration test to determine how many co-integration equations exist between variable. The test statistic was based on two likelihood ratio tests of at most r cointegrating relationship among the variables under the study. Both trace test and maximum eigen values test indicates the number of cointegrating relationships.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_r) \qquad (3)$$

$$\lambda_{max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \qquad (4)$$

Model estimation and diagnostic

The first stage was involved using the Akaike Info Criterion (AIC) to determine the proper lag length for the Vector Auto Regressive (VAR) test.

$$AIC(P) = \ln\left|\hat{\Sigma}(P)\right| + \frac{2}{T} Pn^2 \qquad (5)$$

The general form of vector auto regressive (VAR) of order p is given by:

Or,

$$Y_{1t} = B_{11}Y_{1t-1} + \ldots + B_{11}^{P}Y_{1t-p} + B_{12}Y_{2t-1} + \ldots + B_{12}^{P}Y_{2t-p} + B_{13}Y_{3t-1} + \ldots + B_{13}^{P}Y_{3t-p} + \varepsilon_{1t} \qquad (6)$$

$$Y_{2t} = B_{21}Y_{1t-1} + \ldots + B_{21}^{P}Y_{1t-p} + B_{22}Y_{2t-1} + \ldots + B_{22}^{P}Y_{2t-p} + B_{23}Y_{3t-1} + \ldots + B_{23}^{P}Y_{3t-p} + \varepsilon_{2t} \qquad (7)$$

$$Y_{3t} = B_{31}Y_{3t-1} + \ldots + B_{31}^{P}Y_{3t-p} + B_{32}Y_{3t-1} + \ldots + B_{32}^{P}Y_{3t-p} + B_{33}Y_{3t-1} + \ldots + B_{33}^{P}Y_{3t-p} + \varepsilon_{3t} \qquad (8)$$

Where: ε_t is the vector of error terms (white noise) with mean zero and correlation between the error term is also zero.

B_1, B_2, …, B_P are the coefficients of the matrices for each lag of the VAR model.

Y_t is the vector of the time series variables at time (t)

Y_{1t}, Y_{2t}, Y_{3t} are values of the variables at time (t)

The VAR model was therefore, diagnosticated by using the following tests:

* Autoregressive Conditional Heteroscedasticity test (ARCH)

H_0: There are no ARCH effects in the residuals (implying that the error terms have constant variance)

* Portmanteau test (asymptotic)

H_0: There is no autocorrelation among the among the residuals of the model

* Eigenvalues model stability test

H_0: The model is stable (meaning that all the eigenvalues lie inside the unit circle

Forecast

After the model was estimated and evaluated; the VAR model was then utilized to forecast the external foreign borrowing stock for the next five years. This study used iterative forecasting method which is given by the following form:

$$\hat{Y}_{t+h} = B_1\hat{Y}_{t+h-1} + B_2\hat{Y}_{t+h-2} + \ldots + + B_P\hat{Y}_{t+h-P} \quad (10)$$

Where: $\hat{Y}_{t+h}$ is the forecasted vector of external public debt stock for period (t+h)

B_1, B_2, …, B_P are the coefficients of the matrices of the VAR model

$\hat{Y}_t$ is the actual observed vector of external public debt stocks at time (t)

RESULTS AND DISCUSSIONS

This part presents the results obtained from data analysis, interpretations and discussion of the findings.

Test for stationarity

A stationarity test was performed since the time series data utilized in this study are meant to be stationary. Analyzing time series data requires stationarity. Inconsistent output might result from a lack of stationarity. A time series that has consistent statistical characteristics across time, such as mean, variance, and autocorrelation, is said to be stationary. Non-stationary data is predicted to produce false results, which could imply a relationship exists when none does. The Augmented Dickey Fuller (ADF) test was employed in the study to assess stationarity.

H_0: There is no unit root among the variable (external debt stock, inflation and trade)

Table 1

Unit Root Test for External debt stock

Augmented Dickey-Fuller Test data: External. Debt. stock..... Dickey-Fuller = -1.97, Lag order = 3, p-value = 0.5862 alternative hypothesis: stationary

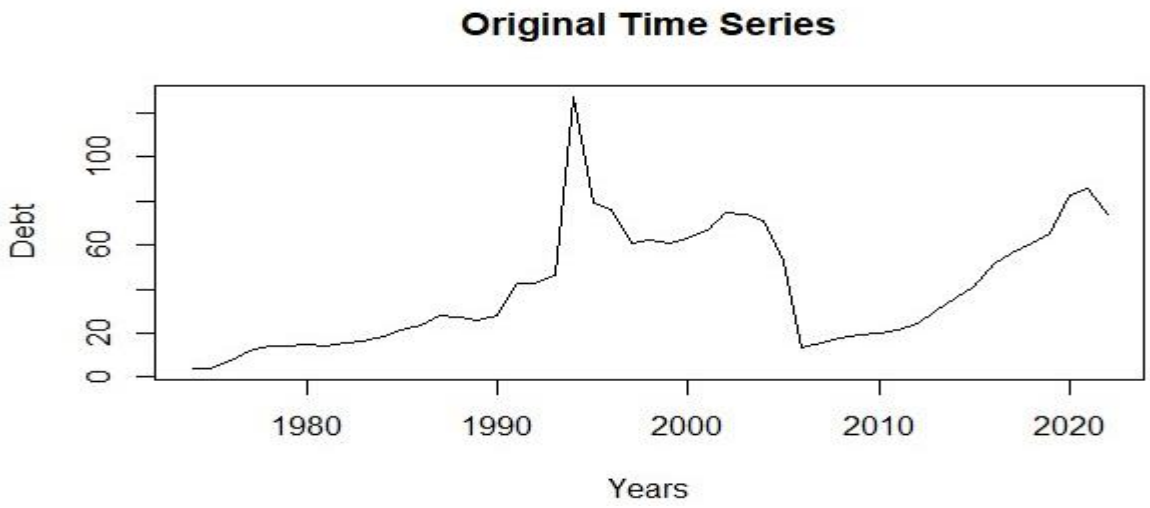

Figure 1: Time plot of External debt stock at levels

In order to assess the external debt stock's characteristics and stationarity, the study created a time series. The results presented in figure 1 showed that External debt has a rising trend from the beginning of the study period. This indicates the time series unit root's existence. From the findings displayed above, external debt stock attained its highest around the year 1994. After 1994, it significantly decreased until around the year 2006 before it exponentially rose again.

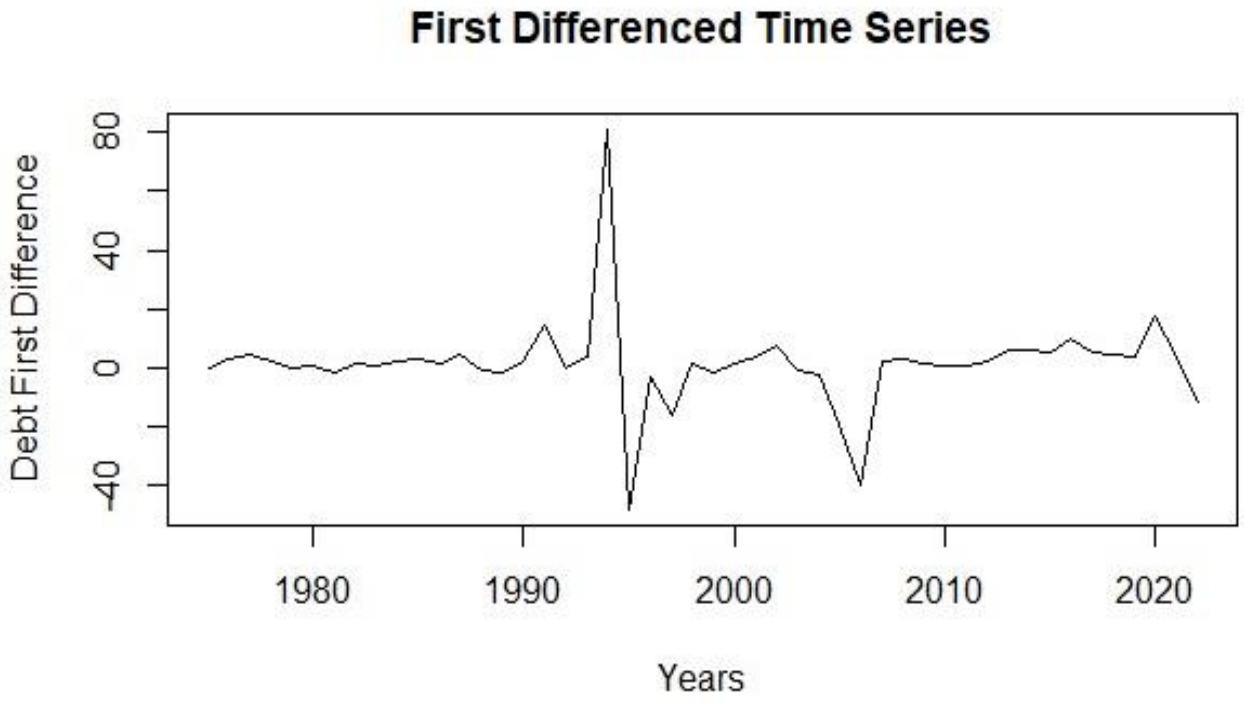

Figure 2: First difference time plot of external debt stock

The results displayed in figure 2 shows that the upwards and downwards of the graph are almost not existing during the period of study.

Table 2

Unit Root Test for External debt stock at first difference

Augmented Dickey-Fuller Test data: External. Debt. stock Dickey-Fuller = -3.3887, Lag order = 3, p-value = 0.06898 alternative hypothesis: stationary

Table 3

Unit Root Test for Inflation

Augmented Dickey-Fuller Test data: Inflation Dickey-Fuller = -2.7237, Lag order = 3, p-value = 0.2846 alternative hypothesis: stationary

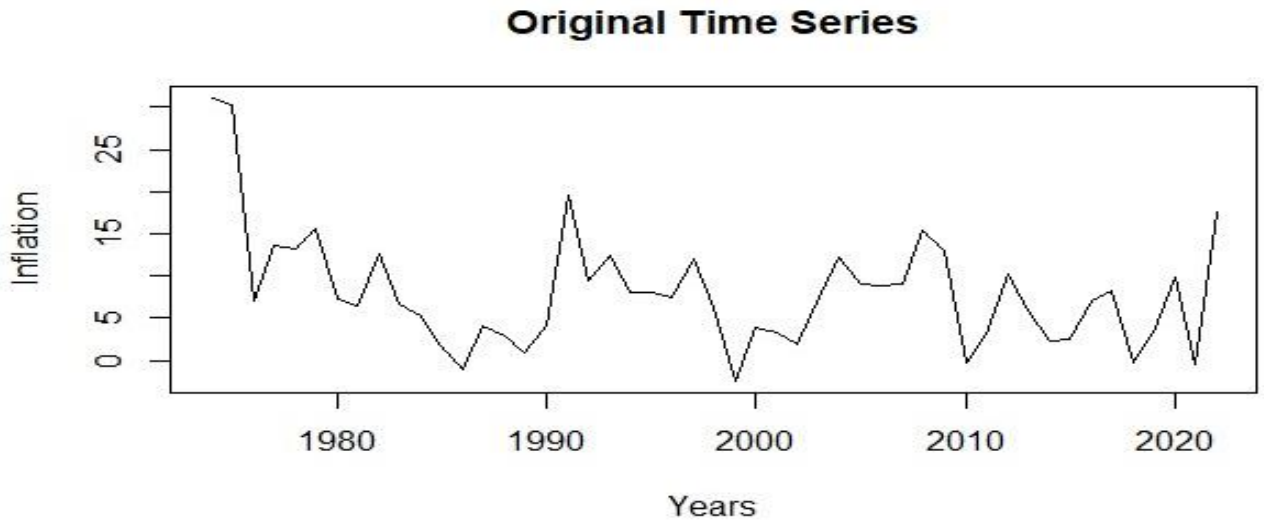

Figure 3: Time plot for inflation at levels

The study developed a time series for inflation to evaluate its properties and stationarity. The results of the presented in figure 2 show that inflation has declined during the course of the investigation. This shows that the inflation time series is not stationary. The graph above shows that inflation was high in the beginning of the study. However, it kept reducing until 1996 before rising again. The figure also shows that inflation attained its lowest around 1998 and it was negative meaning that there was deflation. After 1998, inflation kept rising to the end of the study.

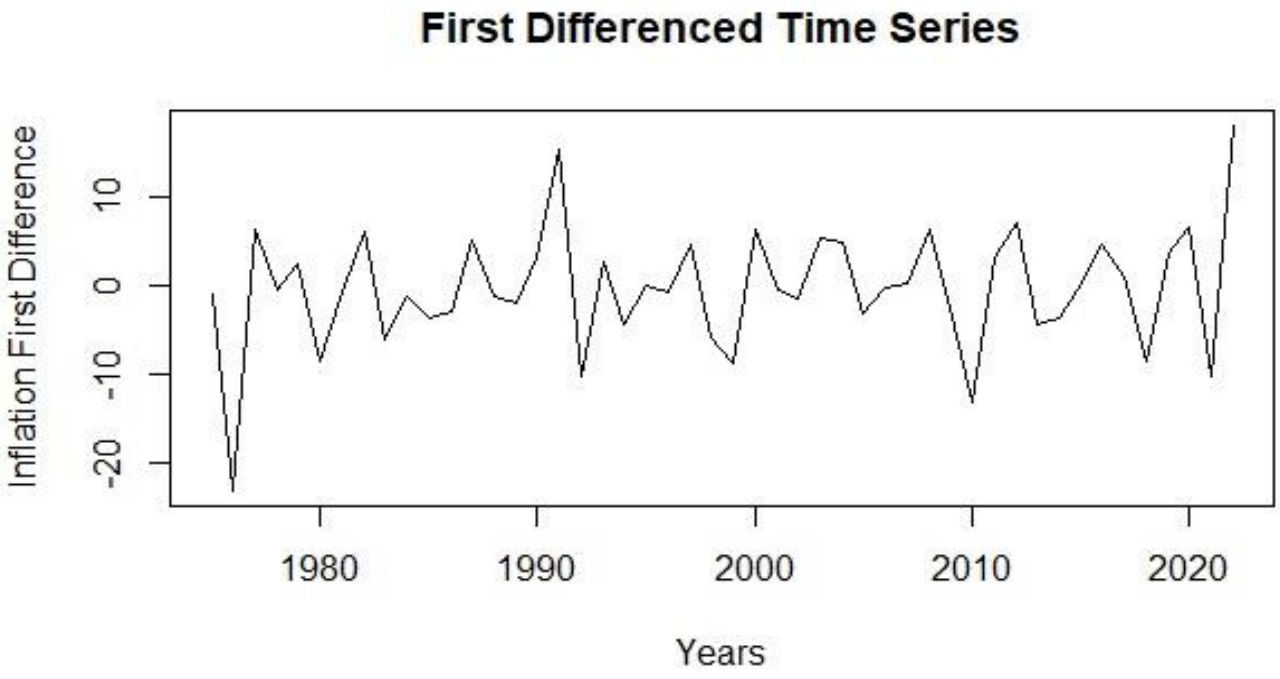

Figure 4: Inflation after first difference

After first difference, the results presented a graph of inflation during the study period. The graph kept the same pace over the study period. Therefore, the findings prove that inflation is integrated of order one this means that it became stationary following initial differentiation.

Table 4

Test of Unit Root for Inflation at first difference

Augmented Dickey-Fuller Test data: inflation Dickey-Fuller = -4.1007, Lag order = 3, p-value = 0.01321 alternative hypothesis: stationary

Table 5

Unit Root Test for Trade

Augmented Dickey-Fuller Test data: Trade Dickey-Fuller = -1.8567, Lag order = 3, p-value = 0.6316 alternative hypothesis: stationary

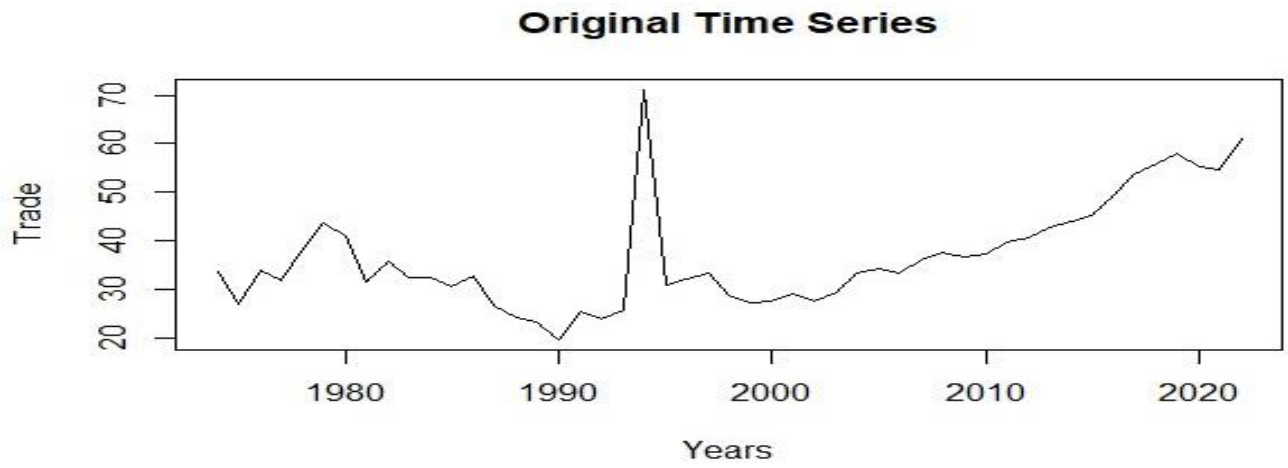

Figure 5: Time plot for Trade at levels

The study developed a time series for trade to access its properties and stationarity. The findings presented in figure 5 proved that trade has a growing tendency for the duration of the study. This suggests that the time series trade is not stationary. The findings obtained recorded the lowest value of trade around 1990 but after that it rose continuously to reach its highest around 1994 before a dramatic decline. After that, the graph of trade observed an ascending trend to the end of the research.

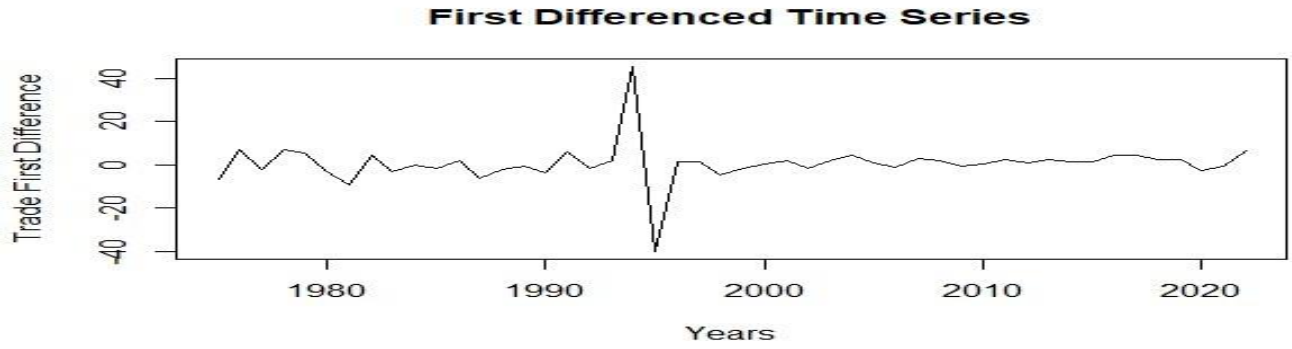

Figure 6: Trade time plot at initial differencing

The results provided in figure 6 recorded that the graph is neither ascending nor descending; thus, this indicates that trade becomes stationary after the first difference.

Table 6

Unit Root Test for Trade at first difference

Augmented Dickey-Fuller Test data: Trade Dickey-Fuller = -4.1678, Lag order = 3, p-value = 0.01041 alternative hypothesis: stationary

Table 7

Summary of the stationarity test

Variable	ADF. Test Statistics	p-value	Statistics at 1st difference	p-value	Order
External debt stock	-1.97	0.5862	-3.3887	0.06898	**I (1)**
Inflation	-2.7237	0.2846	-4.1007	0.01321	**I (1)**
Trade	-1.8567	0.6316	-4.1678	0.01041	**I (1)**

From the table above, external debt stock, inflation and trade are not stationary at 10% level of significance. The findings summarized in table 8 shows that external debt stock is not stationary in the levels, the stationarity test fails to reject the presence of a unit root in the levels as its p-value (0.5862) is greater than 10 % level of significance but after differencing it became stationary (integration of order one I (1)).

When inflation was examined for stationarity, it was discovered that it was not stationary in levels. This means that, at the 10% level of significance, the ADF test was unable to reject the null hypothesis, which is that there is a unit root in the inflation data series. But following the initial difference (integrated of order one I (1)), inflation became stationary. First, a stationarity test was run for trade in levels and first difference to see if a unit root was present. The results of the test indicated that although trade was not stationary within the levels, it did become stationary following the initial differencing, suggesting that trade is integrated at order one I (1).

The first differences in table 8 show that external debt stock, inflation and trade are not stationary in the levels means that they need differencing to be stationary, thus integrated of order one I (1). A linear combination of series I (1) is expected to be I (0) if the series happens to be cointegrated. We therefore proceed with the cointegration test of the time series integrated of order one.

Results and Discussion of the test of cointegration for Johansen

The test of cointegration was performed based on Johansen approach and the objective was to establish if there exist an extended-term association among the variables integrated of order one. The first move was to determine the lag using Akaike information criterion and ten different lag selections criterion were found before conducting co integration test.

Table 8: Johansen co integration test results (eigen values statistics)

H_0: There is no cointegration among the variables

```
          test 10pct  5pct  1pct
r <= 2 |  6.07  7.52  9.24 12.97
r <= 1 | 10.95 13.75 15.67 20.20
r = 0  | 46.30 19.77 22.00 26.81
```

Table 9: Trace statistics results

```
          test 10pct  5pct  1pct
r <= 2 |  6.07  7.52  9.24 12.97
r <= 1 | 17.02 17.85 19.96 24.60
r = 0  | 63.32 32.00 34.91 41.07
```

The outcomes of cointegration test for Johansen are displayed in table 8and table 9. Table 8 shows eigen values statistics while table 9 shows trace statistics Johansen cointegration. The findings of the techniques indicate that there is no cointegration relationship among the variables. The study fails to reject the null hypothesis of no cointegration at 5% level of significance since eigen values test statistics of 46.30 is greater than 22.00

and also trace statistics of 63.32 is greater than 34.91. The values of the two test statistics are different but they all imply the same thing which is the absence of cointegrating relationship.

Model estimation

The endogenous variables in this VAR model are DebtV, InflationV, and TradeV, representing debt levels, inflation rates, and trade volumes, respectively.

The model includes lagged values of each endogenous variable up to lag order 2 (DebtV.l1, InflationV.l1, TradeV.l1, DebtV.l2, InflationV.l2, TradeV.l2), indicating that the current values of the variables are modeled as a function of their past two values.

Table 10: VAR Estimation Results:

==========

Endogenous variables: DebtV, InflationV, TradeV

Deterministic variables: none

Sample size: 46

Log Likelihood: 96.117

Roots of the characteristic polynomial:

0.6964 0.6964 0.3309 0.3309 0.2197 0.1437

Call:

VAR (y = Var_datal, p = 2, type = "none")

Estimation results for equation DebtV:

==========

DebtV = DebtV.l1 + InflationV.l1 + TradeV.l1 + DebtV.l2 + InflationV.l2 + TradeV.l2

Variables	Estimate	Std. Error	*t* value	Pr(>|t|)
DebtV.l1	0.24077	0.17723	1.359	0.1819
InflationV.l1	-0.10212	0.42228	-0.242	0.8102
TradeV.l1	-0.80656	0.60782	-1.327	0.1920
DebtV.l2	-0.02488	0.17488	-0.142	0.8876
InflationV.l2	-0.89353	0.44137	-2.024	0.0496 *
TradeV.l2	-0.29325	0.56609	-0.518	0.6073

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2958 on 40 degrees of freedom

Multiple R-Squared: 0.1617, Adjusted R-squared: 0.03597

F-statistic: 1.286 on 6 and 40 DF, p-value: 0.2856

Estimation results for equation InflationV:

==========

InflationV = DebtV.l1 + InflationV.l1 + TradeV.l1 + DebtV.l2 + InflationV.l2 + TradeV.l2

Variables	Estimate	Std. Error	t value	Pr(>|t|)
DebtV.l1	-0.01215	0.05775	-0.210	0.83447
InflationV.l1	-0.43336	0.13759	-3.150	0.00309 **
TradeV.l1	-0.05592	0.19804	-0.282	0.77911
DebtV.l2	-0.01255	0.05698	-0.220	0.82686
InflationV.l2	-0.35308	0.14381	-2.455	0.01853 *
TradeV.l2	-0.16729	0.18445	-0.907	0.36986

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.09637 on 40 degrees of freedom

Multiple R-Squared: 0.2693, Adjusted R-squared: 0.1597

F-statistic: 2.457 on 6 and 40 DF, p-value: 0.04067

Estimation results for equation Trade V:

==========

Trade V = DebtV.l1 + InflationV.l1 + TradeV.l1 + DebtV.l2 + InflationV.l2 + TradeV.l2

Variables	Estimate	Std. Error	t value	Pr(>|t|)

DebtV.l1	-0.01243	0.05357	-0.232	0.8177
InflationV.l1	0.06895	0.12764	0.540	0.5920
TradeV.l1	-0.47635	0.18372	-2.593	0.0132 *
DebtV.l2	0.02028	0.05286	0.384	0.7033
InflationV.l2	-0.14606	0.13341	-1.095	0.2801
TradeV.l2	-0.27806	0.17110	-1.625	0.1120

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0894 on 40 degrees of freedom
Multiple R-Squared: 0.2673, Adjusted R-squared: 0.1573
F-statistic: 2.432 on 6 and 40 DF, p-value: 0.04249

Interpretation of VAR model

According to the results in table 11, it was found that all variables included in Debt V equation were not statistically significant at all levels except inflation at lag 2. Therefore, each unit increase in InflationV.l2 (inflation at lag 2) is estimated to decrease by 0.89353 units the dependent variable which Debt V representing the external debt level, holding all other variables constant. The p-value associated with InflationV.l2(inflation at lag 2) is 0.0496, which is less than 0.05, indicating that it is statistically significant at the 5% level. The standard error of 0.44137 means that the estimated coefficient (-0.89353) of inflation at lag 2 is expected to vary by 0.44137 if we repeated the sampling process multiple times. T- statistic associated with inflation at lag 2 is -2.024. Its absolute value is greater than the critical value for 95% confidence interval (2.024>2.021) implying that the coefficient is significantly different from zero. Given that all estimated coefficients of other variables in Debt V equation are not statistically significant. This implies that they do not explain the variability of Debt V. However, given that the p value for F-statistic (0.2856) is greater than 0.05 it indicates that the overall model is not significant which is not a problem as F-statistic assesses the joint significance of all coefficients in the model, rather than the predictive ability of the model itself.

The Inflation V equation in VAR model indicates that the coefficients of DebtV.l1(debt at lag 1), TradeV.l1 (trade at lag 1), DebtV.l2 (debt at lag 2), TradeV.l2 (trade at lag 2) are not significant statistically at any standard threshold of significance. This suggests that the lagged values of Debt V and Trade V may not have significant immediate effects on the current value of Inflation V. Thus, the changes in Debt V and Trade V do not exhibit an impact on inflation rate in this model. On the other hand, the outcomes showed that the coefficients for InflationV.l1 (inflation at lag 1) and InflationV.l2 (inflation at lag 2) are statistically significant.

Specifically, the coefficient for InflationV.l1(inflation at lag 1) indicates a significant negative association between the lagged value of Inflation V one period ago and the current value of Inflation V (p-value = 0.00309).

Therefore, each unit increase in InflationV.l1(inflation at lag1) is expected to decrease the current Inflation V by 0.43336 while each unit increase in InflationV.l2(inflation at lag 2) is estimated to decrease the current value of Inflation V by 0.35308. the negative significant association between lagged values of Inflation V and current Inflation V suggest a pattern of mean reversion in inflation rates. This means that high (or low) inflation rates in the past tend to be followed by lower (or higher) inflation rates in the present and the overall model was found to be significant at 5% level given that the p value of F-statistic (0.0496) is less than 0.05.

The standard error associated with inflation at lag 1 is 0.13759 meaning that the associated estimated coefficient is expected to vary by 0.13759 and the absolute value t- statistics is larger than the critical

value of 95% confidence interval (3.150>2.021). Thus, the estimated coefficient is significantly different from zero.

Similarly, the coefficient for InflationV.l2(inflation at lag 2) indicates a significant negative association between the lagged value of Inflation V two periods ago and the current value of Inflation V (p-value = 0.01853). The standard error of inflation at lag 2 is 0.14381 indicates that the estimated coefficient (-0.35308) is expected to vary by 0.14381 when sampling is repeated multiple times. The absolute t-statistic value exceeds the crucial value of 95 % level of confidence (2.455>2.021) which implies that the estimated coefficient is significantly different from zero.

The Trade V equation in VAR model shows that the coefficients of DebtV.l1 (debt at lag1), DebtV.l2 (debt at lag2), InflationV.l1 (inflation at lag 1), InflationV.l2(inflation at lag 2) and TradeV.l2 (-0.01243, 0.06895, 0.02028, -0.14606, -0.27806) respectively, are all statistically non- significant at the 5% level due to corresponding p values that are higher than 0.05. The same equation also suggests that a one-unit increase in TradeV.l1(trade at lag 1) is associated with a decrease of approximately 0.47635 units in current Trade V. This variable is significant at the 0.05 level (p-value = 0.0132), indicating that TradeV.l1 has a significant negative effect on current Trade V. Which means that the higher the values of TradeV.l1 in the past; the lower the values of the current Trade V and vice-versa.

The standard error corresponding to trade at lag 1 (TradeV.l1) is 0.18372 indicates that the estimated coefficient (-0.47635) is expected to vary by 0.18372 when sampling is repeated multiple times. Given that the t-statistic's absolute value (2.593>2.021) is higher than the 95% confidence level's critical value, it may be concluded that the calculated coefficient differs significantly from zero.

All things considered, it seems that the lagged values of Trade V have the most significant impact on current Trade V, with a negative association. However, the other variables (lagged Debt V and lagged Inflation V) don't appear to have significant statistical relationships with current Trade V in this model and the overall model exhibits statistical significance at the 5% level, as indicated by the F-statistics p-value of 0.04249, which is less than 0.05.

Table 11: Covariance matrix of residuals:

Variables	DebtV	InflationV	TradeV
DebtV	0.086022	-2.036e-03	1.346e-02
InflationV	-0.002036	9.287e-03	2.126e-05
TradeV	0.013459	2.126e-05	7.882e-03

The results displayed in table 11 show the output of the covariance matrix. In our case we found a positive covariance between the residuals of Debt V and Trade V which is 0.013459, indicating that they tend to move together while a small negative covariance between the residuals of Debt V and Inflation V (-0.002036), suggesting a weak inverse relationship between them.

Although a very small covariance between the residuals of Inflation V and Trade V (-0.00002126), indicating little linear relationship between them. These results suggest that the residuals of the variables in the model have relatively low covariance with each other, which is a positive indication for the validity of the regression model.

Model diagnostic

For model diagnostic, this study used multivariate Autoregressive Conditional Heteroscedasticity test (ARCH), Portmanteau test (asymptotic) and eigenvalues model stability test respectively to validate the model

Table 12: ARCH (multivariate)

data: Residuals of VAR object var_modelI1
Chi-squared = 170.11, df = 180, p-value = 0.69

The outcomes in table 12 present the output of Autoregressive Conditional Heteroscedasticity test for the residuals of a VAR (Vector Autoregression) model, specifically a multivariate ARCH test. The p-value of the chi-squared test statistic is 0.69. with a p value higher than 0.05 thus there is no enough evidence to conclude that the residuals of the VAR

model exhibit conditional heteroscedasticity. Thus, the assumption of constant variance across observations is not violated.

Table 13: Portmanteau Test (asymptotic)

data: Residuals of VAR object var_modelI1

Chi-squared = 112.88, df = 135, p-value = 0.9172

The findings in the table 13 attest the adequacy of time series models by checking whether they adequately capture the temporal dependencies in the data. The p value associated with the chi-squared test statistic is 0.9172. with a p value greater than 0.05 we conclude that the VAR model's residuals do not provide sufficient evidence of autocorrelation. Put another way, the residuals seem to be accurately representing the temporal dependencies in the data, and after taking the model's structural factors into account, there is no sign of autocorrelation left in summary, the Portmanteau test indicates that there is no significant autocorrelation remaining in the residuals of the VAR model, supporting the validity of the model's predictions and inferences.

Table 14. Eigenvalues model stability test

[1] 0.6964342 0.6964342 0.3308995 0.3308995 0.2196528 0.1436757

The stability requirement of the VAR model was met since Table 14 shows that every eigenvalue of the companion-form matrix was smaller than one in absolute value.

Result and interpretation of forecasting

This study used estimated VAR model to forecast the values of external debt stocks for the next five years.

Table 15. Forecasting results

Years	predicted observed values	Lower bounds at 95% level	Upper bounds at 95% level
2023	74.40840	73.82870	74.98811
2024	74.12299	72.94696	75.29902
2025	74.18098	72.38238	75.97957
2026	74.26490	71.83924	76.69055
2027	74.20027	71.14665	77.25390

Table 15 displays the results for forecasting external debt stock for five years period at 95 % level of significance. All the values lie between the bounds during the forecasting period therefore significant. The forecasted value is expected to be high during the year 2023 but it decreases during the year 2024. The findings in table 15 also provided a range within which the true value is likely to fall. The wider the interval, the less certain the forecast. Thus, the range within which the forecasted value of 2023 lies is the most certain during the forecast period of the study and the less certain forecast is the range within which the forecasted value of 2027 is likely to fall as it represents the wider interval. Therefore, the more periods to forecast; the higher the uncertainty as the confidence interval gets wider gradually according to the findings in table 15.

CONCLUSIONS AND RECOMMENDATIONS

This study was undertaken with the main objective analyzing the economic indicators (Inflation and trade balance) related to external public debt accumulation. This study used VAR model and it was stable with no autocorrelation among variables to achieve various objectives. All the variables under the study were found to be integrated at first order which means that they need to be differenced once to be stationary. The study also revealed that there wasn't long term association between external borrowing stock, inflation and trade balance. The study also revealed that the overall equation of external debt stock was not significant but the findings suggest that the inflation at lag 2 from the same equation is negatively associated with external debt stock by - 0.89353. Thus, it is expected to reduce the external debt stock which doesn't make since economically and

financially while trade does not affect external debt stock at all. However, from the estimated VAR model all others endogenous variables which are inflation and trade balance are related to their own previous values. The model was found to be stable. The study also found that there wasn't autocorrelation among the residuals of the VAR model; thus, confirming the validity of the model predictions. This study tested no heteroscedasticity as well and therefore, the variance is constant across observations. The external debt stock is expected to be 74.20027 in 2027 while it was 74.35809 in 2022 revealing a small reduction in external debt stock accumulation.

This study explained some of the factors influencing external public debt in Rwanda. However, the study found that inflation significantly affect the external public debt stock. The study left other key economic factors that could be related to external public debt stock such interest rates, exchange rates, social and political factors. Thus, the study advocates for additional research to be performed to investigate how these other factors may affect external national debt stock. Furthermore, the study was performed exclusively on Rwanda. An alternative study could employ a panel data methodology to study the influence of different factors affecting foreign borrowings in Uganda, Burundi, Tanzania, and South Sudan

We recommend as well future researchers interested in the topic to consider others types of the data such as quarterly data. They should also think of using current innovative models such as Artificial neural network models and compare them to decide which one provides more accurate results.

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