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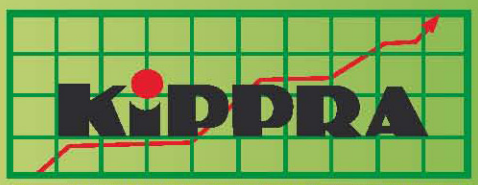

The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

Optimization of Public Debt and its Impact on Kenya's Economic Growth

Benson Kiriga
Hellen Chemnyongoi
Peris Wachira

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THE KENYA INSTITUTE FOR PUBLIC POLICY
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Kenya Institute for Public Policy
Research and Analysis

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KIPPRA in Brief

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Abstract

Kenya's Vision 2030 aims at achieving and maintaining a sustainable and inclusive annual growth of 10 per cent. To achieve this, the government embarked on expansionary fiscal policy, which involves investing in growth enabler projects such as revamping existing infrastructure systems and establishing new ones. However, most of these projects require large funding beyond Kenya's domestic revenue capacity and have led to a widening of budget deficit, which is financed through public debt. Public debt refers to the outstanding liabilities of government requiring future payment of principal and/or interest. The trend of Kenya's public debt stock has been rising sin1989/90. Public debt increased from Ksh 84,051 million in June 1990 to Ksh 5,809,076 million in June 2019 to Ksh 6,649,573 million in May 2019. Nevertheless, even with rising public debt stock size, Kenya's public debt stock as a per cent of GDP of 62 per cent (June 2019) remains below the nations debt limit of Ksh 9 trillion and Low Middle-Income Countries (LMICs) IMF debt sustainability threshold of 70 per cent of GDP, and thus deemed sustainable. Contrary to the Keynesian theory of economic growth on the outcomes of expansionary fiscal policy and investment in growth enablers, Kenya has been unable to attain the Medium-Term Plan (MTPs) targets of 10 per cent annual growth required for the realization of Kenya's Vision 2030. Kenya's real GDP grew from 4.9 per cent in 2017 to 6.3 per cent in 2018 and 5.6 per cent in 2019. This has attracted national concern on debt sustainability models, on whether the debt is good or bad for economic growth especially in Low Medium-Income Countries (LMICs) such as Kenya and if it is good, what is the optimal level of debt that is desirable for economic growth? Using the Impulse Response Functions derived from VECM, the study found that public debt hurts economic growth in the short-run. However, it stimulates the economic growth in the long-run. The study also established that policy makers should be more concerned with public debt stock as a per cent GDP rather than in nominal terms. Growth optimizing debt level was found to be 68 per cent of GDP.

Abbreviations and Acronyms

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag Model
EAC	East African Community
ERS	Economic Recovery Strategy
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GFCT	Gross Fixed Capital Formation
IMF	International Monetary Fund
KER	Kenya Economic Report
KNBS	Kenya National Bureau of Statistics
LMICs	Low Middle Income Countries
MTP	Medium-Term Plan
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
PFM	Public Finance Management
SSA	Sub-Saharan Africa
VECM	Vector Error Correction Model
WEO	World Economic Outlook

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1. Introduction

Public debt refers to the outstanding liabilities of government requiring future payment of principal and/or interest. It indicates how much of government spending or budget deficit is financed through borrowing rather than revenue (Makau, 2008). Liabilities are outstanding obligations of the government and comprise of domestic (owing to national creditors) and external (owing to foreign creditors). The government borrows domestically through the issuance of Treasury bills and bonds by the Central Bank of Kenya and externally through bilateral and multilateral borrowings and sovereign bonds. As of May 2020, Kenya's total public debt stood at Ksh 6.65 trillion, of which 53 per cent was external and 47 per cent domestic debt.

The size of public debt stock is one of the major macroeconomic indicators that form a country's image in the international markets and therefore, a significant FDI inflow determinant (Matiti, 2013). It is also an important stimulus to economic growth if managed well, through capital accumulation and productivity growth especially when the economy is in a recession or when used to finance growth-enhancing projects[1] (Babu et al., 2015). Moreover, public debt complements tax revenues, which enables a country to smoothen its consumption patterns across generations. This raises the societal inter-temporal welfare and crowds in investment through the provision of liquidity services that eases credit conditions faced by households and firms (Eboreime and Sunday, 2017). However, high debt accumulation can drag the economy by crowding out of private investments[2] (Reinhart and Rogoff, 2010). Besides, since most countries are uncertain about the proportion of debt that is to be financed using the country's resource, there is high probability of refinancing, restructuring debt, rescheduling payment or financing debt using inflation tax[3], hence, low economic growth (Agenor and Montiel, 1996). Large public debt stock can also adversely affect domestic price stability, foreign exchange management, and lead to debt overhang (Checherita-Westphal, 2012).

The rising trend of debt stock in the 20th century has not only been a problem associated with developing economies but also with developed economies. This has attracted global concern on debt sustainability and whether debt stimulates or drags economic growth especially in Low Medium Income Countries (LMICs) such as Kenya. There has been a debate among economists, academicians, and researchers on the impact of public debt on economic growth. The question is whether public

1 During recession, the government uses expansionary fiscal policy (increase government spending on growth enhancing projects and reduces taxation), which leads to budget deficits, hence the need to borrow to increase aggregate demand. This results to economic growth and full employment (Minea and Parent, 2012).

2 Government borrowing, especially domestic borrowing, leads to high interest which crowds out private investments.

3 In case of inadequate own resources to finance debt.

debt stimulates economic growth, and if it does, what is the optimal level of public debt that is desirable for economic growth?

The relationship between public debt stock and economic growth in Kenya can be tracked since independence as shown in Table 1.1. From the table, different episodes illustrate that the relationship between economic growth and public debt stock in Kenya is mixed. These episodes include: (i) episodes with low public debt that are associated with a growing economy. An example is the period 1963 to 1980; (ii) episodes with high public debt stock as a per cent of GDP associated with low economic growth. An example is a period 1981 to 1990 and the period 1991 to 2002; (iii) episodes with rising debt accumulation associated with a growing economy, an example is the period 2013 to 2016 and the recent period 2017 to 2018 when the economy grew from 4.9 per cent to 6.3 per cent as public debt accumulation increased to 60.1 per cent from 55.2 per cent.

Table 1.1: Evolution of Kenya's economic growth and public debt

Period	Happenings	rGDP Growth (%)	Public Debt (% GDP) - Year end
1963-1970		5.64	28.1
1971-1980	1973 and 1979 oil shocks, 1979 Coffee boom and collapse of EAC	8.18	28.3
1981-1990	1982 political instability; 1984 drought, macroeconomic instability due to misaligned real exchange rates and Structural Adjustment Programmes (SAPs)	4.08	51.3
1990-2002	1992 multiparty elections; decline in donations; depreciation of the Ksh (Goldenberg scandal); and the 2002 general elections	1.93	60.8
2002-2007	Economic Recovery Strategy (ERS)	5.45	49.0
2008	Implementation of Medium-Term Plan (MTP) I; 2008 Global Financial Crisis (GFC); post-election violence; and implementation of Kenya's Constitution 2010	0.23	41.5
2009		3.31	41.1
2010		8.41	44.4
2011		6.11	43.0
2012		4.56	43.9
2013	Implementation of MTP II	5.88	44.0
2014		5.36	48.6
2015		5.72	51.4
2016		5.88	54.5
2017		4.86	55.2
2018	Implementation of the "Big Four" agenda and MTP III	6.32	60.1
2019		5.40	62.1

Source: Prepared by authors using various strategic plans and reports prepared by the Government of Kenya

1.1 Country Comparison on Public Debt Stock

Rising debt accumulation is currently a major fiscal instability globally. In 2019, North America and South America exhibited the highest public debt as a percentage of GDP (over 100%) in the World. Most of the African countries' debt stock was below 80 per cent of GDP except for Sudan whose gross debt as a per cent of GDP was 207%, Mozambique (108.8%), Angola (95%), and Zambia (91.6%) (Figure 1.1).

Besides, developed economies in the European Union and the seven biggest economies[4] in the world have been grappling with the public debt challenge following the 2008 financial crisis. For example, Greece, Ireland, Italy, Portugal, and Spain reported public debt as a per cent of GDP of 180.8 per cent, 72.8 per cent, 131.4 per cent, 125.4 per cent, and 98.1 per cent, respectively, in 2018. In the same year, France and Germany registered a public debt as a per cent of GDP of 99.3 per cent and 63.85 per cent respectively (WEO, 2019).

Figure 1.1: Worlds gross public debt as a per cent of GDP

Source of Data: World Economic Outlook (WEO), October 2019

In 2018, Kenya was ranked as the 7th country in terms of the size of public debt as a share of GDP compared to other 14 LMICs in Sub-Saharan Africa. Kenya's public debt as a share of GDP was 57.1 per cent in 2018 (National Treasury, 2018).

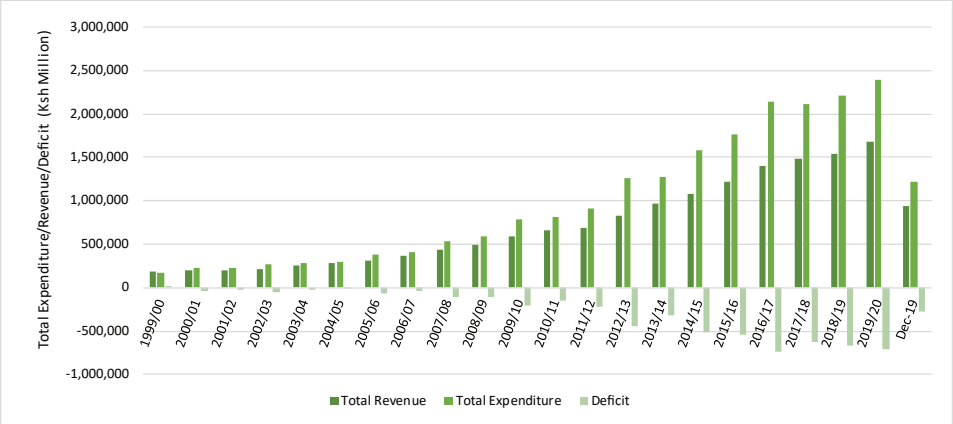
4 Example; France, Germany, Greece, Ireland, Italy, Portugal and Spain.

Cape Verde was ranked first with public debt as a per cent of GDP of 127.7 per cent followed by Sao Tome and Principe (88.6%). These countries were classified as high debt distress countries while Kenya was ranked as moderate (IMF, 2019).

1.2 Review of Public Debt Stock in Kenya

In Kenya, public debt has continued to be a key source of budget financing following subdued growth in revenue and an expansive budget. Figure 1.2 shows that revenue-expenditure gap (deficit) has been widening over the past two decades. For example, budget deficit increased from Ksh 38,208 million in FY 1999/2000 to Ksh 666,718 million in 2018/2019 and to Ksh 235,160 million at the end of the second quarter of 2019/2020. It is this widening of the budget deficit and needs for critical financing for government intervention that has led to increased borrowings to meet budgetary needs by the National Treasury.

Figure 1.2: Trend in budget balance in Kenya

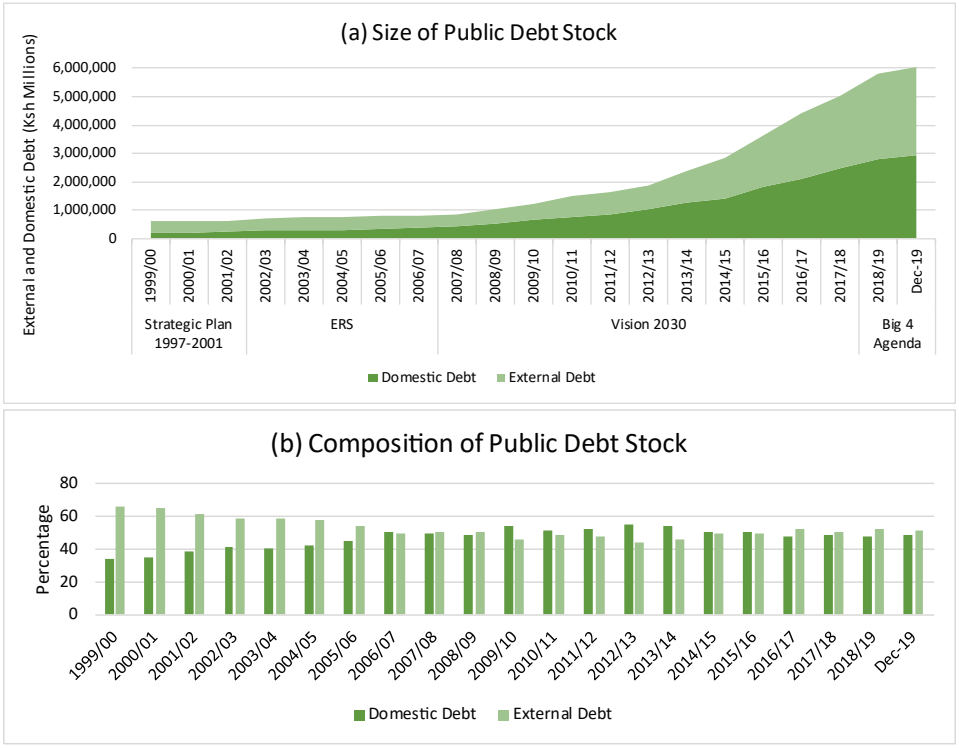


Source of Data: KNBS (Various), Economic Survey

Kenya's public debt stock has been rising since 1989/1990. Public debt increased from Ksh 84,051 million in June 1990 to Ksh 5,809,076 million in June 2019 and to Ksh 6,116,600 and Ksh 6,649,573 in December 2019 and May 2020, respectively. Figure 1.3a shows that the size of public debt stock increased more during implementation of the Kenya Vision 2030 and the "Big Four" agenda. This can be attributed to the government initiative to transform Kenya into a newly industrialized country by the year 2030 by implementing more infrastructure projects that require large funding beyond domestic revenue capacity. Public debt stock increased by 7.5 times from June 2007 to December 2019. Over the same period, domestic debt increased to Ksh 3.00 trillion at the end of the second quarter of 2019 from Ksh 0.40 trillion at the end of June 2007. External debt increased to Ksh 3.11 trillion from Ksh 0.397 trillion in June 2007.

The public debt ratio of external to domestic debt changed from 81:19 in June 1990 to 51:49 in September 2019 against the debt strategy target mix of 60:40. Figure 1.3b shows that between 1998/1999 and 2013/2014, the share of domestic debt has been on an upward trend, which can be attributed to poor donor relations and low credit rating in the 1990s following the Goldenberg scandal. This forced Kenya to depend more on domestic debt. From 2014/2015 to December 2019, the share of domestic debt to total public debt has been exhibiting a downward trajectory due to favourable external borrowing terms that match government borrowing terms (National Treasury, 2019).

Figure 1.3: Public debt stock



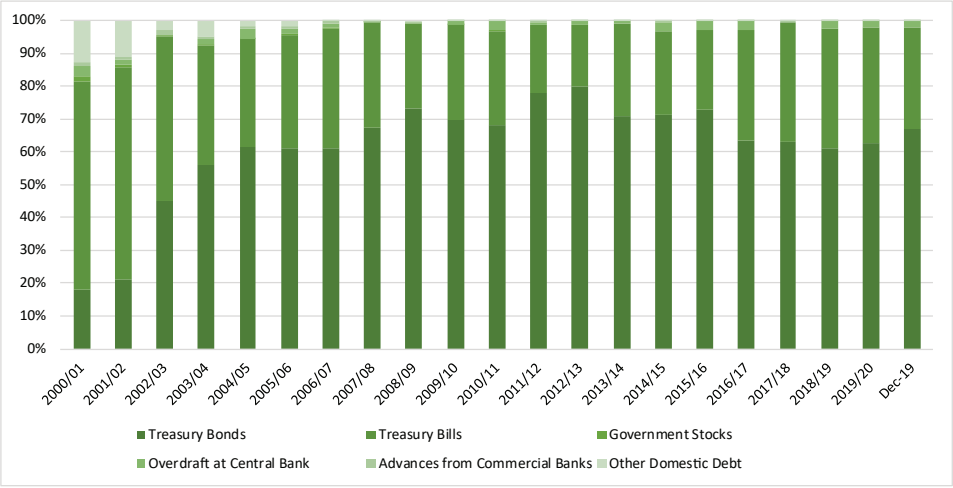
Source of Data: Central Bank of Kenya (2020)

Kenya borrows domestically through the issuance of Treasury Bonds, Treasury bills and sometimes receives an overdraft from the Central Bank of Kenya (CBK) and commercial banks. Domestic debt is not only meant to finance budget deficit but is vital for financial market development and can be used during implementation of monetary policy in an Open Market Operation (OMO).

Kenya has been unable to achieve an 80:20 ratio for domestic debt mix between Treasury Bonds and Treasury Bills required by the Debt Management Strategy (Figure 1.4). Domestic debt mix of Treasury Bonds and Treasury Bills changed

from 18:63 in June 2000 and 73:25 in June 2008 to 62:35 in June 2019 and recently to 64:33 in September 2019. Moreover, Kenya has been relying more on Treasury Bills up until 2014/2015 when the proportion of Treasury Bills to total domestic debt started increasing relative to that of Treasury Bonds. Treasury Bill's debt increased from 24 per cent in June 2008 to 35 per cent in June 2019. This can pose a restructuring and refinancing risk since Treasury Bills are short-term and are used as a cash management tool.

Figure 1.4: Composition of Kenya's domestic debt

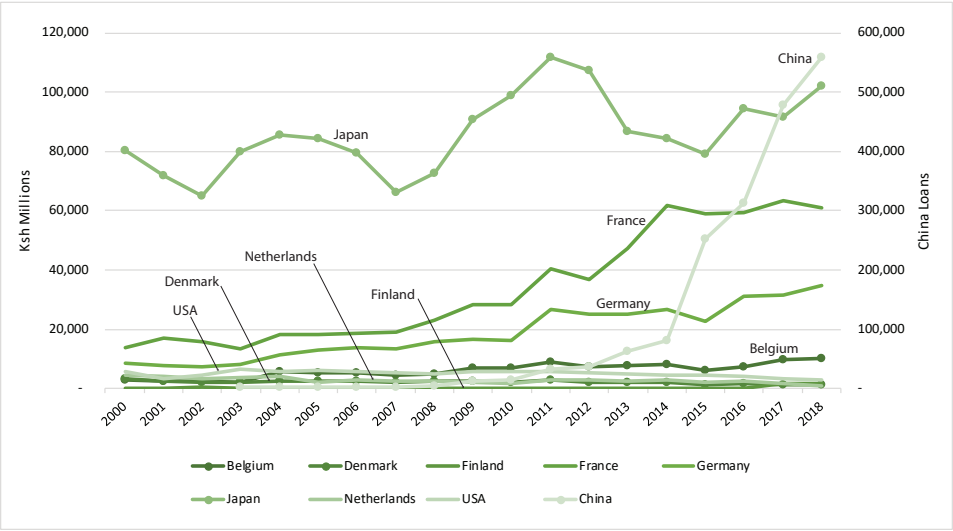


Source of Data: Central Bank of Kenya (2020)

Kenya's external debt is mainly from bilateral, multilateral, external commercial banks, and suppliers' credit. Over the last two decades, Kenya's external debt has been on an upward trend (Figure 1.3a), which can be attributed to the issuance of sovereign bonds, commercial syndicated loans, increase in bilateral credits, foreign exchange rate fluctuations and favourable borrowing terms. As of June 2019, Kenya's external debt stood at Ksh 3.11 trillion, of which 34.2 per cent was owed to external commercial banks, 33.9 per cent to bilateral, 31.2 per cent by multilateral, and 0.7 per cent to suppliers' creditors (National Treasury, 2019).

China and Japan are the main bilateral creditors to Kenya's government. Figure 1.5 shows that between 2009 and 2014, Japan has been the leading lender to Kenya with loans averaging Ksh 94 million. However, from 2014 China has become the leading lender, accounting for 68 per cent of Kenya's total external debt. Kenya's debt from China has grown seven times between 2014 and 2018, attributable to fewer policy conditionalities for credit. China loans are from state-sponsored banks (Exim Bank), implying less bureaucracy.

Figure 1.5: Bilateral debt (Ksh millions)



Source: KNBS (Various), Economic Survey

1.3 Justification of the Study

Kenya's Vision 2030 aims at achieving and maintaining a sustainable and inclusive annual growth of 10 per cent (Republic of Kenya, 2010). It is for that reason that accelerating economic growth by achieving double-digit GDP growth and maintaining a stable macroeconomic environment is one of the major priorities pointed out in the "Big Four" agenda. To achieve this, the government has embarked on expansionary fiscal policy, which involves investing in growth enabler projects such as revamping existing infrastructure systems and establishing new ones. However, most of these projects require large funding beyond Kenya's domestic revenue capacity and have led to a widening of budget deficit, which is financed through borrowing.

Despite government efforts to manage public debt through legal, policy, and institutional framework, the size of public debt stock has been increasing since the 1990s with more debt accumulation witnessed during implementation of the Kenya Vision 2030 and "Big Four" agenda. For example, total public debt stock increased from Ksh 84,051 million in June 1990 to Ksh 1,487,111 million in June 2008, Ksh 5,809,076 million in June 2019 and to Ksh 6,116,600 million in December 2019. Nevertheless, even with rising public debt stock, Kenya's public debt stock as a per cent of GDP of 62 per cent (June 2019) is below Low Middle Income Countries (LMICs) IMF debt sustainability threshold of 70 per cent and

thus deemed sustainable. Besides, the public debt stock is below the National Treasury's debt limit of Ksh 9 trillion.

Contrary to the Keynesian theory of economic growth on the outcomes of expansionary fiscal policy and investment in growth enablers, Kenya has been unable to attain the Medium-Term Plan (MTPs) targets and 10 per cent annual growth required for the realization of Kenya's Vision 2030 (KIPPRA, 2019). Kenya's real GDP grew from 4.9 per cent in 2017 to 6.3 per cent in 2018 before declining to 5.4 per cent in 2019 (KNBS, 2020). This has attracted national concern whether the debt stimulates or drags economic growth and on the optimal level of public debt that is desirable for economic growth especially after the amendment of the PFM Act (2012) that raised the debt limit to Ksh 9 trillion.

There has been debate among economists, academicians, and researchers on the impact of public debt on economic growth. The question is whether public debt stimulates economic growth, and if it does, what is the optimal level of public debt that maximizes economic growth? Several studies have been carried out on the impact of public debt on economic growth and on the public debt-growth threshold, whose results were inconclusive and conflicting (Caner, 2010; Reinhart and Rogoff, 2010; Chechenta-Westphal, 2012; Ergert, 2012; Elmeskor Sutherland, 2012; Minea and Parent, 2012; Mukui, 2013; Mohamed, 2013; Panizza and Presbito, 2014; Thieu-Dao and Hoang-Oanch, 2017 and Ng'eno, 2018). Most of these studies were not based on Kenya's economy, thus they cannot be used to generalize the case in Kenya due to cross country differences in economic behaviours and policies applied.

1.4 Research Questions

(i) Does public debt stimulate economic growth in Kenya?

(ii) Has Kenya over-borrowed or under-borrowed?

1.5 Research Objectives

(i) To determine the impact of public debt on economic growth in Kenya.

(ii) To determine the optimal level of public debt that is desirable for economic growth in Kenya.

2. Literature Review

2.1 Theoretical Literature

The theoretical literature on the impacts of public debt on growth can be classified into four categories: the category that relates the low and manageable level of debt to positive economic growth; the category that relates high debt accumulation to negative economic growth; the category (non-linear effects) that combines both low and high debt accumulation; and lastly the category that argues that public debt has zero impact on economic growth (Patillo et al., 2011).

The neoclassical theory explains that the transitional growth of a country depends on its capital mobility and its ability to borrow and invest. This implies that debt has a positive impact on growth. However, the assumption of perfect international capital mobility is unrealistic in the real world. In the same opinion, Keynes views public debt as a cure to the recession. During a recession, the economy exhibits low investment, unemployment, and low economic growth due to low aggregate demand. Thus, the use of debt to finance expenditure or deficit in this cycle creates employment and increases aggregate demand. Besides, investment of public debt on growth enablers leads to an increase in national income and thus economic growth. Therefore, according to Keynes (1936), public debt acts as an anti-cyclical fiscal measure that saves the economy from recession by stimulating economic growth of a country through capital accumulation and productivity. For example, an increase in public debt flows due to public sector investments, especially in infrastructure, makes the private sector more optimistic about the performance of the economy encouraging private investments, thus stimulating overall economic growth.

In the second category, cases where high debt accumulation harms economic growth can be explained by debt overhang theory. According to this theory, there exists a threshold on the level of debt stock beyond which, any increase in debt crowds out investment and impedes the government from carrying out economic reforms that can stimulate growth (Krugman, 1988 and Sachs, 1989). Debt overhang is an economic condition that occurs when a country's debt is sufficiently large that the creditor has no confidence in debt servicing capability (Lawanson, 2014).

Debt overhang theory is pinned on the basis that if a country's public debt stock exceeds its ability to repay, with some probability that future debt will be greater, then debt service is likely to be an increasing function of a country's output level. In such a case, income generated by a country is taxed away through distortionary types of taxes such as seigniorage to service the debt, while both private and public investments are crowded out, thus, low economic growth (Lawanson, 2014). Debt overhang can also lead to a poor macroeconomic environment, which adversely

affects investment efficiency and government incentive to undertake economic reforms such as fiscal adjustment, thus lower economic growth (Patillo et al., 2011).

The third category of the impact of public debt on economic growth can be explained by combining both cases; low and high debt accumulation. According to this model, debt has a non-linear impact on economic growth, which allows for determination of growth - public debt maximization threshold. In the early stages when a country borrows and invests, high growth is generated. However, at later stages when a country is repaying debt and is/maybe borrowing, growth tends to fall. During this stage, if debt does not crowd out investments, the fall in growth remains higher relative to the absence of debt scenario. However, if debt overhang sets in, investment and growth will fall more relative to the absence of debt scenario.

The fourth category is based on the Ricardian Equivalence Theorem of neutrality by Barro (1974). According to Barro, public debt has no impact on a country's economic growth as debt only postpones taxes to future generations. That is, an increase in government expenditure, which attracts more public debt, reduces future income through increased future taxes. If the household is aware that future taxes will increase, they will reduce their consumption today in favour of future consumption and save an amount that equals the taxes. In such a situation, consumption, investment, and permanent income will remain unchanged, hence a neutral impact on economic growth.

Another way to explain Ricardian view is by using domestic debt perception which is obtained through the issuance of Treasury Bonds and Treasury Bills. According to Barro, in such a case, there are two sets of people; bondholders who view a bond as an asset and they are wealthier; and taxpayers who view a bond as a liability and thus poorer. This implies that debt has a zero impact on economic growth since the amount of assets held by bond/bill holders equals the amount paid by taxpayers.

2.2 Empirical Literature

2.2.1 Public debt threshold

Several studies have been carried out to determine the optimal level of public debt that is desirable for economic growth in different economies. Reinhart and Rogoff (2010) found that any increase in public debt as a per cent of GDP above 90 per cent in developed and emerging economies led to growth reduction. Following Reinhart and Rogoff's (2010) study, Egert (2012) used a non-linear threshold model to estimate the public debt threshold using Reinhart and Rogoff's study dataset. The study found that adverse effects of public debt emerge at a lower level of debt and ranged from 20-60 per cent. Similarly, a study by Woo and Kumar (2015) using three-segment linear splines found that the marginal effects of public

debt on economic growth started decreasing when debt ranged between 30 and 60 per cent. The negative impact of public debt on GDP was due to crowding out effects and exchange rate appreciation (Checherita-Westphal and Rother, 2012).

Chudik et al., 2015 used the Autoregressive Distributed Lag Model (ARDL) to establish the optimal level of public debt that is desirable for economic growth in developed and developing countries. According to the Chudik et al. (2015) study results, the public debt threshold differs across economies. The study found the public debt threshold to be 30 per cent in developing economies, 60 per cent in emerging economies, and 80 per cent in developed economies.

Only a handful of studies have been carried out to determine the public debt threshold in Sub-Saharan Africa. Elbadawi et al. (1997) carried out a study to determine the non-linear effects of debt overhang on economic growth in Sub-Saharan Africa (SSA). Using fixed and random effects panel estimates, the study found a growth maximizing debt to GDP ratio of 97 per cent. Ng'eno (2018) carried out a study to determine the optimal level of external debt that is not harmful to economic growth in Kenya. The study used the ARDL model and quadratic estimation technique on time series data for the period 1980-2017. The study found that any increase in external debt as a per cent of GDP above 61 per cent was growth reducing. However, different results were obtained from a study by (Mupunga and Le Roux, 2015) in Zimbabwe for the period 1980-2012, which found the public debt threshold to be 50 per cent. Contrary, a study by Mohamed (2013) in Tunisia found the public debt threshold to be 30 per cent while Thieu-Dao and Hoang-Oanch (2017) found a 28 per cent external debt threshold in Vietnam. These differences can be attributed to cross-country differences in economic behaviour and differences in the methodology used to estimate the threshold.

Pattillo et al. (2002) conducted a study to determine the level of public debt at which the impact on economic growth becomes negative and the optimal level of public debt at which the marginal impact on growth becomes negative in 93 developing countries. Using a threshold time series model on a panel dataset for the period 1969-1998, the study found that the marginal impact on economic growth becomes negative when debt to GDP exceeded 70 per cent. Moreover, public debt had negative impact on economic growth when debt exceeded 35 per cent.

These results show that the public debt threshold varies across economies and depends on the methodology used. Therefore, these results cannot be used to generalize the case in Kenya due to cross-economy differences in economic behaviour and policies applied.

2.2.2 Impact of public debt on economic growth

Only a few studies on public debt-growth nexus concentrated on Kenya's economy. Mukui (2013) found a linear and negative long-run effect of public debt on economic growth. Similarly, Babu et al. (2014) found a negative effect of external debt on economic growth using a fixed-effect method in EAC countries. Puturoi and Mutuko (2013) found that domestic debt had a positive linear effect on economic growth in Kenya using Ordinary Least Square (OLS) method. These findings were supported by those of Babu et al. (2015) which found a positive impact of domestic debt on economic growth in EAC using the fixed-effect method.

Megersa (2015) carried out a study to examine the existence of a Laffer curve relationship between public debt and economic growth in 21 low-income Sub-Saharan economies for the period 1990-2011. The study used a neoclassical non-linear regression model and found the existence of an inverted u-shaped relationship between public debt and economic growth. Megersa's results support Panizza and Presbitero's (2014) study which found a non-linear impact of public debt on economic growth in OECDs. However, these results contradict those of Mweni, Njuguna and Okech (2016) which found that external debt had a negative but insignificant effect on economic growth in Kenya. These studies failed to determine the optimal level of public debt that is desirable for economic growth, which is what this study is interested in.

Most of the studies reviewed on public debt-growth nexus were cross-regional and specific country studies were uncommon. This implies that the findings of these studies cannot be used to generalize the policy implications of the link between public debt and economic growth in Kenya due to cross-country differences in policies applied and economic behaviour. Therefore, there is need to carry out a study to establish the optimal level of public debt on economic growth in Kenya, which is what this study seeks to achieve.

3. Methodology

3.1 Theoretical Framework

This study is anchored on Solow's-Swan growth model which stipulates that growth is a function of capital, labor, and technology, which can be represented as follows;

$$Y = F(A, L, K) \qquad (3.1)$$

Where Y is the growth rate at time t, A is technological progress, K is capital accumulation and L is labour. The model was preferred since it explains long-term economic growth by taking into account; labour, increasing productivity, and capital accumulation, which in this case is public debt investment. Besides, the model is non-linear, which makes it easier to relate the growth-public debt nonlinearly and estimate growth maximizing public debt level.

This model was then modified by disaggregating capital accumulation to take account of private, government, and human capital. This is due to the possibility that their impact on economic growth is different. For example; human capital can stimulate growth through labour productivity. Thus, equation (3.1) can be rewritten as follows:

$$Y_t = A\,(k^P)\,\alpha\,(k^G)^{\gamma}\,N^{\beta} \qquad (3.2)$$

Where: k^P is private capital, k^G is government capital, $N^{\beta} = NL$ where N is human capital. The growth model assumes that $\alpha = \gamma = \theta$, such that K^{θ} in equation (3.1) equals $(k^P)^{\alpha} \bullet (k^G)^{\gamma}$, implying that economic growth rate depends on the rate of return on both physical and human capital. The Public Finance Management Act of 2012 explains that government borrowing is only used for financing development spending but not recurrent expenditure. This implies that the government borrows to invest in physical capital. Thus, government investment in physical capital depends on how much the government borrows.

$$(k^G) = f(\text{Public debt}) \qquad (3.3)$$

Thus, equation 3.2 can be rewritten as;

$$Y = A.N^{\beta}\,(k^P)^{\alpha} \bullet [k^G\,(Pub_{debt})^{\gamma}] \qquad (3.4)$$

To estimate the impact of public debt on economic growth in Kenya, equation 3.4 was modified by adding other control variables that were found to have a significant impact on economic growth in previous studies. These control variables include; openness to trade $(open_{trade})$, inflation rate *(infl)* and exchange rates *(exc_rate)*. Openness to trade measures the differences in total capital productivity while the exchange rate reflects external shocks. The inflation rate captures macroeconomic stability.

Thus, equation 3.4 becomes:

$$Y = f(N, K, Pub_{debt}, infl, open_{trade}, exc\_rate) \quad (3.5)$$

3.2 Empirical Specification

The study used impulse dynamics derived from the Vector Error Correction Model (VECM) model to determine the impacts of public debt on economic growth in Kenya. The VECM model used to estimate the impact of public debt among other variables on economic growth in Kenya took the following form:

$$GDP_t = \alpha_o + \sum^{l}_{(i=1)} \alpha_i GDP_{(t-i)} + \sum^{m}_{(i=1)} \alpha_i Pub\_debt_{(t-i)} + \sum^{n}_{(i=1)} \alpha_i Inv_{(t-i)} + \sum^{p}_{(i=1)} \alpha_i Hum\_cap_{(t-i)} + \sum^{s}_{(i=1)} \alpha_i Lab\_force_{(t-i)} + \sum^{u}_{(i=1)} \alpha_i Exc\_rate_{(t-i)} + \sum^{q}_{(i=1)} \alpha_i Open\_trade_{(t-i)} + \varepsilon_t \quad (3.6)$$

Where: *GDP* is economic growth, *Pub_debt* is public debt, *inv* is an investment, *Hum_cap* is human capital, *Lab_force* is labour force, *Exc_rate* is the exchange rate and *Open_trade* is an openness to trade.

3.2.1 Impulse response functions

Impulse Response Functions (IRF) measure the unforeseen changes in variables at period *t* and forecasts its effect on other variables at the same period (*t*) and future period. Therefore, IRF helps to estimate the sign and how a variable responds to an impulse of another variable (Hamiliton, 1994). In this study, IRF was based on the following equation:

$$GDP_t = \beta_1 + \varepsilon_{(Y,t)} + \gamma_1 \varepsilon_{(Y,t-1)} + \gamma_2 \varepsilon_{(Y,t-2)} + \ldots + \gamma_i \varepsilon_{(Y,t-i)} \quad (3.7)$$

where $\gamma_i' s_i$ is a vector of parameters that measure the reaction of the dependent variable to innovations in all other variables included in the model, among them a public debt.

3.2.2 Non-linear specification

This involves determining the optimal level of public debt that is desirable for economic growth. This procedure involves determining the level of public debt at which the marginal impact of debt on economic growth becomes negative. To determine the level of debt at which the marginal impact of debt on economic growth becomes negative, the study uses a threshold regression model for time

series[5] (spline specifications). This model was previously used to estimate the optimal inflation rate in Kenya, and Pattillo et al. (2002) to estimate the external debt threshold in SSA. The spline function will take the following form:

$$GDP_t = \alpha_t + \beta X_t + \delta PD_t + \gamma\theta_t (Pub\_debt - Pub\_debt^*) + \varepsilon_t \qquad (3.8)$$

Where: Pub_debt^* is the threshold of public debt and θ_t is a dummy variable ($\{\theta_t = 1 \text{ if } Pub\_debt > Pub\_debt^*\}$ and $\{\theta_t = 0 \text{ if } Pub\_debt < Pub\_debt^*\}$) used to estimate where the impact of public debt on growth is different below and above the threshold. The procedure involves estimating the regression equation (3.8) using different levels of public debt threshold. The threshold that yields maximum R^2 or minimum sum of squares is regarded as the best threshold. That is, the optimal level of public debt is desirable for economic growth.

3.3 Data Sources, Measurement of Variables and Expected Results

The study used annual time series data for the period 1978-2018. Economic growth data measured by the Real annual GDP growth rate, investment rate measured by Gross Fixed Capital Formation (GFCF) as a per cent of GDP, human capital measured by the log of annual secondary school enrolment, Labour force measured by the log of the total number of people employed per year, inflation rate measured consumer price index and exchange rate data measured by the value of one US dollar in Kenyan shilling were obtained from Kenya National Bureau of Statistics (KNBS). Public debt data, which measured public debt (including guaranteed loans) as a per cent of GDP was obtained from public debt management report prepared by the National Treasury for the period 2005-2018 and KNBS for the year 1978-2004. All estimates were based on the assumption that there was 100 per cent investment of public debt according to PFM (2012).

Public debt was expected to have both positive and negative[6] impacts on economic growth. Investment, human capital, and openness to trade were expected to stimulate growth. However, the inflation rate and exchange rates were expected to harm economic growth due to their negative impact on net exports and consumption.

5 This model was introduced by Tong (1978).

6 Due to crowding out of private investment.

4. Empirical Findings

4.1 Descriptive Statistics

Table 4.1: Descriptive Statistics

	Mean	Median	Max	Min	Std. Dev.	Skew-ness	Kurtosis	Jarque-Bera	Prob	Obs
Public Debt	47.11	45.07	75.65	23.63	11.51	0.39	2.90	1.08	0.58	41
Investment	20.16	19.81	29.79	15.00	3.29	0.58	3.22	2.37	0.31	41
Inflation rate	1.40	1.52	2.26	0.35	0.60	-0.25	1.74	3.15	0.21	41
Labour force	6.65	6.70	7.25	5.96	0.40	-0.18	1.72	3.01	0.22	41
Exchange Rate	1.62	1.78	2.01	0.87	0.37	-0.76	2.07	5.44	0.07	41
Human Capital	5.93	5.85	6.47	5.56	0.27	0.66	2.22	3.99	0.14	41
Oppenness to trade	55.37	55.24	72.86	36.18	8.21	-0.13	3.59	0.72	0.70	41
Economic growth	4.08	4.80	7.62	-0.10	2.13	-0.36	2.02	2.53	0.28	41

Source: Authors' calculations, 2020

Based on the study variables characteristics presented in Table 4.1, all variables are normally distributed. This is because the null hypothesis of normally distributed variables was not rejected at a 5 per cent level of significance since the p-value of Jarque Bera is more than 0.05. Concerning skewness, public debt, investment, and human capital were positively skewed while the exchange rate, inflation, labor force, economic growth, and openness to trade were negatively skewed.

4.2 Pre-Estimation Tests

4.2.1 Lag length determination

Before the study objectives were estimated, the lag length was determined using sequential modified LR test statistic (each test at 5% level): Final prediction error (FPE), Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HQ). Based on the lag length selection criteria results presented in Table 4.2, the majority criteria identified the lag length to be 3.

Table 4.2: Lag length determination results

Lag Length	LogL	LR	FPE	AIC	SC	HQ
0	-247.23	NA	0.00	13.43	13.78	13.56
1	47.36	449.63	0.00	1.30	4.399748*	2.40
2	142.94	105.6472*	0.00	-0.37	5.50	1.72
3	254.16	76.10	6.51e-11*	-2.850609*	5.77	0.215920*
* indicates lag order selected by the criterion						

Source: Authors' calculations, 2020

4.2.2 Time series properties

To avoid spurious regression, stationarity and cointegration tests were carried out. Stationarity test involves testing for presence of unit root while cointegration test involves testing for long-run relationship between non-stationary variables.

Stationarity test results

The study used Augmented Dickey-Fuller (ADF) test presented by Dickey and Fuller (1979). ADF test was preferred since it maintains the reliability of tests by making sure that errors are indeed white-noise. The test involved testing for the presence of unit root with constant. If the calculated p-values were greater than critical p-values at 5 per cent level of significance, the null hypothesis of the presence of unit root was not rejected and it was concluded that the series is non-stationary. However, if calculated p-values were less than critical p-values at 5 per cent level of significance, the null hypothesis of the presence of unit root was rejected and the series was concluded to be stationary. All variables were found to be I(1) as presented in Table 4.3

Table 4.3: Stationarity test results

Variable	P-value (level)	P-value (1st difference)	Conclusion
Economic growth	0.1314	0.0000	I (1)
Public debt	0.7812	0.0000	I (1)
Human capital	0.9983	0.0001	I (1)
Investment	0.2167	0.0000	I (1)
Labor force	1.0000	0.0253	I (1)
Inflation rate	0.9654	0.0700	I (1)
Exchange rate	0.9984	0.0002	I (1)
Openness to trade	0.2394	0.0000	I (1)

Source: Authors' calculations, 2020

Cointegration test results

The study used the Johansen cointegration test to test for a long-run relationship between the study variables. Johansen cointegration test was preferred because it allows testing for more than one cointegrating relationship. Moreover, it is used when all variables are integrated of order one. Both Trace and Max-eigenvalue cointegration results shown in Table 4.4 indicate that there are 3 cointegrating equations. This implies that there exists a long-run relationship between economic growth and other independent variables, including debt.

Table 4.4: Cointegration test results

No. of CE(s)	None *	At most 1 *	At most 2 *	At most 3	At most 4	At most 5	At most 6	At most 7
Trace Test								
Eigenvalue	0.84	0.74	0.70	0.50	0.40	0.23	0.14	0.02
Statistic	234.34	162.75	110.71	63.77	36.72	16.61	6.64	0.60
Cri-Value	159.53	125.62	95.75	69.82	47.86	29.80	15.49	3.84
Prob.**	0.00	0.00	0.00	0.14	0.36	0.67	0.62	0.44
Max-eigenvalue test								
Eigenvalue	0.84	0.74	0.70	0.50	0.40	0.23	0.14	0.02
Statistic	71.59	52.05	46.94	27.05	20.11	9.98	6.03	0.60
Crit-Val	52.36	46.23	40.08	33.88	27.58	21.13	14.26	3.84
Prob.**	0.00	0.01	0.01	0.26	0.33	0.75	0.61	0.44

Source: Authors' calculations, 2020

4.3 Impacts of Public Debt on Economic Growth in Kenya

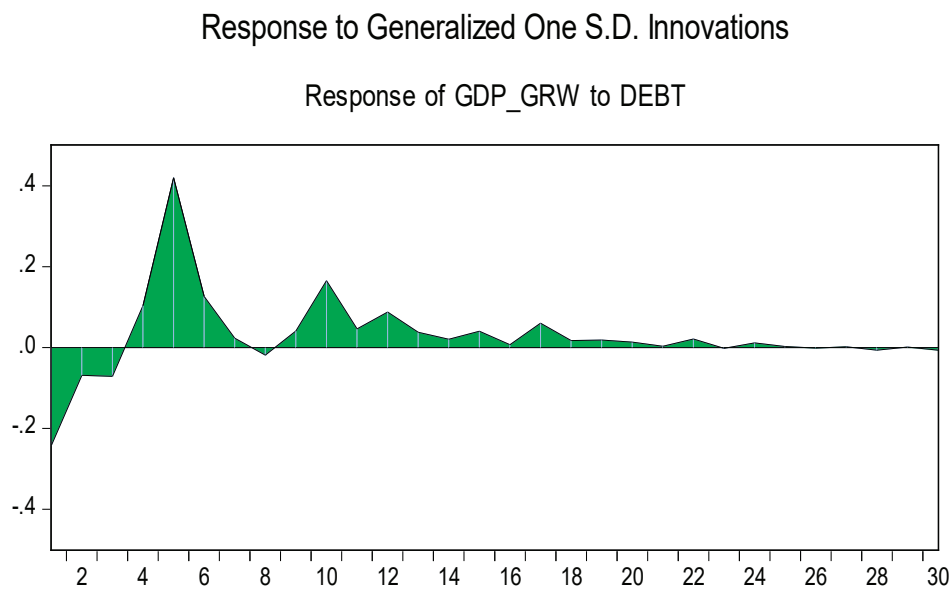
The study used a restricted form of VAR, also known as the Vector Error Correction Model (VECM) since the study variables were cointegrated. The VECM estimates obtained by estimating equation 3.6 were used to derive impulse response functions, which were then used to interpret the impacts of public debt on economic growth in Kenya. Before the impulse dynamics were used for interpretation, diagnostic tests were conducted to confirm that VECM was statistically appropriate. They also ensure that the results were reliable and not spurious.

4.3.1 Impulse response function

Impulse response functions derived from VAR coefficients were used to determine how economic growth responds to an impulse in public debt in Kenya. They were

also used to determine the sign of how economic growth variable responds to shock and external changes in public debt in Kenya (Figure 4.1).

Figure 4.1: Impulse response functions of economic growth on public debt in Kenya



Source: Authors' construction, 2019

From Figure 4.1, it is clear that the response of economic growth due to changes in public debt lasts for a long period before wearing out. Also, it was established that one standard deviation shock to public debt had both negative and positive effect on economic growth in Kenya. Public debt hurts economic growth that gets positive after the 3rd year. The positive impact increases sharply after the fourth year up to the fifth year when the impact starts decreasing. However, the impacts swing slightly into the negative territory after the 7th year. The impact of public debt on economic growth becomes positive and increases sharply after the 8th year. This sharp increase lasts for two years, then the impact starts decreasing. The impact lasts in the positive territory for twenty (20) years before it wears off after the 25th year.

The negative impact of public debt on economic growth in the first few years is as expected. This can be explained through the crowding out effect theory, which argues that public debt harms economic growth through crowding out of private investments. Besides, the negative impact can be explained by the short grace period and maturity period. As stipulated in Section one, the proportion of domestic debt held as Treasury bills has been increasing. T-bill has less than

90 days of maturity period. Additionally, the short grace periods of external debt pressures the government to repay debt and exhaust resources that could have been invested, thus harming economic growth in the short-run. The positive impact of public debt on economic growth after the third year can be explained by Keynesian theory. Keynes argues that public debt stimulates economic growth in the long-run through productivity and capital accumulation. This implies that public debt in Kenya is not harmful to Kenya's economy since it is used to finance growth enablers such as infrastructure.

These results also support the cointegrating results, which found that public debt and economic growth are positively related in the long-run. Besides, the study results support those of (Puturoi and Mutuko, 2013 and Babu et al., 2015) in Kenya and East Africa Community, respectively. The study, therefore, concluded that public debt hurts economic growth in the short-run, which but stimulates the economy in the long-run. This is because the impact of public debt on economic growth lasted shortly in negative territory but lasted longer in the positive territory. Moreover, the magnitude of the impact is greater in the positive territory.

4.3.2 Post-estimation VAR diagnostic tests results

Appendix Figure A1 shows that all roots of the polynomial are within the unit cycle which implies that the model is stable. Appendix Table A4 also shows no problem of heteroscedasticity and serial correlation. This is because the p-values of 0.365 and 0.8791 for heteroscedasticity and serial correlation tests are greater than critical p-values at 5 per cent level of significance, thus there is no problem of heteroscedasticity and serial correlation. The table also shows that the residuals were normally distributed at 5 per cent level of significance. The model was therefore concluded to be stable and statistically appropriate for the estimation of the impact of public debt on economic growth in Kenya.

4.4 Optimal Level of Public Debt that is Desirable for Economic Growth in Kenya

Before the optimal level of public debt was estimated, it was critical for the study to first establish the form (nominal or rates) of public debt that has more effect on economic growth in Kenya. To achieve this, the study estimated the effect of public debt in nominal and in rates on economic growth in Kenya. Based on the Ordinary Least Squares estimates presented in Appendix Table A1 and A2, public debt stock as a per cent of GDP has a greater impact on economic growth (-0.01751) compared to the nominal public debt stock (-0.01593). Therefore, the government should be more concerned with public debt limits as a per cent of GDP, rather than in nominal

values. This study, therefore, estimates the optimal level of public debt stock as a per cent of GDP that is desirable for economic growth in Kenya.

To estimate the optimal level of public debt that is desirable for economic growth in Kenya, the study estimated equation 3.8 using the Ordinary Least Square (OLS) method for K values of debt ranging from 33 to 75. From Appendix Table A3, it was established that the optimal level of debt as a per cent of GDP that is desirable for economic growth in Kenya is 68 per cent. This level was significant at 5 per cent level of significance. The results are different from those of Elbadawi et al. (1997), Reinhart and Rogoff (2010), Patillo et al. (2002), Chudik et al. (2017), and Ng'eno (2018), which found public debt threshold to be 97 per cent in SSA, 90 per cent in developed and emerging economies, 30 per cent in developing countries, 70 per cent in developing countries in SSA and 61 per cent in Kenya. Differences in results is probably due to different methodology, timeframe, region, and type of data used. This threshold differs from 74 per cent for Low Middle Income Countries' threshold provided by the World Bank, probably because these results are country-specific. It is at this level of public debt as a per cent of GDP (68%) that R^2 of 83.52 per cent and adjusted R^2 of 75.61 per cent were maximized and residual sum of squares of 24.42 was minimized. Therefore, any debt stock size below this optimal level has a positive impact on growth. However, if the debt stock size goes above the optimal point, the growth of the economy will fall by 0.708 units (0.941-0.233).

The independent variables used in public debt threshold regression were: lag of public debt, inflation rate, exchange rate, openness to trade, and dummy variables that captured structural breaks. These structural breaks include 1984 drought, 1993 multi-party elections, 1997 national elections, 2008 post-election violence, and 2009 pre-Kenya's constitution preparations. From the results presented in Table 4.5, the coefficients of all these variables were significant at 5 per cent level of significance, except for the 1993 dummy. The coefficients of these dummy variables were negative and significant. It implies that they had adverse effects on economic growth. The adjusted R^2 of 75.61 per cent implies that 75.61 per cent of the changes in economic growth was explained by changes in explanatory variables included in the model. Further, current debt stock has a negative effect on economic growth. However, optimal debt stock differentials and previous period debt stock had a positive effect on economic growth in Kenya as indicated by their coefficients of 0.941 and 0.071, respectively.

Inflation rate coefficient was negative and statistically significant at 5 per cent level of significance. The inflation rate coefficient of -0.743 implies that the inflation rate has a negative effect on economic growth in Kenya at a point of optimal debt stock. That is, a one-unit increase in inflation rate leads to a 0.743 unit decrease in economic growth at a point of optimal debt stock, holding other factors constant. The

results are as per expectation, since an increase in inflation rate reduces consumers' purchasing power and thus a decrease in economic growth through consumption reduction.

The human capital coefficient was positive and statistically significant at 5 per cent level of significance. The coefficient of 0.459 implies that an increase in human capital accumulation by 1 unit increases economic growth at the optimal level of debt stock by 0.459 units holding other factors constant. Similarly, openness to trade had a positive and significant coefficient, which indicates a positive effect on economic growth at a point of optimal debt stock. The results were as expected. This is because openness to trade enables the transfer of knowledge and efficiency gain, which stimulates economic growth. However, the exchange rate coefficient was negative but insignificant.

The significance of the model was also confirmed by the F-statistic of 10.558 and its p-value equal to 0.000 for the joint statistical significance of all the independent variables of the model. Therefore, the null hypothesis that the estimated parameters of the independent variables are jointly insignificant was rejected at a 5 per cent level of significance. The model was therefore concluded to be fit. Moreover, the Durbin-Watson statistic of 1.799, which is closer to 2.000, confirmed that no presence of serial correlation (Table 4.5).

4.4.1 Post-regression diagnostic test results

To ensure that the estimates were efficient and reliable, the test carried out normality, heteroskedasticity test using Breusch Pagan-Godfrey Test, Serial correlation using Breusch-Godfrey Serial LM test and model stability test using Recursive CUSUM test. The results are as indicated in Appendix Table A3. The results prove that OLS is statistically appropriate. OLS estimates were also proven to be efficient and consistent. Thus, the estimates could be used to interpret the results.

Table 4.5: Public debt threshold regression analysis results

Dependent Variable: GDP				
Method: Least Squares				
Sample (adjusted): 1981 2018				
Included observations: 38 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEBT	-0.233	0.034	-6.807	0.000
DEBT(-1)	0.071	0.031	2.254	0.033
DUMMY1993	-2.625	1.722	-1.525	0.140
DUMMY1997	-4.660	1.123	-4.150	0.000
DUMMY2009	-2.689	1.061	-2.535	0.018
LNINFL	-0.743	0.332	-2.238	0.034
LNOPT	3.110	1.063	2.927	0.007
LNHUM_CAP	0.459	1.963	2.338	0.035
EXCH_RATE	-0.052	0.032	-0.592	0.121
DUMMY1984	-2.767	1.060	-2.611	0.015
DUMMY2000	-2.757	1.128	-2.445	0.022
DUMMY2002	-4.027	1.173	-3.434	0.002
DUMMY2008	-3.688	1.110	-3.322	0.003
DEBT68	0.941	0.369	2.555	0.017
C	26.900	4.652	5.782	0.000
R-squared	0.835	Mean dependent var		3.937
Adjusted R-squared	0.756	S.D. dependent var		2.081
S.E. of regression	1.028	Akaike info criterion		3.158
Sum squared resid	26.417	Schwarz criterion		3.719
Log likelihood	-47.011	Hannan-Quinn criter		3.358
F-statistic	10.558	Durbin-Watson stat		1.799
Prob(F-statistic)	0.000			

5. Conclusion and Policy Implications

Based on study results, public debt hurts economic growth in the short-run due to crowding out of private investment and short grace and maturity period. However, the impact on economic growth is positive in the long-run. This implies that a developing country such as Kenya can rely on public debt to finance its growth-enhancing projects since debt stimulates growth in the long-run.

The study also concludes that optimal public debt level as a per cent of GDP that is desirable for economic growth in Kenya is 68 per cent. This implies that any debt stock as a per cent of GDP below 68 per cent rate enables economic growth. However, if public debt stock as a per cent of GDP increases beyond the optimal point, marginal effects on the economic growth in Kenya will start decreasing. Although the results are different from the 70 per cent threshold for Low Middle-Income Countries presented by the World Bank, these results can be acceptable since they are country-specific.

Therefore, Kenya's public debt stock should be maintained below 68 per cent of GDP. Any increase in debt beyond this point would lead to a negative effect on economic growth.

However, this study does not estimate the optimal level of domestic debt and external debt that is desirable for economic growth in Kenya. The study proposes a study that will analyze domestic and external debt thresholds, since the two are used for different spending. Domestic debt supports recurrent expenditure while external debt is used for capital spending.

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Appendix

Table A1: Effect of public debt (rate) on economic growth

OLS Output: Dependent Variable: RGDP			
Sample: 1978 2018			
Variable	**Coefficient**	**Std. Error**	**Prob.**
Inflation rate	-3.53057	7.029702	0.0632
DEBT(%GDP)	-0.01751	0.034235	0.0326
DUMMY1980	-4.85028	1.616211	0.0052
DUMMY2008	-5.08493	1.61192	0.0035
GFC(%GDP)	0.08572	0.119065	0.4768
Exchange rate	-27.3936	6.989969	0.0004
Human Capital	3.8265	7.297066	0.0672
Employment	1.96875	5.916811	0.0515
C	32.71235	50.46037	0.5214
R-squared	0.640506	Mean dependent var	4.083585
Adjusted R-squared	0.550632	S.D. dependent var	2.134195
S.E. of regression	1.430655	Akaike info criterion	3.74533
Sum squared resid	65.49676	Schwarz criterion	4.12148
Log likelihood	-67.7793	Hannan-Quinn criter.	3.882303
F-statistic	7.12675	Durbin-Watson stat	1.479631
Prob.(F-statistic) 0.000022			

Table A2: Effect of public debt (nominal) on economic growth

OLS Output: Dependent Variable: GDP_CONSTANT			
Sample: 1978 2018			
Variable	**Coefficient**	**Std. Error**	**Prob.**
gcf_constant	-0.72851	0.452632	0.1173
exchange_rate	4.14E+09	1.76E+09	0.0255
dummy2003	-1.92E+11	7.99E+10	0.0225
dummy1983	-1.49E+11	7.81E+10	0.0659
debt	-0.01593	0.063385	0.0195
cpi	-8.16E+09	4.50E+09	0.0793
secondary_school_enrol	1534152	247500.7	0.0000
total_em	114499.9	27520.55	0.0002
c	5.33E+11	1.45E+11	0.0008
R-squared	0.995839	Mean dependent var	2.26E+12
Adjusted R-squared	0.994799	S.D. dependent var	1.02E+12
S.E. of regression	7.37E+10	Akaike info criterion	53.0747
Sum squared resid	1.74E+23	Schwarz criterion	53.45085
Log likelihood	-1079.03	Hannan-Quinn criter.	53.21167
F-statistic	957.2945	Durbin-Watson stat	1.502156
Prob(F-statistic)	0.0000		

Table A3: Least squares estimation of public debt threshold model from k = 33 to k = 75

Dependent variable: Economic Growth

Level of public debt stock as a per cent of GDP*	Adjusted R^2	RSS
33	0.6316	50.33
34	0.6320	50.33
35	0.6320	49.90
36	0.6384	49.42
37	0.6418	48.94
38	0.6450	48.50
39	0.6479	48.11
40	0.6516	47.60
41	0.6554	47.08
42	0.6549	47.16
43	0.6554	47.23
44	0.6549	47.15
45	0.6562	47.98
46	0.6567	47.91
47	0.6557	47.03 DW: 1.7470
48	0.6541	47.27
49	0.6513	47.64
50	0.6481	48.09
51	0.6458	48.39
52	0.6436	48.70
53	0.6423	48.87
54	0.6421	48.91
55	0.6516	48.97
56	0.6415	48.98
57	0.6413	49.01
58	0.6416	48.97
59	0.6441	48.64
60	0.6464	48.32

61	0.6497	47.86
62	0.6540	47.28
63	0.6549	47.17
64	0.6551	47.13
65	0.6553	47.10
66	0.6556	47.07
67	0.6557	47.05
68	0.6557	47.03 DW:1.8554
69	0.6556	47.06
70	0.6550	47.14
71	0.6532	47.39
72	0.6488	47.98
73	0.6423	48.88
74	0.6423	48.88
75	0.6423	48.88

Table A4: VAR diagnostic tests results

VAR Condition Check	Statistics	Conclusions
Stability Condition	Roots of a polynomial are within the unit root (shown by Figure A1 of Appendix	VAR is stable
Residual Serial Correlation	LM statistics= 37.73189 P-value = 0.8791	No serial correlation
Residual Multivariate Normality Test	Jarque-Bera Stat (Joint)= 13.63849 P-value=0.058	Residuals are normally distributed
Residual Heteroscedasticity	Chi-square= 853.5573 p-value= 0.365	No heteroscedasticity

Table A5: Post regression diagnostic test results

Type of Test	Statistics	Conclusions
Normality Test	Jarque-Bera= 3.29507 Prob=0.1925 (See Figure A2 of Appendix)	Residuals are normally distributed
Model Stability Test	Residuals within acceptance area at 5 percent level of significance (See figure A3)	Regression is stable and well specified
Serial Correlation	F-statistics= 1.6283 Prob=0.2181	No serial correlation
Heteroskedasticity	Obs*R^2 =4.7133 Chi square prob= 0.669	No heteroskedasticity

Figure A1: VAR stability test results

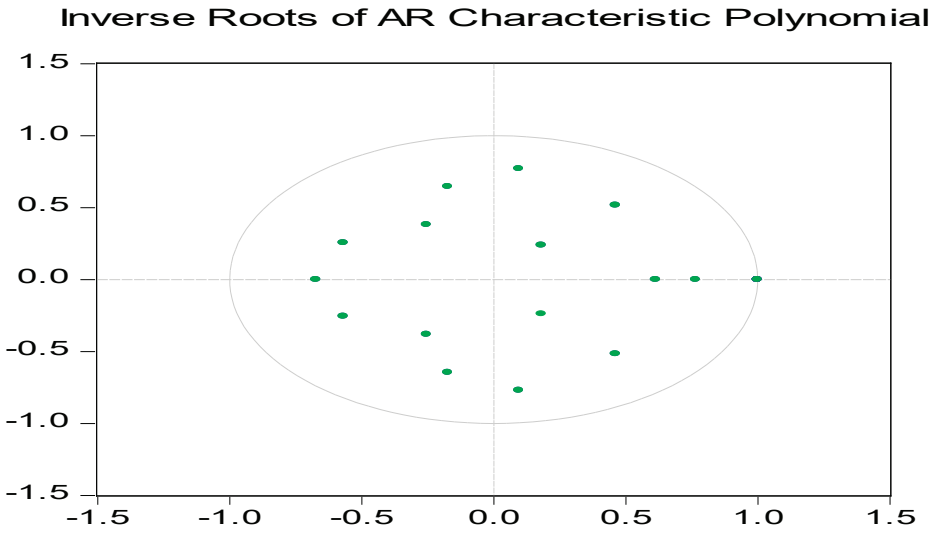
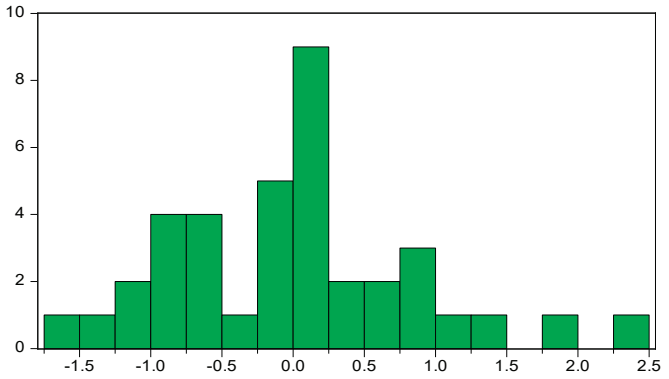
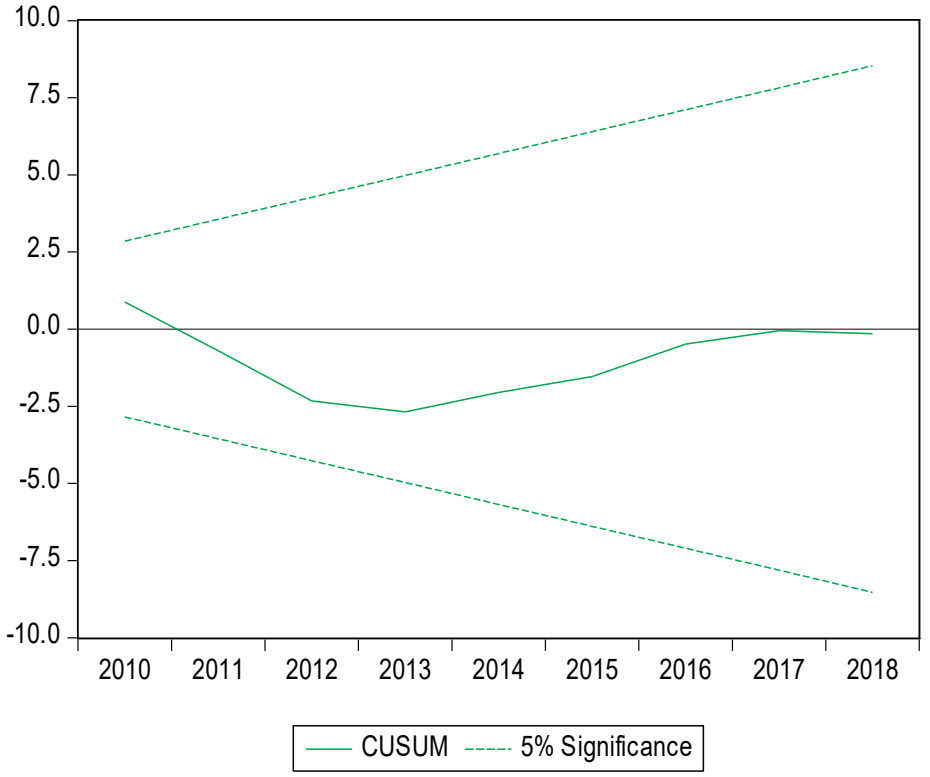


Figure A2: Normality test results



Series: Residuals	
Sample 1981 2018	
Observations 38	
Mean	7.85e-15
Median	0.000000
Maximum	2.357559
Minimum	-1.563589
Std. Dev.	0.844962
Skewness	0.676214
Kurtosis	3.502036
Jarque-Bera	3.295077
Probability	0.192523

Figure A3: Recursive CUSUM stability test results



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