MCom

PUBLIC DEBT AND ECONOMIC GROWTH:

EMPIRICAL EVIDENCE FROM SOUTH AFRICA

A Dissertation

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By

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ABSTRACT

This study seeks to investigate the relationship between public debt and economic growth in South Africa for the period 1977 – 2019. This study also seeks to review economic theories related to public debt and economic growth namely: Neoclassical, Ricardian and Keynesian theory. To achieve the research objective, this study uses the time series technique, namely, the autoregressive distributed lag (ARDL) bounds testing approach of cointegration test and the Granger causality approach to test the causal relationship between variables. Analysis of variance decomposition and impulse response functions are used to illustrate the proportions of movements of variables due to its own shock relative to other variables by shocking one standard deviation.

The study results indicate there is a positive relationship between public debt and economic growth . However, causality runs from economic growth to public debt. Overall, the study results indicate a significant negative long-run relationship between the public debt and economic growth when inflation and gross capital formation are used as controlled variables. However, the relationship is significant in the short run. The impulse response function indicated that there is responsiveness in public debt and GDP growth to shocks of public debt and GDP growth. However, the result of variance decomposition test in explaining the GDP growth and public debt co-movement. In the short run, self-variance of GDP growth co-movement is almost 100%, which reduces to 91.79% percent in the long term. Aside from self-variation, public debt induced no notable variation in bilateral co-movement in short term. In the long-run however, maximum variation of 8.22% is provided by public debt. The above statistics suggest that shock in economic growth accounts for 91.78% fluctuations. A shock to public debt causes fluctuations to GDP growth significantly over time.

Last, as a policy recommendation, South Africa needs undertake aggressive economic strategies with clear objectives and strong commitments, driven by accountable bureaucrats to ensure that public funds are used efficiently. Public debt also needs to be directed through economic growth driven projects and productive expenditures.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction and Background

South Africa is perceived as an African country with great developmental and economic growth potential (UNCTAD, 2018). However, post 2008 global recession South Africa is encircled in serious socio-economic problems. The South African economy is battling its third recession since 1994, first one was in 2008, the second in 2019 and third in 2020 (Stats SA,2020). South Africans continues to have increased high dependency on government and pressure for government to provide public goods and services continuous to increase. The South Africa labour market experiences high unemployment rate (27.1% in 2018Q4), low output and demand in the main sectors (agriculture and manufacturing) has resulted to job losses as output declines. Personal income taxes provide a large portion (38%) to government revenue in 2017/2018 financial year (StatsSA, 2018), with job losses, this revenue will decline. As a result, government needs more resources for public expenditure which leads to investment, economic and social development, service delivery and redress climate and environmental challenges.

Facing these macro-economic challenges, the country is under extensive pressure to provide public services. The labour market indicators show a decline in the number of employed whilst the working age population increases (Stats SA, 2018). According to Quantec Research (2019), the total dependency ratio, which indicates the level of pressure an economy faces in supporting and providing social services to unproductive population that is dependent on productive population, has increased in the country. As a result, financial pressure within the government is significant due to low government revenue. However, government spending may also be used to release the financial pressure as such expenditure may lead to more demand in the economy leading to increased tax base more tax revenue.

Government debt has since 2008 global financial crisis (GFC) played a significant role to drive economic growth, development and to achieve macroeconomic goals in many developing countries (Kose & Ohnsorge, 2019). As a result, South Africa government borrowing increased more than before GFC in every fiscal year to finance its fiscal deficit after 2008. The 2018/19 fiscal year preliminary outcome shows government revenue totalling R1. 272 trillion, expenditure totalling R1.505 trillion and total financing (debt used to finance public expenditure) amounted R232 billion. For the 2019/20 fiscal year, budget deficit is estimated at R255 billion, this is a 9.61% increase from the 2018/19 fiscal year whilst economic growth is slow. In 2019Q4, Statistics South Africa reported a real gross domestic product (measured by production) fell by 1.4%, followed by a decline of 0.8% in 2019Q3. On a year-on-year basis, GDP at market prices declined from 0.8% in 2018 to 0.2% in 2019 (Stats SA, 2018).

Various macroeconomic theories suggest that public sector expenditure should have a positive impact on economic growth. This is given that government expenditure has multiple purposes including, social in economic investment, basic service delivery, transformation of societies, incentivises and support business, funding research and innovation. However, if most of the government expenditure is directed to unproductive types of expenditure, it may cause a decline in economic growth (Teles and Cesar Mussolini, 2014). Against this background, it is vital for policy makers, and all economic participants to be aware of the impact debt has in the economy.

1.2 Research Problem

The South African government has since 2013 adopted a contractionary fiscal policy, fiscal consolidation (Budget Review, 2013). Despite the efforts made by the Minister of Finance to reduce growth in public expenditure in the public sector and more pronounced in recent budget proposals; South Africa continues to borrow large amounts to finance public expenditure. There are conflicting theories and debates about public debt and economic growth (GDP) relationship, particularly the issue of causality and impact. That is, whether increase in public sector debt to fund public expenditure causes economic growth or poor economic performance lead to more public debt. Neoclassical economist believe public debt causes little to no growth, whilst Keynesian theory argues that public debt causes economic growth and the Ricardian theory there is no causal link between public debt and economic growth. However, the empirical implication of different economic theories on the relationship between public debt and economic growth might differ from country to country.

Several researchers have studied the relationship between public debt and economic growth; Godfrey and Cyrus (2013) study results show that domestic debt has a positive and significant effect on economic growth. Whilst António and Sebastian (2009) concluded that there is clear Granger causality and that it is always bi-directional for OECD countries. Also, study by Ayadi, Folorunso & Ayadi, Olusegun (2008) found a negative impact of public debt on growth in

Nigeria and South Africa using data from sample period is from 1980 through 2007. South Africa performs better than Nigeria in the application of external loans to promote growth. Findings from each study and country revealed mixed different results. There is a gap in empirical studies relating to causality between public and debt.

The gap in the literature is diverse, there is lack of recent study based on South Africa public debt and economic growth status. Such study has importance policy implications assist in policy making, planning, and achieving macroeconomic objectives. The global Covid-19 pandemic has seen many countries increasing their fiscal and monitory support to their economies, with many of these countries using public debt to fund their fiscal recovery plan. South Africa has also followed international trend of using public debt to support efforts to deal with Covid-19 and economic recovery.

This study therefore sought to fill this research gap and contribute to existing empirical studies. It is important to empirically investigate the extent to which public debt has significant impact on economic growth, especially in developing economies. Discovering the causation between the two variables government intervention will be needed to initiate the promotion of the variable that causes another. Overall, providing a steady contribution to the GDP of the country. The results of this study will make contribution towards South Africa' formulate policies that are in line with its economic growth expectations. Against this background the following questions will form the basis of this study are:

- What is the trend in debt and economic growth in South African economy?
- Is the short or long-run relationship between debt and economic growth?
- Does public debt induce economic growth or economic growth induce public debt?

1.3 Research Objectives

The general objective of this study is to examine the relationship between public debt and economic growth in South Africa. However, other specific objectives are:

a) To examine trends in the level of public debt and economic growth in South Africa
b) To examine the long-run relationship between public debt and economic growth in South Africa,
c) To examine the causal relationship between public debt and economic growth

1.4 Significance of the dissertation

This study is significant because it will add to the body of knowledge on public debt and economic growth and fill the gap in the literature on the effect of public debt on economic growth in South Africa and its causality. The study is unique in its attempt to investigate public debt and economic growth relationship using from econometrics N-ARDL model and Granger Causality Vector Autoregressive model (VAR) for the South African Economy.

As noted, the level of public debt in the economy can be an indicator which informs us for the economic stance the country is in. An understanding of the relationship between public debt and economic growth in South Africa is critical. Therefore, this study is motivated by the following reasons:

a) This study is motivated by the fact that there is no recent study that has investigated the impact public debt has on economic growth and to what extend does it affect the economy in South Africa. The timing of the is significant given South Africa’s extensive use of debt to finance its annual budget. This research will contribute to existing literature, assist stakeholders to understand the relationship between debt and economic growth and would be an important input to policy makers concerning the role in monitoring public debt position.

b) The importance of this study is multidimensional. It has implications for a variety of policy interventions, like fiscal policy, development and industrial policy. For instance, the National Treasury announced three growth scenarios in 2018 MTBPS, with the focus on economic growth and debt:

1. Scenario A (sluggish domestic growth): South African GDP grows by 0.9% in 2019. The primary deficit peaks at 1.4 per cent in 2020/21 and gradually narrows, while the gross debt-to-GDP ratio climbs to 68 per cent by 2026/27 (National Treasury, 2018).
2. Scenario B (contagion from EM debt and currency crisis): South African GDP contracts in 2019 and 2020. The primary deficit widens further, to 3.6 per cent over the medium term, and remains above 3 per cent over the long term. The debt-to-GDP ratio exceeds 80 per cent by 2026/27 and does not stabilise (National Treasury, 2018).
3. Scenario C (stronger domestic growth): GDP growth is on average one percentage point higher than in the baseline and reaches 3.2 per cent in 2024/25. By 2021/22, government achieves a primary surplus of 0.5 per cent and debt stabilises at 55.4 per cent of GDP in 2020/21 (National Treasury, 2018).

National Treasury stated that gross domestic product could contract in 2019 and 2020 if contagion from a developing-economy debt and currency crisis spreads. Whilst a study by Ojo and Oshikoya (1995) indicated that debt is amongst the most important explanatory variables for sustained long term growth in African countries. With foreign aid or debt is considered a significant source of income for developing countries, considering the saving investment gap. Thus, a study focusing on the impact debt has in South Africa should be of crucial important as it will inform economic planning.

1.5 Organisation of the dissertation

From this chapter, the dissertation was structured as follows: Chapter Two provides a literature review of related studies on public debt and economic growth. Chapter Three deals with the research methodology. Chapter Four presents and discusses the main findings of the study and Chapter Five provides conclusions based on the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter first provides definition of basic concepts for better understanding of the study. This is followed by an analysis of the overview of economic growth and public debt in South Africa. This chapter also reviews previous studies relating to the topic by presenting both theoretical and empirical studies pertaining to the topic is presented. Last, an overview of theoretical literature focusing on theories of public debt and economic growth will be discussed.

2.2 Definitions of terms

This section deals with definitions of study variables, economic growth and public debt are explained below:

2.2.1 Economic growth

Economic growth is well-defined as an increase in market value of the total output of goods and services produced by a country. It is an increase in the capacity of an economy to produce goods and services, compared from one period of time to another. The economic measure of total output is Gross Domestic Output (Abbas, 2005; Sachs, 1989). Economic growth can be either positive or negative. Negative growth can be referred to by saying that the economy is shrinking (Matiti, 2013). The study will use the growth of real GDP growth rate as a measure of economic growth.

2.2.2 Public debt

Public debt serves as an indication of amounts public spending is financed by borrowing instead of taxation revenue (Makau, 2008; Matiti, 2013). Public debt refers to the total of the nation's loan debt contains of all outstanding debt instruments (local and foreign debt) A study by Chervinska (2019) proposes that local public debt is defined as government debt issued under a domestic legal jurisdiction, whilst foreign public debt includes the external debts of government and private debt that is issued by domestic private entities under a foreign jurisdiction. The ratio of total national government debt to gross domestic product (GDP) will be used a proxy for public debt. This is a useful indicator for economic planning because it indicates when debt fluctuates in relation to production (Van de Merwe, 1993). The study will use the Debt to GDP ratio as a measure of public debt.

2.3 Trend of Economic growth and Public Debt in South Africa

2.3.1 Overview of economic growth and public debt in South Africa (1970 – 2019)

The democratic South African government had in 1994 inherited an economy in complete dismay from the apartheid regime. The levels of fiscal mismanagement of the apartheid government were overwhelming. As a result, government took the pragmatic step of attempting to stabilize the ship of state first before embarking on any expansive and directly transformative policies (Hamilton & Viegi, 2009). Government debt management evolved considerably since the 1970s, when the need to develop the debt capital market was identified. Before 1990, the state issued debt only three or four times per year (National Treasury, 2011).

Nevertheless, the explosion of public debt at the beginning of the 1990s was a result of economic policy response of the apartheid government in the 1980s (Hamilton & Viegi,2008). This can be seen from Figure 1(a) from the beginning of the 1980s any attempt to stabilize expenditure as percentage of GDP. By the end of the apartheid, South Africa was on the verge of a debt crisis and had very bad credit rating and consequently high costs of borrowing.

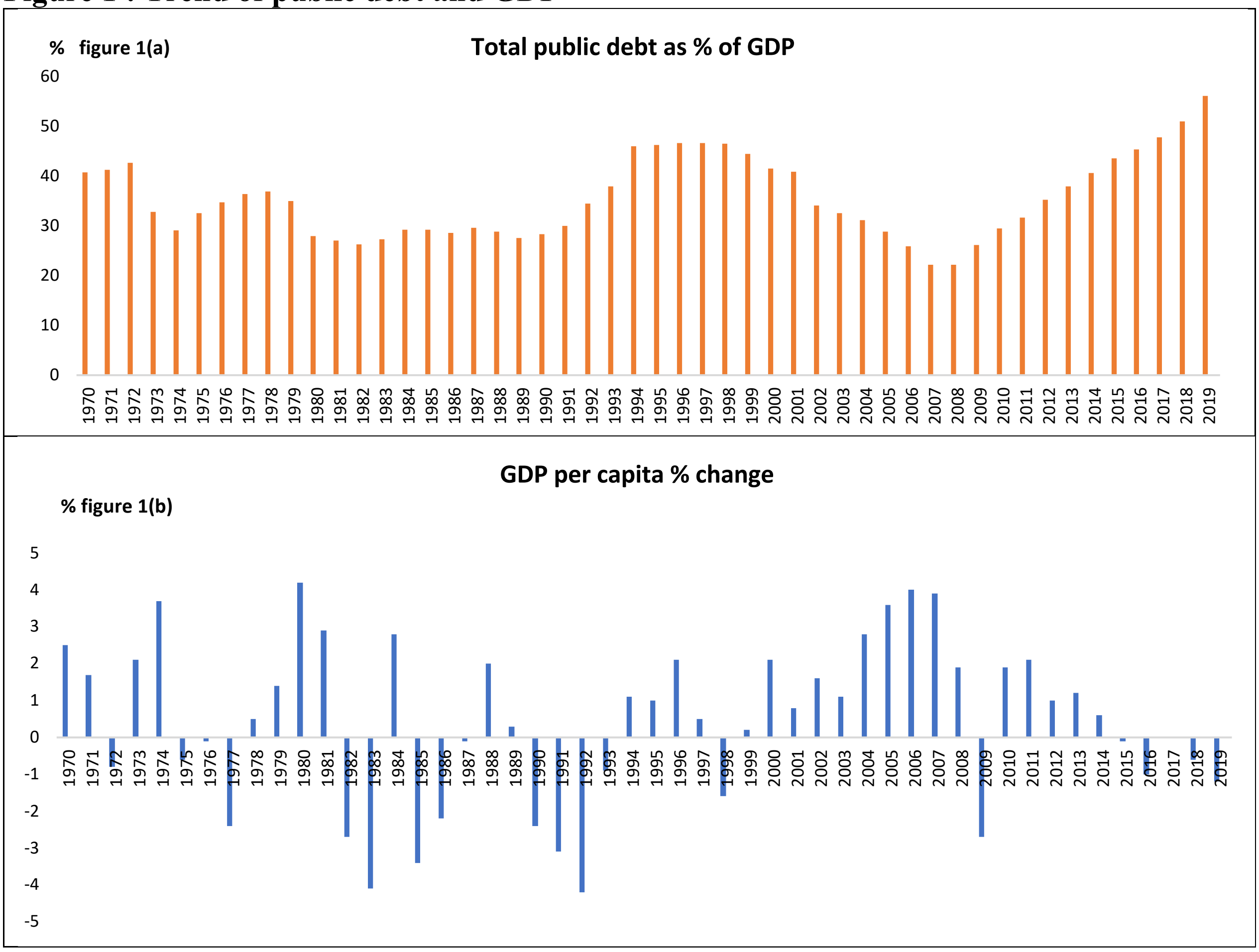
The post-1994 government identified public debt as a major threat to domestic economic recovery, as the country was then struggling to find a balance between growth and debt management (Hamilton & Viegi,2008). Government has in recent times started to use macroeconomic frameworks to guide debt management strategies in order to work towards the achievement of the goals of the National Development Plan (Financial and Fiscal Commission, 2015).

For this study to be meaningful, it is of crucial importance to provide an overview of the trend in public debt and economic growth over the years. The Figure 1 illustrates the ratio of government debt (figure 1a) and annual growth rate of real GDP per capita (figure 1b).

In the 1970s government debt started to stabilize in response to the evolution of debt management strategy (National Treasury, 2011). However, from the 1990s the ratio started to increase at highest levels in 1996 – 1997. In 1996, the debt to GDP was at 46.7%, not excessively high according to the European Union criteria of fiscal discipline that if public debt is above 60% it is deemed to be excessive as an indicator of fiscal discipline. From 1996, government took measures that prevented further increases in the debt level and reduced the debt level as a percentage of GDP (Financial and Fiscal Commission, 2015). For an example, a debt management office was created to manage the cash balances of the public sector. The primary objective of the cash management was to reduce the cost of borrowing (National Treasury, 1996). Figure 1(a) shows the rapid increase in public debt as a percentage of GDP following the financial crisis. After increases prior to 1994, public debt rose above 45% from 1995.

Similar to other countries, the 2008/2009 global financial crisis of 2008/09 led to the South African government to introducing countercyclical fiscal policy. The results were accompanied with large budget deficits and increased government borrowing from capital markets in order to fund these deficits. However, from 2009 the ratio of South Africa's government debt to gross domestic product continued to increase 22.2% in 2008 to 51.6% in 2019.

Figure 1 : Trend of public debt and GDP



Source: SARB, 2020

In figure 1(b) the annual growth rate of real GDP per capita from 1970 – 2019 is presented. From this figure it is apparent that GDP per capita was almost persistently lower in 1980s compared with the 1990s. From 1998, GDP per capita increased to positive levels until 2008/2009 global crisis and recession where GDP per capita was fell by 2.7%. Following the global crisis, the economy recovered until 2015 where South Africa experienced another decline of GDP per capita of 0.1%. The annual growth rate of GDP per capita for the year 2019 is recorded at -1.9% and will most likely decline even further. From the two figures it can also be noted that there no clear direction between public debt and economic, hence this study is of crucial importance.

South African government has made significant progress to manage debt in the country. Debt management started pre-1990 where phase 1 focused on macro stability, principles of debt, cash and risk management. Post-1994, National government began to develop macroeconomic frameworks to inform guidelines and active debt management strategies post 1994. Phase 2, between 1990 and 1999 a comprehensive debt management framework was adopted. In Phase 3, which is 1999 – date, government is more focused on asset and liability management (National Treasury, 2011).

However, national government has undertaken the following measures to reduce and manage public in South Africa, as mentioned in the 2019 Medium Term Budget Policy Statement (MTBPS) amongst others.

- Measure to improve efficiency in the public sector and reduce wasteful expenditure, including limiting claims against the state, including medico-legal claims and Road Accident Benefit Scheme.
- Merge and consolidate entities and regulatory agencies, as well as consider salary controls at a wider range of public entities.
- Dispose of unused land and other assets to make more funds for public goods and services available.
- Manage and reduce the benefits received by political office bearers, through reforms to the Ministerial Handbook.
- Public-service wage bill remains on hold in the third year of the 2018 wage agreement, wage freeze for the next three years (2019/20 – 2022/2023) is being implemented in support of fiscal consolidation.

- Government is working towards stabilising the finances of financially distressed state-owned companies, restructuring, improve their operations and eliminate continuous calls for public resources.

Overall, national government made significant adjustments over the years. Expenditure has been reduced and there are continuous plans to manage the impact of reductions in planned expenditure, reductions to departmental baselines and slowing spending growth to narrow the budget deficit and control use of debt.

2.3.2 Public expenditure by cluster and economic classification in South African

Public expenditure and allocation of funds (Table 1) is often linked with national government priorities. South African public sector spending increased on a year-on-year basis between 2019/20 financial year (FY) and 2018/19FY by 11.7%. In terms of cluster and economic classification expenditure, national government spends mostly on provincial equitable share (30.1%), social services (22.4%) and urban and development infrastructure (12.8%). Compared with 2009/10FY, expenditure on economic services grew by a rate of 279.2% in 2019/20FY.

Table 1 : Public expenditure by cluster and economic classification in South African

R million	2009/10	Expenditure Allocation %	2018/19	Expenditure Allocation %	2019/20	Expenditure Allocation %	Growth rate(%) 2009/10 - 2019/20	Growth rate(%) 2018/19 - 2019/20
Administrative services	81 083.2	10.9%	71 262.9	4.7%	76 048.9	4.5%	-6.2%	6.7%
Economic services	28 125.6	3.8%	53 189.8	3.5%	106 655.6	6.3%	279.2%	100.5%
Social services	147 708.6	19.8%	342 042.8	22.7%	376 699.9	22.4%	155.0%	10.1%
Protection services	104 115.9	13.9%	184 263.8	12.2%	196 410.4	11.7%	88.6%	6.6%
Urban development and infrastructure	92 143.4	12.3%	203 717.5	13.5%	215 930.7	12.8%	134.3%	6.0%
Provincial equitable share	236 890.8	31.7%	470 286.5	31.2%	505 553.8	30.1%	113.4%	7.5%
Debt-service costs	57 129.2	7.6%	181 849.1	12.1%	205 005.0	12.2%	258.8%	12.7%
Total	**747 196.8**	100.0%	**1 506 612.5**	100.0%	**1 682 304.1**	100.0%	125.1%	11.7%

Source: South African National Treasury, National Budget.

2.4 Theoretical Framework and Empirical Literature Review

This section of the research will provide a review of previous studies relating to the topic by presenting both theoretical and empirical studies pertaining to the topic. However, for better understanding of the study, the chapter begins with the definitions of basic concepts (i.e.: public debt and economic growth).

2.4.1 Theoretical Framework

There are different theories that attempt to explain the relationship between economic and economic growth. This study adopts theoretical contentions and perspectives on public debt and economic growth from three schools of thought, namely, Neoclassical, Ricardian and Keynesians school of thought.

a) Neoclassical Theory

The neoclassical theory demonstrates a negative link between economic growth and budget deficit because persistent deficits crowd out private investment. Classicists believe that debt-financed public spending does not fully offset the negative impact of private investment spurs, leading to economic decline (Siddiqui & Malik, 2001). Neoclassical economist believed that public debt leads to an increase the demand for labour and raise wages, hurting profitability and government deficit increases the stock of government bonds, reducing their market price and encouraging high interest rates, making it more expensive for business to finance fixed investment. Thus, efforts to stimulate the economy would be self-defeating (Lee & Ng, 2015).

Furthermore, this school of thought viewed public debt as a capital injection to be used for production investment rather than consumption by individuals, implying that government expenditure should not be financed by means of borrowing regardless of the circumstances (Say, 1880; Ncanywa & Masoga, 2018). Supporting this, Cebula (1995) investigated the impact of U.S. budget deficits on real GDP growth over the period 1955-1992. Study results indicated that federal budget deficits reduce the rate of economic growth. The neoclassical theory provides the hypothesis that public debt causes stagnant growth.

b) Ricardian Theory

In contrast, the Ricardian school views public debt as merely postponing tax and having no real effect. This view is built on the understanding that a lower tax rate and a budget deficit require higher taxes in future (Lee & Ng, 2015). In order to achieve economic growth, it is necessary to reduce the fiscal burden on productive companies while increasing the fiscal burden on the labour sector (Matiti, 2013). Ricardian theory suggests that fiscal stabilization efforts have a neutral impact on economic growth. This theory provides the hypothesis, that there is no causal link between public debt and economic growth, known in the literature as the neutral hypothesis (Reinhart& Rogoff 2014; Barro, 1979, 1990).

c) Keynesian Theory

However, Keynes (1924) school of thought advocated what has been termed countercyclical fiscal policies, which are policies that have counteracted the tide of the business cycle meaning; deficit spending when the economy of a nation suffers from recession or when recovery is long delayed and joblessness is tenaciously high. According to Makin (2015) the increasing government expenditure is linked to higher national output, leading to employment. From this theory that there is a causal link between public debt growth and economic growth.

Keynesian school views that a budget deficit will achieve a national income improvement and need not crowd out private investment, if the resources in the economy are initially under-employed. Public debt costs need not generally be wasteful: that is, government spending on such things as essential research, public health, education and infrastructure could help to grow potential output in the long term. In contrast public debt may increase the economic growth rate when used for productive purposes (Keynes, 1924; Lee & Ng, 2015; Kumudia). Keynesian theory argued that at active government policy could be effective in growing and managing the economy. This theory provides the hypothesis that public debt causes economic growth.

2.4.2 Empirical Literature Review

Under this section, important empirical studies on public debt and economic growth are reviewed. Over the recent years there has been fewer studies that examine the relationship between public debt and economic growth in South Africa. For instance, Iyoha and Milton (1999) investigated the relationship between external debt and economic growth for Sub-Saharan countries during the period 1970 to 1994. This period was understood as the "genesis of debt crisis", the global crisis arose as result of over-borrowing by governments and reckless landing in the 1970s. In the 1980s structural adjustment programmes were recommended by the World Bank and the International Monetary Fund as a solution to the economic crisis brought on by the debt crisis. The results indicated that debt adversely affect investment and a reduction in debt would lead to improvement in investment and economic growth.

Saungweme and Odhiambo (2019) explored the causal relationships between public debt and economic growth for the period from 1970 to 2017 in Zambia using a dynamic multivariate autoregressive-distributed lag bounds testing approach. Study results indicated that there is unidirectional Granger-causality and no causality between the study variables in Zambia.

Conflicting with Iyoha and Milton (1999), a study by Ayadi, Folorunso & Ayadi, Olusegun (2008) found a negative impact of debt on growth in Nigeria and South Africa using data from sample period is from 1980 through 2007. South Africa performs better than Nigeria in the application of external loans to promote growth.

Panizza and Presbitero (2013) surveyed the literature on the links between public debt and economic growth in advanced economies, theoretical models found a negative correlation between debt and growth. Other theories advocate that a reasonable level of debt should drives both developing and developed countries enhance their economic growth.

Egbetunde (2012) study examined the causal nexus between public debt and economic growth in Nigeria between 1970 and 2010, study results show that public debt and economic growth have long run relationship. The findings of the VAR model revealed that there is a bi-directional causality between public debt and economic growth in Nigeria.

Kharusi and Ada (2018) investigated the relationship between government external borrowing and economic growth using time series data for the period 1990 to 2015. The study revealed that there is a negative and significant influence of external debt on economic growth in Oman.

Ogunmuyiwa (2011) examined the relationship external debt has on economic growth in Nigeria using time series data from 1970-2007, results reveal that causality does not exist between external debt and economic growth as causation between debt and growth is insignificant in Nigeria.

Sulaiman and Azeez (2012) examined the effect of external debt on the economic growth of Nigeria using data from 1970 to 2010. Study results show that long-run equilibrium relationship exist among the variables and external debt has contributed positively to the Nigerian economy.

Godfrey and Cyrus (2013) studied the relationship between domestic debt and economic growth with most researchers focusing on external debt in Kenya using time series data spanning 2000 to 2010. The study results show that domestic debt has a positive and significant effect on economic growth.

Lee and Ng (2015) investigated whether public debt contributed to the economic growth in Malaysia over the period 1991 to 2013 and study results indicate that public debt over time has a negative impact on GDP.

António and Sebastian (2009) examined the Granger-causality relationship between the growth of the real GDP per capita and the public debt using OECD annual data for 20 countries between 1988 and 2001. Study results concluded that there is clear Granger causality and that it is always bi-directional.

Malik and Khizar (2010) explored the relationship between external debt and economic growth in Pakistan for the period of 1972-2005, evidence suggests that increase in external debt will lead to decline in economic growth. Panizza and Presbitero (2013) surveyed literature on the links between public debt and economic growth in advanced economies. Study results indicate that theoretical models found a negative correlation between debt and growth.

Presbitero (2012) studied the impact of public debt on growth in advanced and emerging countries over the period 1990 to 2007, study result show that public debt has a negative impact on output growth until it reaches 90 per cent of GDP. However, beyond this threshold, the debt effect on growth becomes irrelevant.

Pattillo et al. (2002) assesses the non-linear impact of external debt on growth using panel data for 93 developing countries over 1969 to 1998, findings of the study suggest that the average impact of debt becomes negative at about 35 to 40 percent of GDP.

Kumar and Woo (2010) examined the impact of high public debt on long-run economic growth based on a panel of advanced and emerging economies over almost four decades. Study results indicate that there is a long run negative relationship between debt and growth.

Cunningham (1993) studied the relationship between debt burden and economic growth for sixteen indebted countries for the period 1971 to 1987. The study results show that growth of a country's debt burden has a negative effect on the economic growth. Karagöl (2002) examined relationship between external debt and economic growth in Turkey for the period 1956 to 1996. The study results indicated a negative relationship between external debt and economic growth in the long run exits. In terms of causality test results; unidirectional causality running from debt service to economic growth was found.

Fosu (1996) studied the relationship between economic growth and external debt of sub-Saharan African countries for the period 1970 to 1986, the study concluded that on average a high debt country faces about one percentage reduction in the GDP annually.

Dritsaki (2013) examined the relationship between economic growth, exports and government debt of Greece over the period 1960 to 2011. The result show that there is a unidirectional Granger causality that runs from exports to economic growth as well as from economic growth to government debt. However, in the long run, a unidirectional Granger causality that runs from economic growth to government debt exists.

The literature shows a mixed impact of debt on economic growth. Some studies concluded that debt has positive impact on economic growth, whilst others indicate otherwise. New evidence needs to be brought forward to assist in providing a better understanding of the issue.
This study attempts to fill the research gap in the literature, to examine the relationship and impact of public debt on economic growth in South Africa. Hence, this study is carried out to analyse the impact of public debt on the economic growth (and vice versa) of South Africa. The purpose of this study is to add to the body of knowledge and to fill the gap in the literature on the effect of public debt on economic growth and vice-versa.

2.5 Concluding remark

This chapter reviewed the theoretical and empirical literature on public debt and economic growth. Theories are in dispute about the relationship and causality between public debt and economic. The Neoclassical theory claims that debt-financed public spending has a negative impact on economic growth. On the other side, the Ricardian school views public debt as merely postponing tax and having no real effect. Whilst the Keynesian theory claims that public debt causes economic growth.

A number of studies attempting to explain the relationship between public debt and economic growth, with little focus on South Africa. Some of these studies produced mixed results over different sample periods. Consequently, the current study aims to at contributing to the existing literature by investigating the relationship between public debt and economic, as well as their causality from South African point of view.

In examining public debt and economic growth relationship, studies used unit root tests to test for stationarity (or non-stationarity), the Autoregressive Distributed Lag (ARDL) cointegration technique and the granger causality test. As a result, this study will use the popular unit roots tests, namely; Augmented Dickey-Fuller Tests, Phillip-Perron test, Dickey-Fuller Generalized Least Squares and KPSS stationarity test. The ARDL approach will be used to test for cointegration. Last, the Engle-Granger causality test will be used to which variables causes and explains the other.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This study section provides the research design and analytical framework used in the literature for examining the trends public debt and economic growth. This section will also provide a description of data and their sources as well as the time coverage of the data.

3.2 Research Design

This study employed quantitative research methodology, specifically a longitudinal research design.

3.2.1 Data Period and Sources

To investigate the relationship between public debt and economic in South Africa, this study will use annual data over the sample period of 1977 to 2019. This gives 49 data observations. The study period has been selected based on availability of information and reliable data. The measure for public debt is the debt to GDP ratio and for economic growth the real GDP growth rate will be used. All data will be obtained from the South African Reserve Bank (SARB) online download facility. The data gathered will be subjected to various econometric tests using E-views.

3.3 Analytical Framework

This sub-section provides the analytical framework adopted to examine the trends and relationship between public debt and economic growth in South Africa. This framework will allow the researcher to study disparities within the data sets over time. Aligned with the research objective of examining causality and trends in the level of public debt and economic growth in South Africa.

The study will adopt three approaches. The first approach deals with the examination of trends (unit roots) in study variables timeseries data, in which a number of unit root and stationarity tests are used to examine trends in house prices. The second approach provides a framework for the estimation of cointegration and long-run relationship between study variables using autoregressive distributive lag (ARDL) model. The last approach deals with the casual relationship between study variables, using the Granger causality test.

3.3.1 Model specification

Various studies have been conducted to find the relationship between public debt and GDP growth by employing various econometrics models. As discussed in literature, the estimation equation is represented:

$$RGDP = \propto_0 + \propto_1 PDT + \propto_2 INFL + \propto_3 GFCF + \varepsilon_t \quad (1)$$

where $RGDP$ is the growth rate of real GDP, PDT is public debt to GDP ratio, inflation (INFL) measured by consumer price index and Gross fixed capital formation (GFCF) in percentage of GDP. ε_t is a pure white noise error-term.

3.3.2 Trend Analysis

In order to examine trends in economic growth and public debt, this study will adopt various unit root tests namely: Augmented Dickey-Fuller tests (ADF) and Phillip and Perron tests (PP) and stationarity (Kwiatkowski–Phillips–Schmidt–Shin (KPSS)) test. These tests are discussed briefly below.

Determining whether a data time series is stationary or not is important as the stationarity status of data influences the behaviour and properties of the data. When time series data is not stationary its statistical determinants vary over time. If a series is stationary (constant statistical determinants such as the mean, constant variance) it has no unit roots, therefore exhibits mean reversion in that it fluctuates around a constant long run mean. On the other hand, the variable is non-stationary, when the series has no tendency to return to a long-run deterministic path, the series contains a unit root. Unit root is a procedure for testing stationarity (Brooks, 2014).

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3.4 Unit Root Tests

Following the evidence in the literature, the proposed study will adopt two commonly used tests for unit root namely; Augmented Dickey-Fuller test (ADF) and Phillip and Perron test

(PP) and Dickey-Fuller Generalized Least Squares test. Also, stationary test is used as a confirmatory test.

a) Augmented Dickey-Fuller Tests (ADF) Unit Root Test

The ADF test is useful in determining the order of integration of the variable which provides the time series properties of the data. Harris (1992) finds that the size and power properties of the ADF test are enhanced if a generous lag is employed. Following a study by Dickey and Fuller (1981). The ADF test is represented as follows;

$$\Delta RGDP_t = \gamma_1 RGDP_{t-1} + \sum_{t=1}^{p} \alpha_{1t} \Delta RGDP_{t-1} + \upsilon_{1t} \qquad (2)$$

$$\Delta PDT_t = \gamma_2 PDT_{t-1} + \sum_{t=1}^{p} \alpha_{2t} \Delta PDT_{t-1} + \upsilon_{2t} \qquad (3)$$

where $\Delta RGDP_t$ is changes in real gross domestic product at time t, ΔPDT_t is changes in public debt at time t, $RGDP_{t-1}$is a previous value of economic growth, $PDT_{t-1}$is a previous value of debt,υ_t is a pure white noise error term,p denotes the number of lagged terms, where change in GDP and debt is expressed as $\Delta RGDP_{t-1} = (RGDP_{t-1} - RGDP_{t-2})$,$\Delta RGDP_{t-2} = (RGDP_{t-2} - RGDP_{t-3})$ and $\Delta PDT_{t-1} = (PDT_{t-1} - PDT_{t-2})$,$\Delta PDT_{t-2} = (PDT_{t-2} - PDT_{t-3})$ respectively. The ADF is tested under the hypothesis:

$H_0: \gamma_1 = 1$ (unit root) against, $H_1: \gamma_1 < 1$ (has no unit root)

$H_0: \gamma_2 = 1$ (unit root) against, $H_1: \gamma_2 < 1$ (has no unit root)

b) Phillip-Perron test (PP) Unit Root Test

Phillip and Perron (1988) provided a similar test to ADF tests, but PP test uses nonparametric statistical methods to modify the test statistic so that no additional lags of the dependent variable are needed in the presence of serially correlated errors. PP test is important since it is able to demonstrate that if structural breaks in the testing framework are allowed, the range of macroeconomic series may turn out stationary (Gujarati & Porter; 2009 and Brooks, 2014).
The PP test regression can be specified as:

$$RGDP_t = \beta' D_t + \gamma_1 RGDP_{t-1} + u_{1t} \qquad (4)$$

$$PDT_t = \beta' D_t + \gamma_2 PDT_{t-1} + u_{2t} \qquad (5)$$

where PDT_t denotes the vector of deterministic terms, $RGDP_{t-1}$is a previous value of economic growth, $PDT_{t-1}$is a previous value of debt and $u_{1t}u_{2t}$is I(0) and may be heteroskedastic. The

PP tests correct for any serial correlation and heteroskedasticity in the errors u_{1t} and u_{2t}non-parametrically by modifying the Dickey Fuller test statistics. The hypothesis to be tests is:

$H_0: \gamma_1 = 1$ (unit root) against, $H_1: \gamma_1 < 1$ (has no unit root)

$H_0: \gamma_2 = 1$ (unit root) against, $H_1: \gamma_2 < 1$ (has no unit root)

c) Dickey-Fuller Generalized Least Squares (DF-GLS) Unit Root Test

The Dickey-Fuller Generalized Least Squares (DF-GLS) unit root test proposed by Elliot et al (1996) is basically an ADF test, except that the procedure transforms the data using general least squares (GLS) rationale. The test uses the GLS approach to de-trended data and then uses an ADF test regression to test for unit root. DF-GLS test is known as an efficient unit root test as it gives the best overall performance in terms of small sample size and power. The DF-GLS test is specified as: $\Delta RGDP_t = \gamma_1 RGDP^d{}_{t-1} + \sum_{t=1}^{p} \alpha_{1t} \Delta RGDP^d{}_{t-1} + \upsilon_{1t}$ (5)

$$\Delta PDT_t = \gamma_2 PDT^d{}_{t-1} + \sum_{t=1}^{p} \alpha_{2t} \Delta PDT^d{}_{t-1} + \upsilon_{2t} \tag{6}$$

where, $RGDP^d$ and PDT^d is the de-trend (de-meaned) of economic growth and public debt series and υ_{it} is the error term. The DF-GLS is tested under the hypothesis:

$H_0: \gamma_1 = 0$ (unit root) against, $H_1: \gamma_1 < 0$ (has no unit root)

$H_0: \gamma_2 = 0$ (unit root) against, $H_1: \gamma_2 < 0$ (has no unit root)

d) Kwiatkowski, Phillips, Schmidt and Shin (KPSS) Unit Root Test

Determining whether a data time series is stationary or not is important as the stationarity status of data influences the behaviour and properties of the data (Brooks, 2014).

Following the weaknesses of unit root tests, this study will adopt stationarity test as a confirmatory test. The most commonly used stationarity test, the KPSS test, is due to Kwiatkowski, Phillips, Schmidt and Shin (1992). The KPSS test is presented as:

$$IRDGP_t = \beta' D_t + \mu_t + \upsilon_t \tag{7}$$

$$PDT_t = \beta' D_t + \mu_t + \upsilon_t \tag{8}$$

$\mu_t = \mu_{t-1} + \varepsilon_t$, where $\varepsilon_t \sim WN(0, \sigma_\varepsilon^2)$

where $D_t$contains deterministic components (constant or constant plus time trend), u_t is I(0) and may be heteroskedastic, u_t is a pure random walk with innovation variance $\sigma_\varepsilon^2 = 0$, which suggests that $u_t$is a constant.

The null hypothesis is formulated as:

H_0: $\sigma_\varepsilon^2 = 1$ (stationary) against, H_1: $\sigma_\varepsilon^2 < 1$ (nonstationary, unit root)

3.5 Autoregressive Distributive Lag (ARDL)

This study will adopt the Autoregressive Distributed Lag (ARDL) cointegration technique or bound cointegration technique to test the relationship between public debt and economic growth. Cointegration is an econometric concept that mimics the existence of a long-run equilibrium among underlying economic time series that converges over time. The major advantage of this approach lies in its identification of the cointegrating vectors where there are multiple cointegrating vectors (Lin, Liang & Tsai, 2019).

The ARDL (p,q1,q2......qk) model approach to Cointegration testing takes this form:

$$\Delta RGDP_t = \alpha_{0i} + \alpha_{1t} + \delta_{11} RGDP_{t-1} + \delta_{21} PDT_{t-1} + \sum_{j=1}^{p} \gamma_i \, \Delta RGDP_{t-i} + \sum_{j=1}^{q} \partial_2 \, \Delta PDT_{t-i} + u_{1t} \quad (9)$$

$$\Delta PDT_t = \alpha_{0i} + \alpha_{2t} + \delta_{21} PDT_{t-1} + \delta_{22} RGDP_{t-1} + \sum_{j=1}^{p} \gamma_i \, \Delta PDT_{t-i} + \sum_{j=1}^{q} \partial_2 \, \Delta RGDP_{t-i} + u_{1t} \quad (10)$$

where p and q are the optimal number of lags of public debt and real GDP, α_{0i} is the intercept term, Δ denotes a first difference operator, γ_i and $\partial_2$are the short-run coefficient parameters, δ_1 is the long run regression coefficient which is normalised on δ_2 and the disturbances u_{1t}. The notation of the model structure is expressed in ARDL (p, q).

In order to examine whether a cointegrated relationship exists between the variables, F statistics were used to jointly test the null hypothesis of the absence of cointegration:

H_0: $\delta_{01} = \delta_{02} = \ldots = \delta_{ij} = 0$ (null, i.e. the long run relationship does not exist) against,

H_1: $\delta_{01} \neq \delta_{02} \neq \ldots \neq \delta_{ij} \neq 0$ (Alternative, i.e. the long run relationship exists)

Rejecting the null hypothesis implies that PDT and RGDP have a long-run co-movement relationship, which states cointegration between the variables exists at the level of significance.

This study adopts the ARDL approach as it is applicable irrespective of whether the considered variables are $I(0)$ or $I(1)$ or a mixture of both, stationary or nonstationary, and thus avoids the spurious regression (Narayan, 2005).

3.6 Error Correction Model

The Error Correction Model (ECM) allows the researcher to link together the short-run dynamics and long-run relationship between two cointegrated variables. The error correctionmodel (ECM) of the ARDLmodel is expressed ashere is an error correction model (ECM) of the cointegration relationship.

The ECM is formulated as follows: given that $\hat{u}_t = RGDP_t - \hat{\beta}PDT_t$

$$\Delta RGDP_t = \gamma_1 + \beta_1 \Delta PDT_{t-1} - \Pi EC_{t-1} + \varepsilon_{1t} \tag{11}$$

Where γ_1 is a constant, β_1 indicate short run relationship between changes in saving and investment, ΠEC_{t-1} denotes long-run relationship between changes in savings and investment, Π describes the speed of adjustment back to equilibrium and EC_t is the error correction component (Brooks, 2014).

3.7 Granger Causality Test

Granger (1996) provided a more comprehensive test of causality, the Granger causality test: a statistical method which assumes that the information relevant to the prediction of the respective variable, public debt and economic growth is contained in time series properties of the data on variables. The Granger causality test whether a change in public debt causes economic growth to change or change in economic growth causes debt to change (Gujarati & Porter, 2009). Granger causality procedure is tested within the Vector autoregressive (VAR) framework, with two variables, economic growth (I) and debt, the model is specified as:

$$RGDP_t = \gamma_{10} + \gamma_{11} RGDP_{1t-1} + \cdots + \gamma_{1k} RGDP_{1t-k} + \alpha_{11} PDT_{2t-1} + \cdots + \alpha_{1k} PDT_{2t-k} + u_{1t} \tag{12}$$

$$PDT_t = \gamma_{20} + \gamma_{21} PDT_{2t-1} + \cdots + \gamma_{2k} PDT_{2t-k} + \alpha_{21} RGDP_{2t-1} + \cdots + \alpha_{2k} RGDP_{2t-k} + u_{2t} \tag{13}$$

Equation (13) and (14) can rewritten as follows:

$$RGDP_t = \gamma_{10} + \sum_{i=1}^{p} \gamma_i \, RGDP_{t-1} + \sum_{j=1}^{q} \alpha_j \, PDT_{t-1} + u_{1t} \quad (14)$$

$$PDT_t = \gamma_{20} + \sum_{i=1}^{p} \gamma_i \, PDT_{t-1} + \sum_{j-1}^{q} \alpha_j \, RGDP_{t-1} + u_{2t} \quad (15)$$

where p and q are the optimal number of lags of debt and real GDP, respectively, subscript t is the time period; i and j are the i^{th} and j^{th} year respectively and the disturbances u_{1t} and μ_{2t} are assumed to be uncorrelated.

Based on (15) and (16) the hypothesis is:

$H_0 : \alpha_{11} = \alpha_{12} = ... = \alpha_{ij} = 0$ (PDT_t does not Ganger cause $RGDP_t$) against,

$H_1 : \alpha_{11} \neq \alpha_{12} \neq ... \neq \alpha_{ij} \neq 0$

$H_0 : \alpha_{21} = \alpha_{22} = ... = \alpha_{ij} = 0$ ($RGDP_t$ does not Ganger cause PDT_t) against

$H_1 : \alpha_{21} \neq \alpha_{22} \neq ... \neq \alpha_{ij} \neq 0$

The Granger causality test has a weakness of not indicating that movements of one variable causes movement in the other variables and does not measure the shocks of variables (Brooks, 2014). To overcome these weaknesses, this study uses impulse response function and variance decomposition process.

3.8 Variance decomposition and impulse response

The variance decomposition function and impulse response functions are used to indicate the proportions of the movements in variables due to own shock against those other variables by shocking one standard deviation. Variance decompositions reveal the effect of public debt on GDP growth (Brooks, 2014, Swanson & Granger, 1997).

3.9 Assumptions of the study

In the context of this study it is assumed that:

- Future economic performance follows a known historical pattern, this means past trend explain future events and a relationship is expected to continue in the future (Hirschey, 2009).
- This study also isolates the relationship between the two study variables by assume other factors which may influence the study are held constant.

- Secondary data downloaded by the research is valid and reliable.
- The unit root tests Augmented Dickey-Fuller, Dickey-Fuller Generalized Least Squares and Phillips-Perron tests are conducted under the assumption that the timeseries data is trend or level stationary; in the latter case, the trend is removed.
- The ARDL model assumes linearity amongst variables (change i.e. a percentage change in independent variable will lead to a percentage change in the dependant) and symmetrical adjustment (Adznan & Masih, 2018).

CHAPTER FOUR

DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents and discusses analytical results from various frameworks adopted to examine the relationship between public debt and economic growth. The frameworks are as presented in the presented in the previous chapter. The presentation of the analyses are divided and presented into four sections. The first begins with preliminary results (descriptive statistics). The second section provides with trend analysis, where various unit root and stationary test results are presented and discussed. The third section delivers results of the relationship between public debt and economic growth. The chapter ends with summary and conclusion of the results from the various models adopted in the study.

4.2 Preliminary Results

Table 4.1 presents a summary of statistical measures of location and distribution of public debt and economic growth variables. Debt to GDP ratio has a negative mean of -3.23 while GDP growth rate mean is 2.23. Debt to GDP ratio standard deviation is small compared to GDP growth indicating that the values are close to the mean of the data set. A standard deviation of 1.81 means that the values in the data set on average are farther away from the mean.

Table 2: Summary of statistics for public debt and economic growth

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Jarque-Bera (p-value)
GDP growth rate (GDP)	2.23	32.5	6.6	-2.1	2.22	-0.15	2.2	1.3 (0.52)
Debt to GDP (PDT)	-3.23	-3.4	0.7	-6.6	1.81	0.37	2.25	2 (0.37)
Inflation (CPI)	10.6	9.6	24.9	1.4	5.8	0.64	2.67	3.1 (0.21)
Capital formation (GFCF)	20.55	19.3	30.9	15.2	4.31	0.9	2.73	5.91 (0.05)

Source: Own computation. Notes: Statistics in brackets () are probabilities

According to Brooks (2014) and Gujarati (2009) skewness refers to how symmetric the residuals are around zero the skewness. For a normally distributed variable the skewness (a measure of symmetry) should be zero and kurtosis (which measures how tall or peakedness the normal distribution tail is) should be 3. Table x shows that GDP growth skewness coefficient is negative, which indicates a left skewed distribution and that the distribution is far from symmetrical with a Kurtosis which indicates that the distribution is peaked. Debt to GDP skewness coefficient (0.37) indicates non-symmetry rather it has a long right tail, with the kurtosis coefficient indicating that the distribution is lower than normal distribution.

The Jarque-Bera (JB) is a test for normality of the data, based on skewness and kurtosis. The null hypothesis for JB test is for a normally distributed series, is a combined hypothesis of having kurtosis of 3 and skweness value of 0. The null hypothesis of normal distribution is rejected at 5 percent significance level if the probability value is less than 0.05. (Hill, Griffiths & Lim, 2008, Gujarati 2009 and Brooks, 2014).

The JB statistic with is associated probability vale (p-value) is indicated in table x. Application of the Jarque–Bera test shows that the JB statistic for debt is about 2.00 and the probability of obtaining such a statistic under the normality assumption is about 37%. For GDP growth, the JB statistic is 1.30 with the probability of 52%. Therefore, we fail to reject the hypothesis of normal distribution for both variables.

Table 3: Correlation analysis

	CPI	PDT	GFCF	GDP
CPI	1	0.074687	0.396553	-0.14326
PDT	0.074687	1	0.076493	0.395365
GFCF	0.396553	0.076493	1	-0.07669
GDP	-0.14326	0.395365	-0.07669	1

Source: Own computation
Note: GDP= GDP growth rate; PDT=Debt to GDP; CPI= Inflation; GFCF=Gross Fixed Capital formation

Correlation analysis is a statistical instrument that is used to measure the degree or strength of linear association between two variables. We treat any (two) variables symmetrically; there is no distinction between the dependent and explanatory variables. The coefficient of determination is the coefficient of correlation, denoted by r. Variables are being tested whether they have a positive or a negative relationship and how close the relationship is (Gajarati, 2009, Brooks, 2014).

Table 3 shows that there is positive correlation between GDP growth and public debt to GDP ratio; negative correlation between GDP and consumer inflation, and gross capital formation. The results of correlation indicate that there no multicollinearity problem across independent variable as all correlation coefficient less than 0.8.

4.3 Unit root and stationarity tests

Defining whether a data series is stationary or non-stationary is important as the assumptions of the classical time series require that a series must be stationary with mean of zero and finite variance. Non-stationary can lead to spurious regression. Therefore, unit root tests applied to determine whether the variables are stationary before conducting the causality test. The Unit Root test used in this study is the Augmented Dickey-Fuller, the Phillip-Perron, Dickey-Fuller Generalized Least Squares test, followed by the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) stationarity test. The test results are presents in tables below and the analyses are presented both in levels and first difference.

Table 4 reports the results of the ADF test for public debt and economic growth. On the level form, it is evident that at 5% significance level, we fail to reject the null hypothesis of unit root. However, by first-differencing of the series, both the variables become stationary at all significance levels, which implies that the series are integrated of order one (I(1)).

Table 4: Augmented Dickey-Fuller Tests (ADF) unit root test results

Variables	ADF test in level						ADF test in first difference					
	Test statistic	Critical value 1%	Critical value 5%	Critical value 10%	Model	Lag	Test statistic	Critical value 1%	Critical value 5%	Critical value 10%	Model	Lag
PDT	-2.55	-4.19	-3.52	-3.19	I,T	0	-6.06*	-3.60	-2.94	-2.61	I	0
GDP	-4.25*	-4.19	-3.52	-3.19	I,T	0	-7.61*	-3.60	-2.94	-2.61	I	0
CPI	-4.75	-4.19	-3.52	-3.19	I,T	0	-6.84*	-3.62	-2.94	-2.61	I	3
GFCF	-1.80	-4.20	-3.52	-3.19	I,T	1	-4.38*	-3.60	-3.93	-2.61	I	1

Source: Own computation

Note: I denotes constant, I,T denotes constant and trend, None denotes no constant and no trend,* denotes significance at 1% and **denotes significance at 5%. ***denotes significance at 10%. H0: unit root. The decision to reject null hypothesis is made at 5% level of significance. Lag length selection is based on Schwarz's Information criterion.

Table 5 below reports the results of the PP test for debt and investment. This test results is consistent with that of the ADF test above. It is also evident that both variables follow a random walk, as the null hypothesis of unit root cannot be rejected at 5% significance level. Also, by first-differencing of the series, all the variables become stationary, which implies that the series are integrated of order one (I(1)).

Table 6 presents the DF-GLS unit root test results. The evidence from the test results for conflicts with that of the ADF and PP unit test results at 5% significance level, we reject the null hypothesis. On the other hand, the series are stationary at first-difference meaning that the series are integrated of order one (I(1)).

Table 5: Phillip-Perron test (PP) unit root test results

Variables		PP test in level						PP test in first difference				
	Test statistic	Critical value			Model	Band-width	Test statistic	Critical value			Model	Band-width
		1%	5%	10%				1%	5%	10%		
PDT	-2.54	-4.19	-3.52	-3.19	I,T	3	-6.27*	-3.6	-2.94	-2.61	I	11
GDP	-4.32**	-4.19	-3.52	-3.19	I,T	1	-18.99*	-3.6	-2.94	-2.61	I	40
CPI	-4.57	-4.19	-3.52	-3.19	I,T	9	-16.76*	-3.6	-2.94	-2.61	I	21
GFCF	-1.91	-4.19	-3.52	-3.19	I,T	4	-4.52*	-3.6	-2.94	-2.61	I	4

Source: Own computation

Note: I denotes constant, I,T denotes constant and trend, None denotes no constant and no trend,* * denotes significance at 1%, **denotes significance at 5% and *** denotes significance at 10%. H_0: stationary. The decision to reject null hypothesis is made at 5% level of significance. Bandwidth is based on Newey-West.

Table 6: Dickey-Fuller Generalized Least Squares (DF-GLS) unit root test results

Variables	DF-GLS test in level						DF-GLS test in first difference					
	Test statistic	Critical value			Model	Lag	Test statistic	Critical value			Model	Lag
		1%	5%	10%				1%	5%	10%		
PDT	-2.52	-3.77	-3.19	-2.89	I,T	0	-6.09*	-2.62	-1.95	-1.61	I	0
GDP	-4.17*	-3.77	-3.19	-2.89	I,T	0	-6.06*	-2.62	-1.95	-1.61	I	0
CPI	-4.61*	-3.77	-3.19	-2.89	I,T	0	-6.56*	-2.63	-1.95	-1.61	I	3
GFCF	-1.62	-3.77	-3.19	-2.89	I,T	1	-3.11*	-2.62	-1.95	-1.61	I	0

Source: Own computation

Note: I denotes constant, I,T denotes constant and trend, None denotes no constant and no trend,* denotes significance at 1% and **denotes significance at 5%. ***denotes significance at 10%. H0: unit root. The decision to reject null hypothesis is made at 5% level of significance. Lag length selection is based on Schwarz's Information criterion.

The analysis of trends using stationary tests as reported in Table 7. The KPSS stationary test is used as confirmatory test. KPSS results indicate that the null hypothesis of stationarity can be rejected for debt series. However, for GDP growth, we fail to reject null hypothesis of stationarity. The above unit root tests and stationary test show conflicting results. To avoid problem of spurious regression, variables will differenced once, I(1).

Table 7: Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test results

Variables	KPSS test in level						KPSS test in first difference					
	Test statistic	Critical value			Model	Band-width	Test statistic	Critical value			Model	Band-width
		1%	5%	10%				1%	5%	10%		
PDT	0.10*	0.22	0.15	0.12	I,T	4	0.21*	0.74	0.46	0.35	I	11
GDP	0.12*	0.22	0.15	0.12	I,T	1	0.40*	0.74	0.46	0.35	I	23
CPI	-4.61*	-3.77	-3.19	-2.89	I,T	0	-6.56*	-2.63	-1.95	-1.61	I	3
GFCF	0.19**	0,22	0.15	0.12	I,T	5	0.28	0.74	0.46	0.35	I	3

Source: Own computation

Note: Note: I denotes constant, I,T denotes constant and trend, None denotes no constant and no trend ,* denotes significance at 1%, **denotes significance at 5% and ***denotes significance at 10%. H0: stationary. The decision to reject null hypothesis is made at 5% level of significance. Bandwidth is based on Newey-West.

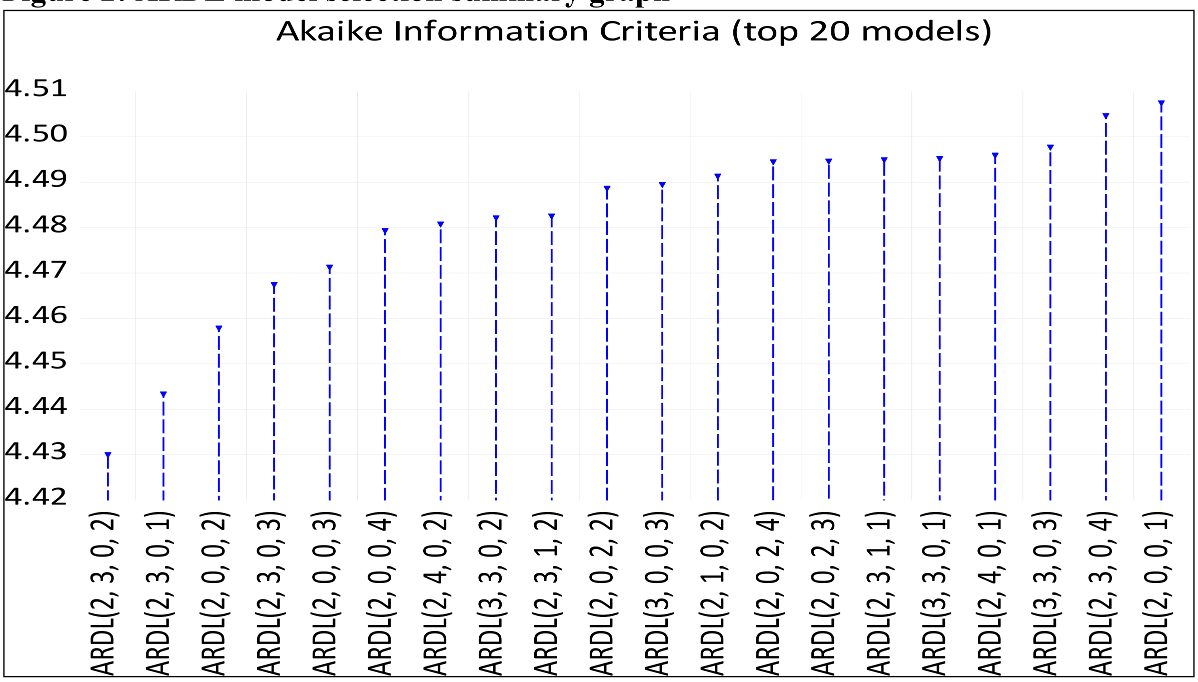
4.4 Empirical Results

To examine the relationship between debt and economic growth, this study adopts several methods to confirm any existing relationship between the two variables based on economic theories discussed in chapter two. This section begins with ARDL bounds cointegration results, followed by long-run regression results and short run regression results. The Granger causality test results will be presented thereafter. Last, the impulse response function and variance decomposition will be interpreted.

4.4.1 ARDL bounds cointegration results

The ARDL model is estimated with automatic lag selection using E-views version ten is ARDL (2,3,0,2) model, it was selected depending on the least Akaike info criterion (AIC) model selection method, as shown in figure 2. There are significant effects of the lags of some of the macroeconomic variables on GDP. There is highly significant effect of the third lag of public debt (DPDT (-3)) and there is no lag of inflation(DCPI) chosen for describe on GDP.

Figure 2: ARDL model selection summary graph



Source: Own computation

Table 8 presents cointegration results of the bounds testing. The ARDL bounds test approach is used to test the null hypothesis that no cointegration exits (against alternative hypothesis that cointegration exists). The computed F-statistic is compared with critical values, when the computed F-statistic is greater than the upper bound (I(1)), the null hypothesis of no integration is rejected. However, if the F-statistic is less than the lower bound (I(0)), we fail to reject the hypothesis of no cointegration (Nurudee, 2017). The model for this study has four variables, as a results there are three independent variables in the model (k=3). The bound test approach determines if long-run relationship exits with the null hypothesis of no long-run relationship. According to the F-statistic computed at 13.62, is greater the upper bound critical value at all level of significance 1%, 5%, 2.5% and 10%. This leads to a conclusion that there is a long-run relationship, cointegration exists amongst variables.

Table 8: **F-Bounds Test results**

Test Statistic	**Value**	**Significant level**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	13.61637	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61
Actual Sample Size	39		Finite Sample: n=40	
		10%	2.933	4.02
		5%	3.548	4.803
		1%	5.018	6.61
			Finite Sample: n=35	
		10%	2.958	4.1
		5%	3.615	4.913
		1%	5.198	6.845

Source: Own computation

Null Hypothesis: No levels relationship

4.4.2 Long and short run regression results

Based on the evidence of the long-run cointegration relationship from Table 8, the coefficients of long run effect are estimated. Table 9 shows short- and long-run coefficients of the public debt– economic growth model. The first part of the ARDL model results in table 10 show short-run cointegration results with short run estimates that include error correction term which represents the speed of adjusting to the long run equilibrium from the short run. In the short run the impact of public debt to growth model is positive and high at 51.41% and gross capital formation at 48.99%. This indicates that both variables enhance economic growth.

Table 9: **ARDL short and long run results**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short-run coefficients				
C	-0.321121	0.29848	-1.07586	0.2912
D(DGDP(-1))	0.634098***	0.17924	3.537725	0.0014
D(DPDT)	0.446496**	0.18894	2.363177	0.0253
D(DPDT(-1))	0.768227***	0.2278	3.372352	0.0022
D(DPDT(-2))	0.514111**	0.20616	2.493706	0.0188
D(DGFCF)	0.694238**	0.28915	2.400935	0.0232
D(DGFCF(-1))	0.489885	0.32608	1.502362	0.1442
CointEq(-1)*	-2.506992***	0.32284	-7.76538	0.000
Long-run coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
DPDT	-0.030107	0.2462	-0.12229	0.9035
DCPI	-0.029733	0.02617	-1.13625	0.2655
DGFCF	-0.1820	0.16088	-1.13127	0.2675
R-squared	0.817467			
Adjusted R-squared	0.776249			
F-statistic	19.83313			
Prob(F-statistic)	0			
Durbin-Watson stat	2.167719			

Source: Own computation
*Note: GDP= GDP growth rate; PDT=Debt to GDP; CPI= Inflation; GFCF=Gross Fixed Capital formation; ***, ** and * denotes significance at 1%, 5% and 10% respectively.*

The error correction term (CointEq(-1)*) indicates how much of the equilibrium error is corrected, that is to the extent to which any disequilibrium in the previous period is being adjusted in current point. A positive coefficient indicates a divergence while a negative coefficient indicates convergence. If the estimate of ECT = 1, then 100% of the adjustment takes place within the period, or the adjustment is instantaneous and full, if the estimate of ECT = 0.5, then 50% of the adjustment takes place each period. If ECT = 0 then there is no adjustment (Asteriou,2011; Abonazel & Elnabawy, 2020). However, the ECT coefficient is negative (-2.506992) and significant, confirming the long run relationship amongst variables with their lags. The coefficient of -2.506992 implies that deviation from the long run growth is corrected at the speed of 250.70%. This also indicates that the existence of oscillatory adjustment process. Oscillatory adjustment process is the fast pace of the model system as it corrects its previous disequilibrium in order to reach long run equilibrium stable range. This implies that public debt, inflation and gross fixed capital formation does not have long-term effect on economic growth (Dávila, Pagán & Soydemir, (2002).

In the long run, the estimated coefficients of the long-run relationship are insignificant for public debt, inflation and gross fixed capital formation. The variable also prove to have negative impact on economic growth. Long-run study results are aligned with the Neoclassical theory that public debt does not lead to economic growth. Following economic theory, it is expected by the Neoclassical school of thought debates that a a negative link between economic growth and public debt exists. Classicists believe that debt-financed public spending does not fully offset the negative impact of private investment spurs, leading to economic decline (Siddiqui & Malik, 2001). The neoclassical theory provides the hypothesis that public debt causes stagnant growth.

Secondly, the Ricardian school views public debt as merely postponing tax and having no real effect (Lee & Ng, 2015). This theory provides the hypothesis, that there is no causal link between public debt and economic growth, known in the literature as the neutral hypothesis (Reinhart& Rogoff 2014; Barro, 1979, 1990). Last, Keynesian (1924) school of thought provides the hypothesis that public debt causes economic growth. According to Makin (2015) the increasing government expenditure is linked to higher national output, leading to employment.

Overall, the study results indicate a significant negative long-run relationship between the public debt and economic growth when inflation and gross capital formation are used as controlled variables. However, the relationship is significant in the short run.

It can be noted in table 9 that the model adopted has high R-squared and adjusted R-squared vales, 81.75% and 77.62% respectively, this signals the sufficient power of the model to predict the relationship between the study variables. The Durbin-Watson test statistic value is withing the range of 1.5 to 2.5 which is a sign of normality in the model.

Table 10: Granger Causality test results

Null Hypothesis:	**Obs**	**F-statistic**	**Prob.**
DPDT does not Granger Cause DGDP	40	2.14541	0.1322
DGDP does not Granger Cause DPDT		4.35754***	0.0204

Source: Own computation
*Note: GDP= GDP growth rate; PDT=Debt to GDP; ** denotes significance at5% and 10% respectively.*

Table 10 above shows granger causality test results, which examines whether public debt causes economic growth or economic growth causes public debt. Using 5% significance level

and looking at the probability values, it is possible to conclude that there is no causality relationship between savings and investment:
We accept the null hypothesis that public debt does not granger cause economic growth and accept the hypothesis that economic growth does not cause public debt.

Table 11 presents the result of variance decomposition test in explaining the GDP growth and public debt co-movement. In the short run, self-variance of GDP growth co-movement is almost 100%, which reduces to 91.79% percent in the long term. Aside from self-variation, public debt induced no notable variation in bilateral co-movement in short term. In the long-run however, maximum variation of 8.22% is provided by public debt. The above statistics suggest that shock in economic growth accounts for 91.78% fluctuations. A shock to public debt causes fluctuations to GDP growth significantly over time.

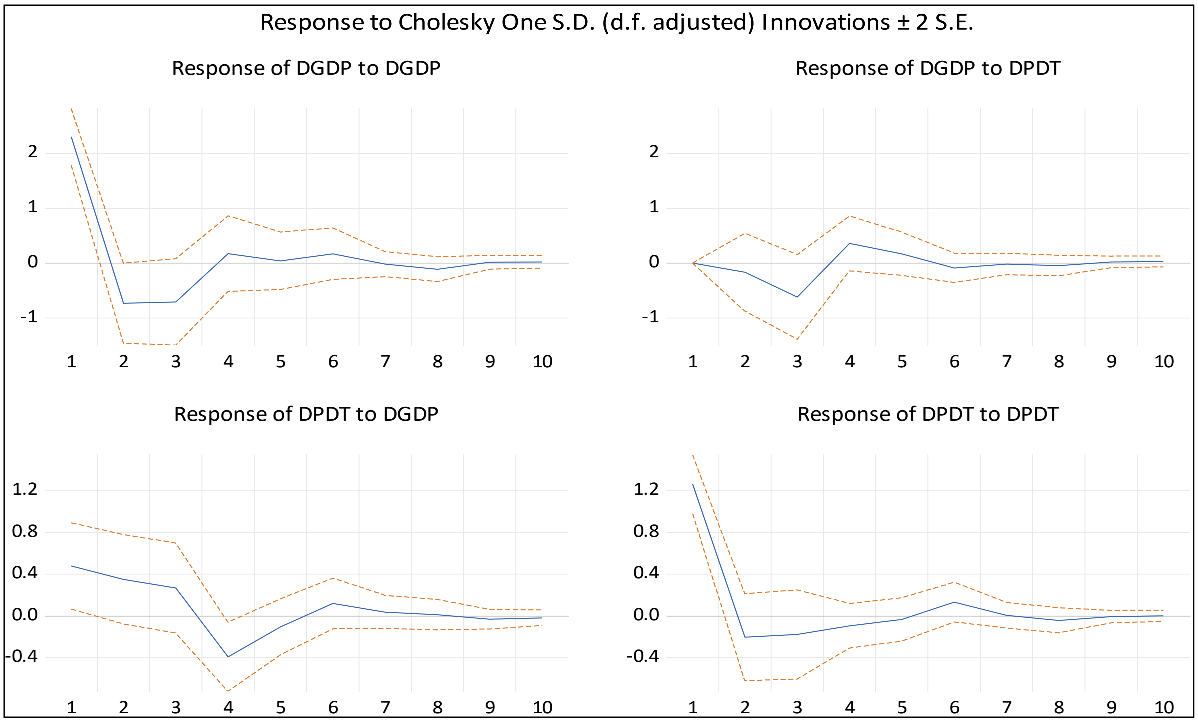
Table 11: **Variance decomposition analysis**

Period	S.E.	DGDP	DPDT
1	2.369905	100	0
2	2.518466	99.3247	0.675299
3	2.675347	94.7451	5.254896
4	2.731202	92.14365	7.856351
5	2.733069	92.02147	7.978526
6	2.739534	91.79065	8.209345
7	2.739882	91.79036	8.209635
8	2.741774	91.79132	8.208676
9	2.742342	91.78511	8.21489
10	2.742456	91.78063	8.219365

Source: Own computation

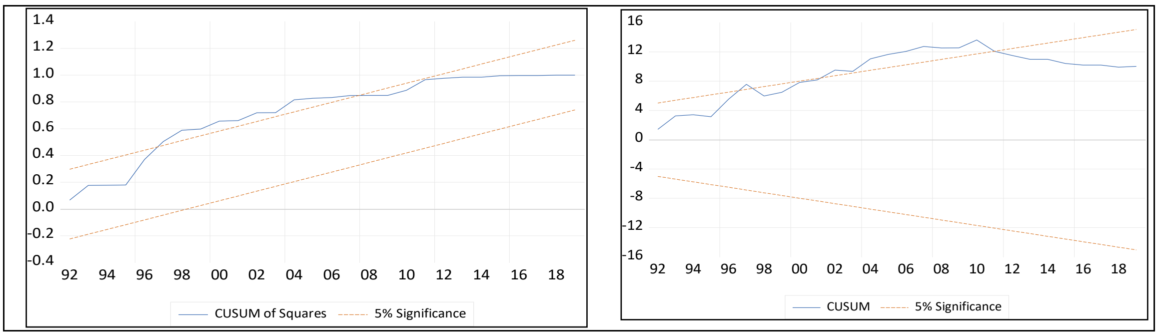
Figure 3 below shows how shock of the movements in variables due to own shock against those other variables by shocking one standard deviation, which brings the variables towards each other. There is responsiveness in public debt and GDP growth to shocks of public debt and GDP growth.

Figure 3: Impulse response results



Source: Own computation

Figure 4: CUSUM stability tests



Source: Own computation

Stability test results are shown in figure 4. The cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) are used to check stability of the model. The test results show evidence that the model is stable over time at 5% significance level. This stability is shown by the movement of blue lines located within the critical lines (two-red dotted lines) in the figures.

CHAPTER FIVE

CONCLUSION

5.1 Introduction

This final chapter summarises the main findings of this study in relation to the research questions and objectives as articulated in Chapter One.

5.2 Main Findings

The aim of this research was to review economic theory relating to public debt and economic. Also examine the statistical relationship between the study two variables. Based on the evidence from the estimation results of the two empirical frameworks employed in this study, the highlights of the finding can be summarised as follows:

First, public debt remains a macroeconomic problem and one of the hot debates involving economic growth in South Africa. The ratio of public debt to GDP ratio has significantly increased. This study also notes the inherence of public debt from the apartheid government which the post-apartheid government had to manage. However, over the year this public debt has increased to new record high levels.

Second, economic theory debate about the relationship between public debt and economic growth was reviewed. The Neoclassical theory claims that debt-financed public spending has a negative impact on economic growth. On the other side, the Ricardian school views public debt as merely postponing tax and having no real effect. Whilst the Keynesian theory claims that public debt causes economic growth. This raises a question of causality between public debt and economic growth.

Last, empirical findings of the study show that the is no causality that runs from public debt to economic growth. The study found causality which runs from economic growth to public debt and investment but not that of government savings. Therefore, this study rejects the Neoclassic theory and Ricardian theory as the empirical results are aligned with the Keynesian theory in the South African context. However, a long-run positive relationship between the two study variables exists.

Another important finding is that the results also suggest that the inclusion of control variables in the estimation of growth equation has an important impact on the GDP growth rate. Inflation and Gross Fixed Capital formation has a negative relationship with economic growth.

5.3 Policy Recommendations

The empirical study results of this study provide policy makers with a better macroeconomic understanding of public debt in relation to economic growth. It is recommended that government pay particular attention to its expenditures and revenue collection in order to minimize the need to attain more public debt. Government must make fiscal adjustments through cuts in expenditures, this will lead to reduced level of deficit financing. This should become top priority in South Africa as the economy heavy depends on government in most parts of the country.

As a policy recommendation, South Africa needs undertake aggressive economic strategies with clear objectives and strong commitments, driven by accountable bureaucrats to ensure that public funds are used efficiently. Public debt also needs to be directed through economic growth driven projects and productive expenditures. This will ensure that public debt in both the short and long run stimulates aggregate demand and thus, economic growth. Policies aimed at debt management, economic frameworks and supportive projects will increase economic growth. Similar to Ncwaywa and Masoga (2018), this study suggests that public debt needs to be managed as high public debt would have negative effects in the long run and later stage of borrowing will lead to subdued growth.

5.4 Limitations of the study and avenues for future research

It is important at this juncture to at least point out a limitation of this study. The analysis of trends in public debt and economic growth focused only on linear unit root tests without structural breaks. Therefore, this study suggests that further studies on trend analysis should incorporate a non-linear unit root test and unit root tests with structural breaks. Further studies may also explore the relationship between the study variables using a non-linear ARDL model. Future studies may divide the period of study into those specific phases of South Africa's economic and political transformation could give more relevant results of the relationship between these two variables. Finally, many other macroeconomic variables can be included in the model to better understand the relationship between public debt and economic growth.

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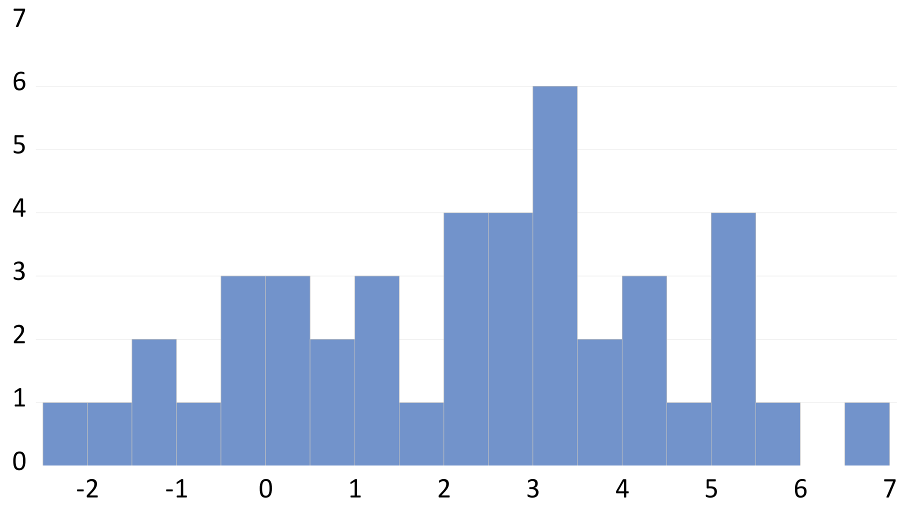
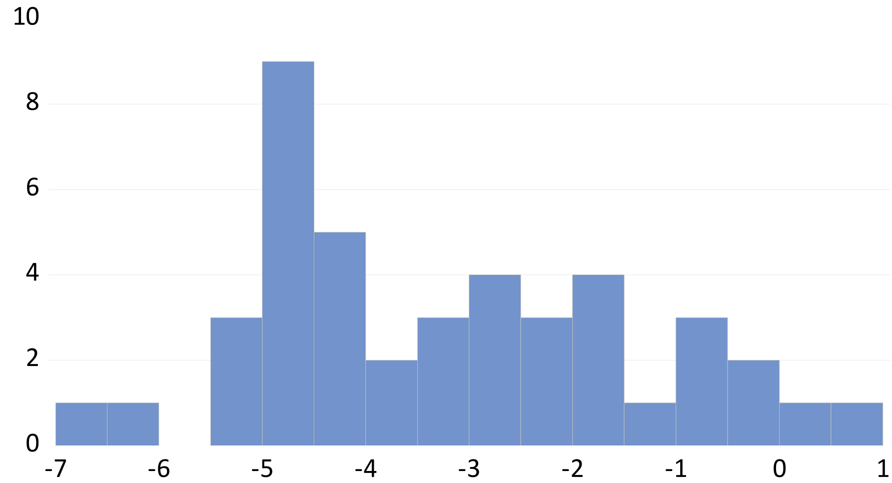
Figure xx: Histograms



Series: GDP	
Sample 1977 2019	
Observations 43	
Mean	2.230233
Median	2.500000
Maximum	6.600000
Minimum	-2.100000
Std. Dev.	2.218701
Skewness	-0.151423
Kurtosis	2.204038
Jarque-Bera	1.299445
Probability	0.522191



Series: PDT	
Sample 1977 2019	
Observations 43	
Mean	-3.227907
Median	-3.400000
Maximum	0.700000
Minimum	-6.600000
Std. Dev.	1.806249
Skewness	0.366319
Kurtosis	2.247882
Jarque-Bera	1.975203
Probability	0.372469

Figure xx: Unit Root Test results

Augmented Dickey-Fuller test

Null Hypothesis: PDT has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.511859	0.3212
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PDT)
Method: Least Squares

Date: 02/18/21 Time: 16:34
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PDT(-1)	-0.294993	0.117440	-2.511859	0.0163
C	-0.604932	0.550522	-1.098832	0.2786
@TREND("1977")	-0.016843	0.016913	-0.995816	0.3255

R-squared	0.154902	Mean dependent var	-0.035714
Adjusted R-squared	0.111564	S.D. dependent var	1.408826
S.E. of regression	1.327916	Akaike info criterion	3.473847
Sum squared resid	68.77104	Schwarz criterion	3.597967
Log likelihood	-69.95079	Hannan-Quinn criter.	3.519342
F-statistic	3.574254	Durbin-Watson stat	1.739471
Prob(F-statistic)	0.037557		

Null Hypothesis: D(PDT) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.060881	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PDT,2)
Method: Least Squares
Date: 02/18/21 Time: 16:35
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PDT(-1))	-1.003425	0.165558	-6.060881	0.0000
C	-0.036519	0.225613	-0.161864	0.8722

R-squared	0.485042	Mean dependent var	-0.056098
Adjusted R-squared	0.471838	S.D. dependent var	1.987593
S.E. of regression	1.444479	Akaike info criterion	3.620925
Sum squared resid	81.37423	Schwarz criterion	3.704513
Log likelihood	-72.22895	Hannan-Quinn criter.	3.651363
F-statistic	36.73427	Durbin-Watson stat	1.936069
Prob(F-statistic)	0.000000		

Null Hypothesis: GDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.247411	0.0087
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	

	10% level	-3.191277	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 02/18/21 Time: 16:37
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	-0.629363	0.148176	-4.247411	0.0001
C	1.660942	0.731978	2.269115	0.0289
@TREND("1977")	-0.010221	0.026845	-0.380742	0.7055

R-squared	0.320101	Mean dependent var	0.007143
Adjusted R-squared	0.285234	S.D. dependent var	2.491879
S.E. of regression	2.106730	Akaike info criterion	4.396900
Sum squared resid	173.0941	Schwarz criterion	4.521019
Log likelihood	-89.33490	Hannan-Quinn criter.	4.442395
F-statistic	9.180714	Durbin-Watson stat	1.809515
Prob(F-statistic)	0.000540		

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.614243	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GDP,2)
Method: Least Squares
Date: 02/18/21 Time: 16:39
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	-1.176856	0.154560	-7.614243	0.0000
C	-0.064410	0.384873	-0.167355	0.8680

R-squared	0.597842	Mean dependent var	-0.090244
Adjusted R-squared	0.587530	S.D. dependent var	3.837043
S.E. of regression	2.464297	Akaike info criterion	4.689241
Sum squared resid	236.8376	Schwarz criterion	4.772830
Log likelihood	-94.12943	Hannan-Quinn criter.	4.719679
F-statistic	57.97669	Durbin-Watson stat	2.145897
Prob(F-statistic)	0.000000		

Null Hypothesis: BD has a unit root
Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.511859	0.3212
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BD)
Method: Least Squares
Date: 02/18/21 Time: 21:11
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BD(-1)	-0.294993	0.117440	-2.511859	0.0163
C	-0.604932	0.550522	-1.098832	0.2786
@TREND("1977")	-0.016843	0.016913	-0.995816	0.3255

R-squared	0.154902	Mean dependent var	-0.035714
Adjusted R-squared	0.111564	S.D. dependent var	1.408826
S.E. of regression	1.327916	Akaike info criterion	3.473847
Sum squared resid	68.77104	Schwarz criterion	3.597967
Log likelihood	-69.95079	Hannan-Quinn criter.	3.519342
F-statistic	3.574254	Durbin-Watson stat	1.739471
Prob(F-statistic)	0.037557		

Null Hypothesis: D(BD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.060881	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BD,2)
Method: Least Squares
Date: 02/18/21 Time: 21:15
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BD(-1))	-1.003425	0.165558	-6.060881	0.0000
C	-0.036519	0.225613	-0.161864	0.8722

R-squared	0.485042	Mean dependent var	-0.056098
Adjusted R-squared	0.471838	S.D. dependent var	1.987593
S.E. of regression	1.444479	Akaike info criterion	3.620925
Sum squared resid	81.37423	Schwarz criterion	3.704513
Log likelihood	-72.22895	Hannan-Quinn criter.	3.651363
F-statistic	36.73427	Durbin-Watson stat	1.936069

Prob(F-statistic)	0.000000

Null Hypothesis: CPI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.750121	0.0022
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CPI)
Method: Least Squares
Date: 02/18/21 Time: 21:18
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI(-1)	-0.717432	0.151034	-4.750121	0.0000
C	12.42499	2.916397	4.260391	0.0001
@TREND("1977")	-0.227429	0.071270	-3.191080	0.0028

R-squared	0.367967	Mean dependent var	-0.197619
Adjusted R-squared	0.335555	S.D. dependent var	5.448315
S.E. of regression	4.441112	Akaike info criterion	5.888436
Sum squared resid	769.2157	Schwarz criterion	6.012555
Log likelihood	-120.6572	Hannan-Quinn criter.	5.933931
F-statistic	11.35282	Durbin-Watson stat	1.921665
Prob(F-statistic)	0.000130		

Null Hypothesis: D(CPI) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.836995	0.0000
Test critical values:	1% level	-3.615588	
	5% level	-2.941145	
	10% level	-2.609066	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CPI,2)
Method: Least Squares
Date: 02/18/21 Time: 21:19
Sample (adjusted): 1982 2019
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CPI(-1))	-3.023186	0.442180	-6.836995	0.0000
D(CPI(-1),2)	1.462612	0.351258	4.163923	0.0002
D(CPI(-2),2)	0.940738	0.254326	3.698951	0.0008

D(CPI(-3),2)	0.443301	0.152423	2.908357	0.0065
C	-0.924921	0.762158	-1.213555	0.2335

R-squared	0.761697	Mean dependent var	-0.073684
Adjusted R-squared	0.732812	S.D. dependent var	9.012264
S.E. of regression	4.658458	Akaike info criterion	6.037325
Sum squared resid	716.1407	Schwarz criterion	6.252797
Log likelihood	-109.7092	Hannan-Quinn criter.	6.113989
F-statistic	26.36985	Durbin-Watson stat	2.020507
Prob(F-statistic)	0.000000		

Null Hypothesis: GFCF has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.796760	0.6881
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GFCF)
Method: Least Squares
Date: 02/18/21 Time: 21:24
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GFCF(-1)	-0.102358	0.056968	-1.796760	0.0805
D(GFCF(-1))	0.358545	0.143813	2.493130	0.0173
C	2.197713	1.477872	1.487080	0.1455
@TREND("1977")	-0.011202	0.020009	-0.559877	0.5789

R-squared	0.213485	Mean dependent var	-0.243902
Adjusted R-squared	0.149714	S.D. dependent var	1.302315
S.E. of regression	1.200877	Akaike info criterion	3.296450
Sum squared resid	53.35794	Schwarz criterion	3.463627
Log likelihood	-63.57722	Hannan-Quinn criter.	3.357327
F-statistic	3.347658	Durbin-Watson stat	1.701624
Prob(F-statistic)	0.029269		

Null Hypothesis: D(GFCF) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.380047	0.0012
Test critical values:	1% level	-3.605593	
	5% level	-2.936942	
	10% level	-2.606857	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GFCF,2)

Method: Least Squares
Date: 02/18/21 Time: 21:24
Sample (adjusted): 1980 2019
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GFCF(-1))	-0.756424	0.172698	-4.380047	0.0001
D(GFCF(-1),2)	0.238172	0.149938	1.588473	0.1207
C	-0.197723	0.196623	-1.005595	0.3211

R-squared	0.349984	Mean dependent var	-8.47E-17
Adjusted R-squared	0.314848	S.D. dependent var	1.458310
S.E. of regression	1.207100	Akaike info criterion	3.286356
Sum squared resid	53.91231	Schwarz criterion	3.413022
Log likelihood	-62.72713	Hannan-Quinn criter.	3.332155
F-statistic	9.960845	Durbin-Watson stat	2.051984
Prob(F-statistic)	0.000346		

Phillip-Perron test (PP) Unit Root Test

Null Hypothesis: PDT has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.538904	0.3090
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Residual variance (no correction)	1.637406
HAC corrected variance (Bartlett kernel)	1.677134

Phillips-Perron Test Equation
Dependent Variable: D(PDT)
Method: Least Squares
Date: 02/18/21 Time: 16:41
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PDT(-1)	-0.294993	0.117440	-2.511859	0.0163
C	-0.604932	0.550522	-1.098832	0.2786
@TREND("1977")	-0.016843	0.016913	-0.995816	0.3255

R-squared	0.154902	Mean dependent var	-0.035714
Adjusted R-squared	0.111564	S.D. dependent var	1.408826
S.E. of regression	1.327916	Akaike info criterion	3.473847
Sum squared resid	68.77104	Schwarz criterion	3.597967
Log likelihood	-69.95079	Hannan-Quinn criter.	3.519342
F-statistic	3.574254	Durbin-Watson stat	1.739471
Prob(F-statistic)	0.037557		

Null Hypothesis: D(PDT) has a unit root
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.271622	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Residual variance (no correction)	1.984737
HAC corrected variance (Bartlett kernel)	0.943795

Phillips-Perron Test Equation
Dependent Variable: D(PDT,2)
Method: Least Squares
Date: 02/18/21 Time: 16:41
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PDT(-1))	-1.003425	0.165558	-6.060881	0.0000
C	-0.036519	0.225613	-0.161864	0.8722

R-squared	0.485042	Mean dependent var	-0.056098
Adjusted R-squared	0.471838	S.D. dependent var	1.987593
S.E. of regression	1.444479	Akaike info criterion	3.620925
Sum squared resid	81.37423	Schwarz criterion	3.704513
Log likelihood	-72.22895	Hannan-Quinn criter.	3.651363
F-statistic	36.73427	Durbin-Watson stat	1.936069
Prob(F-statistic)	0.000000		

Null Hypothesis: GDP has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.321971	0.0071
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Residual variance (no correction)	4.121289
HAC corrected variance (Bartlett kernel)	4.469929

Phillips-Perron Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 02/18/21 Time: 16:43
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	-0.629363	0.148176	-4.247411	0.0001
C	1.660942	0.731978	2.269115	0.0289
@TREND("1977")	-0.010221	0.026845	-0.380742	0.7055

R-squared	0.320101	Mean dependent var	0.007143
Adjusted R-squared	0.285234	S.D. dependent var	2.491879
S.E. of regression	2.106730	Akaike info criterion	4.396900
Sum squared resid	173.0941	Schwarz criterion	4.521019
Log likelihood	-89.33490	Hannan-Quinn criter.	4.442395
F-statistic	9.180714	Durbin-Watson stat	1.809515
Prob(F-statistic)	0.000540		

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Bandwidth: 40 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-18.99425	0.0001
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Residual variance (no correction)	5.776527
HAC corrected variance (Bartlett kernel)	0.355854

Phillips-Perron Test Equation
Dependent Variable: D(GDP,2)
Method: Least Squares
Date: 02/18/21 Time: 16:43
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	-1.176856	0.154560	-7.614243	0.0000
C	-0.064410	0.384873	-0.167355	0.8680

R-squared	0.597842	Mean dependent var	-0.090244
Adjusted R-squared	0.587530	S.D. dependent var	3.837043
S.E. of regression	2.464297	Akaike info criterion	4.689241
Sum squared resid	236.8376	Schwarz criterion	4.772830
Log likelihood	-94.12943	Hannan-Quinn criter.	4.719679
F-statistic	57.97669	Durbin-Watson stat	2.145897
Prob(F-statistic)	0.000000		

Null Hypothesis: BD has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.538904	0.3090
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Residual variance (no correction)	1.637406
HAC corrected variance (Bartlett kernel)	1.677134

Phillips-Perron Test Equation
Dependent Variable: D(BD)
Method: Least Squares
Date: 02/18/21 Time: 21:32
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BD(-1)	-0.294993	0.117440	-2.511859	0.0163
C	-0.604932	0.550522	-1.098832	0.2786
@TREND("1977")	-0.016843	0.016913	-0.995816	0.3255

R-squared	0.154902	Mean dependent var	-0.035714
Adjusted R-squared	0.111564	S.D. dependent var	1.408826
S.E. of regression	1.327916	Akaike info criterion	3.473847
Sum squared resid	68.77104	Schwarz criterion	3.597967
Log likelihood	-69.95079	Hannan-Quinn criter.	3.519342
F-statistic	3.574254	Durbin-Watson stat	1.739471
Prob(F-statistic)	0.037557		

Null Hypothesis: D(BD) has a unit root
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.271622	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Residual variance (no correction)	1.984737
HAC corrected variance (Bartlett kernel)	0.943795

Phillips-Perron Test Equation
Dependent Variable: D(BD,2)
Method: Least Squares
Date: 02/18/21 Time: 21:33
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BD(-1))	-1.003425	0.165558	-6.060881	0.0000
C	-0.036519	0.225613	-0.161864	0.8722

R-squared	0.485042	Mean dependent var	-0.056098
Adjusted R-squared	0.471838	S.D. dependent var	1.987593
S.E. of regression	1.444479	Akaike info criterion	3.620925
Sum squared resid	81.37423	Schwarz criterion	3.704513

Log likelihood	-72.22895	Hannan-Quinn criter.	3.651363
F-statistic	36.73427	Durbin-Watson stat	1.936069
Prob(F-statistic)	0.000000		

Null Hypothesis: CPI has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 9 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.569872	0.0037
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Residual variance (no correction)	18.31466
HAC corrected variance (Bartlett kernel)	12.20598

Phillips-Perron Test Equation
Dependent Variable: D(CPI)
Method: Least Squares
Date: 02/18/21 Time: 21:36
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI(-1)	-0.717432	0.151034	-4.750121	0.0000
C	12.42499	2.916397	4.260391	0.0001
@TREND("1977")	-0.227429	0.071270	-3.191080	0.0028

R-squared	0.367967	Mean dependent var	-0.197619
Adjusted R-squared	0.335555	S.D. dependent var	5.448315
S.E. of regression	4.441112	Akaike info criterion	5.888436
Sum squared resid	769.2157	Schwarz criterion	6.012555
Log likelihood	-120.6572	Hannan-Quinn criter.	5.933931
F-statistic	11.35282	Durbin-Watson stat	1.921665
Prob(F-statistic)	0.000130		

Null Hypothesis: D(CPI) has a unit root
Exogenous: Constant
Bandwidth: 21 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-16.76188	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Residual variance (no correction)	27.97903
HAC corrected variance (Bartlett kernel)	2.645614

Phillips-Perron Test Equation
Dependent Variable: D(CPI,2)
Method: Least Squares
Date: 02/18/21 Time: 21:37
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CPI(-1))	-1.238814	0.155461	-7.968642	0.0000
C	-0.261814	0.847558	-0.308905	0.7590

R-squared	0.619509	Mean dependent var	-0.017073
Adjusted R-squared	0.609753	S.D. dependent var	8.681731
S.E. of regression	5.423454	Akaike info criterion	6.266893
Sum squared resid	1147.140	Schwarz criterion	6.350482
Log likelihood	-126.4713	Hannan-Quinn criter.	6.297332
F-statistic	63.49926	Durbin-Watson stat	2.105069
Prob(F-statistic)	0.000000		

Null Hypothesis: GFCF has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.905269	0.6341
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

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

Residual variance (no correction)	1.547813
HAC corrected variance (Bartlett kernel)	1.778123

Phillips-Perron Test Equation
Dependent Variable: D(GFCF)
Method: Least Squares
Date: 02/18/21 Time: 21:39
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GFCF(-1)	-0.109152	0.058496	-1.865967	0.0696
C	1.869424	1.531651	1.220528	0.2296
@TREND("1977")	0.003297	0.020719	0.159138	0.8744

R-squared	0.136176	Mean dependent var	-0.309524
Adjusted R-squared	0.091877	S.D. dependent var	1.354812
S.E. of regression	1.291075	Akaike info criterion	3.417577
Sum squared resid	65.00814	Schwarz criterion	3.541696
Log likelihood	-68.76912	Hannan-Quinn criter.	3.463072
F-statistic	3.074031	Durbin-Watson stat	1.235905
Prob(F-statistic)	0.057583		

Null Hypothesis: D(GFCF) has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.523146	0.0008
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Residual variance (no correction)	1.426676
HAC corrected variance (Bartlett kernel)	1.236769

Phillips-Perron Test Equation
Dependent Variable: D(GFCF,2)
Method: Least Squares
Date: 02/18/21 Time: 21:40
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GFCF(-1))	-0.647571	0.141173	-4.587076	0.0000
C	-0.134735	0.196198	-0.686732	0.4963

R-squared	0.350447	Mean dependent var	0.065854
Adjusted R-squared	0.333792	S.D. dependent var	1.500435
S.E. of regression	1.224679	Akaike info criterion	3.290785
Sum squared resid	58.49370	Schwarz criterion	3.374374
Log likelihood	-65.46109	Hannan-Quinn criter.	3.321223
F-statistic	21.04127	Durbin-Watson stat	1.727788
Prob(F-statistic)	0.000046		

The Dickey-Fuller Generalized Least Squares (DF-GLS)

Null Hypothesis: PDT has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-2.516697
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 42

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/18/21 Time: 16:47
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.284550	0.113065	-2.516697	0.0159

R-squared	0.133395	Mean dependent var	-0.030493
Adjusted R-squared	0.133395	S.D. dependent var	1.408826
S.E. of regression	1.311499	Akaike info criterion	3.403740
Sum squared resid	70.52122	Schwarz criterion	3.445113
Log likelihood	-70.47854	Hannan-Quinn criter.	3.418905
Durbin-Watson stat	1.713137		

Null Hypothesis: D(PDT) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-6.088245
Test critical values:	1% level	-2.622585
	5% level	-1.949097
	10% level	-1.611824

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/18/21 Time: 16:47
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.990197	0.162641	-6.088245	0.0000

R-squared	0.480545	Mean dependent var	-0.056098
Adjusted R-squared	0.480545	S.D. dependent var	1.987593
S.E. of regression	1.432522	Akaike info criterion	3.580837
Sum squared resid	82.08471	Schwarz criterion	3.622632
Log likelihood	-72.40716	Hannan-Quinn criter.	3.596057
Durbin-Watson stat	1.940432		

Null Hypothesis: GDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-4.171677
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 42

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/18/21 Time: 16:48
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.600597	0.143970	-4.171677	0.0002

R-squared	0.297961	Mean dependent var	-0.012839
Adjusted R-squared	0.297961	S.D. dependent var	2.491879
S.E. of regression	2.087890	Akaike info criterion	4.333706
Sum squared resid	178.7307	Schwarz criterion	4.375080
Log likelihood	-90.00784	Hannan-Quinn criter.	4.348871
Durbin-Watson stat	1.799241		

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-6.057355
Test critical values:	1% level	-2.622585
	5% level	-1.949097
	10% level	-1.611824

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/18/21 Time: 16:48
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.955933	0.157814	-6.057355	0.0000

R-squared	0.478134	Mean dependent var	-0.090244
Adjusted R-squared	0.478134	S.D. dependent var	3.837043
S.E. of regression	2.771890	Akaike info criterion	4.901024
Sum squared resid	307.3350	Schwarz criterion	4.942818
Log likelihood	-99.47099	Hannan-Quinn criter.	4.916243
Durbin-Watson stat	1.980141		

Null Hypothesis: D(BD) has a unit root
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.271622	0.0000
Test critical values:	1% level	-3.600987	
	5% level	-2.935001	
	10% level	-2.605836	

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

Residual variance (no correction)	1.984737
HAC corrected variance (Bartlett kernel)	0.943795

Phillips-Perron Test Equation
Dependent Variable: D(BD,2)

Method: Least Squares
Date: 02/18/21 Time: 21:29
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(BD(-1))	-1.003425	0.165558	-6.060881	0.0000
C	-0.036519	0.225613	-0.161864	0.8722

R-squared	0.485042	Mean dependent var	-0.056098
Adjusted R-squared	0.471838	S.D. dependent var	1.987593
S.E. of regression	1.444479	Akaike info criterion	3.620925
Sum squared resid	81.37423	Schwarz criterion	3.704513
Log likelihood	-72.22895	Hannan-Quinn criter.	3.651363
F-statistic	36.73427	Durbin-Watson stat	1.936069
Prob(F-statistic)	0.000000		

Null Hypothesis: BD has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-2.516697
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 42

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/18/21 Time: 22:03
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.284550	0.113065	-2.516697	0.0159

R-squared	0.133395	Mean dependent var	-0.030493
Adjusted R-squared	0.133395	S.D. dependent var	1.408826
S.E. of regression	1.311499	Akaike info criterion	3.403740
Sum squared resid	70.52122	Schwarz criterion	3.445113
Log likelihood	-70.47854	Hannan-Quinn criter.	3.418905
Durbin-Watson stat	1.713137		

Null Hypothesis: D(BD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-6.088245
Test critical values:	1% level	-2.622585
	5% level	-1.949097
	10% level	-1.611824

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/18/21 Time: 22:07
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.990197	0.162641	-6.088245	0.0000

R-squared	0.480545	Mean dependent var	-0.056098
Adjusted R-squared	0.480545	S.D. dependent var	1.987593
S.E. of regression	1.432522	Akaike info criterion	3.580837
Sum squared resid	82.08471	Schwarz criterion	3.622632
Log likelihood	-72.40716	Hannan-Quinn criter.	3.596057
Durbin-Watson stat	1.940432		

Null Hypothesis: CPI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-4.608965
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 42

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:31
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.678655	0.147247	-4.608965	0.0000

R-squared	0.341260	Mean dependent var	0.034068
Adjusted R-squared	0.341260	S.D. dependent var	5.448315
S.E. of regression	4.422004	Akaike info criterion	5.834585
Sum squared resid	801.7190	Schwarz criterion	5.875958
Log likelihood	-121.5263	Hannan-Quinn criter.	5.849750
Durbin-Watson stat	1.907183		

Null Hypothesis: D(CPI) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-6.562643
Test critical values:	1% level	-2.627238

	5% level	-1.949856
	10% level	-1.611469

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:32
Sample (adjusted): 1982 2019
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-2.914232	0.444064	-6.562643	0.0000
D(GLSRESID(-1))	1.386181	0.353833	3.917619	0.0004
D(GLSRESID(-2))	0.893195	0.256912	3.476662	0.0014
D(GLSRESID(-3))	0.418646	0.154279	2.713567	0.0104

R-squared	0.745494	Mean dependent var	-0.073684
Adjusted R-squared	0.723037	S.D. dependent var	9.012264
S.E. of regression	4.742905	Akaike info criterion	6.050477
Sum squared resid	764.8351	Schwarz criterion	6.222855
Log likelihood	-110.9591	Hannan-Quinn criter.	6.111808
Durbin-Watson stat	1.948527		

Null Hypothesis: GFCF has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-1.617748
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 41

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:33
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.085048	0.052572	-1.617748	0.1138
D(GLSRESID(-1))	0.389508	0.138710	2.808079	0.0077

R-squared	0.190856	Mean dependent var	0.033680
Adjusted R-squared	0.170109	S.D. dependent var	1.302315
S.E. of regression	1.186388	Akaike info criterion	3.227254
Sum squared resid	54.89312	Schwarz criterion	3.310843
Log likelihood	-64.15871	Hannan-Quinn criter.	3.257692
Durbin-Watson stat	1.730027		

Null Hypothesis: D(GFCF) has a unit root

Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-3.105325
Test critical values:	1% level	-2.622585
	5% level	-1.949097
	10% level	-1.611824

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:34
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.381803	0.122951	-3.105325	0.0035

R-squared	0.192657	Mean dependent var	0.065854
Adjusted R-squared	0.192657	S.D. dependent var	1.500435
S.E. of regression	1.348175	Akaike info criterion	3.459469
Sum squared resid	72.70304	Schwarz criterion	3.501263
Log likelihood	-69.91911	Hannan-Quinn criter.	3.474688
Durbin-Watson stat	1.781800		

The KPSS test

Null Hypothesis: PDT is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.098368
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	3.156744
HAC corrected variance (Bartlett kernel)	8.425654

KPSS Test Equation
Dependent Variable: PDT
Method: Least Squares
Date: 02/18/21 Time: 16:54
Sample: 1977 2019
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.935201	0.545414	-5.381606	0.0000
@TREND("1977")	-0.013938	0.022360	-0.623369	0.5365

R-squared	0.009389	Mean dependent var	-3.227907
Adjusted R-squared	-0.014772	S.D. dependent var	1.806249
S.E. of regression	1.819542	Akaike info criterion	4.080441
Sum squared resid	135.7400	Schwarz criterion	4.162358
Log likelihood	-85.72949	Hannan-Quinn criter.	4.110650
F-statistic	0.388589	Durbin-Watson stat	0.599649
Prob(F-statistic)	0.536495		

Null Hypothesis: D(PDT) is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.216345
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	1.937534
HAC corrected variance (Bartlett kernel)	0.920262

KPSS Test Equation
Dependent Variable: D(PDT)
Method: Least Squares
Date: 02/18/21 Time: 16:54
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.035714	0.217387	-0.164289	0.8703

R-squared	0.000000	Mean dependent var	-0.035714
Adjusted R-squared	0.000000	S.D. dependent var	1.408826
S.E. of regression	1.408826	Akaike info criterion	3.546912
Sum squared resid	81.37643	Schwarz criterion	3.588285
Log likelihood	-73.48516	Hannan-Quinn criter.	3.562077
Durbin-Watson stat	1.943437		

Null Hypothesis: GDP is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.119436
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	4.808064
HAC corrected variance (Bartlett kernel)	6.544824

KPSS Test Equation
Dependent Variable: GDP
Method: Least Squares
Date: 02/18/21 Time: 16:55
Sample: 1977 2019
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.214059	0.673118	3.289258	0.0021
@TREND("1977")	0.000770	0.027595	0.027909	0.9779

R-squared	0.000019	Mean dependent var	2.230233
Adjusted R-squared	-0.024371	S.D. dependent var	2.218701
S.E. of regression	2.245574	Akaike info criterion	4.501195
Sum squared resid	206.7468	Schwarz criterion	4.583111
Log likelihood	-94.77569	Hannan-Quinn criter.	4.531403
F-statistic	0.000779	Durbin-Watson stat	1.231408
Prob(F-statistic)	0.977870		

Null Hypothesis: D(GDP) is stationary
Exogenous: Constant
Bandwidth: 23 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.389856
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	6.061616
HAC corrected variance (Bartlett kernel)	0.598239

KPSS Test Equation
Dependent Variable: D(GDP)
Method: Least Squares
Date: 02/18/21 Time: 16:56
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007143	0.384505	0.018577	0.9853

R-squared	0.000000	Mean dependent var	0.007143
Adjusted R-squared	0.000000	S.D. dependent var	2.491879
S.E. of regression	2.491879	Akaike info criterion	4.687472
Sum squared resid	254.5879	Schwarz criterion	4.728846
Log likelihood	-97.43692	Hannan-Quinn criter.	4.702637
Durbin-Watson stat	2.314525		

Null Hypothesis: BD has a unit root
Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-2.516697
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 42

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:39
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.284550	0.113065	-2.516697	0.0159

R-squared	0.133395	Mean dependent var	-0.030493
Adjusted R-squared	0.133395	S.D. dependent var	1.408826
S.E. of regression	1.311499	Akaike info criterion	3.403740
Sum squared resid	70.52122	Schwarz criterion	3.445113
Log likelihood	-70.47854	Hannan-Quinn criter.	3.418905
Durbin-Watson stat	1.713137		

Null Hypothesis: D(BD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-6.088245
Test critical values:	1% level	-2.622585
	5% level	-1.949097
	10% level	-1.611824

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:41
Sample (adjusted): 1979 2019
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.990197	0.162641	-6.088245	0.0000

R-squared	0.480545	Mean dependent var	-0.056098
Adjusted R-squared	0.480545	S.D. dependent var	1.987593
S.E. of regression	1.432522	Akaike info criterion	3.580837
Sum squared resid	82.08471	Schwarz criterion	3.622632
Log likelihood	-72.40716	Hannan-Quinn criter.	3.596057
Durbin-Watson stat	1.940432		

Null Hypothesis: CPI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-4.608965
Test critical values:	1% level	-3.770000
	5% level	-3.190000
	10% level	-2.890000

*Elliott-Rothenberg-Stock (1996, Table 1)
Warning: Test critical values calculated for 50 observations
and may not be accurate for a sample size of 42

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:42
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-0.678655	0.147247	-4.608965	0.0000

R-squared	0.341260	Mean dependent var	0.034068
Adjusted R-squared	0.341260	S.D. dependent var	5.448315
S.E. of regression	4.422004	Akaike info criterion	5.834585
Sum squared resid	801.7190	Schwarz criterion	5.875958
Log likelihood	-121.5263	Hannan-Quinn criter.	5.849750
Durbin-Watson stat	1.907183		

Null Hypothesis: D(CPI) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=9)

		t-Statistic
Elliott-Rothenberg-Stock DF-GLS test statistic		-6.562643
Test critical values:	1% level	-2.627238
	5% level	-1.949856
	10% level	-1.611469

*MacKinnon (1996)

DF-GLS Test Equation on GLS Detrended Residuals
Dependent Variable: D(GLSRESID)
Method: Least Squares
Date: 02/19/21 Time: 08:43
Sample (adjusted): 1982 2019
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GLSRESID(-1)	-2.914232	0.444064	-6.562643	0.0000
D(GLSRESID(-1))	1.386181	0.353833	3.917619	0.0004
D(GLSRESID(-2))	0.893195	0.256912	3.476662	0.0014
D(GLSRESID(-3))	0.418646	0.154279	2.713567	0.0104

R-squared	0.745494	Mean dependent var	-0.073684
Adjusted R-squared	0.723037	S.D. dependent var	9.012264
S.E. of regression	4.742905	Akaike info criterion	6.050477

Sum squared resid	764.8351	Schwarz criterion	6.222855
Log likelihood	-110.9591	Hannan-Quinn criter.	6.111808
Durbin-Watson stat	1.948527		

Null Hypothesis: GFCF is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.190850
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	11.40703
HAC corrected variance (Bartlett kernel)	52.17146

KPSS Test Equation
Dependent Variable: GFCF
Method: Least Squares
Date: 02/19/21 Time: 08:47
Sample: 1977 2019
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	24.94958	1.036794	24.06416	0.0000
@TREND("1977")	-0.209559	0.042504	-4.930289	0.0000

R-squared	0.372203	Mean dependent var	20.54884
Adjusted R-squared	0.356891	S.D. dependent var	4.313068
S.E. of regression	3.458825	Akaike info criterion	5.365130
Sum squared resid	490.5024	Schwarz criterion	5.447047
Log likelihood	-113.3503	Hannan-Quinn criter.	5.395338
F-statistic	24.30775	Durbin-Watson stat	0.154282
Prob(F-statistic)	0.000014		

Null Hypothesis: D(GFCF) is stationary
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.278484
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	1.791814
HAC corrected variance (Bartlett kernel)	2.431423

KPSS Test Equation
Dependent Variable: D(GFCF)
Method: Least Squares
Date: 02/19/21 Time: 08:49
Sample (adjusted): 1978 2019
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.309524	0.209052	-1.480606	0.1464

R-squared	0.000000	Mean dependent var	-0.309524
Adjusted R-squared	0.000000	S.D. dependent var	1.354812
S.E. of regression	1.354812	Akaike info criterion	3.468725
Sum squared resid	75.25619	Schwarz criterion	3.510098
Log likelihood	-71.84322	Hannan-Quinn criter.	3.483890
Durbin-Watson stat	1.198971		

ARDL model

Results of ARDL (2,3,0,2) model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DGDP(-1)	-0.8729***	0.2126	-4.1051	0.0003
DGDP(-2)	-0.6341***	0.2074	-3.0571	0.0049
DPDT	0.4465	0.2687	1.6614	0.1078
DPDT(-1)	0.2463	0.2852	0.8636	0.3952
DPDT(-2)	-0.2541	0.2526	-1.0062	0.3229
DPDT(-3)	-0.5141*	0.2566	-2.0035	0.0549
DCPI	-0.0745	0.066	-1.1295	0.2683
DGFCF	0.6942*	0.3661	1.8962	0.0683
DGFCF(-1)	-0.6606*	0.3776	-1.7497	0.0911
DGFCF(-2)	-0.4899	0.3684	-1.3299	0.1943
C	-0.3211	0.3273	-0.981	0.335
R-squared = 0.550613				
Adjusted R-squared = 0.390118				
Schwarz criterion = 4.869254				
Hannan-Quinn criter. = 4.568392				
Prob(F-statistic) = 0.004833				

ARDL Error Correction Regression
Dependent Variable: D(DGDP)
Selected Model: ARDL(2, 3, 0, 2)
Case 3: Unrestricted Constant and No Trend
Date: 02/22/21 Time: 22:05
Sample: 1977 2019
Included observations: 39

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.321121	0.298478	-1.075863	0.2912
D(DGDP(-1))	0.634098	0.179239	3.537725	0.0014
D(DPDT)	0.446496	0.188939	2.363177	0.0253
D(DPDT(-1))	0.768227	0.227802	3.372352	0.0022
D(DPDT(-2))	0.514111	0.206164	2.493706	0.0188
D(DGFCF)	0.694238	0.289153	2.400935	0.0232

D(DGFCF(-1))	0.489885	0.326076	1.502362	0.1442
CointEq(-1)*	-2.506992	0.322842	-7.765376	0.0000

R-squared	0.817467	Mean dependent var	-0.087179
Adjusted R-squared	0.776249	S.D. dependent var	3.905676
S.E. of regression	1.847474	Akaike info criterion	4.246198
Sum squared resid	105.8080	Schwarz criterion	4.587441
Log likelihood	-74.80086	Hannan-Quinn criter.	4.368633
F-statistic	19.83313	Durbin-Watson stat	2.167719
Prob(F-statistic)	0.000000		

* p-value incompatible with t-Bounds distribution.

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	13.61637	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61

t-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-7.765376	10%	-2.57	-3.46
		5%	-2.86	-3.78
		2.5%	-3.13	-4.05
		1%	-3.43	-4.37

ARDL Long Run Form and Bounds Test
Dependent Variable: D(DGDP)
Selected Model: ARDL(2, 3, 0, 2)
Case 3: Unrestricted Constant and No Trend
Date: 02/23/21 Time: 11:30
Sample: 1977 2019
Included observations: 39

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.321121	0.327333	-0.981022	0.3350
DGDP(-1)*	-2.506992	0.368332	-6.806336	0.0000
DPDT(-1)	-0.075478	0.615405	-0.122648	0.9033
DCPI**	-0.074540	0.065992	-1.129524	0.2683
DGFCF(-1)	-0.456279	0.391772	-1.164654	0.2540
D(DGDP(-1))	0.634098	0.207416	3.057124	0.0049
D(DPDT)	0.446496	0.268745	1.661410	0.1078
D(DPDT(-1))	0.768227	0.367974	2.087718	0.0460
D(DPDT(-2))	0.514111	0.256607	2.003500	0.0549
D(DGFCF)	0.694238	0.366115	1.896231	0.0683
D(DGFCF(-1))	0.489885	0.368366	1.329887	0.1943

* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.

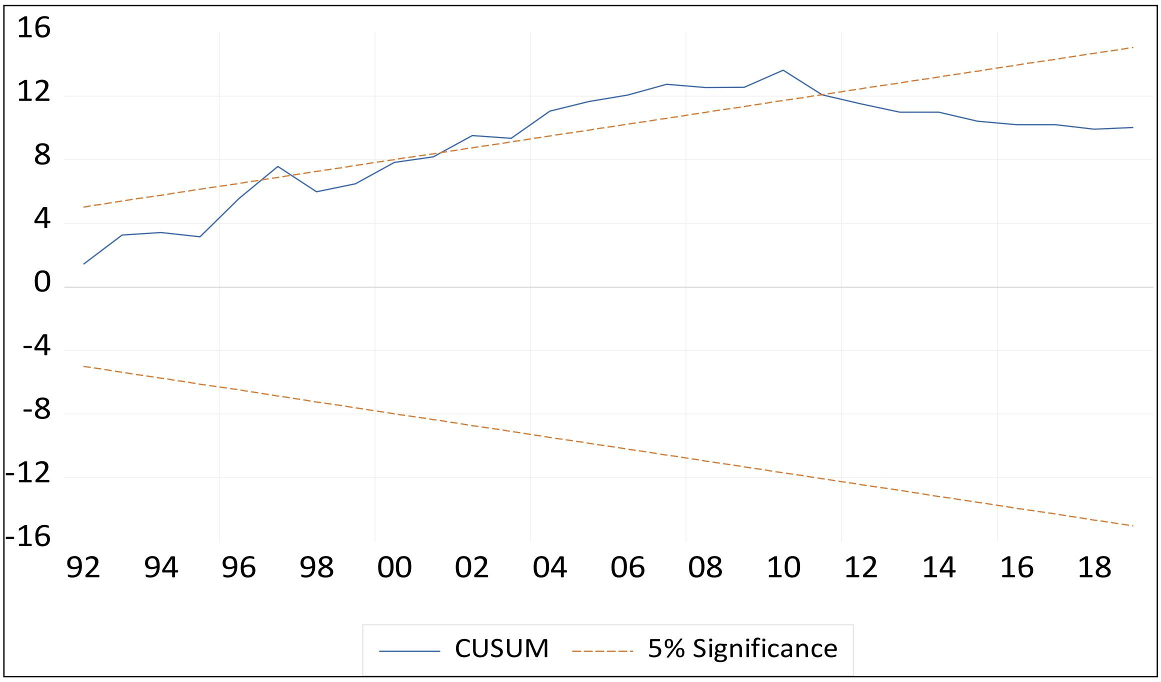
DPDT	-0.030107	0.246197	-0.122288	0.9035
DCPI	-0.029733	0.026168	-1.136247	0.2655
DGFCF	-0.182002	0.160884	-1.131267	0.2675

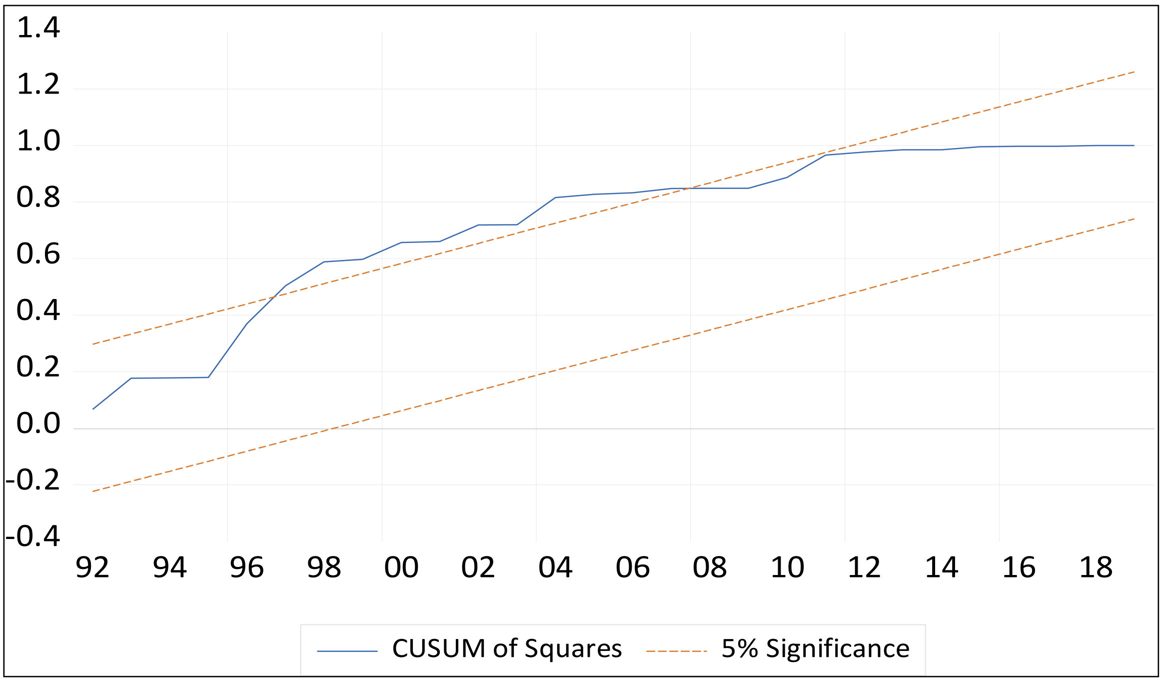
EC = DGDP - (-0.0301*DPDT -0.0297*DCPI -0.1820*DGFCF)

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	13.61637	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61
			Finite Sample:	
Actual Sample Size	39		n=40	
		10%	2.933	4.02
		5%	3.548	4.803
		1%	5.018	6.61
			Finite Sample: n=35	
		10%	2.958	4.1
		5%	3.615	4.913
		1%	5.198	6.845

t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-6.806336	10%	-2.57	-3.46
		5%	-2.86	-3.78
		2.5%	-3.13	-4.05
		1%	-3.43	-4.37

Stability test





Date: 02/23/21 Time: 10:21
Sample: 1977 2019
Included observations: 39
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.*| . |	.*| . |	1	-0.088	-0.088	0.3284	0.567
. | . |	. | . |	2	-0.016	-0.024	0.3397	0.844
. |*. |	. |*. |	3	0.149	0.147	1.3261	0.723
. | . |	. | . |	4	-0.010	0.017	1.3302	0.856
. | . |	. | . |	5	0.030	0.036	1.3736	0.927
. | . |	. | . |	6	-0.040	-0.058	1.4510	0.963

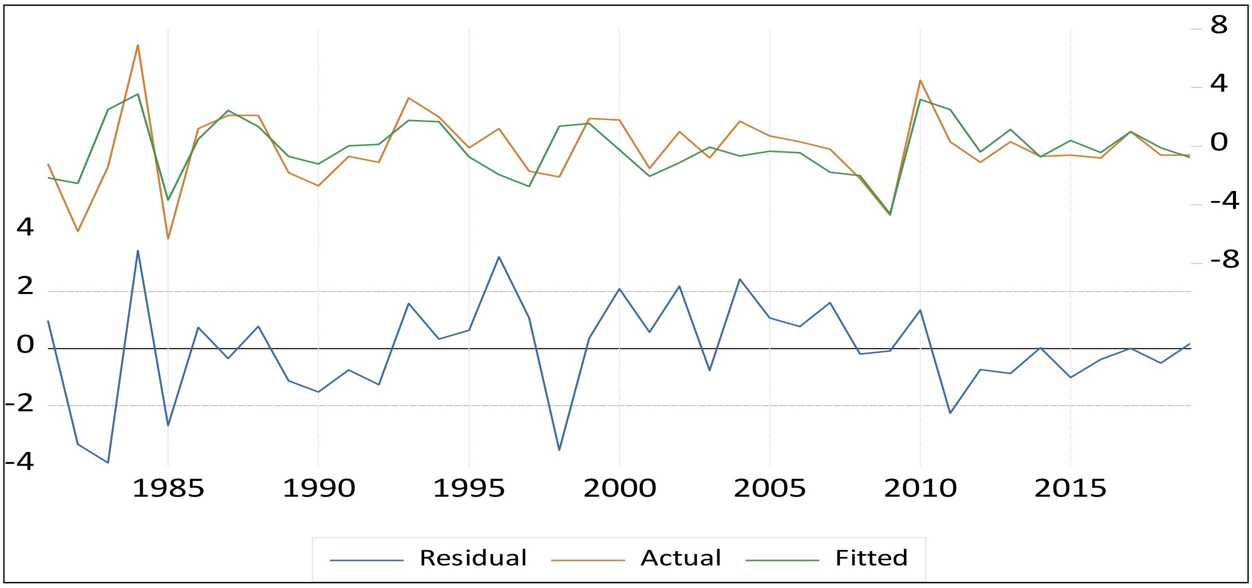
. | . |	. | . |	7	0.071	0.064	1.7005	0.975
. |*. |	. |*. |	8	0.081	0.084	2.0354	0.980
. |*. |	. |*. |	9	0.074	0.109	2.3285	0.985
. | . |	. | . |	10	-0.058	-0.064	2.5134	0.991
.*| . |	.*| . |	11	-0.146	-0.189	3.7238	0.977
. | . |	.*| . |	12	-0.064	-0.144	3.9650	0.984
. | . |	. | . |	13	0.005	0.005	3.9663	0.992
**| . |	.*| . |	14	-0.224	-0.186	7.1661	0.928
. | . |	. | . |	15	-0.040	-0.064	7.2706	0.950
. |*. |	. | . |	16	0.095	0.063	7.9031	0.952

*Probabilities may not be valid for this equation specification.

Granger Causality Test

Pairwise Granger Causality Tests
Date: 02/19/21 Time: 12:54
Sample: 1977 2019
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DPDT does not Granger Cause DGDP	40	2.14541	0.1322
DGDP does not Granger Cause DPDT		4.35754	0.0204



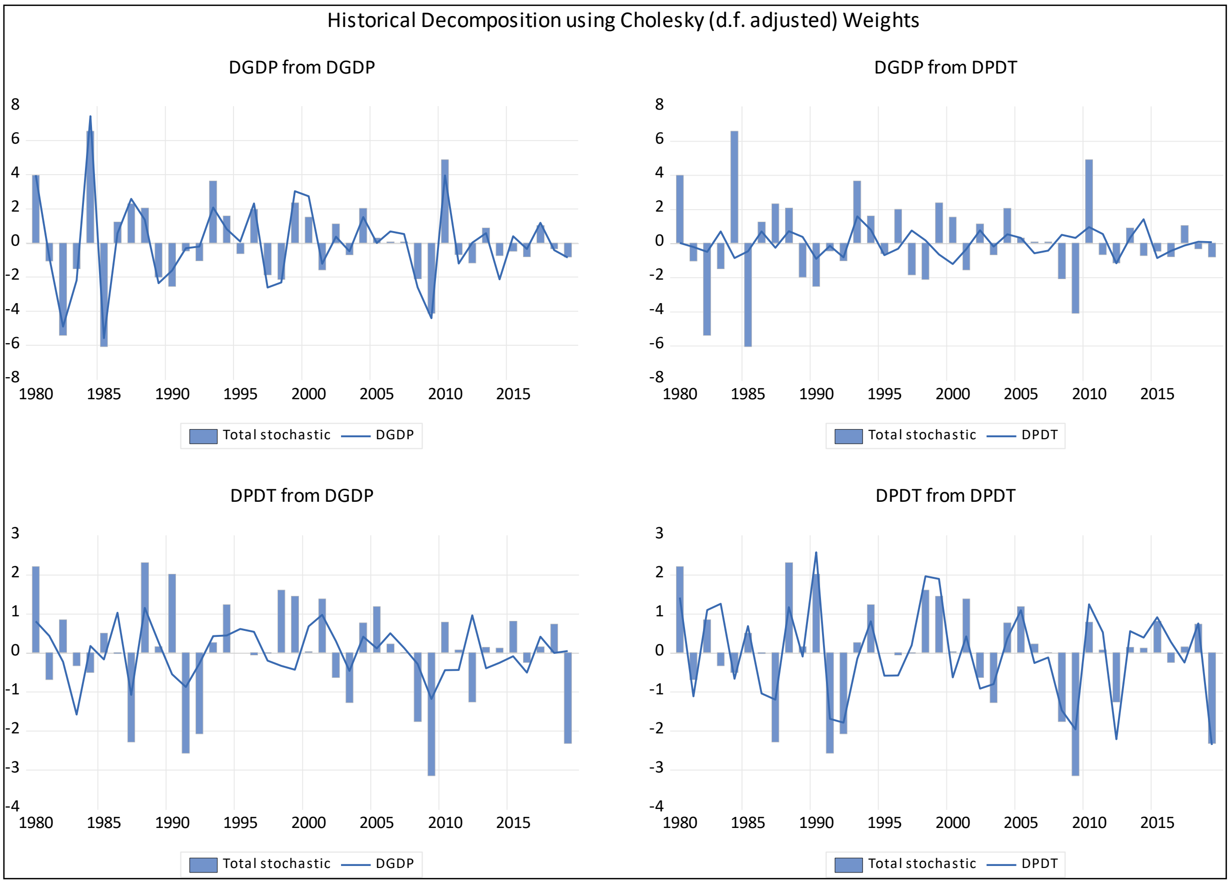
Variance decomposition and impulse response function

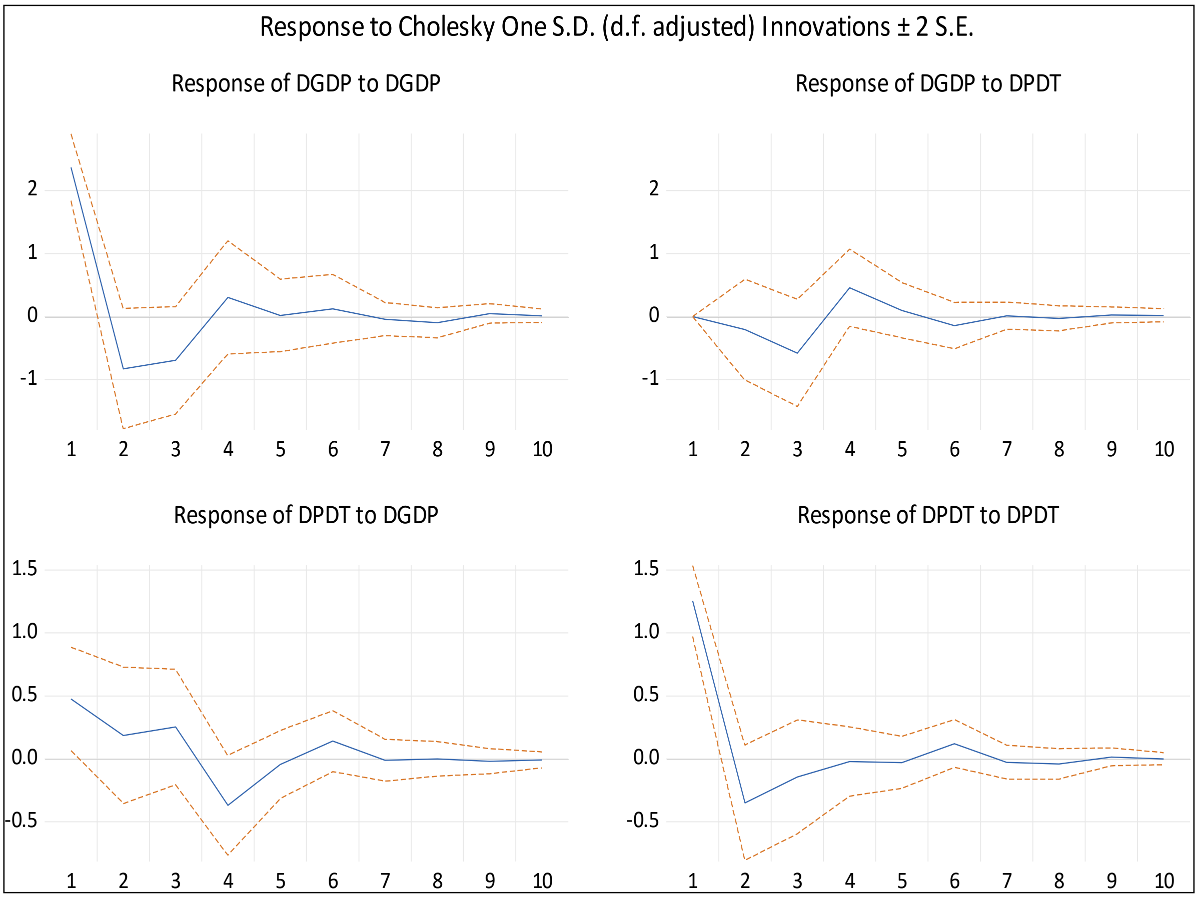
Variance Decomposition of DGDP: Period	S.E.	DGDP	DPDT
1	2.369905	100.0000	0.000000
2	2.518466	99.32470	0.675299
3	2.675347	94.74510	5.254896
4	2.731202	92.14365	7.856351
5	2.733069	92.02147	7.978526
6	2.739534	91.79065	8.209345
7	2.739882	91.79036	8.209635
8	2.741774	91.79132	8.208676
9	2.742342	91.78511	8.214890

Period	S.E.	DGDP	DPDT
10	2.742456	91.78063	8.219365

Variance Decomposition of DPDT: Period	S.E.	DGDP	DPDT
1	1.341454	12.57302	87.42698
2	1.398428	13.33321	86.66679
3	1.428404	15.91979	84.08021
4	1.475248	21.15318	78.84682
5	1.476228	21.21911	78.78089
6	1.487869	21.78469	78.21531
7	1.488156	21.78220	78.21780
8	1.488722	21.76567	78.23433
9	1.488929	21.77726	78.22274
10	1.488952	21.77973	78.22027

Cholesky Ordering: DGDP DPDT




Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.
Response of DGDP to DGDP
Response of DGDP to DPDT
Response of DPDT to DGDP
Response of DPDT to DPDT