
# UNIVERSITY OF NAIROBI

# MODELING MACROECONOMIC DETERMINANTS OF PUBLIC DEBT IN KENYA

BY

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# Abstract

This study utilizes cointegration analysis to analyze the experience of Kenya's public debt for the period 2001 to 2021 applying the Johanson cointegration method coupled with VECM analysis. Quarterly time series data sourced from CBK were used. Public debt is the dependent variable while the independent variables are USD exchange rate, capital and reserves, trade balance, budget deficit, net foreign assets, and interest payments on debts. The result showed that trade balance, budget deficit, and interest payments on debts are stationary in levels while USD exchange rate, public debt, capital and reserve, net foreign asset, and the credit to the private sector are non-stationary. They are however stationary at first difference making them integrating time series of order 1 at a 5% level. The study provides evidence of a long-run dynamic relationship among public debt and capital and reserves, net foreign assets, interest payments on debts, and credit to the private sector. ECM model support the cointegration relationship results with the error term of -0.0454. The ECM identifies net foreign asset, USD exchange rate, and capital and reserves as the main determinants of increasing public debt following a long-run relationship. Net foreign assets and credit to the private sector hurt public debt while USD exchange rate and capital and reserves have a positive effect in a long-run relationship. The VECM model is statistically significant at a 5% level. The public debt is likely to hit Ksh 9.887 trillion mark with a margin error of 0.681 by December 2023.

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# Declaration and Approval

I the undersigned declare that this dissertation is my original work and to the best of my knowledge, it has not been submitted in support of an award of a degree in any other university or institution of learning.

31/08/2022

Signature Date

JOHN NJENGA
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In my capacity as a supervisor of the candidate's dissertation, I certify that this dissertation has my approval for submission.

31/8/2022

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John Njenga

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# Contents

# Special Terms

VECM- Vector Error Correction Models
ECT- Error Correction Term
OLS- Ordinary Least Square
I(2)- Cointegration of order 2
I(d)- Integration of order d. For d =0, 1, ... I(d) is the maximum number of differences required to make a non-stationary time series stationary.
MTP- Medium-Term Plans
VAR- Vector Auto regression
CBK- Central Bank of Kenya
KIPPRA- Kenya Institute of Public Policy Research and Analysis
I(1)- Integration of order 1
I(0)- Integration of order 0
ECM- Error Correction Model
USD- US Dollar
GDP- Gross Domestic Product per capital
CNY- China Yuan
IMF-International Monetary Fund
IDA- International Development Association
PV-Present Value
PFM- Public Finance Management
OLS- Ordinary Least Square
VAR- Vector Auto-Regression

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# 1 INTRODUCTION

## 1.1 Background Information

By definition, government expenditure is the amount of money that is spent on development projects and recurrent expenditure which are met by public revenues. A budget deficit occurs when the amount of revenue collected does not meet the projected budget which is attributed to heavy investment in infrastructure, financing development projects, natural calamities and disasters, economic crises and increasing recurrent government expenditures. To overcome this budget deficit, governments opt for public borrowing. Public debt is the total amount of liabilities of a country's government which includes bonds and other securities. Public debt is either domestic or external. Domestic public debt is money government owes its citizens, commercial banks and other financial institutions within the country. External debt is obligations owed to foreign countries, commercial banks and institutions. Debts play an important role in bridging the budget deficit gap. A budget deficit occurs when the government spends more than the revenue collected. Government expenditure falls into two categories; recurrent expenditure and development expenditure. Recurrent expenditures are government spending that does not result in acquiring fixed assets for the country such as loan servicing, payment of salaries and allowances, public administration, law and order. Development expenditure is the spending meant to increase income and improve productivity such as infrastructure development, agricultural development and investment in parastatals.

IMF in conjunction with the World Bank developed revised guidelines on public debt management policy paper in the year 2014. The revised guidelines help policymakers at the country level to adopt a reform framework that strengthens quality debt management and reduces vulnerability to financial or structural shocks. The importance of the guidelines is to help governments in ensuring that public debt levels and rates are both on a sustainable trajectory and debt servicing is possible to meet risk and cost objectives under a wide range of economic scenarios such as financial market stress and economic stress.

In Kenya, PFM Act 2012 provides the regulatory framework for the management of public finance and assets at the national level and county level. Section 50(5) of the act, empower the parliament to provide the thresholds for debt entitlement of the national government and its entities. The ceiling is set on an annual basis and the government cannot exceed the ceiling. At the end of 2021, the borrowing threshold was Ksh 9 trillion

with a borrowing space of Ksh 1.66 trillion. However, parliament revised the borrowing threshold to Ksh 10 trillion in the Fiscal year 2022/23.

Central bank of Kenya, pursuant to the CBK Act issues regulations, supervision and licensing of the financial institutions to promote financial stability. All its efforts are geared towards fostering solvency, liquidity and proper functioning in the financial system. Previously, prior to 2014 the CBK has been issuing monthly economic performance reviews in addition to the annual economic performance review. In the year 2015, they began a quarter economic performance review in the administration policy change. In the quarterly economic review, they analyze the Country's performances concerning: inflation; development in the money, balance of payments and exchange rates; credit and interest rates; economic performance; government budgetary performance; banking sector; development in public debt; global economy; capital markets and statement of financial position of the Central Bank of Kenya.

In sub-Saharan Africa, Kenya boasts as one of the largest economies. Kenya has continuously experienced a GDP growth over the last two decades, as a result of public infrastructure projects, appropriate economic and fiscal policies and strong public and private sector investment.

In 2007, Kenya adopted a long-term economic plan dubbed "Vision 2030" to attain a middle-class country status by the year 2030. The plan is implemented in successive MTP which outlines the necessary projects, policies and programmes the government implements over a five-year time phase. The government in 2017 unveiled the third MTP covering the next five years with the country expected to experience an increased export GDP ratio, inclusive and broad-based economic growth and growth in the industrial or manufacturing sector.

The government started implementing the "Big Four" Agenda in 2018 highlighting the four main agendas as the vision 2030 economic and social pillars. They also help in achieving the development aspirations as spelled out in the Kenya 2010 constitution.

The world economies greatly suffered from the Covid-19 pandemic from early 2020 to 2021. There were several mitigation and prevention strategies advocated for in the fight against the pandemic. Some of the mitigation strategies applied were: lockdown, closure of learning institutions, close of public facilities and cessation of movement were applied to help stop the spread of the pandemic. As a result, most of the economic activities were affected. The Covid-19 pandemic has greatly grappled the Kenya economy resulting in borrowing to stabilize the economy. Over the period, the country sought emergency financing from international financial institutions namely, IMF, world bank and Africa development Bank to be able to finance the gap and support the ailing economy. With

the aid sourced during the pandemic, Kenya's debt present value is 67.9% which is less than the 70% threshold expressed as a percentage of the GDP. Furthermore, external debt present value is 50.9% which also falls below the 55% threshold. The public debt servicing burden remains high despite debt service suspension from international partners.

## 1.2 Problem statement

Kenya's public debt has been increasing over the last decade with current debt standing at approximately Ksh 8 trillion as of December 2021. As of December year 2010, public debt was at 51.0% of GDP compared to December 2021 where it's approximately 67.9% of the GDP. The increase is mainly attributed to the infrastructural development over the same period. In order to understand the dynamics of the public debt one has to investigate the underlying macroeconomic factors that influence its growth. Thus, there's a need to identify macroeconomic factors that have led to the growth of public debt over the last twenty years.

Technically, the problem entails investigating the long-term equilibrium and short-term dynamic relation between public debt and the independent macroeconomic variables that are; USD exchange rate, capital and reserves, trade balance, budget deficit, net foreign assets, interest payments on debts, and credit to the private sector.

## 1.3 Objectives of the study

The main objective is to determine the factors that contribute to the growth of public debt in Kenya. The specific objectives are to:

i) Determine a long-run equilibrium relation between public debt and other macroeconomic variables

ii) Determine short-run dynamic effects among macroeconomic variables

iii) Forecast public debt in the feasible future.

## 1.4 Significance of the study

The results of the study will inform the behavior of public debt and aid in the identification of long-term equilibrium and short-term dynamic relations among other macroeconomic variables. The established stable casual relationship between public debt and other macroeconomic variables will provide a better approach to the debt management framework and improve the credit worthiness rating of Kenya. Undoubtedly, the results of the study will promote policy and regulatory framework that leverage towards enhancing economic growth through sound debt management for sustainable development. The ultimate goal of any progressive government is to cushion its citizenry from the burden of public debt - which may lead to undesirable high rates of taxation and inflation which of course lower the standard of living.

# 2 LITERATURE REVIEW

## 2.1 Theoretical literature

Barro (1979) constructed a public debt theory that holds the Ricardian invariance theorem as a first-order proposition except in scenarios where the timing of taxation and the excess burden may lead to the debt issue. The theorem holds the central proposition that implicates deficits being varied to maintain tax rate consistency. Taxation posts a distortionary effect on economic growth and the feasible option is public debt to finance the budget deficit. Ricardian invariance theorem preposition states that taxation will transfer the resulting burden to the public. This will lead to an increased cost of living and reduced purchasing power in a country's economy.

Rahman et al. (2019) conducted a systematic review on public debt's effect on economic growth. A country's economy can be affected either negatively or positively by public debt depending on the amount and the purpose. A positive effect is felt when both the economy and levels of debt grow simultaneously. This creates a preferred condition where debt is increased to meet national development objectives. On the other, a negative effect is felt when the economic growth decrease with an increasing debt level a situation that calls for the postponement of Government major projects.

Aybar (2019) article on the theory of public debt highlights the effect of public debt on:

- price levels - debt causes inflation which is induced by the operation of various economic mechanisms resulting in to increase in price levels.
- income distribution - the effect of debt on income depends on the income group where the debt is transferred and the income group with debt cost.
- production - Society will always sacrifice private-sector production if the acquired debt is used to finance recurrent expenditure.
- economic development - developing countries that do not manage the borrowed fund well are likely to end up in debt financing by acquiring other debts.

## 2.2 Empirical literature

### 2.2.1 Cointegration Analysis

Econometric analysis is the application of statistical and mathematical techniques to problems in finance. Cointegration is one of the techniques that has been widely used in public debt analysis. Ryan et al. (2014) assessed Kenya's Public Debt Dynamics and Sustainability where he indicated that the public debt was sustainable. The study used annual data for the period 1983 to 2013 applying cointegration and stochastic debt sustainability approaches. The VAR model resulted in sustainable debt and the depreciation in the exchange rate having no significant effect on the average interest rates on external debt. Swamy (2015) empirical investigation on government debt and its macroeconomic determinants where economic groupings, political, income groupings, and governance groupings of countries in addition to macroeconomic variables were analyzed. Foreign direct investments, government expenditure. Real GDP growth, inflation and population were observed to have a negative effect on debt growth while gross fixed capital formation, final consumption expenditure and trade openness influenced positively.

Kirui (2017) KIPPRA Discussion Paper attempted to evaluate and establish macroeconomic elements that accelerate debt accumulation in Kenya. The paper used annual data covering the period 1975 to 2014. The variables of the study were public debt as a ratio of the GDP, Gross fixed capital formation, interest payments on debts, real growth rate of GDP, real interest rate, saving gap, exchange rate of the USD, trade openness and foreign direct investment. All predictor variables were significant except the real interest rate. The study applied the Engle-Granger two-step procedure cointegration and ECM model to test for short-run dynamics and long-run equilibrium relation. Omrane et al. (2017) carried out a case study in Tunisia on macroeconomic determinants of public debt growth. They used a VECM model to analyze the annual data ranging from 1986 to 2015. The study provided evidence that inflation and investment have a negative effect on debt while real interest rate, budget deficit and trade openness have a positive effect on debt. The budget deficit had the highest effect among the predictor in Tunisia.

A study by Attapattu et al. (2018) on the long-run association between public debt and economic growth in Sri Lanka for the period 1977 to 2012 showed a long-run relationship. The study applied the Johansen test for cointegration and error correction model. The error correction term was significant, evidence of a long-run relationship. Any disequilibrium is corrected at a speed of 58% over the years. Amayo (2019) examined the impact of capital and recurrent expenditure on public debt in Kenya using VECM model for the period 1980 to 2015 annual data. The study concluded that the public debt had a significant positive relationship with recurrent expenditure and a negative effect on capital

expenditure.

Khan et al. (2019) study on Cointegration between macroeconomic factors and the exchange rate USD/CNY using yearly data for China's economy for the period 1980 to 2017 showed significant results. Cointegration analysis using an auto-regressive distributed lag model showed a positive effect of GDP growth and trade openness on the exchange rate USD/CNY. Furthermore, inflation rates had a negative effect on USD/CNY exchange rate. Iiyambo et al. (2020) assessed the relationship between the public debt, government expenditure and revenue in Namibia using data for the period 1980 to 2018. Short-run dynamics were analyzed using an ECM that showed a positive relationship between government expenditure and revenue. The error correction term indicated 46.6% annual correction speed for any shift from equilibrium. Granger causality test showed that the spend-revenue hypothesis does not hold but the tax–spend hypothesis is supported.

### 2.2.2 Economic growth

Kangara (2015) concluded that gross debt had a negative effect on economic growth for the period 2015 to 2014. Mageto (2015) using quarterly data for the period 2000 to 2003 concluded that debt increased investment and economic growth.

Kobey (2016) found that control variables were related to economic growth for the period 1993 to 2015. The study used a model with GDP growth rate expressed as a function of public debt, unemployment rate and inflation rate. There exist a negative effect but no significant indicators of economic growth. Ngugi (2016) noted that domestic debt, inflation rate and debt serving had a negative effect on GDP growth while real exchange rate, private investment, lagged GDP and external debt impacted positively for the period 1980 to 2013. Using quarterly data for the period 1995 to 2015, Mwangi (2017) noted an insignificant positive effect of debt on economic growth.

### 2.2.3 Debt determinant

Chironga (2003) studied the structure, magnitude, level, and determinants of public domestic debt in Kenya. The study used OLS techniques to analyze data for the period 1990 to 2001. Domestic debt trend, direct impact on the economy and indirect impact on capital formation and the investment sector were also examined. The study concluded that domestic debt at a value of Ksh 222 billion which is equivalent to 36.6% of the total debt was short-term in form of Treasury bills as of December 2001. Short-term Treasury bills have tenor below one year which makes repayments expensive and have a detrimental effect on the economy. The study also established a sharp increase in domestic debts that is explained by a reduced external grant inflow, concessional loans, mopping

up excess money supply using government securities, external debt servicing support to loss-making parastatals, ineffective fiscal policies and sterilizing capital inflows caused by high-interest rates. Matiti (2013) studied the effect of selected determinants on public debt in Kenya. The study applied multiple regression analysis to establish the effect of macroeconomic variables on public debt in Kenya for the period 2003 to 2012 using annual data. The study concluded that there exists a direct relationship between public debt and the predictors namely, the balance of payments, budget deficit and exchange rates. The study further noted an increase in both debts and exchange rates, a decrease in grants, and a high budget deficit over the project period.

### 2.2.4 Debt optimum level and Sustainability

Ng'eno (2018) study using 1980 to 2017 time-series data provided evidence of a 61% optimum level for external debt expressed as a fraction of the GDP. Beyond this mark, external debt results in negative economic growth. IDA (2020) published an article on Debt Sustainability Analysis in Kenya which provided evidence of Kenya's debt being sustainable. The report however noted the debt distress risk changed from moderate to high due to the global impact of Covid-19 crisis. As a result of the global crisis, several debt vulnerability indicators worsened both the external and gross public debt. The pandemic crisis led to a sharp decline in economic growth and exports. Kenya experienced a decline in tax revenues expressed as a shared of the GDP. The debt indicators are expected to improve as export rebound post the pandemic period. A strong fiscal response from authorities is required in addressing the crisis that caused an increase in budget deficits. Kiriga et al. (2020) research on the optimization of Kenya's debt showed that in the short-run public debt negatively affects economic growth but in the long run, it enhances economic growth. The study used VECM impulse response model to analyze 1978 to 2018 annual time series data. The optimum level for Kenya's debt was derived as 68% of the GDP

## 2.3 Scope of literature review

The existing literature on Kenya's public debt does not cover recent years and no study dealt with the macroeconomic factors that have led to public debt growth. In the year 2002, Kenya experienced a government transition that introduced various governmental policies in the public sector resulting in good economic performance. With 2001/2002 as the baseline years, the study seeks to identify macroeconomic factors that have led to the growth of Kenya's public debt.

# 3 METHODOLOGY

## 3.1 Data

This empirical study used the quarterly time series data for Kenya covering the period 2001 to 2021 and was sourced from the Central Bank of Kenya. Kenya's public debt is the dependent variable with the predictor variables being USD exchange rate, capital and reserves, trade balance, budget deficit, net foreign assets, interest payments on debts, and credit to the private sector.

**Table 1. Data description**

| Variables | identifiers | description |
|---|---|---|
| public debt | PD | Ksh billions |
| Capital and reserves | CR | Ksh billions |
| Trade balance | TB | Ksh billions |
| Budget deficit | BD | Ksh billions |
| Net foreign assets | NFA | Ksh Billions |
| Interest payments on debts | IPD | Ksh billions |
| Credit to private sector | CPS | Ksh billions |
| USD exchange rate | USDR | quarterly exchange rate |

The study investigates the long-run relationship between debt growth and USD exchange rate, capital and reserves, trade balance, budget deficit, net foreign assets, interest payments, and credit to the private sector in Kenya. The study used a model of the form:

$$PD = f(CR, TB, BD, NFA, DF, IPD, CPS, USDR) \tag{1}$$

## 3.2 Models

### 3.2.1 Unit root test

Time series data is categorized as either stationary or non-stationary. A weak stationary time series is defined as one who's second order moments are constant. In order to carry out cointegration test, the time series must be of the same integrating order that is I(1). Order of integration is the number times a non stationary times series is differenced to obtain a stationary time series. Unit root test is used to check variable where a variable is stationary in levels or after finding the difference. The unit root test is used with the following model:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-1} + \gamma_t \tag{2}$$

where: $\Delta X_t$ is the first variable difference that capture serial correlation; $\delta_1 t$ is the linear trend component, and $\gamma_t$ is the error term.

Generally, unit root tests involve testing the null hypothesis $\delta_2 = 0$ that is the existence of unit root of $X_t$ versus an alternative hypothesis that $\delta_2 < 0$. The study use the Phillips-Perron Unit Root Test

### 3.2.2 Cointegration and Johansen Cointegration test

#### Cointegration

Suppose $X_t = (X_{1t}, X_{2t}, \ldots, X_{nt})'$ denote an $n \times 1$ vector of I(d) time series. $X_t$ is cointegrated if there exist an $(n \times 1)$ vector $\vec{\beta} = (\beta_1, \beta_2, \ldots, \beta_n)'$ such that

$$\beta' X_t = \beta_1 X_{1t} + \beta_2 X_{2t} + \cdots + \beta_n X_{nt} \sim I(0) \tag{3}$$

Equation (3) means that non-stationary time series in $X_t$ cointegrate if there exists a stationary linear combination of the time series. A long-run equilibrium relationship is the linear combination of time series of the same integrating order. The cointegration vector is normalized following normalization assumptions to obtain $\vec{\beta} = (1, -\beta_2, -\beta_3, \ldots, -\beta_n)'$ such that

$$\beta' X_t = X_{1t} - \beta_2 X_{2t} - \cdots - \beta_n X_{nt} \sim I(0) \tag{4}$$

By making $X_{1t}$ the subject, equation 5 reduces to

$$X_{1t} = \beta_2 X_{2t} + \cdots + \beta_n X_{nt} + \mu_t \tag{5}$$

where $\mu_t \sim I(0)$ is the cointegrating residual which is equal to zero in the long-run equilibrium.

Thus cointegration relationships are

$$X_{1t} = \beta_2 X_{2t} + \cdots + \beta_n X_{nt} \tag{6}$$

For the $(n \times 1)$ cointegrating vector, there may exist $0 < r < n$ linearly independent cointegrating vectors that is multiple cointegration relations. This implies that $\beta'$ becomes an **r** by **n** cointegrating matrix with cointegrating rank **r** for **r** < **n**.

$$\begin{aligned} \vec{\beta}_1 &= (\beta_{11}, \beta_{12}, \ldots, \beta_{1n})' \\ \vec{\beta}_2 &= (\beta_{21}, \beta_{22}, \ldots, \beta_{2n})' \\ &\ddots \\ \vec{\beta}_r &= (\beta_{r1}, \beta_{r2}, \ldots, \beta_{rn})' \end{aligned} \tag{7}$$

Thus

$$\begin{aligned} \beta_1' X_t &= \beta_{11} X_{1t} + \beta_{12} X_{2t} + \cdots + \beta_{1n} X_{nt} \sim I(0) \\ \beta_2' X_t &= \beta_{21} X_{1t} + \beta_{22} X_{2t} + \cdots + \beta_{2n} X_{nt} \sim I(0) \\ &\ddots \\ \beta_r' X_t &= \beta_{r1} X_{1t} + \beta_{r2} X_{2t} + \cdots + \beta_{rn} X_{nt} \sim I(0) \end{aligned} \tag{8}$$

Equation (8) give cointegration matrix as follows:

$$\beta' = \begin{pmatrix} \beta_1' \\ \beta_2' \\ \vdots \\ \beta_r' \end{pmatrix} = \begin{pmatrix} \beta_{11} & \beta_{12} & \ldots & \beta_{1n} \\ \beta_{21} & \beta_{22} & \ldots & \beta_{2n} \\ & & \vdots & \\ \beta_{r1} & \beta_{r2} & \ldots & \beta_{rn} \end{pmatrix} \tag{9}$$

### Cointegration Test

Cointegration test is a statistical technique used to test the existence of a long-run equilibrium relationship. Cointegration test covers two scenarios:

- at most one cointegrating vector
- possibly $0 \leq r < n$ cointegrating vector

For one cointegrating vector, Eagle and granger (1986/87) casualty test is used, while for $0 \leq r < n$ cointegrating vectors, Johansen et al. (1990) procedure is used.

For variables of the same cointegration order, then the Johansen et al. (1990) test of cointegration is applied to test for a long-term relationship between the variables.

The first difference form model is given by:

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \varepsilon_t \tag{10}$$

where: $\Delta X_t$ is a $k \times 1$ variables vector; $\mu$ is a $k \times 1$ constant term vector; $\Gamma_i \quad (i = 1, 2, \ldots, k-1)$ is $k \times k$ coefficient matrix; $\Pi$ is $k \times k$ coefficient matrix; $\varepsilon_t$ is a $k \times 1$ disturbance term coefficients.

Johansen et al. (1990) presented two likelihood ratio tests of at most r cointegrating relationships among variables: - $\lambda_{trace}$ and -$\lambda_{max}$ based on trace statistic and eigenvalues respectively.

#### Maximal eigenvalue test

This is a likelihood ratio test based on the maximal eigenvalue of the stochastic matrix. The null hypothesis is that the number of cointegrating vectors is less than or equal to**r** versus an alternative of $r+1$ cointegrating vectors. The test statistic is given as:

$$\lambda_{max} = -Nln(1 - \hat{\lambda}_{r+1}) \tag{11}$$

**Trace statistic test**

This is a likelihood ratio test based on the trace of the stochastic matrix. The null hypothesis is that the there are at most **r** cointegrating vector versus an alternative of at least $r+1$ cointegrating vectors. The test statistic is given as:

$$\lambda_{trace} = -N \sum_{i=r+1}^{k} ln(1-\hat{\lambda}_i) \tag{12}$$

### 3.2.3 Error correction model

For non-stationary and cointegration series of the first order, the variable relationship is assessed through an ECM model. Engle et al. (1987) stated that long-run equilibrium established by cointegration implies that deviations from equilibrium are stationary with finite variance as represented by a ECM model. The above long-run cointegration produces a ECM of the form

$$\Delta(PD_t) = \Delta PD_{t-1} + \Delta CR_{t-1} + \Delta TB_{t-1} + \Delta BD_{t-1} + \Delta NFA_{t-1} + \Delta IPD_{t-1} + \Delta CPS_{t-1} + \Delta USDR_{t-1} + \lambda \mu_{t-1} + \nu_t \tag{13}$$

where: $\mu_{t-1}$ are estimated residuals of the cointegration regression which represents the deviation from the equilibrium state during a time t; $\lambda$ is the short run parameter which represents the dependent variable reaction from the equilibrium at the start of each time t. It must be negative but if not, reject the existence of the error correction model ECM; and $\nu_t$ is a white noise disturbance

The ECM model involves testing the null hypothesis that there are no lags versus an alternative hypothesis of first-order autocorrelation. The ECM model is used to test for short-term dynamics using Durbin–Watson statistic which is given as:

$$WD = \frac{\sum_{t=2}^{T}(\rho_t - \rho_{t-1})^2}{\sum_{t=1}^{T}{\rho_t}^2} \sim F(n,m) \tag{14}$$

Where $\rho_t$ are residuals from an OLS regression.

### 3.2.4 Cointegration VECM model

#### VECM model

VECM is used to estimate the variables related to each other through a long-run equilibrium. If there exist a cointegration relation, then VECM model is applied to estimate the effect of the predictors. VECM model consist of a VAR with stationary growth variables ($\Delta X_t$) that describe a short-run dynamic and error correcting equation with non stationary level variables ($X_t$) that describe the long-run equilibrium.

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + CD_t + \varepsilon_t \tag{15}$$

where: $\Delta X$ is the first difference of X; $\Pi$ is a coefficient matrix of cointegrating relationships; $\Gamma$ is a coefficient matrix of $\Delta X_{t-i}$; C is a coefficient matrix of a vector of deterministic terms $d_t$; and $\varepsilon_t$ is an error term with mean zero and variance-covariance matrix $\Sigma$.

$\Pi X_1$ is the first lag of linear combinations of non-stationary level variables or error correction terms (ECT) which represent long-term relationships among non-stationary level variables.

#### Forecast

To forecast public debt in Kenya, the VECM model in difference was transformed to a VAR model in levels thus including the short-run and the the long-run relationship of the variables.

$$X_t = X_{t-1} + \Delta X_t \tag{16}$$

where $\Delta X_t$ is given by equation (15)

For model validation, the data set was divided into two sets: - the large set covering the period first quarter in 2001 to the second quarter in 2020 and a small set of seven observations for comparison with forecasts.

## 3.3 Analysis Software

The study used R software to evaluate the models. The package tseries provides the ts function for time series properties and the pp.test function used for Phillips - perron unit root test. The package urca provides: ca.jo function for Johansen cointegration test; cajorls function to generate the ECM model and cajorls function to estimate unrestricted VECM model. The package vars provides the vec2var function which transforms the VECM model in difference to a VAR model in levels.

# 4 DATA ANALYSIS AND RESULTS

## 4.1 Descriptive statistics

The summary statistics of the variables in the study are as shown in table 2 where the total number of observations used, mean, minimum, maximum and standard deviation are indicated. Overall public debt has the highest standard deviation while USD exchange rate has the least. The standard deviations indicate how far the values are from the sample mean. Budget deficit has positive and negative values, when negative it's a deficit while a positive it's a surplus. Trade balance all value being negative implying that Kenya experiences more imports than export through the project period.

**Table 2. Descriptive statistics**

| | PD | CR | TB | BD | NFA | IPD | CPS | USDR |
|---|---|---|---|---|---|---|---|---|
| Number of observation | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 |
| mean | 2414.6 | 417.1 | -164.86 | -376.5 | 369.7 | 232.8 | 1302.4 | 86.6 |
| median | 1485.5 | 340.8 | -167.7 | -117.6 | 286.1 | 113.6 | 1054.5 | 83.5 |
| maximum | 7996.3 | 1165.3 | -14.6 | 79.0 | 939.9 | 1354.1 | 270.1 | 109.8 |
| minimum | 604.0 | 63.3 | -365.8 | -2171.8 | 87.8 | 15.5 | 3059.2 | 63.0 |
| std. dev. | 2123.9 | 322.2 | 103.5 | 520.7 | 234.1 | 283.4 | 934.7 | 12.9 |

**Data Transformation**

All the variables were translated by a constant whose value was 2173 to eliminate the negative values and then given a log transformation. A log transformation removes dummies in the values thus stabilizing the time series data variance. All the variables were considered for translation to avoid affecting the underlying relationship among the variables.

Figure 1 and 2 show the plot of the project variables after the data transformation process.

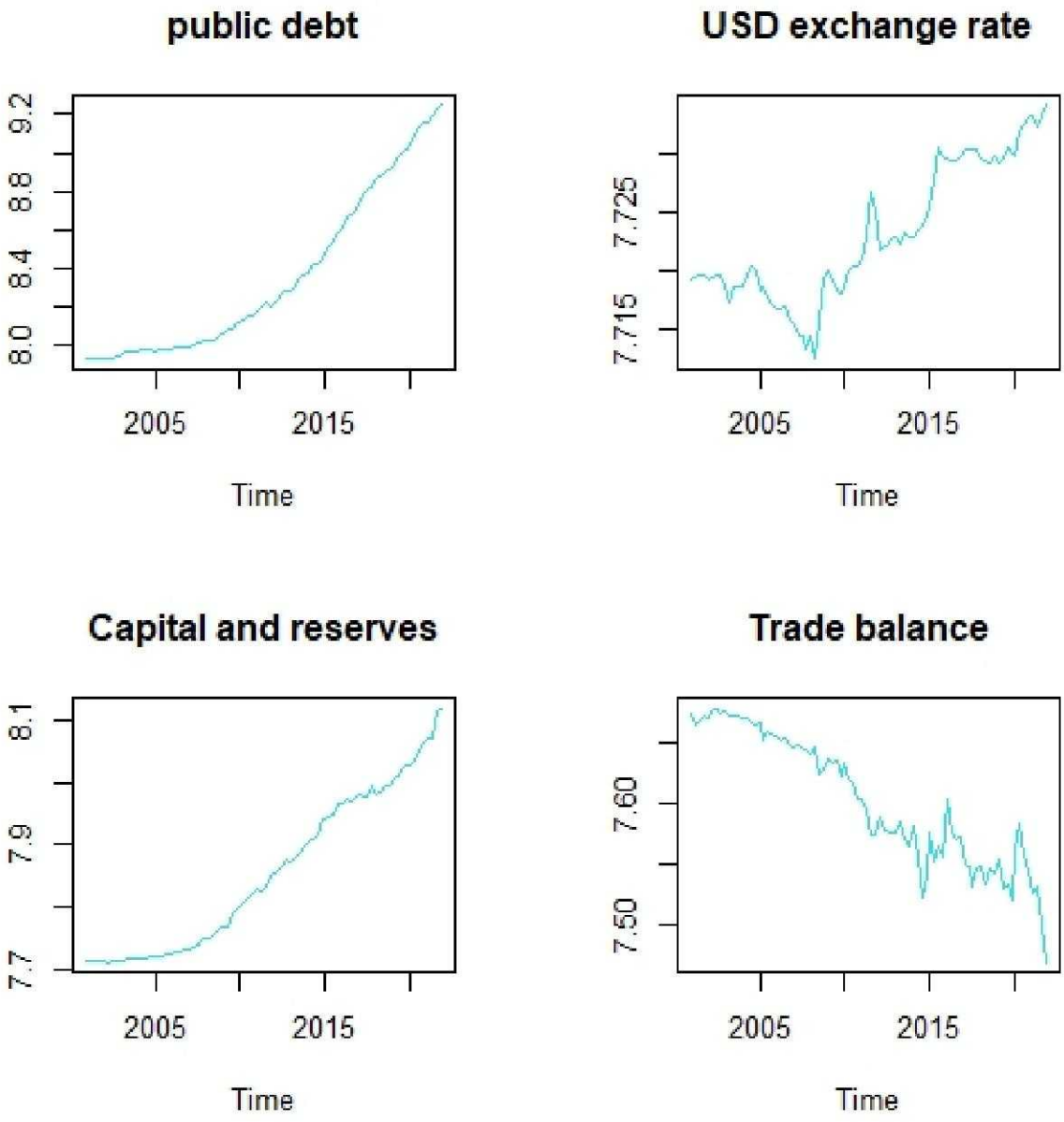


**Figure 1. pd,usdr,cr and tb plot**

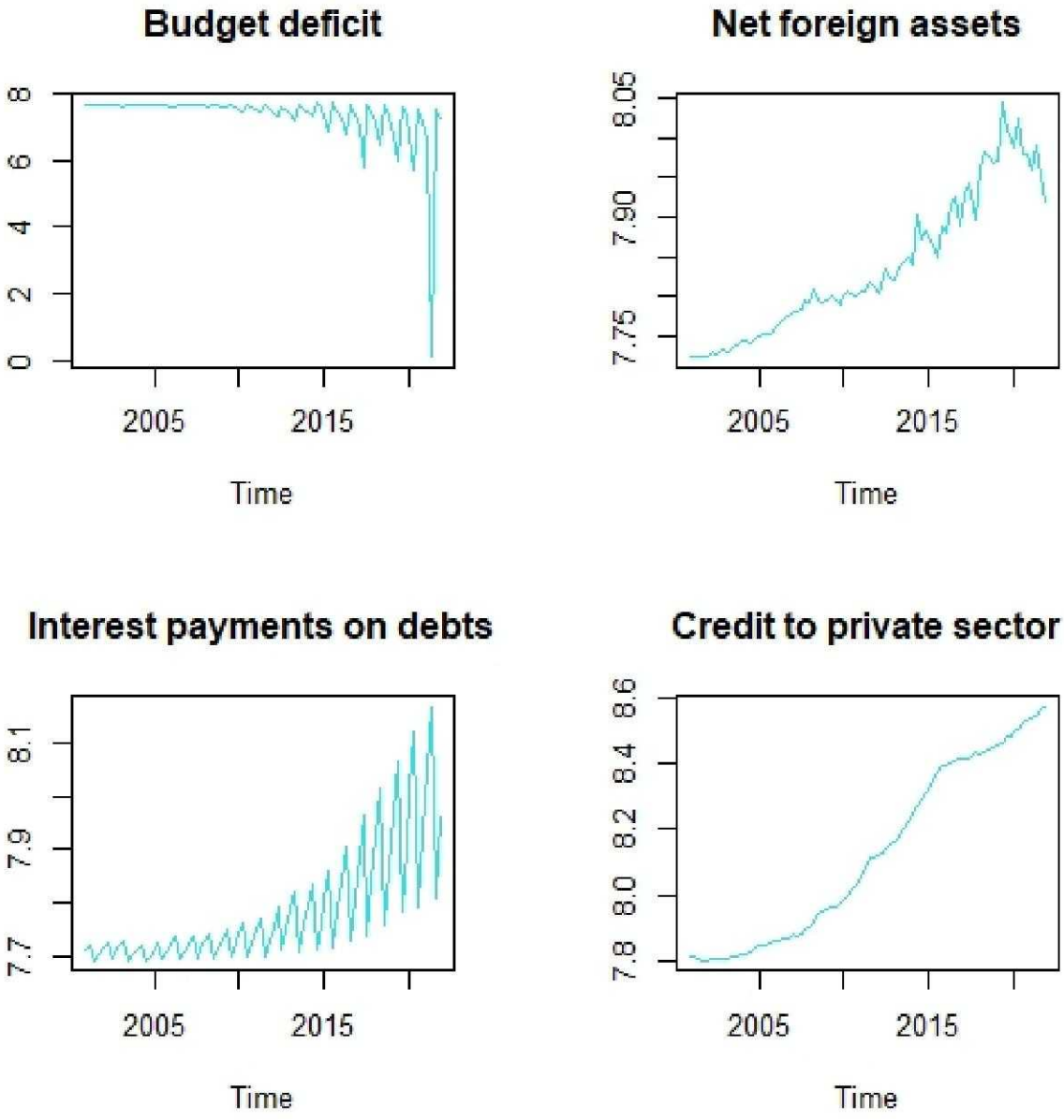


**Figure 2. bd,nfa,ipd and cps plot**

## 4.2 Model Fitting

### 4.2.1 Unit root test

**Table 3. Unit root test results**

| P-P test | | | | | |
|---|---|---|---|---|---|
| Variables | in levels | p value | 1st $\Delta$ | p value | Order |
| PD | -0.67653 | 0.99 | -78.806 | $< 0.01$ | I(1) |
| USDR | -8.0189 | 0.6464 | -61.817 | $< 0.01$ | I(1) |
| CR | -3.2996 | 0.9193 | -101.68 | $< 0.01$ | I(1) |
| TB | -30.12 | $< 0.01$ | | | I(0) |
| BD | -80.202 | $< 0.01$ | | | I(0) |
| NFA | -18.629 | 00.07818 | -94.246 | $< 0.01$ | I(1) |
| IPD | -68.246 | $< 0.01$ | | | I(0) |
| CPS | -5.3078 | 0.8067 | -38.869 | $< 0.01$ | I(1) |

From the table above, trade balance, budget deficit and interest payments on debts are stationary at a 5% level of significance. USD exchange rate, public debt, capital and reserve, net foreign asset and credit to the private sector are non-stationary at a 5% level of significance. Non-stationary time series have a trend or seasonality property thus their first moments are not constant that is variance, mean and covariance. They are however stationary at first difference attaining the integrating time series of order 1 property at a 5% level of significance. Differencing is a technique that removes seasonality and trend in time series. Times series of the same integrating order cointegrate. Public debt is the dependent variable and the independent variables of integrating order 1 are considered for the cointegration test.

### 4.2.2 Cointegration test

The characteristic function gives the eigenvalues as:
$\hat{\lambda}_1 = 0.5830; \hat{\lambda}_2 = 0.4042; \hat{\lambda}_3 = 0.2173; \hat{\lambda}_4 = 0.1156; \hat{\lambda}_5 = 0.0354; \hat{\lambda}_6 = 2.7943 \times 10^{-15}$

From table 4 for null hypothesis using Eigenvalues, r = 0, the calculated Eigenvalue value (70.85) is greater than the critical Eigenvalue (34.40) at a 5% level of significance, implying a co-integration relationship. For the null hypothesis, r=1, the test statistic value 41.94 is greater than the critical value (28.14) at a 5% level of significance, implying a co-integration relationship.

**Table 4. Johansen Cointegration test**

| | Eigen Values | | critical value | | |
|---|---|---|---|---|---|
| Null | Alternative | Test statistic | 90% | 95% | 99% |
| $r = 0$ | $r = 1$ | 70.85 | 31.66 | 34.40 | 39.79 |
| $r = 1$ | $r = 2$ | 41.94 | 25.56 | 28.14 | 33.24 |
| $r = 2$ | $r = 3$ | 19.85 | 19.77 | 22.00 | 26.81 |
| $r = 3$ | $r = 4$ | 9.95 | 13.75 | 15.67 | 20.20 |
| $r = 4$ | $r = 5$ | 2.92 | 7.52 | 9.24 | 12.97 |
| | Trace statistic | | critical value | | |
| Null | Alternative | Test statistic | 90% | 95% | 99% |
| $r = 0$ | $r = 1$ | 145.51 | 71.86 | 76.07 | 84.45 |
| $r = 1$ | $r = 2$ | 74.66 | 49.65 | 53.12 | 60.16 |
| $r = 2$ | $r = 3$ | 32.72 | 32.00 | 34.91 | 41.07 |
| $r = 3$ | $r = 4$ | 12.87 | 17.85 | 19.96 | 24.60 |
| $r = 4$ | $r = 5$ | 2.92 | 7.52 | 9.24 | 12.97 |

However for the null hypothesis, r= 2, the test statistic (19.85) is less than the critical value (22.00) at a 5% level of significance, implying the cointegration relation is not significant. The above results illustrate the existence of two cointegration relationships. The trace statistic test supports the result of the maximal eigenvalue test of r=2

The corresponding significant normalized vectors are given as vector $\vec{\beta}_1'$ and $\vec{\beta}_2'$ respectively. The vector includes a constant as the cointegration model had a constant.

$$\vec{\beta}_1' = (1, 1.9192, -3.8755, 0.02180, -0.7741, 12.0495)' \quad (17)$$
$$\vec{\beta}_2' = (1, 19.9597, -12.0152, -2.6284, 4.4453, -83.712)'$$

Figure 3 show the first cointegration relationship obtained by $\vec{\beta}_1'\vec{Y}_t$, where

$$\vec{Y}_t = (PB_t, USDR_t, CR_t, NFA_t, CPS_t)' \quad (18)$$

Similarly the second cointegration relationship is obtained by $\vec{\beta}_2'\vec{Y}_t$, shown in figure 4.

The resulting cointegration eqautions are:

$$PB = -1.9192USDR + 3.8755CR - 0.0218NFA + 0.6641CPS - 12.0495 \quad (19)$$
$$PB = -19.9597USDR + 12.0152CR + 2.6284NFA - 4.4453CPS + 83.7120$$

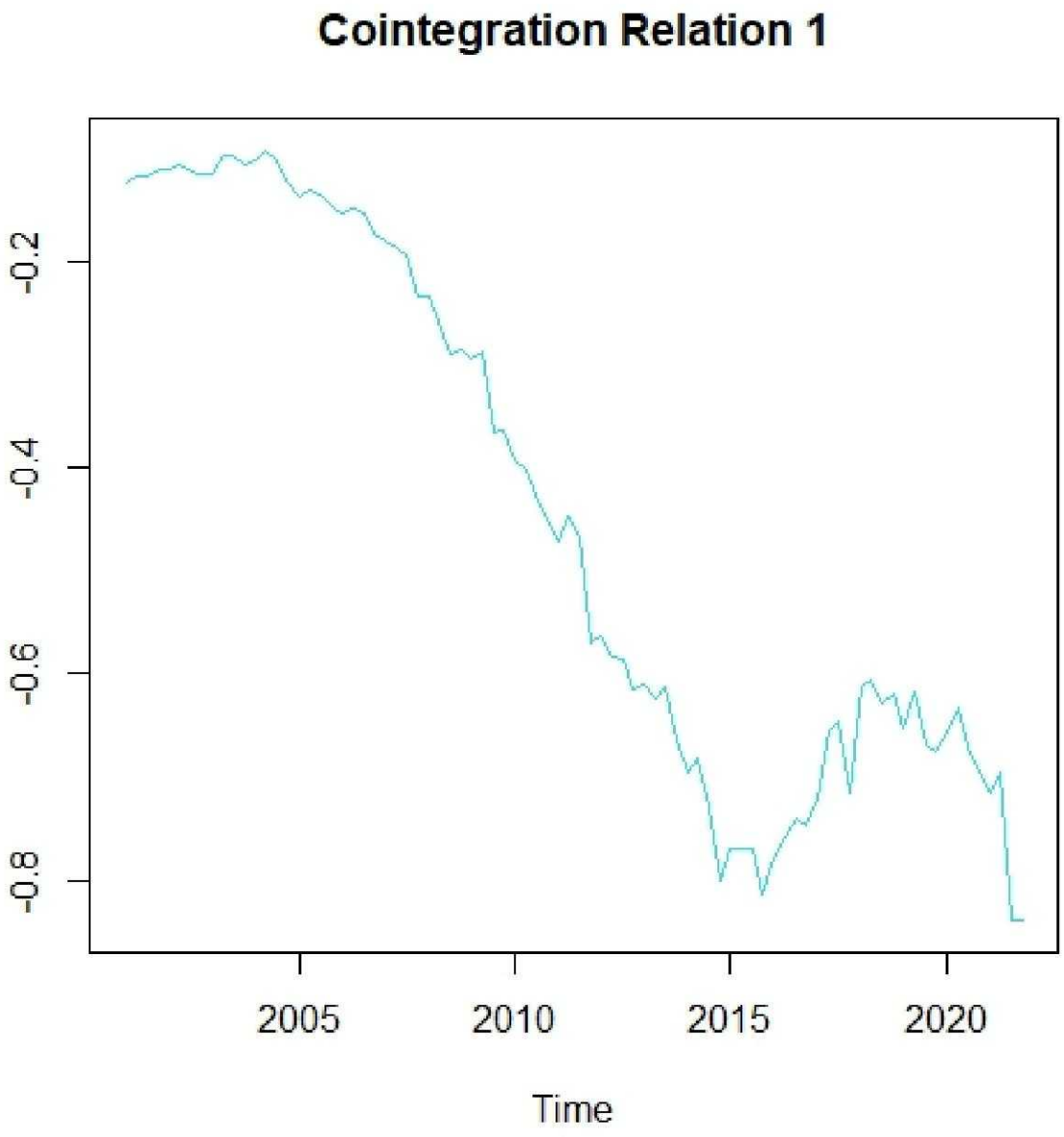


**Figure 3. Cointegration relation 1 graph**

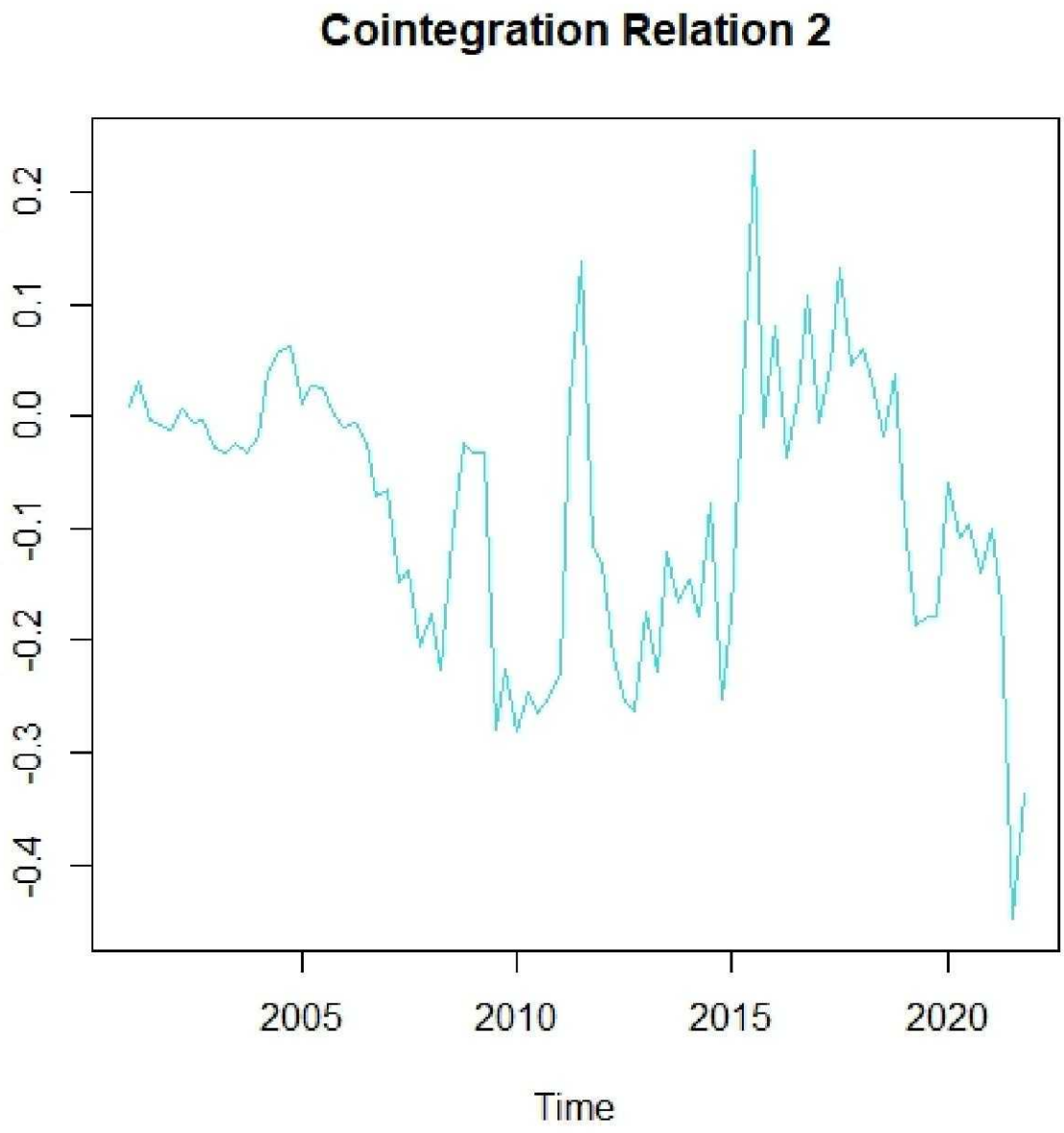


**Figure 4. Cointegration relation 2 graph**

### 4.2.3 ECM model

From equation (13), by eliminating the variables interest payments on debts, trade balance and budget deficit reduces to

$$\Delta PD_t = \beta_1 \Delta PD_{t-1} + \beta_2 \Delta USDR_{t-1} + \beta_3 \Delta CR_{t-1} + \beta_4 \Delta NFA_{t-1} + \beta_5 \Delta CPS_{t-1} + \beta_6 \gamma_{t-1} + \nu_t \tag{20}$$

The ECM results as are shown below;

**Table 5. ECM results**

| Variable | Estimate | Std. Error | p value |
|---|---|---|---|
| $\beta_1$ | -0.1307 | 0.1228 | 0.2908 |
| $\beta_2$ | 1.0408 | 1.2215 | 0.3970 |
| $\beta_3$ | 0.5842 | 0.2264 | 0.0119 |
| $\beta_4$ | -0.1169 | 0.0747 | 0.1221 |
| $\beta_5$ | -0.3759 | 0.1726 | 0.0327 |
| $\beta_6$ | -0.0454 | 0.0063 | $< 0.001$ |

Model diagnostics: $SE(residual) = 0.01046$ on $df = 72$; $R^2 = 0.8096$; $R_A^2 = 0.7858$; $F(9,72) = 34.02$; $p - value = 0.0001$

The model is statistically significant at a 5% level. The results of the ECM equation (20) provide evidence of a short-term dynamic relationship between public debt in Kenya and USD exchange rate, capital and reserve, net foreign asset and credit to the private sector at a 5% level. The error correction term $\beta_6 = -0.0454$ is negative as expected, confirming a long-term equilibrium confirming cointegration results. In the short run, an increase in net foreign asset and credit to the private sector by 1 % then induce a reduction in debt by 0.11% and 0.38 % respectively. Inversely, increasing USD exchange rate and capital and reserve by 1 % will induce an increase in debt by 1.04% and 0.58% respectively.

### 4.2.4 Cointegration VECM model

#### VECM model

Equation (15) reduces to

$$\Delta(pd_t) = ect_1 + ect_2 + ect_3 + sd1 + sd2 + sd3 + \beta_1\Delta(PD_{t-1}) + \beta_2\Delta USDR_{t-1} + \beta_3\Delta CR_{t-1} + \beta_4\Delta NFA_{t-1} + \beta_5\Delta CPS_{t-1} + CD \quad (21)$$

**Table 6. VECM results**

| Variable | Estimate | Std. Error | P value |
|---|---|---|---|
| $ect_1$ | 0.0629 | 0.0341 | 0.0695 |
| $ect_2$ | -2.7293 | 0.8754 | 0.0027 |
| $ect_3$ | 0.1129 | 0.1209 | 0.354 |
| $sd_1$ | 0.0004 | 0.0032 | 0.8957 |
| $sd_2$ | 0.0126 | 0.0034 | 0.0005 |
| $sd_3$ | 0.0064 | 0.0034 | 0.0629 |
| $\beta_1$ | -0.1077 | 0.1241 | 0.3887 |
| $\beta_2$ | -0.7336 | 1.1848 | 0.5379 |
| $\beta_3$ | 0.7057 | 0.214 | 0.0016 |
| $\beta_4$ | -0.3625 | 0.0897 | 0.0001 |
| $\beta_5$ | -0.2779 | 0.1835 | 0.1346 |

Model diagnostics: $SE(residual) = 0.0093$ on $df = 65$; $R^2 = 0.8467$; $R^2_A = 0.8208$; $F(11,65) = 32.65$; $p - value = 0.0001$

The model is statistically significant at a 5% level.

## Forecast

The forecast horizon for the study was fourteen with seven for validation and seven for predicting future values for the years 2022 and 2023. The model simultaneously forecasts for all the variables in the study as shown in the appendix figure 6 and table ?? . Table 7 presents the observed and forecast values of public debt for the validation period.

**Table 7. Public debt comparison of observed and forecast results**

| year | quarter | observed value | predicted value | lower bound | upper bond | 95% CI |
|---|---|---|---|---|---|---|
| 2020 | q3 | 9.1371 | 9.1125 | 9.0957 | 9.1294 | 0.0168 |
| 2020 | q4 | 9.1543 | 9.1233 | 9.1001 | 9.1466 | 0.0232 |
| 2021 | q1 | 9.1604 | 9.1497 | 9.1233 | 9.1761 | 0.0264 |
| 2021 | q2 | 9.1988 | 9.1807 | 9.1514 | 9.2101 | 0.0294 |
| 2021 | q3 | 9.2271 | 9.2 | 9.1682 | 9.2319 | 0.0319 |
| 2021 | q4 | 9.2476 | 9.2179 | 9.1839 | 9.2519 | 0.034 |
| 2022 | q1 | 9.2662 | 9.2401 | 9.2401 | 9.2041 | 0.0360 |

Out of seven predicted values, only two values correspond to July up to December 2020 and the public debt falls outside the 95% confidence level. This period corresponds to the period when Kenya's government introduced pandemic mitigation measures and economic incentives. However, the values are within the neighborhood of the upper bound for each estimated value. The table provides enough evidence of the model's ability to make satisfactory inferences for the post-sample period. Equation 16 results in the following predicted values for public debt for the period 2022 to 2023 as shown in table 8.

**Table 8. Public debt forecast results**

| year | quarter | predicted value | Debt in billion Ksh | lower limit | upper limit |
|---|---|---|---|---|---|
| 2022 | q2 | 9.2711 | 8453.435 | 8059.252 | 8862.802 |
| 2022 | q3 | 9.2902 | 8658.35 | 8235.728 | 9097.004 |
| 2022 | q4 | 9.3077 | 8849.567 | 8396.206 | 9321.225 |
| 2023 | q1 | 9.323 | 9019.509 | 8606.484 | 9612.203 |
| 2023 | q2 | 9.361 | 9453.009 | 8910.358 | 10022.23 |
| 2023 | q3 | 9.380 | 9676.512 | 9079.189 | 10305.54 |
| 2023 | q4 | 9.3976 | 9886.765 | 9224.838 | 10587.13 |

The public debt is expected to increase hitting a value of Ksh 9.887 trillion mark with a margin error of 0.681 by December 2023.

# 5 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The study sort to establish a significant short-dynamic and long-term equilibrium between public debt and the independent variables that are: USD exchange rate, capital and reserves, trade balance, budget deficit, net foreign assets, interest payments on debts, and credit to the private sector. The study provides sufficient evidence to conclude that trade balance, budget deficit and interest payments on debts are stationary while USD exchange rate, public debt, capital and reserve, net foreign assets and credit to the private sector are of integrating order 1.

The study provides evidence of the existence of long-run dynamic relationships among public debt and capital and reserves, net foreign assets and USD exchange rate. Both the maximal eigenvalue and trace statistic Cointegration test resulted in two cointegrating relationships. Vector error correction model supports the results of the cointegration relationship with the error term of -0.0454. The ECM identifies net foreign asset, USD exchange rate and capital and reserves as the main determinant of increasing public debt following a long-run relationship. Net foreign assets and credit to the private sector have a negative effect on public debt while USD exchange rate and capital and reserves have a positive effect in a long-run relationship. The VECM model is statistically significant at a 5% level. The public debt is likely to hit Ksh 9.887 trillion mark with a margin error of 0.681 by December 2023.

## 5.2 Recommendations

### 5.2.1 Public debt

The study notes a sharp drift in interest payment on debts from 2015 with a similar drift implicated in the budget deficit. They form a cyclic linear trend the lowest being the third quarter (July to September) and the highest being the second quarter (April to June) that is fairly similar, resulting in stationary time series. Further scrutiny of the revenue follows a similar property as shown in the appendix. This may result in a scenario of acquiring debt to service existing debts. The government is implementing a policy framework of acquisition of external concessional loans and lengthening debt maturity profile, With the properties highlighted, it's recommended that the maturity of loans be lagged/translated with respect to time avoiding the second quarter (April to June) period. Trade balance is identified as a stationary variable over the project period. Kenya's economy is mostly agricultural-based, and policy guidance on the protection of Kenya's farming activities

from the internal market needs to be developed. This will help reduce the fraction of agricultural product/input imports, reducing the trade balance gap.

Net foreign assets and credit to the private sector hurt public debt, its recommended that the government develop necessary regulatory policies to harness the benefits of net foreign assets and also create more room for borrowing in the private sector. Fiscal policies are required to stabilize the USD exchange rate to mitigate the positive effect it has on debt. An assessment needs to be carried out on capital and reserve to avert the positive effect on debt.

### 5.2.2 Further research

The project period covered from the first quarter in 2001 to the fourth quarter in 2021, however, transfers to the county government started in the year 2013. I recommend further study in the future with transfer to the county as a predictor variable in public debt growth. Finally, further research is recommended on the stationary predictor variables to determine their effect on public debt growth using spurious regression.

# Bibliography


[1] Amayo, S. A. (2019). Impact of Capital and Recurrent Expenditure on Public Debt in Kenya. *Doctoral thesis, University of Nairobi.*

[2] Attapattu, A. and Padmasiri, H. (2018). Long Run Association between Public Debt and Economic Growth in Sri Lanka. *Modern Economy* 9(4), 775–789.

[3] Aybar, S. C. (2019). Theory of public debt and current reflections. *Public economics and finance*, IntechOpen.

[4] Barro, R. J. (1979). On the determination of public debt. *Journal of Political Economy*, 87(5), 940-971.

[5] Chironga, C. (2003). The structure, magnitude, level, and determinants of public domestic debt in Kenya for the period 1990-2001. *Unpublished MBA Project, University of Nairobi.*

[6] Engle, R. F. and Granger, C. W. J. (1978). Co-integration and error correction: representation, estimation and testing. *Econometrica: Journal of the Econometric Society*, 55, 251-276.

[7] IMF and IDA (2020). Kenya Joint World Bank IMF Debt Sustainability Analysis. *https://documents1.worldbank.org/curated/en/ 796991589998832687 / pdf / Kenya - Joint - World - Bank - IMF - Debt - Sustainability-Analysis.pdf.*

[8] Johansen, S. and Juselius, k. (1990). Maximum likelihood estimation and inference on cointegration with application to the demand for money. *Oxford Bulletin of Economics and statistics*, 52(2), 169–210.

[9] Kangara, L. M. (2015). The effect of national debt on economic growth in Kenya. *Masters thesis, University of Nairobi.*

[10] Kiriga, B. and Chemnyongoi, H. (2020). Optimization of Public Debt and its Impact on Kenya's Economic Growth. *KIPPRA Discussion Paper, 245*

[11] Kirui, E. (2017). Macroeconomic Determinants of Public Debt Accumulation in Kenya. *KIPPRA Discussion Paper*,196.

[12] Kobey, G. L. (2016). Effect of public debt on economic growth in Kenya. *Doctoral thesis, University Of Nairobi.*

[13] Lewis, J. and Vinal, J. (2014). Revised guidelines for public debt management. *International Monetary Fund: Washington, DC, USA.*

[14] Iiyambo, H. and Kaulihowa, T. (2020). An assessment of the relationship between public debt, government expenditure, and revenue in Namibia. *Public sector economics* 44(3), 331–353.

[15] Mageto, J. N. (2015). Public debt and economic growth in Kenya. *Masters thesis, Kenyatta University.*

[16] Matiti, C. M. (2013). The effect of selected determinants on public debt in Kenya. *Doctoral thesis, University of Nairobi.*

[17] Muhammad, K. K., Jian-Zhou, T. and Muhammad, I. K. (2019). Co- integration between macroeconomic factors and the exchange rate USD/CNY. *Financial Innovation*, 5(1), 1-15.

[18] Mohamedamin, A. H. (2021). The effect of national public debt on economic growth in Kenya. *Masters thesis, University of Nairobi.*

[19] Mwangi, D. N. (2017). The impact of public debt on economic growth in Kenya. *Masters thesis, Makerere University.*

[20] Ngugi, W. N. (2016). Effect of public debt on economic growth in Kenya. *Masters thesis, Kenyatta University.*

[21] Omrane, B. S. and Omrane, H. (2017). Macroeconomic determinants of public debt growth: A case study for Tunisia. *Theoretical & Applied Economics*,24,4.

[22] Rahman, N. H. A., Ismail, S. and Ridzuan, A. R. (2019). A systematic review of public debt effect on economic growth. *Cogent Business and Management*, 6(1), 1701339(30).

[23] Ryan, T. and Maana, I. (2014). An assessment of Kenya's public debt dynamics and sustainability. *Central Bank of Kenya, Nairobi.*

[24] Swamy, V. (2015). Government debt and its macroeconomic determinants–an empirical investigation. *SSRN 2601875.*

# Appendix

Trade balance is obtained by finding the difference between a country's export and imports. Negative implies more imports than exports A budget deficit is a scenario where the expenditures exceed the revenue generated over the budget period. Negative values imply a deficit while positive values are surplus. Figure 5 shows the plot of Government revenue, interest payments on debts, and budget deficit. The budget deficit plot is inverted but similar to revenue and interest payments on debt plots.

**Table 9. Data**

| yr | qrt | cps | pd | cr | nfa | usdr | tb | bd | ipd |
|---|---|---|---|---|---|---|---|---|---|
| 2001 | q1 | 291.177 | 603.9961 | 68.637 | 87.821 | 78.17333 | -22.8837 | -26.735 | 55.348 |
| 2001 | q2 | 293.584 | 605.7906 | 65.843 | 87.844 | 78.35333 | -42.5387 | -47.196 | 79.41 |
| 2001 | q3 | 279.786 | 611.2177 | 68.562 | 89.506 | 78.94333 | -36.2749 | -9.414 | 17.148 |
| 2001 | q4 | 271.679 | 606.2866 | 65.729 | 90.725 | 78.88333 | -25.052 | -22.482 | 39.757 |
| 2002 | q1 | 270.119 | 609.3361 | 65.452 | 90.845 | 78.25667 | -30.9071 | -40.415 | 64.697 |
| 2002 | q2 | 278.094 | 613.739 | 63.296 | 98.825 | 78.47 | -14.5502 | -57.121 | 86.354 |
| 2002 | q3 | 282.982 | 625.8428 | 68.882 | 98.421 | 78.81667 | -15.3668 | -24.747 | 19.199 |
| 2002 | q4 | 288.737 | 629.5581 | 69.584 | 103.539 | 78.94667 | -24.9946 | -53.362 | 48.805 |
| 2003 | q1 | 286.763 | 635.6205 | 70.534 | 105.552 | 76.99667 | -18.7895 | -73.309 | 75.013 |
| 2003 | q2 | 288.83 | 696.43 | 71.085 | 104.631 | 73.92667 | -26.4572 | -94.567 | 99.759 |
| 2003 | q3 | 293.713 | 714.3191 | 74.591 | 117.019 | 76.84333 | -26.4295 | -18.1205 | 16.94348 |
| 2003 | q4 | 302.888 | 711.3396 | 77.856 | 122.443 | 76.98 | -27.0266 | -7.658 | 40.696 |
| 2004 | q1 | 309.911 | 714.0597 | 75.513 | 132.103 | 76.89333 | -32.2949 | -18.223 | 62.985 |
| 2004 | q2 | 324.144 | 749.3921 | 75.508 | 132.461 | 79.07667 | -32.581 | -15.298 | 83.136 |
| 2004 | q3 | 341.294 | 754.1841 | 80.66 | 131.229 | 80.51667 | -40.4401 | -6.813 | 15.45082 |
| 2004 | q4 | 368.683 | 735.3674 | 84.796 | 140.427 | 79.95 | -42.8933 | 10.518 | 34.581 |
| 2005 | q1 | 376.302 | 721.1873 | 86.728 | 150.678 | 75.81333 | -39.7655 | 48.436 | 59.20544 |
| 2005 | q2 | 381.724 | 749.5482 | 87.981 | 154.764 | 76.62333 | -69.8306 | 20.874 | 83.443 |
| 2005 | q3 | 388.768 | 747.6603 | 88.169 | 154.612 | 75.27333 | -53.2443 | -44.075 | 20.599 |
| 2005 | q4 | 398.491 | 743.6038 | 92.473 | 156.72 | 73.49 | -57.9229 | -78.076 | 49.939 |
| 2006 | q1 | 415.534 | 753.0678 | 94.777 | 174.149 | 72.35 | -62.5284 | -92.237 | 83.012 |
| 2006 | q2 | 428.936 | 789.0758 | 97.427 | 190.239 | 72.43667 | -70.9214 | -117.677 | 113.546 |
| 2006 | q3 | 431.714 | 794.2394 | 100.863 | 201.674 | 72.97333 | -65.8547 | -31.0992 | 20.929 |
| 2006 | q4 | 446.824 | 792.8638 | 108.787 | 208.134 | 70.45667 | -79.665 | -70.2369 | 50.254 |
| 2007 | q1 | 466.158 | 795.3435 | 110.276 | 220.389 | 69.68333 | -82.4316 | -78.112 | 82.872 |
| 2007 | q2 | 451.614 | 801.2541 | 117.101 | 222.749 | 67.28 | -76.9639 | -70.217 | 116.349 |
| 2007 | q3 | 474.374 | 835.5021 | 123.696 | 225.497 | 67.15667 | -85.4152 | 3.622 | 23.464 |
| 2007 | q4 | 519.457 | 844.9821 | 141.468 | 255.359 | 64.73667 | -85.7143 | -37.137 | 58.265 |
| 2008 | q1 | 530.705 | 869.8233 | 146.968 | 249.564 | 67.46333 | -92.3971 | -86.798 | 93.329 |
| 2008 | q2 | 572.95 | 870.5787 | 153.392 | 291.292 | 62.95333 | -81.3844 | -147.242 | 129.023 |
| 2008 | q3 | 632.438 | 882.2879 | 169.369 | 254.13 | 69.75667 | -129.138 | -0.113 | 22.42 |
| 2008 | q4 | 662.317 | 972.8993 | 183.725 | 249.496 | 78.41333 | -120.869 | -78.47 | 59.658 |

| yr | qrt | cps | pd | cr | nfa | usdr | tb | bd | ipd |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | q1 | 676.092 | 988.3728 | 191.61 | 256.276 | 79.88667 | -100.531 | -97.343 | 100.924 |
| 2009 | q2 | 697.168 | 1053.49 | 196.436 | 267.977 | 78.05667 | -107.117 | -213.611 | 142.656 |
| 2009 | q3 | 701.077 | 1075.596 | 247.435 | 255.293 | 75.94667 | -104.211 | -58.424 | 29.714 |
| 2009 | q4 | 747.312 | 1177.941 | 258.339 | 243.756 | 75.32333 | -131.288 | -109.705 | 83.847 |
| 2010 | q1 | 768.205 | 1177.274 | 273.302 | 268.187 | 76.70667 | -108.059 | -250.217 | 128.708 |
| 2010 | q2 | 809.025 | 1225.72 | 284.388 | 280.279 | 79.64667 | -134.082 | -425.283 | 173.304 |
| 2010 | q3 | 852.607 | 1298.926 | 308.054 | 278.113 | 80.69333 | -142.034 | -55.564 | 30.463 |
| 2010 | q4 | 898.49 | 1320.138 | 322.151 | 269.835 | 80.83667 | -167.057 | -164.555 | 91.775 |
| 2011 | q1 | 964.808 | 1396.896 | 340.75 | 286.132 | 82.20667 | -167.701 | -249.756 | 141.353 |
| 2011 | q2 | 1054.465 | 1487.111 | 330.663 | 281.927 | 86.32667 | -184.116 | -356.125 | 198.56 |
| 2011 | q3 | 1158.794 | 1564.109 | 347.864 | 310.079 | 94.85 | -225.528 | -44.034 | 34.431 |
| 2011 | q4 | 1173.137 | 1485.488 | 397.832 | 295.203 | 91.52333 | -227.273 | -231.556 | 99.06975 |
| 2012 | q1 | 1193.587 | 1564.201 | 401.235 | 276.161 | 83.54 | -197.534 | -499.595 | 159.281 |
| 2012 | q2 | 1224.115 | 1633.38 | 423.652 | 321.776 | 84.76 | -219.93 | -629.873 | 241.805 |
| 2012 | q3 | 1248.943 | 1724.654 | 437.321 | 351.973 | 84.60333 | -218.372 | -124.151 | 55.51536 |
| 2012 | q4 | 1295.395 | 1793.238 | 463.874 | 325.992 | 85.71667 | -223.124 | -348.018 | 149.2615 |
| 2013 | q1 | 1328.352 | 1794.611 | 456.731 | 319.554 | 86.49667 | -221.663 | -570.782 | 232.7436 |
| 2013 | q2 | 1380.034 | 1894.191 | 475.755 | 361.225 | 84.98333 | -204.556 | -843.225 | 314.6084 |
| 2013 | q3 | 1465.824 | 2057.429 | 485.78 | 372.795 | 87.17667 | -232.531 | -57.1803 | 50.57395 |
| 2013 | q4 | 1555.586 | 2111.552 | 517.813 | 387.292 | 86.15 | -243.358 | -233.184 | 164.2082 |
| 2014 | q1 | 1629.175 | 2171.586 | 540.127 | 370.55 | 86.33667 | -210.636 | -402.298 | 243.1512 |
| 2014 | q2 | 1736.149 | 2370.256 | 551.309 | 529.426 | 87.43333 | -262.431 | -630.377 | 350.3442 |
| 2014 | q3 | 1825.423 | 2348.702 | 571.012 | 446.493 | 88.49 | -325.202 | 71.5221 | 63.20114 |
| 2014 | q4 | 1902.034 | 2478.445 | 633.12 | 479.654 | 90.04333 | -288.994 | -151.898 | 167.6299 |
| 2015 | q1 | 1926.281 | 2675.234 | 638.951 | 462.064 | 91.81 | -221.351 | -648.257 | 272.7371 |
| 2015 | q2 | 2056.934 | 2829.058 | 649.391 | 435.524 | 97.00667 | -268.567 | -1222.71 | 419.1509 |
| 2015 | q3 | 2170.531 | 2938.495 | 656.513 | 389.722 | 103.8933 | -244.171 | 79.04286 | 73.57355 |
| 2015 | q4 | 2232.327 | 3155.201 | 712.466 | 489.796 | 102.0733 | -262.423 | -357.584 | 231.2413 |
| 2016 | q1 | 2248.906 | 3312.106 | 705.656 | 470.139 | 101.77 | -167.019 | -712.524 | 375.135 |
| 2016 | q2 | 2270.561 | 3618.727 | 729.428 | 560.885 | 101.0233 | -223.823 | -1246.56 | 536.7588 |
| 2016 | q3 | 2305.261 | 3703.574 | 722.245 | 590.228 | 101.3367 | -233.708 | -31.4974 | 95.53838 |
| 2016 | q4 | 2347.121 | 3827.298 | 739.444 | 493.574 | 101.9433 | -229.138 | -575.851 | 287.1111 |

| yr | qrt | cps | pd | cr | nfa | usdr | tb | bd | ipd |
|---|---|---|---|---|---|---|---|---|---|
| 2017 | q1 | 2341.638 | 4104.022 | 753.965 | 601.408 | 103.3133 | -271.862 | -1094.61 | 489.3048 |
| 2017 | q2 | 2333.345 | 4406.446 | 741.892 | 642.558 | 103.4367 | -274.441 | -1849.09 | 701.9192 |
| 2017 | q3 | 2371.027 | 4483.034 | 739.985 | 610.059 | 103.4333 | -306.69 | -36.6078 | 118.2175 |
| 2017 | q4 | 2418.192 | 4569.63 | 797.673 | 516.31 | 103.39 | -278.501 | -458.25 | 360.1186 |
| 2018 | q1 | 2400.159 | 4884.081 | 755.172 | 697.646 | 101.61 | -276.785 | -945.596 | 588.2469 |
| 2018 | q2 | 2440.045 | 5039.035 | 762.35 | 756.908 | 100.9633 | -302.266 | -1547.06 | 857.131 |
| 2018 | q3 | 2468.512 | 5146.168 | 787.322 | 742.071 | 100.6733 | -281.101 | -88.7487 | 164.952 |
| 2018 | q4 | 2490.088 | 5272.503 | 792.07 | 714.099 | 102.08 | -287.14 | -620.452 | 430.7888 |
| 2019 | q1 | 2512.968 | 5424.531 | 829.939 | 719.984 | 100.5767 | -266.568 | -1248.76 | 699.3772 |
| 2019 | q2 | 2574.743 | 5808.623 | 834.959 | 939.903 | 101.68 | -308.961 | -1774.05 | 1011.318 |
| 2019 | q3 | 2648.852 | 5963.406 | 882.567 | 835.444 | 103.8833 | -302.106 | -131.118 | 230.1791 |
| 2019 | q4 | 2667.874 | 6048.927 | 893.394 | 804.453 | 102.4533 | -327.948 | -576.65 | 525.8044 |
| 2020 | q1 | 2738.014 | 6282.824 | 893.922 | 767.701 | 102.0867 | -247.835 | -1308.86 | 848.6335 |
| 2020 | q2 | 2774.536 | 6694.232 | 911.57 | 885.952 | 106.9167 | -208.861 | -1878.23 | 1190.922 |
| 2020 | q3 | 2850.948 | 7120.598 | 972.098 | 749.66 | 108.14 | -258.261 | -237.383 | 245.1515 |
| 2020 | q4 | 2889.526 | 7281.826 | 1000.179 | 746.941 | 109.3467 | -284.249 | -909.278 | 607.9465 |
| 2021 | q1 | 2945.619 | 7339.707 | 1019.028 | 691.027 | 109.8167 | -317.316 | -1389.6 | 973.4396 |
| 2021 | q2 | 2981.133 | 7712.393 | 1028.673 | 783.781 | 107.76 | -305.464 | -2171.89 | 1354.083 |
| 2021 | q3 | 3059.152 | 7996.3 | 1165.282 | 661.862 | 109.6567 | -365.736 | -230.519 | 282.8326 |
| 2021 | q4 | 3112.871 | 8206.74 | 1178.928 | 581.352 | 111.9 | -419.443 | -777.853 | 687.4178 |

**Table 10. predicted values of the predictor variables**

| year | quarter | USDR | CR | NFA | CPS |
|---|---|---|---|---|---|
| 2020 | Q3 | 108.6634 | 910.603 | 894.9719 | 2817.184 |
| 2020 | Q4 | 108.6634 | 946.8026 | 851.654 | 2867.648 |
| 2021 | Q1 | 106.9664 | 951.6545 | 890.5449 | 2890.428 |
| 2021 | Q2 | 107.3837 | 958.1919 | 946.3534 | 2939.481 |
| 2021 | Q3 | 109.033 | 975.1555 | 941.6903 | 2997.269 |
| 2021 | Q4 | 108.9052 | 1001.27 | 942.7214 | 3050.354 |
| 2022 | Q1 | 108.3622 | 1007.844 | 966.7705 | 3084.006 |
| 2022 | Q2 | 108.8276 | 1017.111 | 1023.894 | 3139.342 |
| 2022 | Q3 | 110.4986 | 1034.432 | 1018.18 | 3200.786 |
| 2022 | Q4 | 110.3912 | 1061.909 | 1016.288 | 3257.948 |
| 2023 | Q1 | 109.8958 | 1068.93 | 1041.03 | 3294.676 |
| 2023 | Q2 | 110.4209 | 1078.625 | 1099.155 | 3354.091 |
| 2023 | Q3 | 112.1433 | 1096.669 | 1092.875 | 3419.787 |
| 2023 | Q4 | 112.0724 | 1125.008 | 1090.668 | 3480.782 |

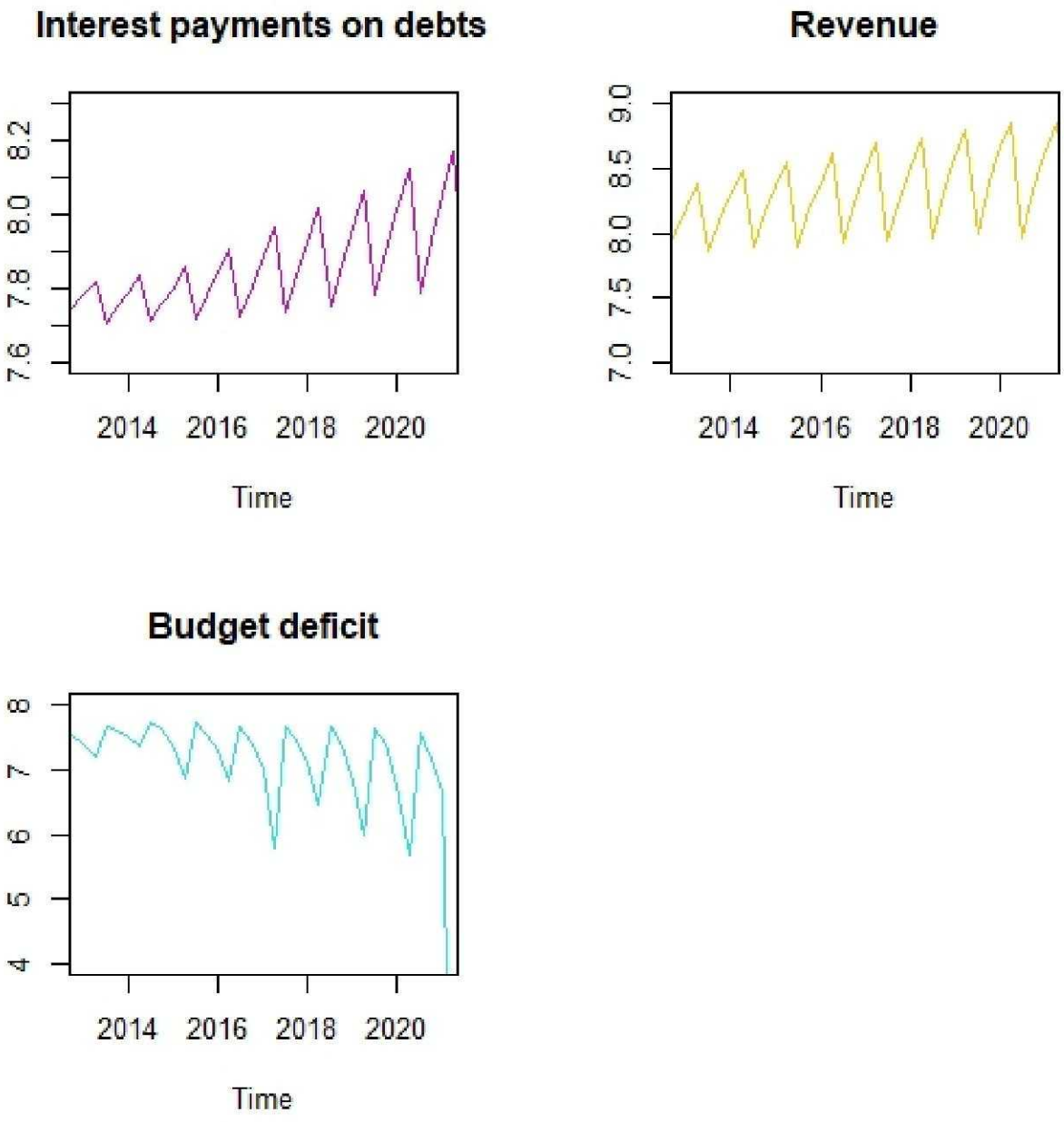


**Figure 5. budget deficit, revenue and interest payments on debts plot as from 2014**

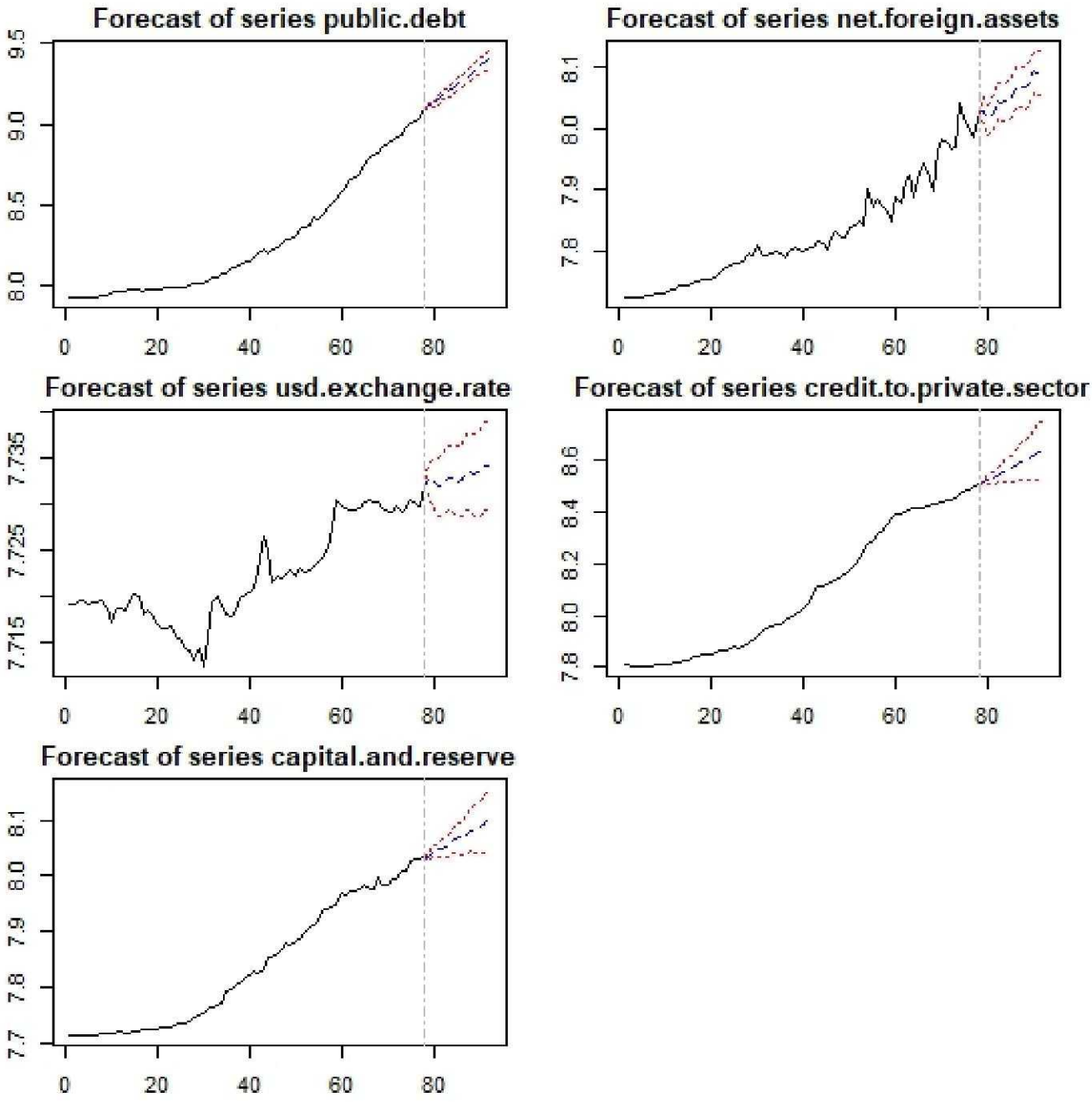


Figure 6. Forecast for all variables