Asymmetries in the revenue-expenditure nexus: New evidence from South Africa

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ASYMMETRIES IN THE REVENUE-EXPENDITURE NEXUS: NEW EVIDENCE FROM SOUTH AFRICA

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ABSTRACT: In this study, we relax the conventional assumption of a linear cointegration relationship in the revenue-expenditure nexus by examining asymmetric equilibrium effects in the South African fiscal budget using quarterly data collected between 1960:Q1 and 2016:Q2. Our mode of empirical investigation is the MTAR model supplemented with a TEC component. Our estimation results can be summarized into three main empirical findings. Firstly, we find that the long-run elasticity between revenue and expenditure is less-than-unity which implies that the fiscal budget is weakly unsustainable. Secondly we find that positive 'shocks' to the fiscal budget are eradicated fairly quickly which means that fiscal authorities must implement their policies in a continuous, on-going fashion over the long run. Lastly, we observe bi-directional causality between revenues and expenditures which offers support in favour of the fiscal synchronization hypothesis. This last result implies that fiscal authorities should amend fiscal imbalances through increased consolidation between revenue collection and expenditure allocation.

Keywords: Revenue; Expenditure; Fiscal budget sustainability; Threshold cointegration; MTAR; Causality; South Africa.

JEL Classification Code: C12; C13; C32; C51; H61; H62.

1 Introduction

Following the bankruptcy filing by the Lehman brothers in September 2008, the world economy experienced the worst financial crisis since the Great Depression. In response to the financial crisis and the subsequent global recession, most economies worldwide adopted counter-cyclical fiscal policies which have caused governments to run large budget deficits in order to boost economic recovery. For European countries, excessive accumulation of fiscal debt eventually lead to the European sovereign debt crisis of 2009. In African countries, debt accumulation has not been as severe as in the Euro area, and yet it should be noted that African countries have been historically characterized by governments which lack adequate fiscal discipline. Therefore, African governments naturally possess persistent fiscal imbalances, which has forced policymakers to rely more on monetary policy instruments in pursuing macroeconomic stability. More often than not, this reliance on monetary policy has proven to be unsuccessful in providing macroeconomic stability for African economies. Thus concerning African economies, fiscal sustainability is regarded as a more suitable policy option that can be used to lessen short-run fluctuations in important economic variables such as income, output and employment.

Developments which occurred subsequent to the sub-prime crisis have re-ignited an important debate on fiscal sustainability in African countries. One of the key themes in the debate concerns the expenditure-revenue relationship and it's effect on the budget deficit. For an emerging African economy like South Africa, which displayed impressive fiscal sustainability by boasting a budget surplus of 0.6 percent of GDP and 1 percent of GDP respectively in the two fiscal years before the crisis (i.e. 2006/2007 and 2007/2008), the debate is quite substantial. In particular, the need to know the relationship between the budget deficit and the expenditure-revenue correlation is important for the South African government because government expenditure plays a key factor in eradicating the lingering social ills of the Apartheid regime as well as being instrumental in reducing the existing wide poverty gap. In also considering the deterioration of government debt metrics since 2008 and the resulting downgrade of South African government debt rating by all three major credit rating agencies (i.e. Moody's, Standard and Poor's (S&P) and Fitch ratings) further emphasizes the need for government to improve fiscal prudence in the form of lowering the current fiscal deficit. So far, the 2015 medium term budget policy statement (MTBPS) highlights government plans of returning to fiscal sustainability by reducing it's expenditures while simultaneously increasing

it's tax revenue over a rolling three-year period of 2016-2019. It is thus important for South African fiscal authorities to know the nature and dynamic relationship between government expenditure and revenue.

Notably, the relationship between government expenditure and revenue in South Africa has not gone un-investigated as the issue has been addressed in the previous empirical studies of Narayan and Narayan (2006), Nyamongo et. al. (2007), Lusinyan and Thornton (2007), Ndahiriwe and Gupta (2010), Ghartey (2010), Jibao et. al (2012) and Baharumshah et. al. (2016). Nonetheless, the empirical results presented by the aforementioned authors tend to present conflicting evidences hence making it difficult to draw precise policy implications form these studies as a collective unit. One plausible explanation to these contradictions in empirical results, is that most of these studies have conducted their empirical investigation under linear econometric frameworks. Recently, it has been speculated that relying on such linear empirical models may produce spurious results and there exists three explanations which argue for the presence of asymmetries in the adjustment process of fiscal policy. The first is attributed to the closeness between the budget and the business cycle due to the presence of automatic stabilizers as well as the observation that business cycles display asymmetric behaviour (Paleologou, 2013). The second explanation is that policymakers may react in a different way to changes in a deficit or surplus (Baharumshah et. al., 2016). Lastly, the response of taxpayers to changes in the effective tax rate or tax base may lead to asymmetric differences in the budget (Ewing et. al., 2006).

So far, the study of Baharumshah et. al. (2016) has investigated the possibility of asymmetric cointegration relations in the expenditure-revenue nexus for the case of South Africa using the TAR model and MTAR threshold cointegration model of Enders and Siklos (2001). And even so, the authors have been unsuccessful in capturing asymmetries in the relationship and resolved to rely on conventional symmetric error correction modelling to establish the intended relationship. We attribute this failure of capturing asymmetric cointegration effects to three shortcomings associated with the preceding study. Firstly, the authors employ annual data which, as demonstrated by Ndahiriwe and Gupta (2010) for a similar case of South Africa, tends to produce insignificant cointegration effects between government expenditure and revenue. A more viable option, as shown by the Ndahiriwe and Gupta (2010), would be to use quarterly data in empirical investigations. Secondly, the study's transformation of the raw data into logarithmic form, naturally linearizes the data, hence

minimizing the possibility of capturing any possible asymmetric cointegration relationship between the time series. Therefore, in order to effectively capture nonlinearities in the data, one must perform the empirical analysis on raw, quarterly data. In this present study, we do so by examining the empirical relationship between government expenditure and revenue by employing quarterly data over a twenty year period ranging from 1994:Q1 to 2016:Q2. Methodological, our study follows a host of other empirical works (i.e. Ewing et. al. (2006), Payne et. al. (2008), Zapf and Payne (2009), Saunoris and Payne (2010), Young (2011), Apergis et. al. (2012), Paleologou (2013) and Tiwari and Mutascu (2015)) in using the MTAR framework to model asymmetric cointegration relations between revenue and expenditure for developed economies. To the best of our knowledge, there currently exists no other study for sub Saharan African (SSA) countries which has used the MTAR framework to successfully model asymmetric cointegration between revenue and expenditure. Our study therefore bridges an important gap in the empirical literature.

The rest of the paper is structured as follows. Section 2 provides an overview of the fiscal budget in South Africa. Section 3 is the literature review which discuss both theoretical and empirical literature on the subject matter. Section 4 articulates the empirical models used in the study whereas section 5 presents the empirical results of the study. The study is concluded in section 6 in the form of policy implications and directions for future research.

2 An overview of the fiscal budget in South Africa

In retrospective, South Africa's fiscal budget position in the post-World War II period can be conveniently described as evolving over three phases. The first phase can be approximated from the period ranging from the Sharpeville Massacre of 1960 until the end of the Apartheid regime in 1994 and can be described as the unstable phase. Notably during this phase the South African economy entered into a new political era of 'Grand Apartheid' during the 1960's; a large portion of the fiscal budget was spent on military expenditure items; political tensions began to heighten from the early 1960's through to the early 1990's; the world economy experienced a downward trend throughout the 1980's; international sanctions were imposed on the South African economy between 1977 and 1993, there was a large brain drain, massive disinvestment and capital outflows experienced during the 1980's, a foreign debt standstill was imposed against national treasury in 1985 as well as the country experiencing a severe drought period in the early 1990's; soaring rates of inflation from 1973 to 1979. As a

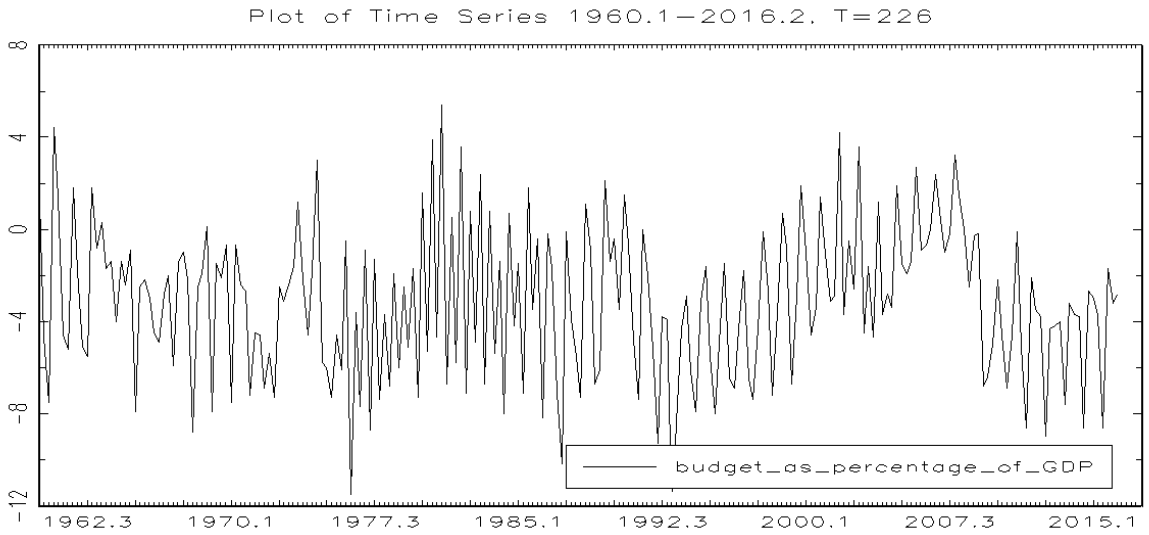
consequence of this host of historic events, the fiscal deficit displayed unstable tendencies averaging 2.34 percent of GDP during the 1960's, 4.13 percent of GDP during the 1970's and 2.82 percent of GDP during the 1980's.

The second phase corresponds with the periods dating from the democratic elections of 1994 up until the global recessionary period of 2009 and can be referred to as the improving phase of the fiscal budget. During this phase the newly-elected ANC government began to take stringent fiscal policy measures to address the social and economic imbalances caused by over fifty years of the Apartheid regime. In order to do so the government implemented three successive, large scale fiscal programmes. The first programme was the Reconstruction and Development Programme (RDP) which saw fiscal authorities designate numerical fiscal budgets targets inclusive of a budget deficit target of 2.5 percent of GDP as well as the attainment of a stable tax-to-GDP ratio of 25 percent. To this end, the Katz tax commission was assigned the responsibility of improving tax collection and administration in the interest of meeting expenditure obligations and ultimately reducing fiscal borrowing pressures. Even though the deficit fell from 5.1 to 4.6 percent of GDP between 1994 and 1996, fiscal authorities had not attained the set 2.5 percent target goal. This was mainly due to the fact that the RDP programme ignored the gathering of new taxes through the expansion of the tax base and rather focused on fiscal prudence and the reallocation of existing public revenues (Phiri, 2016). Thus in 1996 the RDP was replaced by a second policy programme the Growth, Employment and Redistribution (GEAR) policy which envisioned the government's budget deficit and tax policies as key to transforming South Africa into a competitive, outward oriented economy as stipulated in the "Washington Consensus". Notably, it is under the GEAR policy that the fiscal budget began to tremendously improve with the budget deficit being lowered from 5.4 to 0.3 percent of GDP between 1996 and 2005. However, the GEAR policy was heavily criticized on the basis of placing too much emphasis on the government budget deficit at the expense of microeconomic reforms which would address deeper social issue such as unemployment and income inequality. This eventually led to the abandonment of the GEAR programme in favour of a third fiscal programme the ASGISA programme in 2005 which focused more on microeconomic reforms.

The ASGISA programme stands as a fiscal policy which transcends from the second to the third phase in fiscal budget developments. Initially, the fiscal budget performance under the ASGISA programme began on a very high note, with record high budget surpluses of 0.6

and 1 percent of GDP in 2006 and 2007, respectively. However, the collapse of the Lehman Brothers in 2008 which triggered the worldwide recessionary period of 2009 marks the beginning of the third phase of fiscal budget evolution and is representative of a deteriorating phase of budget developments. During this phase the economy managed to achieve post-Apartheid record high budget deficits of 6.3, 4.7 and 4.7 and 5 percent of GDP in the consecutive years of 2009, 2010, 2011 and 2012. In 2013, fiscal authorities decided on abandoning the ASGISA programme, and began running number of alternative policy programmes such as the National Development Plan (NDP), New Growth Path (NGP), Industrial Policy Action Plan (IPAP) and the South African National Infrastructure Plan (SANIP) which are designed to specifically address the country's triple challenge of poverty, inequality and unemployment. On the revenue collection side, the Davis Tax Committee was appointed in 2013 to boost revenue collections through tax reforms in order to fund these key policy programmes with emphasis placed on infrastructure development. However, despite these developments, the budget deficit averaged a relatively high rate of 4.3 percent of GDP between 2013 and 2015, and this by itself highlights the challenge facing fiscal authorities in returning the budget to sustainable levels experienced prior to the recessionary period. Nonetheless, the three discussed phases of developments in the fiscal budget are easily identified in Figure 1 which presents the time series movement of South Africa's fiscal budget as a percentage of GDP between 1960 and 2015.

Figure 1: Fiscal budget as a percentage of GDP



3 Literature Review

3.1 Theoretical propositions of the revenue-expenditure nexus

From a theoretical perspective, the relationship between revenues and expenditure is considered a classical problem of public economics. So far, there are four propositions that have been put forward in the literature concerning the revenue-expenditure relationship. Firstly, there is the tax-and-spend hypothesis which was put forward by Friedman (1978) and Buchanan and Wagner (1978). According to this view, tax revenue is the cause of government expenditure although Friedman (1978), on one hand, argues for a positive relationship between the variables whereas Buchanan and Wagner (1978), on the other hand, contend for a negative relationship. In terms of policy implications, Friedman (1978) suggests that a decrease in taxes will reduce fiscal expenditure and eventually lower the budget deficit whilst an increase in tax revenue is accompanied by increases in public expenditure which results in fiscal imbalances. Conversely, Buchanan and Wagner (1978) speculate that cuts in direct taxes create a fiscal illusion in which the public will speculate that the cost of government programs has fallen. As a result the public will demand for more public spending which if undertaken will result in increased government expenditure and ultimately higher budget deficits. Therefore the panacea for budget deficits in such a circumstance would be an increase in taxes with a preference on indirect taxes as a cheaper alternative for financing expenditures, even though this may come

at the expense of higher interest rates and inflation which would lead to crowding out of private sector spending (Tiwari and Mutascu, 2016).

The second proposed hypothesis found in the literature is commonly referred to as the displacement effect hypothesis. This hypothesis comes courtesy of the works of Peacock and Wiseman (1979) and is consider as one the most reliable explanations of the revenue-expenditure relationship. Under this hypothesis, government expenditure is the cause of government revenue and not vice versa. Peacock and Wiseman (1979) particularly observe that during periods of crisis governments tend to increase their expenditure levels as a form of a fiscal stimulus packages and consequentially, the temporary increases in government expenditure can lead to permanent increases in government revenues over the long-run. In other words, governments tend to spend first then attempt to recover public expenditure through increased revenue collections. Notably, this view is associated with the Keynesian principle of compensatory finance whereby deficits are created in order to boost up levels of economic activity. Then through the workings of a built-in mechanism, the budgetary multiplier effect would itself eliminate any output gap and ensure a higher tax base, from which the extra tax revenue would be generated to offset the initial created fiscal deficit (Obinyeluaku, 2015). However, pursuing such a course of fiscal action may exert negative effects on shareholders and investors and may even cause them to mitigate to other countries since further increases in taxes are generally expected. The appropriate policy stance in this situation is to reduce state expenditures which would then reduce tax revenue collection and ultimately lower the budget deficit.

The third theoretical propositions was initially proposed by Musgrave (1966) and later refined by Meltzer and Richard (1981). According to the authors, government's decision on the optimal levels of revenue and expenditure spending depends on the public's attitude towards the welfare maximizing demand for public goods and services as well as on their attitudes towards the redistribution function of the government (Konukcu-Onal and Tosun, 2008). Thereafter, government weighs the costs and benefits of its activities against the corresponding costs before committing to a fiscal program and consequentially, government revenue and expenditure interact interdependently. This gives rise to the fiscal synchronization hypothesis in which fiscal revenue and expenditure exert bi-directional causality and hence improvements on both fiscal revenue and expenditures are required in order to make improvements on the budget deficit. To illustrated the fiscal synchronization hypothesis, Barro

(1979) developed a tax-smoothing model based on the Richardian invariance theorem, stating that deficit-financed government expenditure today results in future tax liabilities which are fully capitalized by tax payers (Nyamongo et. al., 2007).This implies that fiscal authorities must take simultaneous decisions on revenues and expenditures in order to conserve a balance budget approach to fiscal policy.

The final theoretical proposition, known as the fiscal neutrality or institutional separation hypothesis, suggests that there exists no causal relationship in the revenue-expenditure relationship and thus decisions concerning government revenue and expenditure are taken independently. This hypothesis is rooted in the studies of Wildavsky (1988) and Baghestani and McNown (1994). There are two rational explanations for the dynamics surrounding the institutional separation neutrality hypothesis. Firstly, no causality between revenues and expenditures can occur when institutions responsible for revenue collection and disbursement of government outlays are separate, as is the case for federal governments (Ghartey, 2010). Secondly, in the case of parliamentary system of government, it can occur if the Minister of Finance, who controls both institutions of government, fails to coordinate the cost of government activities with associated benefits, because of parochial party reasons (Ghartey, 2010). The achievement of fiscal balance would thus be a matter of pure coincidence since taxation decisions are made independently of decisions to allocate public spending. Moreover, the greater the conflict between among different legislative and executive government institutions, the more difficult it is to successfully implement deficit-reducing measures (Obinyeluaku, 2015).

3.2 Empirical review of the literature

From an empirical point of view, there exists a prolific literature which has sought to determine whether a country or a panel of countries can be categorized as being in conformity with either i) the tax-and-spend hypothesis ii) the displacement effect hypothesis iii) the fiscal synchronization hypothesis, or iv) the institutional separation hypothesis. For convenience sake, these studies can be broken down into four main groups of literature. The first group are the early empirical studies which used vector autoregressive (VAR) frameworks to investigate the direction of causality established between fiscal revenue and expenditure exclusively for the US economy (i.e. Blackley (1986), Anderson et. al. (1986), Von Furstenburg et. al. (1986), Manage and Marlow (1986), Miller and Russek (1990), Ram (1988), Bohn (1991), Jones and

Joulifain (1991) and Hoover and Sheffrin (1992). The second group of studies are the panel studies which can be further disseminated into five sub-groups. The first sub-group investigates for European countries (i.e. Joulifain and Mookerjee (1991), Owoye (1995), Koren and Stiassny (1998), Garcia and Henin (1999), Kollias and Makrydakis (2000), Kollias and Paleoloou (2006), Afonso and Rault (2009), Chang and Chiang (2009) and Bolat (2014)); the second sub-group investigates for Latin American countries (i.e. Baffes and Shah (1994), Ewing and Payne (1998) and Cheng (1999)); the third sub-group for Asian countries (i.e. Narayan (2005), Karim et. al. (2006), Mehrara et. al. (2011), Magazzino (2014)), the fourth sub-group for African countries (i.e. Wolde-Rufael (2008), Ghartey (2010) and Magazzino (2012)) and the last sub-group for studies on mixed economies (i.e. Chang et. al. (2002) Mehrara et. al. (2012), Petanlar and Sadeghi (2012) and Mutascu (2015)).

The third group of studies investigated the revenue-expenditure nexus for individual countries and this cluster of studies is more inclusive of the contribution Latin American, Asian and African empirical literature to the revenue-expenditure debate. Some notable works belonging to this group of research studies include Huang and Tan (1992) for Taiwan; Li (2001) for China; Provopoulos and Zambaras (1991), Kollias and Makrydakis (1995), Katrakilidis (1997) for Greece; Bella and Quinteri (1995) for Italy; Hatemi-J and Skukur (1999) for Finland; Koren and Stiassny (1995) for Austria; Park (1998) for Korea; Al-Quadir (2005) for Saudi Arabia; Murat and Murat (2009) and Al-Zeaud (2014) for Jordan; Valeriu (2010) and Jalil and Hye (2010) for Romania; Lukovic and Grbic (2014) for Serbia; Mithani and Khoon (1999), Tsen and Ping (2005), Taha and Loganathan (2008), Hong (2009), and Nanthakumar et. al. (2011) for Malaysia; Darrat (1998), Aslan and Tasdemir (2009) and Dogan (2013) for Turkey; Al-Khulaifi (2012) for Qatar; Aisha and Khatoon (2010) and Ali and Shah (2012) for Pakistan; Elyasil and Rahimi (2012) for Iran; Moalusi (2004) for Botswana; Carneiro et. al. (2005) for Guinea-Bissau; Eita and Mbazima (2008) for Namibia; Obioma and Ozughalu (2010), Aregbeyen and Ibrahim (2012), Elyasil and Rahimi (2012), Ogujibuba and Abraham (2012), Nwosu and Okafor (2014) for Nigeria; Keho (2010) for Ivory Coast; Obeng (2015) and Takumah (2015) for Ghana; and finally Nyamongo et. al. (2007), Lusinyan and Thornton (2007) and Ndahiriwe and Gupta (2010) for South Africa.

The final group of empirical studies investigate possible nonlinear relationship between government revenue and expenditure. The main idea behind this group of studies is that the sustainability of the fiscal budget switches depending upon whether an economy is above or

below some threshold estimate. Belonging to this cluster of nonlinear studies are the works of Bajo-Rubio et. al. (2004, 2006) for the Spanish economy; Arestis et. al. (2004), Ewing et. al. (2006), Zapf and Payne (2009), Gil-Alana (2009), Cipollini et. al. (2009) and Young (2011) for the US economy; Paleologou (2013) for 3 EU countries; Apergis et. al. (2012), Athanasenas et. al. (2014) for the Greek economy; Aworinde (2013) and Aworinde and Ogundipe (2015) for the Nigerian economy; Keho (2011) for Cote d'Ivoire; Payne et. al. (2008) for the Turkish economy; Tiwari and Mutascu (2015) for the Romanian economy, Saunoris and Payne (2010) for the UK economy and Jibao et. al. (2012) and Baharumshah et. al. (2016) for the South African economy. Notwithstanding the inexhaustible literature on the subject matter, the collective verdict on the relationship between revenue and expenditure remains inconclusive. A comprehensive summary of the reviewed studies is provided in Tables 1a) through 1d) in the appendix of the paper.

4 Methodology

The empirical literature examining the sustainability of budget deficits is primarily concerned with whether or not the government's intertemporal solvency constraint is violated. The empirical model used in our study begins with the assumption that government finances its deficits with bonds which have a one year maturity period. Denoting B_t as government debt; G_t as government's purchase of goods, services and transfer payments; R_t as government's revenues and i_t as the real interest rate, the government's one-period budget constraint at time t is specified as:

$$G_t + (1 + i_t)B_{t-1} = R_t + B_t \qquad (1)$$

Solving equation (1) for B_t and iterating forward over an infinite horizon yields the following intertemporal budget constraint:

$$B_0 = \sum_{s=0}^{\infty} \prod_{i=1}^{t} \Pi(1 + i_t)^{-1} (R_{t+s} - G_{t+s}) + \lim_{s \to \infty} \prod_{i=1}^{\infty} (1 + i_t)^{-1} B_{t+s} \qquad (2)$$

Intertemporal budget solvency requires that the current debt must be financed by surpluses in future periods such that as time approaches infinity the discounted value of the

debt converges to zero. This assumption is realized through the imposition of the following transversality condition:

$$\lim_{s\to\infty}(1+i_t)^{-1}B_{t+s}=0 \qquad (3)$$

If equation (3) holds then the intertemporal budget balance is satisfied hence ensuring that government operates its fiscal budget in absence of a Ponzi scheme. Substituting equation (3) into equation (2) implies that a sustainable intertemporal budget exists when maturing debt obligations are not 'bubble-financed' by the issuing new debt. This is also equivalent to saying that the fiscal budget is sustainable only if government debt is not expected to grow as fast, on average, than the mean real interest rate, with the latter term denoting a proxy for the growth rate of the economy (Bajo-Rubio et. al., 2006). In order to draw an empirical cointegration relationship between R_t and G_t, Haikko and Rush (1991) further assume that the real interest rate evolves as a stationary process. This enables the authors to transform equations (1) through (3) into the following empirical regression:

$$R_t=\alpha_0+\alpha_1 G_t+\mu_t \qquad (4)$$

Where μ_t is a well-behaved error correction term. Moreover, the fiscal budget is deemed strongly sustainable if R_t and G_t are cointegrated and $\alpha_1 = 1$; weakly sustainable if R_t and G_t are cointegrated and $0 < \alpha_1 < 1$; and unsustainable if $\alpha_1 \leq 0$. According to the classic Engle and Granger (1987) theorem, cointegration between R_t and G_t can be validated under the following two conditions. Firstly, both R_t and G_t variables must be found to be first difference stationary time series (i.e. I(1) processes). Secondly, the extracted long-run cointegration error term, μ_t, must be a levels stationary process (i.e. I(0) processes). In order to increase the effectiveness of the testing procedure for cointegration effects, Enders and Silkos (2001) devise a method which involves modelling the long-run equilibrium error term as the following threshold cointegration process:

$$\mu_t=I_t\rho_1\mu_t+(I_t-1)\rho_1\mu_t+\sum_{i=1}^{p}\beta_i\,\Delta\xi_{t-i}+\varepsilon_t \qquad (5)$$

Where the indicator functions are defined as:

$$I_{.t} = \begin{cases} 1, if \mu_{t-1} \geq \tau \\ 0, if \mu_{t-1} < \tau \end{cases} \quad (6)$$

$$M_{.t} = \begin{cases} 1, if \mu_{t-1} \geq \Delta\tau \\ 0, if \mu_{t-1} < \Delta\tau \end{cases} \quad (7)$$

The term τ is the threshold estimate of the equilibrium error which is responsible for regime switching behaviour and is consistently estimated using the minimization criterion described in Hansen (2000). Combining equation (5) and (6) results in the TAR model which allows the degree of autoregressive decay to depend on the state variable of interest (Enders and Granger, 1998). On the other hand, combining equation (5) with (7) results in the MTAR model which allows a variable to display different amounts of autoregressive decay depending on whether it is increasing or decreasing (Enders and Siklos, 2001). The coefficients of the threshold error terms, ρ_1 and ρ_2, measure the rate of equilibrium adjustment for positive shocks (i.e. ρ_1) and for negative shocks (i.e. ρ_2) to the intertemporal budget. If $|\rho_1| > |\rho_2|$, then positive shocks to the intertemporal budget are eradicated quicker than negative shocks to the budget. On the other hand, if $|\rho_1| < |\rho_2|$, then negative shocks to the intertemporal budget are eradicated quicker than positive shocks to the budget. These coefficients are also used to further test for two empirical hypotheses which are meant to validate threshold cointegration. Firstly they are used in testing the null hypothesis of no cointegration effects (i.e. H_{10}: $\rho_1 = \rho_2 = 0$) against the alternative of linear cointegration effects (i.e. H_{11}: $\rho_1 \neq 0$, $\rho_2 \neq 0$) using a conventional F-statistic. Under the second test, the null hypothesis of a linear cointegration effects is tested as H_{20}: $\rho_1 = \rho_2$, and this is tested against the alternative hypothesis of an otherwise threshold cointegration effects i.e. H_{21}: $\rho_1 \neq \rho_2$, this time using a modified F-statistic. Only if both tests statistics exceed their critical values, can one conclude on significant threshold cointegration effects among the time series and obtain 'non-spurious' regression estimates for the coefficients α_0, α_1, ρ_1 and ρ_2 from equations (4) and (5).

5 Data and empirical results

5.1 Data description and unit root tests

The data used to carry out our empirical analysis consists of the quarterly series of i) total expenditure by national government (i.e. R_t) ii) total national government revenue (i.e. G_t)

and iii) the fiscal budget deficit/surplus expressed as a ratio of GDP((i.e. FB_t). All data has been retrieved from the South African Reserve Bank (SARB) online database over the period 1960:Q1 to 2016:Q4. As a preliminary step before investigating possible threshold cointegration effects, we firstly examine the integration properties of the individual time series variables. To this end, we employ three unit root tests namely; the Augmented Dickey-Fuller (i.e. ADF), the Kwiatkowski et. al. (1992) (i.e. KPSS) and the Hylleberg et. al. (1990) (i.e. HEGY) tests. Whereas the ADF and HEGY unit root tests have the unit root as the null hypothesis, the KPSS tests presents a stationary null hypothesis. Moreover, the HEGY test differs from the ADF and PP test in that it tests for the presence of unit roots at different frequencies. For empirical purposes the HEGY is performed at a zero frequency (i.e. HEGY[tpi1]) and at semi-annual frequency (i.e. HEGY[tpi2]). All unit root tests are performed without a constant or a trend and the results of the empirical exercise are reported in Table 1.

Table 1: Unit root test results

unit root test	time series					
	R_t	ΔR_t	E_t	ΔE_t	FB_t	ΔFB_t
ADF	-0.10	-15.51***	-0.08	-15.69***	-4.73***	-17.01***
KPSS	8.94***	-0.02	-7.44***	0.02	0.19	0.01
HEGY[t(pi1)]	1.41	-7.98***	1.37	-7.71***	-1.35	-7.73***
HEGY[t(pi2)]	-0.98	-1.09***	-1.70	-2.15**	-1.83*	-2.13***

Note: "***", "**" and "*" denote the 1 percent, 5 percent and 10 percent significance levels, respectively. Δ denotes a first difference operator.

Lag length for the unit root tests are determined by the AIC.

As is evident from our unit root test results, both revenues and expenditures time series cannot reject the unit root null hypothesis in their levels for both ADF and HEGY unit root tests whereas the fiscal budget cannot rejects the unit root hypothesis for the same tests. However, in their first differences the ADF and HEGY statistics manage to reject the unit root null at all levels of significance levels. Concerning the KPSS test statistics, the revenue and expenditure time series reject the stationary null at all critical levels whereas the stationary null cannot be reject for the fiscal budget time variable. Conversely, the KPSS statistics cannot reject the stationary null for all the observed time series in their first differences. In summarizing these results, we conclude on revenues and expenditure being I(1) first difference time series whereas the fiscal budget is a stationary I(0) variable. Notably, these results are in

coherence with the previous studies of Narayan and Narayan (2006), Nyamongo et. al. (2007), Lusinyan and Thornton (2007), Ndahiriwe and Gupta (2010), Ghartey (2010), Jibao et. al (2012) and Baharumshah et. al. (2016) and this permit us to proceed to model and estimate our threshold cointegration models.

5.3 Threshold cointegration analysis and error correction modelling

Having confirmed that the revenue and expenditure time series are first difference stationary process, we proceed to our threshold cointegration analysis of the time series variables. As previously discussed, before any estimation of the threshold models we must first test for two null hypothesis of cointegration and threshold cointegration effects in order to validate the existence of threshold cointegratioin between the time series variables. The results of the empirical tests are summarized in Table 2 below. The F-statistic, Φ, which tests the first null hypothesis of no cointegration against the alternative of cointegration effects, produces estimates of 112.22 and 122.38 for the TAR and MTAR models, respectively. Note that these F-values exceed their critical values at all levels of significance. We also test a second hypothesis of linear cointegration against the alternative of threshold cointegraton using the modified F-statistic denoted as Φ*. We obtain a modified F-value of 1.75 for the TAR model which fails to reject the linear cointgration hypothesis at all critical levels. On the other hand, the F-value of 3.51 obtained for the MTAR model manages to reject the linear null at a 10 percent significance level hence providing sufficient evidence of MTAR threshold cointegration among the time series. Other studies in the literature which find similar findings of the suitability of the MTAR as opposed to the TAR cointegration model between revenue and expenditure include Ewing et. al. (2006), Payne et. al. (2008), Young (2011) and Apergis et. al. (2012).

Table 2: Threshold cointegration tests

dependent variable	Model	Φ	Φ*
	TAR	122.22	1.75
		(0.00)***	(0.46)
rev_t			
	MTAR	122.38	3.51
		(0.00)***	(0.21)*

Notes: Significance levels: '***", '**', '*' denote the 1%, 5% and 10% significance levels respectively. p-values of test statistics are reported in parentheses.

Having confirmed threshold cointegration effects between the time series, we proceed to estimate the MTAR threshold model of revenue-expenditure. The empirical results of the OLS estimates of the long-run regression coefficient between government revenue (i.e. α_1) and expenditure as well as the estimates for the coefficients of the threshold error terms (i.e. ρ_1 and ρ_2) are reported in Table 3. Based on the results reported in Table 3 below, it should be firstly observed that the long-run regression coefficient produces a less-than-unity elasticity of 0.67 and judging by it's associated p-value, this is a highly significant estimate. Generally, this result implies that, over the long-run, the fiscal budget is weakly sustainable with fiscal taxes collections being able to cover only 67 percent of the corresponding expenditure items. This is a rather plausible result seeing that the South African government has been operating at a budget deficit for most of the time during the period of our investigation (i.e. 1960 – 2016). Notably, other authors who report less-than-unity elasticity include Nyamongo et. al. (2007) for South Africa, Payne et. al. (2008) for Turkey, Zapf and Payne (2009) for the US, Saunoris and Payne (2010) for the UK, Paleologou (2013) for Germany and Greece, and Tiwari and Mutascu (2016) for Romania.

In turning to the coefficient estimates of the threshold error terms, we obtain an estimate of -1.18 for ρ_1 and -0.91 for ρ_2 which are both significant estimates at all critical levels. Since $|\rho_1| > |\rho_2|$, then our obtained results particular result implies that there is quicker equilibrium reversion following a positive shock to governments budget whereas equilibrium adjustment is slower following a negative shock to the budget. In other words, the speed of adjustment when the budget is improving is faster than when the budget is worsening and hence it is more problematic to adjust budgetary deficit as opposed to budget surpluses. Collectively, the estimation results obtained from our MTAR cointegration model imply that whilst the fiscal budget is weakly sustainable as a whole, periods of budgetary disequilibrium are easier to correct for budget surpluses when compared to that of budget deficits. We note that similar inferences have been drawn from the study of Apergis et. al. (2012).

Table 3: MTAR regression estimates

coefficients	estimate	standard error	t-value	p-value
α_0	4.71	1.09	4.33	0.00***
α_1	0.67	0.04	14.93	0.00***
threshold error term estimates				
ρ_1	-1.18	0.12	-9.73	0.00***
ρ_2	-0.91	0.08	-11.40	0.00***
τ		3.47		
RSS		2.91		
R^2		0.50		
F-statistic		112.4		
p-value		0.00***		

Notes: Significance levels: '***', '**', '*' denote the 1%, 5% and 10% significance levels respectively.

Given our evidence of threshold cointegration between government revenue and expenditure permits us to model threshold error correction effects as a means of capturing short-run and long-run asymmetric adjustment equilibrium dynamics between the observed time series. In denoting $\gamma^{-}\mu_{t-1}$ and $\gamma^{+}\mu_{t-1}$ as the threshold error correction terms, the corresponding TEC specification for the MTAR model is given as:

$$\Delta R_t = \alpha_0 + \sum_{i=1}^{n} \psi_i \Delta R_{t-1} + \sum_{i=1}^{q} \delta_i \Delta G_{t-1} + \gamma^{-} \mu_{t-1} (\Delta ect_{t-1} < \tau) + \gamma^{+} ect_{t-1} (\Delta ect_{t-1} \geq \tau) + \nu_{t1} \quad (10)$$

$$\Delta G_t = \alpha_0 + \sum_{i=1}^{n} \psi_i \Delta R_{t-1} + \sum_{i=1}^{q} \delta_i \Delta G_{t-1} + \gamma^{-} \mu_{t-1} (\Delta ect_{t-1} < \tau) + \gamma^{+} ect_{t-1} (\Delta ect_{t-1} \geq \tau) + \nu_{t2} \quad (11)$$

The term $\gamma^{-}ect_{t-1}$ measures of the speed of equilibrium revision below its threshold estimate whereas $\gamma^{+}ect_{t-1}$ measures it below the threshold. Based on the TEC regressions (10) and (11), two hypotheses can be further tested for. Firstly, the null hypothesis of no asymmetric TEC effects can be tested as H_{30}: $\gamma^{-} = \gamma^{+}$ and this hypothesis is tested against the alternative of an otherwise threshold error correction mechanism i.e. H_{31}: $\gamma^{-} \neq \gamma^{+}$. Once the null hypothesis is rejected in favour of the alternative of a TEC effects, then causality tests can be performed on

the time series. The null hypothesis that revenue does not granger cause expenditure is tested as H_{40}: $\psi_i = 0$, i=1,…,k, whereas the null hypothesis that expenditure do not granger cause revenue is tested as H_{50}: $\delta_i = 0$, i=1,…,k. Table 3 summarizes the results of the tests for TEC effects, the TEC model estimates as well as the granger causality results. All three null hypotheses, that is H_{30}, H_{40} and H_{50}, are tested using a conventional F-test statistic.

Table 4: Threshold error correction (TEC) estimates

dependent variable	independent variable	estimate	standard error	t-value	p-value
ΔR_t	intercept	3.32	0.38	8.78	0.00***
	R^-_{t-1}	0.06	0.09	0.65	0.52
	R^+_{t-1}	-1.04	0.11	-9.85	0.00***
	G^-_{t-1}	0.02	0.08	0.21	0.84
	G^+_{t-1}	-0.72	0.08	-9.46	0.00***
	ect^-_{t-1}	-0.62	0.08	-7.78	0.00***
	ect^+_{t-1}	-0.30	0.15	-2.01	0.04**
ΔG_t	intercept	1.74	0.47	3.68	0.00***
	R^-_{t-1}	0.04	0.11	0.37	0.71
	R^+_{t-1}	-0.62	0.13	-4.68	0.00***
	G^-_{t-1}	-0.42	0.09	-4.39	0.00***
	G^+_{t-1}	-0.74	0.09	-7.75	0.00***
	ect^-_{t-1}	0.33	0.10	3.33	0.00***
	ect^+_{t-1}	0.68	0.18	3.69	0.00***
hypotheses tests, causality tests and diagnostic tests					
H_{03}: $\gamma^- = \gamma^+$			4.40		
			(0.04)**		
H_{04}: ψ_i=0			11.67		
			(0.00)***		
H_{05}: $\delta_i = 0$			50.22		
			(0.00)***		
DW			1.98		
			(0.85)		
LB(4)			0.00***		
LB(8)			0.00***		
LB(12)			0.00***		

Notes: Significance levels: '***', '**', '*' denote the 1%, 5% and 10% significance levels respectively. p-values of hypotheses tests and diagnostic tests are reported in parentheses. DW and LB respectively denote the Durbin Watson and Ljung Box statistics and for serial correlation with the LB test being performed up to 12 lags.

In referring to the results reported in Table 4 above, we firstly note that in testing the null hypothesis of no asymmetric error correction effects we obtain a F-statistic of 4.40 which manages to reject the null at a 10 percent significant level (thus indicating asymmetric error

correction effects within the system of estimated regressions). We also note that the while error correction terms, $\gamma^{-}\mu_{t-1}$ and $\gamma^{+}\mu_{t-1}$, of the revenue equation (10) both produce negative and highly significant estimates of -0.62 and -0.30, respectively, the error correction terms of the expenditure equation (11) both produce significantly positive estimates of 0.33 and 0.68, respectively. And because only the threshold error correction terms from the revenue equation produce the correct sign on the coefficients, we conclude that only government revenue responds to budgetary disequilibrium whereas this is not the case for government expenditure. Specifically, our results entail that government revenues respond to both an improving and to a worsening budget, with 62 percent of budgetary disequilibrium being corrected by revenues during a worsening budget whereas 30 percent of disequilibrium being corrected by revenues during an improving budget. This results concur with those obtained earlier from our MTAR estimates by entailing that disturbances to improving budgets are easier to 'correct' than for worsening budgets. Concerning short run effects, we observe highly significant coefficients for $R_{t-1}^{+}$and G_{t-1}^{+} variables in the revenue equation in the upper regime of the model (i.e. $\mu_{t-1} \geq \tau$). By interpretation, this implies that short-run effects are present when revenue responds to budgetary disequilibrium and the budget is improving.

In lastly examining the results of our causality tests as reported at the bottom of Table 4, we find that the F-statistics estimate testing the null hypothesis that revenue does not granger cause expenditure is 11.67 and this statistic exceeds it's critical value at a 5 percent level of significance. Similarly, the F-statistics testing the null hypothesis that expenditure does not granger cause revenue produces an estimate of 50.22 and this statistic exceed it's critical value at all significance levels. By effect, this result implies bi-directional causality between government revenues and expenditure for the South Africa economy and this offers support in favour the fiscal synchronization hypothesis. Notably, the previous studies of Nyamongo et. al. (2007), Lusinyan and Thornton (2007), Ghartey (2010) and Baharumshah et. al. (2016) confirm similar bi-directional causality between the time series for South African data albeit using varying linear empirical methods to arrive at such conclusions.

6 Conclusion

Subsequent to the global recession period of 2009, many researchers have been inclined to investigate the sustainability of the fiscal budget by examining cointegration effects between fiscal revenue and expenditure. From this group of studies, there has recently emerged a new

wave of empirical research which hypothesizes on a nonlinear revenue-expenditure relationship serving as a more plausible description of the relationship between the time series variables. In acknowledgment to the absence of empirical works depicting such a nonlinear relationship between revenues and expenditures for developing as well as African countries, this current study sought to bridge this gap with an application to the South African economy which is well known for it's superior fiscal governance among SSA countries. Using the MTAR model coupled with a corresponding TEC component applied to quarterly time series collected between 1960:Q1 to 2016:Q2, our study was able to provide sufficient evidence of a nonlinear revenue-expenditure cointegration relationship for the data.

Our empirical results particularly show that the fiscal budget is weakly sustainable with an elasticity estimate of less-than-unity. This finding is not surprising given the unsustainability of South Africa's budget during our period of study, more prominently for periods extending from the mid-1970's through to the early 1990's. Our estimation results further reveal, that positive disturbances to the fiscal budget are corrected at a quicker rate than negative ones. We find this result to be plausible since it adheres to recent historical data accounts. For instance, during the global recession period of 2009 fiscal authorities were obligated to provide fiscal stimulus packages to boost economic recovery. These events caused negative shocks to the fiscal budget which have lingered on until this present day and the fiscal deficit has since averaged values last experienced in the pre-Apartheid era. Note that this result is in accordance with our MTAR estimates which find that worsening budgets are more difficult to control than improving budgets. Furthermore, the results obtained from our causality tests suggests that there existsan exploitable interlink between revenues and expenditures as is reminiscent of the fiscal synchronization hypothesis. This particular finding holds strength in our case study since it concurs with findings of the bulk majority of previous South African studies (i.e. Nyamongo et. al. (2007), Lusinyan and Thornton (2007), Ghartey (2010) and Baharumshah et. al. (2016)).

So, what then are the relevant policy implications that can be derived from our empirical study? For starters, in view of South Africa's weakly sustainable budget, fiscal authorities are encouraged to undertake stringent measures which will improve the current fiscal budgetary stance. In particular, the current fiscal deficit is an indication that revenue collections are not on par with government expenditures items. Given the crucial role which government expenditure plays in supporting the unemployment and poverty eradication goals stipulated in the recent NGP and NDP macroeconomic policies, it would be absurd to expect drastic cuts in

government revenues as a means of cutting the budget deficit in order to an end of fiscal sustainability. The onus therefore lies with tax authorities to ensure that revenue collections are up-to-date with fiscal expenditure obligations.

Currently, the Davies Tax Committee has been assigned the responsibility of undertaking a number of tax reform measures in order to widen the base for tax collections. However, our empirical analysis indicates that pursing such 'positive shocks' to the fiscal budget will be eradicated fairly quickly. Therefore such tax reforms should be implemented as a continuous, on-going process over the long-run. In also considering our finding in support of the fiscal synchronization hypothesis, we further advise tax authorities to work closely with other fiscal institutions in moving towards a common goal of fiscal sustainability. As a natural development to our study, future research can take the following two courses. Firstly, from a revenue collection standpoint, future studies can probe into finding the optimal tax structure mix of direct and indirect taxes which will be most beneficial for the South African economy. Secondly, from an expenditure perspective, future research can focus on determining the optimal level of government spending conducive for economic prosperity in South Africa.

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APPENDIX A

Table 1a: Review of the associated literature: Early empirical works

Author	Country/Countries	Period	Methodology	Findings
Anderson et. al. (1986)	US	1946-1983	Granger causality	GE→GR
Blackley (1986)	US	1929-1982	Granger causality	GE→GR
Von Furstenburg et. al. (1986)	US	1954-1982	VAR	GE→GR
Manage and Marlow (1986)	US	1929-1982	Granger causality	GE↔GR
Miller and Russek (1990)	US	post-World War II	VAR and ECM	GE↔GR
Ram (1988)	US	1929-1983	Granger causality	GR→GE
Bohn (1991)	US	1792-1988	ECM	GR→GE
Jones and Joulifain (1991)	US	1972-1860	ECM	GE→GR
Hoover and Sheffrin (1992)	US	1954-1779	UDL	GR→GE

Note: GE represents government expenditures, GR represents government revenue, GE→GR means expenditure granger causes revenue, GR→GE means revenues granger causes expenditure, GE↔GR means that there is bi-directional causality between expenditure and revenues, GE≠GR means there is no causality between the variables. VAR, ECM and UDL denote vector autoregressive, error correction model and unrestricted distributive lag model, respectively.

Table 1b: Review of the associated literature: Panel studies

Author	Countries	Period	Methodology	Findings
Joulifain and Mookerjee (1991)	22 OECD countries	European countries 1961-1986	VAR	Italy and Canada: GR→GE. Austria, Finland, France, Greece, Japan, UK, US: GE→GR. Australia, Belgium, Denmark, Iceland, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland: GE≠GE.
Owoye (1995)	7 European countries	1961-1990	ECM	Ireland: GE↔GR. Italy and Japan: GR→GE. Canada, France, Germany, UK, US: GE↔GR.
Koren and Stiassny (1998)	9 European countries	1953-1992	Structural VAR	Germany, Netherlands, UK, US: GR→GE. Austria, France, Italy: GE→GR.
Garcia and Henin (1999)	5 European countries	1960-1996	ECM	Sweden and Switzerland: GE↔GR. Canada, France, Germany, US: GR→GE.

Kollias and Makrydakis (2000)	Greece, Spain, Portugal and Ireland.	1960-1995	ECM	Japan: GE→GR. Spain: GR→GE. Greece and Ireland: GE↔GR.
Kollias and Paleoloou (2006)	15 EU countries	1960-2002	VECM	Portugal: GE≠GE. Denmark, Greece, Ireland: GE↔GR. Netherlands, Portugal Sweden: GE≠GE.
Afonso and Rault (2009)	25 EU countries	1998-2006	Panel granger causality tests	Finland, France, Italy, Spain, UK: GR→GE. Italy, France, Spain, Greece, Portugal: GE→GR. Belgium, Germany, Austria, Finland, UK: GR→GE.
Chang and Chiang (2009)	15 OECD	1992-2006	Panel VAR	GE↔GR
Bolat (2014)	10 EU countries	1980-2013	Panel granger causality tests	GE→GR.
		Latin American countries		
Baffes and Shah (1994)	3 Latin American countries	1895-1985	ECM	Brazil: GR→GE.
Ewing and Payne (1998)	5 Latin American countries	1950-1994	ECM	Argentina and Mexico: GE↔GR. Columbia, Ecuador, Guatemala: GR→GE.
Cheng (1999)	8 Latin American countries	1949-1995	Granger-causality tests	Chile and Paraguay: GE↔GR. Columbia, Dominican Republic, Honduras, Paraguay: GR→GE. Chile, Panama, Brazil, Peru: GR↔GE.
		Asian countries		
Narayan (2005)	9 Asian countries	1960-2000	Conditional ECM	Indonesia, Nepal, Singapore, Sri Lanka: GR→GE.
Karim et. al. (2006)	ASEAN-5 countries	1970-2000		India, Malaysia, Pakistan, Thailand, Philippines: GE≠GE. Indonesia, Malaysia, Philippines: GE→GR. Thailand and Singapore: GR→GE.
Mehrara et. al. (2011)	40 Asian countries	1995-2008	Panel cointegration and panel causality tests	GR↔GE.
Magazzino (2014)	10 ASEAN countries	1980-2012	Panel cointegration and individual causality tests	Brunei, Thailand: GE≠GE. Cambodia, Vietnam: GR↔GE. Indonesia, Laos, Malaysia, Philippines, Singapore: GR→GE. Myanmar: GE→GR.
		African countries		
Wolde-Rufael (2008)	13 African countries	1964-2003	VAR	Burkina Faso: GE→GR.

				Ethiopia, Ghana, Kenya, Nigeria, Mali, Zambia: GR→GE. Mauritius, Swaziland, Zimbabwe: GR↔GE. Botswana, Burundi, Rwanda: GE≠GE.
Ghartey (2010)	Kenya, Nigeria and South Africa	1960-2007	ARDL	Kenya: GR→GE. Nigeria and South Africa: GR↔GE.
Magazzino (2012)	15 ECOWAS countries	1980-2011	Granger causality tests	Benin, Cote d'Ivoire, Guinea Bissau, Ghana: GE≠GE. Burkina Faso, Senegal, Togo, Guinea, Liberia, Nigeria, Sierra Leone: GE→GR. Mali: GR↔GE. Niger, Gambia, Cape Verde: GR→GE.
Chang et. al. (2002)	10 developed and developing countries	Mixed economies 1951-1996	ECM	Japan, Lebanon, South Korea, Taiwan, Tunisia, UK, US: GR→GE. Australia and South Africa: GE→GR. Canada: GR↔GE. New Zealand and Thailand: GE≠GE.
Petanlar and Sadeghi (2012)	15 oil exporting countries	2000-2009	Panel VAR and panel causality tests	GR→GE.
Mehrara et. al. (2011)	11 oil exporting countries	1980-2009	Panel cointegration and panel granger causality tests	GR→GE.
Mutascu (2015)	PIIGS countries	1988-2014	Bootstrap panel granger causality tests	Greece and Italy: GR→GE. Portugal: GR→GE. Ireland and Spain: GE≠GE.

Note: GE represents government expenditures, GR represents government revenue, GE→GR means expenditure granger causes revenue, GR→GE means revenues granger causes expenditure, GE↔GR means that there is bi-directional causality between expenditure and revenues, GE≠GR means there is no causality between the variables.

Table 1c: Review of the associated literature: Single country analysis

Author	Country	Period	Methodology	Findings
Provopoulos and Zambaras (1991)	Greece		Granger causality tests	GE→GR
Huang and Tan (1992)	Taiwan	1951-1987	VAR	GR→GE
Bella and Quinteri (1995)	Italy	1866-1989	VECM	GE→GR
Kollias and Makrydakis (1995)	Greece	1950-1990	VECM	GE→GR

Koren and Stiassny (1995)	Austria	1954-1992	VAR	GE→GR
Katrakilidis (1997)	Greece	1974-191	VECM	GE↔GR
Darrat (1998)	Turkey	1967-1994	VECM	GR→GE
Park (1998)	Korea	1964-1992	VECM	GR→GE
Hatemi-J and Skukur (1999)	Finland	1960-1997	VAR	GR→GE
Mithani and Khoon (1999)	Malaysia	1970-1994	VECM	GE↔GR
Li (2001)	China	1950-1997	VAR and VECM	GE↔GR
Moalusi (2004)	Botswana	1976-2000	VECM	GR→GE
Al-Quadir (2005)	Saudi Arabia	1964-2001	VECM	GE↔GR
Carneiro et. al. (2005)	Guinea-Bissau	1981-2002	VECM	GE→GR
Tsen and Ping (2005)	Malaysia	1965-2002	VECM	GR→GE
Lusinyan and Thornton (2007)	South Africa	1895-2015	VAR	1985-1960: GE↔GR 1962-2005: GE→GR 1985-1960: GE↔GR
Nyamongo et. al. (2007)	South Africa	1994-2004	VAR	GE↔GR
Eita and Mbazima (2008)	Namibia	1977-2007	VAR	GR→GE
Taha and Loganathan (2008)	Malaysia	1970-2006	VAR	GE↔GR
Hong (2009)	Malaysia	1970-2007	VECM	GE→GR
Aslan and Tasdemir (2009)	Turkey	1950-2007	Granger causality tests	GE↔GR
Murat and Murat (2009)	Jordan	1950-2007	VECM	GE↔GR
Aisha and Khatoon (2010)	Pakistan	1972-2007	VECM	GE→GR
Keho (2010)	Ivory Coast	1960-2005	ARDL, VAR and VECM	GR→GE
Ndahiriwe and Gupta (2010)	South Africa	1960-2005	VECM	GE↔GR
Obioma and Ozughalu (2010)	Nigeria	1970-2007	VECM	GR→GE
Jalil and Hye (2010)	Romania	1998-2008	ARDL	GE↔GR
Valerui (2010)	Romania	1995-2007	VECM	GE≠GE
Nanthakumar et. al. (2011)	Malaysia	1970-2009	ARDL	GR→GE
Ali and Shah (2012)	Pakistan	1976-2009	VECM	GE≠GE
Al-Khulaifi (2012)	Qatar	1980-2011	VECM	GR→GE
Aregbeyen and Ibrahim (2012)	Nigeria	1970-2008	ARDL	GR→GE
Elyasil and Rahimi (2012)	Iran	1963-2011	ARDL	GE↔GR
Ogujibuba and Abraham (2012)	Nigeria	1970-2011	VECM	GR→GE
Dogan (2013)	Turkey	1924-2011	VECM	GE→GR

Al-Zeaud (2014)	Jordan	1990-2011	VECM	GE↔GR
Lukovic and Grbic (2014)	Serbia	2003-2012	VAR	GE→GR
Nwosu and Okafor (2014)	Nigeria	1970-2011	VAR and VECM	GE→GR
Obeng (2015)	Ghana	1980-2013	VAR	GR→GE
Takumah (2015)	Ghana	1986-2012	VECM	GE↔GR

Note: GE represents government expenditures, GR represents government revenue, GE→GR means expenditure granger causes revenue, GR→GE means revenues granger causes expenditure, GE↔GR means that there is bi-directional causality between expenditure and revenues, GE≠GR means there is no causality between the variables.

Table 1d: Review of the associated literature: Nonlinear studies

Author	Country/Countries	Period	Methodology	Findings
Arestis et. al. (2004)	US	1947-2002	TAR unit root tests	Stationary process when the ratio of the budget to GDP is below the threshold of -0.313. Unit root process when the ratio of the budget to GDP is above the threshold of -0.313.
Bajo-Rubio et. al. (2004)	Spain	1964-2001	TAR unit root tests	The ratio of the budget to GDP is low persistent below the threshold of -1.90. The ratio of the budget to GDP is highly persistent above the threshold of -1.90.
Bajo-Rubio et. al. (2006)	Spain	1964-2003 1982-2004	TVECM	Above the threshold of 5.30 and 7 for the ratios of general and central government deficit as a ratio of GDP, immediate adjustment would lead to a fall in the deficit and vice versa.
Ewing et. al. (2006)	US	1958-2003	TAR and MTAR	Asymmetric cointegration. Revenues and expenditures respond to worsening budgets but not to improving ones. GE≠GE in the short-run. GE↔GR in the long-run.
Cipollini et. al. (2009)	US	1947-2004	TVECM	Fiscal authorities should intervene in the budget only when real deficit per capita exceeds a threshold of 8.859.
Payne et. al. (2008)	Turkey	1968-2004	TAR and MTAR cointegration model	No asymmetric cointegration, GR→GE.
Zapf and Payne (2009)	US	1959-2005	TAR and MTAR cointegration model	No asymmetric cointegration

Gil-Alana (2009)	US	1947-1992	Fractional integrated TAR and MTAR cointegration model	Very little evidence of asymmetric cointegration.
Saunoris and Payne (2010)	UK	1955-2009	TAR and MTAR cointegration model	Asymmetric cointegration. Revenues and expenditures respond to worsening budgets quicker than to improving ones. GE→GR over long-run.
Keho (2011)	Ivory Coast	1960-2007	TVECM	Asymmetric cointegration. GR→GE in periods of budget deficit. GE→GR in periods of budget surplus.
Young (2011)	US	1959-2007	TAR and MTAR cointegration model	Asymmetric cointegration. Revenues and expenditures respond to worsening budgets quicker than to improving ones.
Apergis et. al. (2012)	Greece	1957-2009	TAR and MTAR cointegration model	Asymmetric cointegration with GE→GR in the short run and GE↔GR in the long-run.
Jibao et. al. (2012)	South Africa	1960-2008	LSTECM	Equilibrium adjustment is quicker during a deficit and lower during a surplus.
Aworinde (2013)	Nigeria	1961-2012	Nonlinear causal tests	GR→GE
Paleologou (2013)	Sweden, Greece and Germany	1965-2009	TAR and MTAR cointegration model	No asymmetric cointegration in Sweden and Germany, GE↔GR in both countries. Asymmetric cointegration in Greece with GE→GR.
Piergallini and Postigliola (2013)	Italy	1861-2012	STR	The ratio of the budget to GDP is low persistent below the threshold of -1.10. The ratio of the budget to GDP is highly persistent above the threshold of -1.10.
Athanasenas et. al. (2014)	Greece	1999-2010	NARDL	Asymmetric cointegration with GE↔GR
Tiwari and Mutascu (2015)	Romania	1999-201	TAR and MTAR cointegration model	Asymmetric cointegration. Revenues and expenditures respond to worsening budgets quicker than to improving ones. GE→GR
Aworinde and Ogundipe (2015)	Nigeria	1961-2012	TAR and MTAR cointegration model	Asymmetric cointegration. Revenues and expenditures respond to worsening budgets quicker than to improving ones. GE↔GR

Baharumshah et. al. (2016)	South Africa	1960-2013	TAR and MTAR cointegration model	No asymmetric cointegration

Note: GE represents government expenditures, GR represents government revenue, GE→GR means expenditure granger causes revenue, GR→GE means revenues granger causes expenditure, GE↔GR means that there is bi-directional causality between expenditure and revenues, GE≠GR means there is no causality between the variables. TAR and MTAR represent threshold autoregressive and momentum threshold autoregressive models respectively. TVECM denotes the threshold vector error correction model. NARDL is the nonlinear autoregressive distributive lag model.