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Department of Economics Working Paper Series

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Uwilingiye Josine

University of Pretoria

Rangan Gupta

University of Pretoria

Working Paper: 2007-08

June 2007

Department of Economics

University of Pretoria

0002, Pretoria

South Africa

Tel: +27 12 420 2413

Fax: +27 12 362 5207

TEMPORAL CAUSALITY BETWEEN BUDGET DEFICIT AND INTEREST RATE: THE CASE OF SOUTH AFRICA

Uwilingiye Josine*

and

Rangan Gupta+

Abstract

This paper investigates the direction of temporal causality between budget deficit and interest rate in South Africa using quarterly data for the period of 1961:02 to 2005:04, and also for annual data covering 1961 to 2005. Based on a multivariate Vector Error Correction Model (VECM), estimated using Johansen's (1991, 1995) Maximum Likelihood Approach, we find that budget deficit Granger causes interest rate in the quarterly data. However, for the annual data, no causal relationship could be detected between the budget deficit and the Treasury bill rate. The two variables of interest are, however, positively cointegrated for both data frequency. Interestingly though, exactly the same results were obtained from simple Granger causality tests based on a bivariate framework, comprising merely of budget deficit and interest rate.

Keywords: Cointegration Test, Granger Causality Test, Vector Autoregressive Model, Vector Error Correction Model.

JEL classification: C01; C32; H20; H50.

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* Graduate Student, Department of Economics, University of Pretoria, South Africa. Contact details: E-mail:juwilingiye@yahoo.fr, Cell: +27 72 425 1121

+ To whom correspondence should be addressed. Senior Lecturer, University of Pretoria, Department of Economics, Pretoria, 0002, South Africa. Contact details: E-mail: rangan.gupta@up.ac.za, Phone: +27 12 420 3460, fax: +27 12 362 5207.

1. INTRODUCTION

The issue of whether government deficit raises interest rate has received quite a bit of attention in recent years. Conventional macroeconomic paradigm implies that large deficits will increase interest rate which, in turn, will discourage interest-sensitive private expenditures, especially investment, and, hence, adversely affect economic activity.

Even though, the relationship between interest rate and budget deficit has been an important empirical question for a while, results have been ambiguous. While some studies have found a positive relationship, others indicate that the two variables are unrelated. Moreover, in some instances, bidirectional causality has also been observed.

Given that there exists no coherent finding, as far as the relationship is concerned, and seems to be country-specific,[1] it is important to analyze the relationship in the context of the South African economy. This is more so, with the South African economy planning to increase expenditure in the lead up to world cup in 2010. It is, thus, essential to figure out whether deficit causes an increase in interest rates and, hence, could lead to a slowdown in economic activity.

For this purpose, our study uses a Vector Error Correction Model (VECM), estimated using Johansen's (1991, 1995) maximum likelihood approach. Note that Johansen's (1991, 1995) approach incorporates a potential channel of causation which might exist if the variables are cointegrated or have a common stochastic trend (Granger,1983; Miller and Russek,1990), unlike in the standard Granger causality test. And, hence, provides a more robust analysis of causality.

The paper is organised as follows: Besides, the introduction and conclusions, Section 2 discusses the literature on the causality between budget deficit and interest rate. Section 3 lays out the methodology and the data, while, Section 4 presents the empirical results.

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[1] See for further details in Section 2.

2. LITERATURE REVIEW

Conventional wisdom suggests that higher government deficit will increase the interest rate which, in turn, will crowd-out private investment and lead to slow down in economic activity. Economists have, however, debated on the direction of causality between government deficit and interest rate, using both, theoretical and empirical models. In summary, the results have been found to be ambiguous.

The loanable funds model predicts that, in the absence of debt monetisation, the effects of large fiscal deficits could lead to large effects on interest rates. Brunner (1984), indicates that since interest rates are determined by stock demand and supply, based on the portfolio analysis, and not by flow demands and supply, as suggested by the loanable funds model, this could lead to either significant or negligible effects of deficits on interest rates, depending on the sizes of accumulated stock of debts and deficits.

According to Premchand (1984), the budget deficit financed by borrowing from the private sector leads to an increase in the supply of government bonds, and to attract the private sector to buy these bonds, the government has to offer them at a low price, which essentially implies an upward pressure on interest rates, which causes crowding out of investment in the private sector. According to Mankiw (1997), as government spending increases, it raises planned aggregate expenditure and, hence, output. The resulting increase in real demand for money reduces demand for bonds by pushing down the bond prices and raising the interest rate. Evans (1987a) suggests that an increase in government budget deficit, resulting from lower taxes with constant government consumption, would tend to raise disposable income, and, hence, domestic consumption. If, at least, a part of the increase in consumption is devoted to domestically produced goods, money demand would increase, and the nominal interest rate would then need to rise to ensure the money market equilibrium.

Yallen (1989), however, adds another channel through which crowding out occurs. He points out that in a closed economy; deficit finance raises real interest rate and crowds out investment. But, in small open economy, with international capital mobility, government deficit raises interest rate, leading to an inflow of foreign funds. In such a situation, with a flexible exchange rate regime in place, the domestic currency appreciates and causes a reduction in the competitiveness of the economy's products in the international market.

Zahid (1988) argues, that when the government budget deficit is defined properly to reflect the government excess demand for funds from non-governmental public, and the counter cyclical variations in the deficit figures are adjusted for, a positive impact of deficits on real interest rate is observed for the United States over the period of 1971-1980. Tanzi (1985), based on American data, also finds a positive relationship between higher fiscal deficits and interest rates. Gupta (1992) noted a positive relationship between budget deficits and interest rates in four Asian economies at the 5 percent level of significance, and could also add two more countries to the list at a higher level of significance. Kuehlwein and Samalapa (1999) also report budget deficits to have raised real interest rates in Thailand.

Miller and Russek (1991), used standard Granger causality and Vector Error Correction to examine the issue of causality between fiscal deficits and interest rate, based on both quarterly and annual data. The findings were mixed. Using standard Granger causality, there was little evidence suggesting that deficit Granger causes interest rate or vice versa on both quarterly and annual data. However, Miller and Russek (1991) found that when the error correction framework was used, bidirectional causality between federal deficit and long term interest rates was detected in all formulations, except in the case of annual data, which provided some weak evidence of the deficit causing the short-term interest rate.

Some authors, like Mankin (1983), Darrat (1989, 1990), examining the impact of interest rates on fiscal deficits supports the hypothesis that long-term interest rates have significantly increased the budget deficit measures of the United States. Cheng (1998), however, finds no evidence of causality between budget deficits and long term interest rate in Japan. Instead, he detected a causality relationship running from deficits to short term interest rate using Hsiao's version of the Granger causality method.

In complete contrast to this, the Ricardian equivalence hypothesis discussed by Bailey (1972) and Barro (1974, 1981, 1987a, b), concluded that interest rate does not rise in response to federal deficits, since these deficits are fully offset by increases in private saving. This is because taxpayers anticipate future tax increases which are required to satisfy the government budget constraint. This finding was supported by Plosser (1982) and Evans (1985, 1987a, b). Evans (1985) dealing with the question of whether large deficits tend to produce higher interest rate argues that large deficit has never been associated with high interest rate over a century of US history, and, interestingly, the trend was rather negative during the postwar period. McMillin (1986), also echoes similar findings. Based on a multivariate Granger causality test on the effects of American federal deficits on short-term interest rates, the author suggested that none of the measures of deficits Granger causes the interest rate. Evans (1987a), based on a model where a country's nominal interest was an increasing function of domestic government consumption and domestic expected inflation, and a decreasing function of domestic real money supply, found no evidence of budget deficit to increase the real rate of interest, when estimated for Canada, France, Germany, Japan, the United Kingdom and the United States. Interestingly, Kolluri and Giannaros (1987) and Swamy *et al.* (1990), finds that increases in budget deficits actually depresses interest rates.

Akinbode (2004) used the London school method and Granger causality tests to analyse the relationship between fiscal deficits and interest rates in South Africa. Based on his study, the author concluded that budget deficit and interest rates are independent of each other.

Given that the empirical results are sensitive to the choice of variables, the econometric approach, as well as the frequency of data, we examine the issue of causality between budget deficit and interest rate, using a multivariate cointegration and Vector Error Correction analysis. This approach helps us to avoid possible distortions to the inferences of causality, as is often the case with Granger causality tests due to the omission of a relevant channel – the one that exists when variables are cointegrated. Moreover, the robustness of the results is checked by starting the analysis with quarterly data and then repeating the same with annual data. Our analysis thus aims to verify the claims made by Akinboade (2004) using an alternative approach, and, hence, should be considered as its extension.

3. Data and Methodology

3.1 Data discussion

In this study, the quarterly time-series data covers the period from the second quarter of 1961 (1961:02) to the fourth quarter of 2005 (2005:04), while, the annual data covers the period of 1961 to 2005. All data used, are obtained from the South African Reserve Bank and the International Financial Statistics. The variables used in our study are: the Treasury bill rate (*tbr*), budget deficit as a percentage of GDP (*def_gdp*), change in debt (*ch_debt*), trade balance (*btrade*), inflation (*infl_gdpdefl*) calculated as the percentage change in the GDP deflator and real Gross Domestic Product (*lrgdp*). In addition to the variables, we also use three centred (orthogonalised) seasonal dummy variables to remove seasonality, since our data is not deseasonalized. Note that real GDP is the only variable converted to its logarithmic form, since some of the other variables had negative values.

3.2 Granger causality, cointegration analysis and error correction model.

As a part of the preliminary investigation of the temporal causality between deficit and interest rate, we perform the simple Granger causality test. But as pointed out earlier, we, however, go ahead and also use a multivariate approach to see if our results from the bivariate framework continue to hold when we allow for additional variables and cointegration.

Note the simple Granger causality test, laid out in Granger (1969), examines whether the current movements of a variable y can be merely explained by the past values of y, or adding lagged values of another variable x, can improve the explanation of y. y is said to be Granger-caused by x, if x helps in the prediction of y, or equivalently, if the coefficients on the lagged x's are statistically significant.

The possible findings for causation are:

i) x causes y, but not vice versa;

ii) y causes x, but not vice versa;

iii) x Granger causes y and y Granger causes x, and;

iv) x and y are independent to each other.

It is important to note that the statement "x Granger causes y" does not imply that y is the effect or the result of x. Granger causality tends to measure precedence and information content, but does not by itself indicate causality in the more common use of the term. At this stage, it is important to emphasize that the outcome of standard Granger causality test is sensitive to the number of lags introduced in the model.

However, it is possible that long run equilibrium relationship exist among the variables. In this regard, Granger (1983, 1986) and Engle and Granger (1987) provides a more comprehensive test of causality in a multivariate framework by allowing for a causal linkage between two cointegrated variables. This addition to the standard test for Granger causality considers the possibility that the lagged *level* of a variable, $\boldsymbol{y}$, may help to explain the current change in another variable, ***x*,** even if past changes in ***y*** do not. The intuition is that if ***y*** and ***x*** have a common trend, then the current change in ***x*** is partly the result of ***x*** moving into alignment with the trend value of y. Such causality may not be detected by the standard Granger causality test, which only examines whether past *changes* in a variable help to explain current changes in another variable.
In more formal terms, this alternative test for Granger causality is based on error-correction models that incorporate information from the cointegrated properties of time-series variables. Two (or more) variables are co-integrated if they share common trend(s). To test for causality when variables are cointegrated, the following error correction equation is used:

$$Dx_t = \alpha_0 + \sum_{i=1}^{q} \beta_{xi} Dx_{t-i} + \sum_{i=1}^{q} \beta_{yi} Dy_{t-i} + \alpha_1 \mu_{t-1} + e_t \qquad (1)$$

where x_t , and y_t are first-differenced stationary and cointegrated time series, μ_{t-1} is the lagged value of the error term obtained from the following cointegration equation:

$$x_t = \phi_0 + \phi_1 y_t + \mu_t \qquad (2)$$

The inclusion of μ_{t-1}, which must be stationary if the first-differenced stationary x and y series are co-integrated, differentiates the error-correction model from the standard Granger causality regressions. By including μ_{t-1} , the error-correction model introduces an additional channel through which Granger causality can emerge. Based on equation (1), the null hypothesis that y does not Granger cause x is rejected not only if the β_{yi}'s are jointly significant, but also if the coefficient on μ_{t-1} is significant. Thus, in contrast to the standard Granger causality test, the error-correction approach allows for the finding that y Granger causes x, even if the coefficients on lagged changes in y are not jointly significant.

In this study, however, Johansen's (1991, 1995) Full Information Maximum Likelihood (FIML) approach is used to estimate not only the long run relationship between variables but also the associated short-run adjustments processes. The reason is that, unlike the Engle and Granger (1987) framework, the FIML approach allows for more than one cointegrating relationship, when more than two variables are involved in the econometric specification. Based on a restricted Vector Autoregressive framework, the Johansen's (1991, 1995) approach also does not require treating the variables, whose causal relationship is not analysed, as exogenous.

A VAR model with *p* lags can be represented as follows:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_k y_{t-p} + Bx_t + \varepsilon_t \quad (3)$$

where y_t is a vector non-stationary *I(1)* variables, $A_1, A_2, ..., A_p$ and B are different matrices of coefficients to be estimated, x_t is a vector of deterministic variables and, finally ε_t is the vector of innovations. This VAR can be rewritten in first difference as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-1} + Bx_t + \varepsilon_t \quad (4)$$

where $\Pi = \sum_{i=1}^{k} A_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{k} A_j$

Based on Granger’s representation theorem, with six variables in the VAR system (k = 6), the number of cointegrating relations can vary between 0 and k-1, which means that at most five cointegrating equations ($r < k$) can be obtained. Based on the 6 variables, our VECM can be represented as fallows:

$$
\begin{bmatrix} \Delta tbr \\ \Delta def\_gdp \\ \Delta ch\_debt \\ \Delta btrade \\ \Delta \inf l\_gdpdefl \\ \Delta lrgdp \end{bmatrix}
=
\begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \\ d_{41} & d_{42} & d_{43} \\ d_{51} & d_{52} & d_{53} \\ d_{61} & d_{62} & d_{63} \end{bmatrix}
\begin{bmatrix} D1 \\ D2 \\ D3 \end{bmatrix}
+
\begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix}
\begin{bmatrix} \Delta tbr_{t-1} \\ \Delta def\_gdp_{t-1} \\ \Delta ch\_debt_{t-1} \\ \Delta btrade_{t-1} \\ \Delta \inf l\_gdpdefl_{t-1} \\ \Delta lrgdp_{t-1} \end{bmatrix}
+
$$

$$
\begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} & \alpha_{16} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} & \alpha_{36} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} & \alpha_{46} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} & \alpha_{56} \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & \alpha_{66} \\ \alpha_{71} & \alpha_{72} & \alpha_{73} & \alpha_{74} & \alpha_{75} & \alpha_{76} \end{bmatrix}
\begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} & \beta_{71} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} & \beta_{52} & \beta_{62} & \beta_{72} \\ \beta_{13} & \beta_{23} & \beta_{33} & \beta_{43} & \beta_{53} & \beta_{63} & \beta_{73} \\ \beta_{14} & \beta_{24} & \beta_{34} & \beta_{44} & \beta_{54} & \beta_{64} & \beta_{74} \\ \beta_{15} & \beta_{25} & \beta_{35} & \beta_{45} & \beta_{55} & \beta_{65} & \beta_{75} \\ \beta_{16} & \beta_{26} & \beta_{36} & \beta_{46} & \beta_{56} & \beta_{66} & \beta_{76} \\ & & & & & & \end{bmatrix}
\begin{bmatrix} tbr_{t-1} \\ def\_gdp_{t-1} \\ ch\_debt_{t-1} \\ btrade_{t-1} \\ \inf l\_gdpdefl_{t-1} \\ lrgdp_{t-1} \\ C \end{bmatrix}
+
\begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix}
\quad (5)
$$

Note the finding of cointegration necessarily implies the existence of temporal causality in at least one direction, and if any of the cointegrating equations deviate from its long run relationship, adjustment will be made gradually by the elements of the α matrix, known as the loading matrix of the VECM.

4. Empirical results

The univariate characteristics of the quarterly data was analysed by using the Augmented Dickey Fuller and Phillips Perron tests, in levels.[2] The Treasury Bill rate and real gross domestic product were found to be integrated of order one I(1), while others were I(0). But using the annual data, inflation, besides Treasury Bill rate and real gross domestic product, were found to be integrated

[2]See Appendix I for further details.

of order one (*I (1)*). Since non-stationary variables are involved the use of a VECM, based on differenced and, hence, stationary data is required to determine the direction of temporal causality between budget deficit and interest rate in a multivariate framework.

4.1 Quarterly data

Before we analyse the Granger causality in a multivariate framework, bivariate Granger causality tests, reported in Table 1, were used to provide a preliminary idea of the direction of causality between interest rate and budget deficit. Alternatively, this means that we check if the past value of deficit helps in the prediction of the current interest rate, or if the past value of interest rate helps in explaining the movements of the current budget deficit.

Table 1: Pairwise Granger Causality Tests (lag length: 2)

Null Hypothesis:	Obs	F-Statistic	Probability
DEF_GDP does not Granger Cause DTBR	176	2.48543	0.08629
DTBR does not Granger Cause DEF_GDP		1.51753	0.22219

The results show that the null of budget deficit does not Granger causes interest rate is rejected at the 10 percent level of significance, but the null that interest rate does not Granger cause deficit cannot be rejected at the 10 percent level of significance. Therefore, based on the simple Granger causality tests, it appears that Granger causality runs in one direction, and that is from deficit to interest rate.

Given that now we have a preliminary idea about the direction of causality in a bivariate framework, we go ahead and use the Johansen's (1991, 1995) methodology to check whether the results from the bivariate framework carries over to a more general econometric structure. More precisely, the Johansen's (1991, 1995) approach allows us to check for the robustness of the results obtained from the two-variable model. Before we perform the tests of cointegration, a test for the stability of the VAR model was carried out. With no roots lying outside the unit circle for the estimated VAR[3] based on 4 lags[4], we conclude that the basic system laid out in equation (3) is stable. Note the choice of 4 lags is based on the Akaike Information and Hannan-Quinn Information criteria. Including four lags in the VAR and allowing for no deterministic trend in the data, but an intercept and no trend in the cointegrating equation, we perform the tests for cointegration. The results have been reported in Table 2. Based on the Pantula Principle, both the Trace and the Maximum Eigen Value tests, show that there are two stationary relations in the data ($r = 2$) at the 5 percent level of significance.

Table 2: Johansen Cointegration Tests

Panel A: Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.297734	150.7210	103.8473	0.0000
At most 1 *	0.211507	89.22197	76.97277	0.0043
At most 2	0.117482	47.87397	54.07904	0.1592
At most 3	0.085911	26.12818	35.19275	0.3348
At most 4	0.037167	10.49827	20.26184	0.5909
At most 5	0.022209	3.907989	9.164546	0.4260

Panel B: Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.297734	61.49907	40.95680	0.0001
At most 1 *	0.211507	41.34800	34.80587	0.0072
At most 2	0.117482	21.74579	28.58808	0.2906
At most 3	0.085911	15.62990	22.29962	0.3253
At most 4	0.037167	6.590285	15.89210	0.7192
At most 5	0.022209	3.907989	9.164546	0.4260

[3] See Appendix III for further details.
[4] See Appendix II for further details.

Based on the two cointegrating relationship, the VECM can be visualized as follows:

$$\begin{bmatrix} \Delta tbr \\ \Delta def\_gdp \\ \Delta ch\_debt \\ \Delta btrade \\ \Delta \inf l\_gdpdefl \\ \Delta lrgdp \end{bmatrix} = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \\ d_{41} & d_{42} & d_{43} \\ d_{51} & d_{52} & d_{53} \\ d_{61} & d_{62} & d_{63} \end{bmatrix} \begin{bmatrix} D1 \\ D2 \\ D3 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix} \begin{bmatrix} \Delta tbr_{t-1} \\ \Delta def\_gdp_{t-1} \\ \Delta ch\_debt_{t-1} \\ \Delta btrade_{t-1} \\ \Delta \inf l\_gdpdefl_{t-1} \\ \Delta lrgdp_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \\ \alpha_{71} & \alpha_{72} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} & \beta_{17} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} & \beta_{25} & \beta_{26} & \beta_{27} \end{bmatrix} \begin{bmatrix} tbr_{t-1} \\ def\_gdp_{t-1} \\ ch\_debt_{t-1} \\ btrade_{t-1} \\ \inf l\_gdpdefl_{t-1} \\ lrgdp_{t-1} \\ C \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \tag{6}$$

The unrestricted results from the Johansen's (1991, 1995) cointegration approach is reported below in Table 3.

Table3: Unrestricted Results

Unrestricted Cointegrating Coefficients

TBR	DEF_GDP	CH_DEBT	BTRADE	INFL_GDPDEFL	LRGDP	C
-0.054882	-0.013285	-0.008756	1.05E-05	-0.581462	-0.994964	15.84849
0.099350	-0.650936	-0.036758	1.62E-05	-0.370935	0.086969	-2.950569
0.318811	0.038519	0.002215	-0.000185	-0.414888	-3.034044	34.26243
-0.105865	-0.559822	0.003768	4.85E-05	-0.343008	1.768812	-21.31083
0.039104	0.149488	-0.001243	0.000174	-0.469486	1.078864	-12.33250
-0.182719	0.183375	-0.002097	-7.16E-05	-0.250065	0.604773	-4.329618

Unrestricted Adjustment Coefficients

D(TBR)	-0.114601	-0.159699	-0.088455	0.034600	-0.092112	0.090238
D(DEF_GDP)	-0.447179	0.048010	-0.178302	0.400330	-0.055311	-0.145034
D(CH_DEBT)	7.171906	29.72025	-9.339717	-9.754176	-3.715443	1.542265
D(BTRADE)	427.1637	120.8031	675.8234	149.7828	-238.7956	-84.89178
D(INFL_GDP DEFL)	0.049832	-0.111967	0.398208	0.339032	0.163971	0.103353

D(LRGDP)	0.006272	-0.001312	-0.003059	0.000571	-0.000464	-0.000350

Given two cointegrating relations (*r=2)*, the Johansen (1991, 1995) procedure gives the maximum likelihood estimates of the unrestricted cointegrating relations $\beta' X_t$. Even if the unrestricted β is uniquely determined, depending on the chosen normalization, β is not necessarily meaningful from an economic point of view. Therefore, an important part of long-run cointegration analysis is to impose (over-) identifying restrictions on β to achieve economic interpretability *(*Hendry *et al.* 2000).

Since we are more interested in the relationship between the interest rate and the budget deficit, both the variables have been restricted to be equal to unity in the first and second cointegrating equations, respectively. To have binding restrictions, significant statistics and identified parameters, a number of restrictions were imposed on the VAR. In the first cointegrating equation the coefficients on the balance of trade and the inflation were restricted to zero, while, in the second cointegrating equation, the coefficient of change in debt was set to zero. The fact that the restrictions were binding for the two cointegrating relations, was vindicated by the value of the LR [$\chi^2(1) = 0.026713$] test statistic.[5]

After having imposed the restrictions, the two long run cointegrating equations obtained were as follows:

The first cointegrating vector

tbr = 4.465041*def_gdp* + 0.216533*ch_debt*- 4.422692*lrgdp* (7)

[5.64694] [6.71346] [-0.98113]

The second cointegrating vector

*def_gdp=*0.581911*tbr*- 0.0000782*btrade* +3.467932*infl_gdpdefl* +6.874037 *lrgdp*

[2.09643] [-0.42582] [5.16998] [1.61398] (8)

First of all, we observe that all the coefficients, except for the real GDP in the first cointegrating relationship and the balance of trade in the second

[5] The p-value for the binding restrictions was equal to 0.87.

cointegration equation, are statistically significant. Moreover, the results show that 1 unit change in budget deficit as percentage of GDP leads to 4.47 percent change in Treasury bill rate in the same direction. While, from the second cointegrating relationship we observe that, 1 percent increases in the Treasury bill rate leads 0.58 percent increase in the measure of the deficit. Note the signs of the other variables in the two cointegrating relationship also conform to economic intuition.

At this stage, it is important investigate which variables enter significantly into the process of the system, following a short-run disequilibrium. For this purpose we carried out the weak exogeneity tests. Weakly exogenous variables refer to variables that are generated outside the equation. A variable is said to be weakly exogenous if, (when a condition is set on it by restricting the alphas representing the adjustment coefficients on loading matrix to zero) there is no loss of information about the parameter of interest. The results of the weak exogeneity test have been reported in Table 4.

Table 4: Exogeneity test

Variable	Restriction	Restricted Log-likehood	LR statistic	df*	Probability	Conclusion
tbr	$\alpha_{11}=\alpha_{12}=0$	-2994.389	6.993004	3	0.072121	endogenous
def_gdp	$\alpha_{21}=\alpha_{22}=0$	-2994.702	7.618104	3	0.054600	endogenous
Ch_debt	$\alpha_{31}=\alpha_{32}=0$	-2998.957	16.12916	3	0.001067	endogenous
btrade	$\alpha_{41}=\alpha_{42}=0$	-2992.798	3.810351	3	0.282684	Weak exogenous
Infl_gdpdefl	$\alpha_{51}=\alpha_{52}=0$	-2991.111	0.436486	3	0.932606	Weak exogenous
lrgdp	$\alpha_{61}=\alpha_{62}=0$	-3003.361	24.93660	3	0.000016	endogenous

* df is the degree of freedom equal to the number of restrictions

With respect to the cointegrating space, the null hypothesis (*the endogenous variable is weakly exogenous*) is not rejected for only balance of trade and inflation. As far as the parameters of the cointegrating relationships are concerned, as four variables are endogenous in the system, it means that information could have been lost by not explicitly modelling the process determining one particular variable, except for the measures of balance of trade and inflation, jointly with that determining other endogenous variables. At this stage, it must be kept in mind that the ith endogenous variable is said to be exogenous, if the ith row of the α matrix is entirely zero. Thus, if an individual element of α is zero, it implies that the variable of interest does not respond to the discrepancy from a long-run equilibrium for a particular equation in the VECM. The loading coefficients of the parsimonious VECM (PVECM) have been reported below in Table 5.

As can be seen from Table 5, 3 percent of the deviation from the long-run equilibrium in the Treasury bill equation in quarter *t* is corrected in quarter *t+1* by the interest rate itself, while the deficit tends to correct nearly 1 percent of the discrepancy. For the deficit equation, however, the interest rate and the deficit corrects for, respectively, nearly 4 and 8 percent of the deviation in period *t+1*. Interestingly, the change in debt and GDP, the latter though by very small degree, tends to push the system away from equilibrium. Note bigger the adjustment coefficients, the quicker the adjustment process. Since the adjustment coefficients on the balance of trade and inflation are zero, they play no part in the adjustment process.[6]

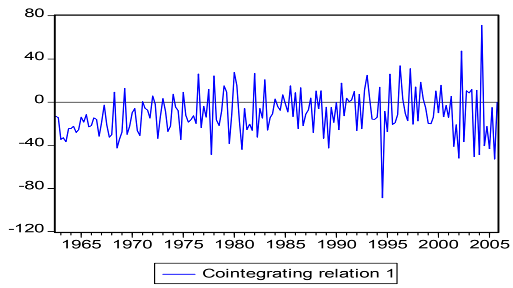
Table 5: Loading Matrix of the PVECM

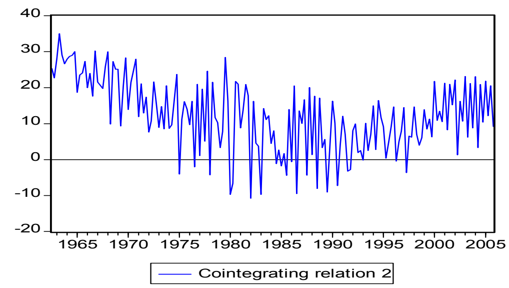
	D(TBR)	D(DEF_GDP)	D(CH_DEBT)	D(BTRADE)	D(INFL_GDP DEFL)	D(LRGDP)
CE I	-0.032674	-0.008121	5.482322	0.000000	0.000000	3.67E-05
	[-2.28854]	[-0.26247]	[5.60821]	[NA]	[NA]	[0.17762]
CE II	-0.038278	-0.075159	5.452560	0.000000	0.000000	0.001097
	[-2.16209]	[-1.95894]	[4.49810]	[NA]	[NA]	[4.28345]

[6] All, the restrictions, i.e., both on the alpha and the beta matrix were found to be binding, since the value of the chi-squared statistic was $\chi^2(5) \approx 4.896$ with a p-value of 0.43.

Figure 1 shows the plots of the two cointegrating relations. Note, since the graphs show mean-reverting residuals to the equilibrium, which is zero, the estimated cointegrating relations are appropriate.[7]

Figure 1: Residuals for the cointegrating equation 1 and 2.





It is worth noting that Granger causality is quite different from a test for exogeneity (Enders, 2004: 283). While exogeneity of one variable, means that it is not affected by the contemporaneous values of the remaining variables, Granger causality refers only to the effects of past values of the other variables on the variable of our concern. However, from the VECM, it is possible to determine if the coefficients of a particular lagged differentiated regressor are significantly equal to zero. If yes, then that particular variable does not Granger cause the independent variable.

Table 6: VECM Granger Causality

Panel A: Dependent variable: D(TBR)

Excluded	Chi-sq	df	Prob.
D(DEF_GDP)	8.070793	4	0.0890
D(CH_DEBT)	8.167907	4	0.0856
D(BTRADE)	1.436359	4	0.8379

[7] Diagnostic tests, reported in Appendix IV, indicate the residuals of the cointegrating relationships are not only normally distributed, but also no evidence of autocorrelation and heteroscedasticity could be found.

D(INFL_GDP DEFL)	3.416953	4	0.4906
D(LRGDP)	2.276310	4	0.6851
All	21.03788	20	0.3949

Panel B: Dependent variable: D(DEF_GDP)

Excluded	Chi-sq	df	Prob.
D(TBR)	2.525093	4	0.6401
D(CH_DEBT)	1.628485	4	0.8037
D(BTRADE)	16.55585	4	0.0024
D(INFL_GDP DEFL)	1.653332	4	0.7992
D(LRGDP)	12.52989	4	0.0138
All	37.51909	20	0.0101

The results, reported in Table 6, shows that the null of deficit does not Granger causes interest rate is rejected at the 10 percent level of significance, while the same of interest rate does not Granger causes deficit cannot be rejected at 10 percent level of significance. This, thus, means that deficit Granger causes interest rate. Interestingly, this is exactly what we obtained, using the bivariate Granger causality tests. However, as can be seen from Panel A of Table 6, change in debt also Granger causes the Treasury bill rate, while from Panel B, balance of trade and GDP is found to Granger cause deficit. In addition, the block causality tests reported in Panel B reveals that interest rate, change in debt, balance of trade, inflation rate and GDP jointly Granger causes deficit at the 1 percent level of significance.

So in summary, we find that the results of the bivariate Granger causality tests on interest rate and deficit are retained in a multivariate framework, accounting for plausible cointegrating relationship. Clearly, then, having checked for the robustness of the bivariate causality tests, we can conclude that, in quarterly data, deficit has Granger caused interest rate for the South African economy over the period of 1961:02 to 2005:04.

4.2 Annual Data

As with the quarterly data, we start off, for the annual data, by performing the pairwise Granger causality tests between budget deficit and interest rate. The results have been reported in Table 7.

Table 7: Pairwise Granger Causality Tests (lag length=2)

Null Hypothesis:	Obs	F-Statistic	Probability
DEF_GDP does not Granger Cause DTBR	42	0.78462	0.46374
DTBR does not Granger Cause DEF_GDP		0.20789	0.81324

The tests show that neither of the null hypotheses of budget deficit does not Granger cause interest rate nor the interest rate does not Granger causes deficit can be rejected at the 10 percent level of significance. Therefore, based on the bivariate Granger causality tests, it appears that there is no causal relationship between interest rate and budget deficit in the annual data over the period of 1961 to 2005.

Moving on to the Johansen (1991, 1995) methodology, we find that the VAR satisfies the stability condition, since no root lies outside the unit circle.[8] . Moreover, based on the Akaike information and Hannan-Quinn information criteria, we find that the 1 lag optimally represents the structure of the annual data modelled in the VAR.[9]

Having ensured that, the VAR is stable and 1 lag is required to describe the data, we carry out the cointegration tests by allowing for a linear deterministic trend in the data, and an intercept but no trend in the cointegrating equation. Table 8 below reports the results of the cointegration test for the annual data.

[8] See Appendix VII.
[9] See Appendix VI.

Table 8: Johansen Cointegration Tests

Panel A:Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.566527	103.9204	95.75366	0.0122
At most 1	0.402551	67.97564	69.81889	0.0695
At most 2	0.353645	45.82693	47.85613	0.0766
At most 3	0.331791	27.06148	29.79707	0.1001
At most 4	0.194105	9.725875	15.49471	0.3024
At most 5	0.010327	0.446389	3.841466	0.5041

Panel B: Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.566527	35.94476	40.07757	0.1359
At most 1	0.402551	22.14871	33.87687	0.5961
At most 2	0.353645	18.76546	27.58434	0.4328
At most 3	0.331791	17.33560	21.13162	0.1567
At most 4	0.194105	9.279486	14.26460	0.2636
At most 5	0.010327	0.446389	3.841466	0.5041

While, the Trace test indicates 1 cointegrating relation (r = 1) at the 5 percent level of significance, the Maximum Eigen Value tests finds no cointegrating relationship at the 5 percent level of significance. However, given that the Trace statistic is a more reliable test for cointegration,[10] we proceed with the analysis based on one cointegrating vector.

[10] See LeSage (1999) for further details.

Given that there exists one cointegrating relationship, the cointegrating vector and the loading matrix in the cointegrating space can be visualized as follows:

$$\begin{bmatrix} \Delta tbr \\ \Delta def\_gdp \\ \Delta ch\_debt \\ \Delta btrade \\ \Delta \inf l\_gdpdefl \\ \Delta lrgdp \end{bmatrix} = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix} \begin{bmatrix} \Delta tbr_{t-1} \\ \Delta def\_gdp_{t-1} \\ \Delta ch\_debt_{t-1} \\ \Delta btrade_{t-1} \\ \Delta \inf l\_gdpdefl_{t-1} \\ \Delta lrgdp_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \\ \alpha_{41} \\ \alpha_{51} \\ \alpha_{61} \\ \alpha_{71} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} & \beta_{17} \end{bmatrix} \begin{bmatrix} tbr_{t-1} \\ def\_gdp_{t-1} \\ ch\_debt_{t-1} \\ btrade_{t-1} \\ \inf l\_gdpdefl_{t-1} \\ lrgdp_{t-1} \\ C \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \quad (9)$$

The unrestricted results from the Johansen (1991, 1995) cointegration approach have been reported below in Table 9.

Table 9: Unrestricted results

Unrestricted Cointegrating Coefficients

TBR	DEF_GDP	CH_DEBT	BTRADE	INFL_GDPDEFL	LRGDP
-0.088554	0.208854	-0.003153	9.75E-06	-0.077155	-2.774264
0.284593	-0.684319	-0.009580	-6.62E-06	-0.253892	-1.822059
-0.228402	-0.110504	0.004142	1.16E-05	-0.146942	1.776664
-0.204192	-0.795310	-0.009476	5.62E-05	-0.007897	2.327504
0.018934	-0.341206	-0.001286	-4.63E-05	0.053791	-2.138064
0.201556	-0.482347	-0.000808	3.85E-05	0.057585	-3.141841

Unrestricted Adjustment Coefficients (alpha):

D(TBR)	-0.036210	-1.184462	0.061887	0.313716	0.453069	-0.043252
D(DEF_GDP)	-0.752556	0.151995	0.418585	0.335769	0.077313	0.014617
D(CH_DEBT)	34.86273	21.02626	-70.18613	42.00805	16.95787	-5.873389
D(BTRADE)	-1396.560	3035.712	-1747.471	-3469.524	3302.040	183.6149
D(INFL_GDP DEFL)	0.093613	0.510288	0.909193	0.190971	-0.019969	0.274056
D(LRGDP)	0.004035	-0.001638	0.006888	0.002536	-0.000348	-0.000623

Since we are interested in the relationship between budget deficit and interest rate, we normalize the cointegrating relationship with respect to the budget deficit. As in the case of the quarterly data, to have binding restrictions, significant statistics and identified parameters, a number of other restrictions were imposed on the VAR. Specifically, the coefficients corresponding to the change in debt, inflation and balance of trade were restricted to zero. The restrictions, based on the likelihood ratio test, were found to be binding.[11]
Based on the above restrictions, the obtained long-run relationship is as follows:

$$def\_gdp = 0.239137\ tbr + 6.029010 lrgdp \qquad (10)$$
$$[1.69795] \qquad [3.34955]$$

We find that all the coefficients are statistically significant and a 1 unit increase in the budget deficit leads to a 0.23 increase in the Treasury bill rate.

Table 10: Exogeneity test

Variable	Restriction	Restricted Log-likehood	LR statistic	df*	Probability	Conclusion
tbr	$\alpha_{11=}0$	-862.2510	1.818642	4	0.769070	Weak exogenous
def_gdp	$\alpha_{21}=0$	-868.2535	13.82377	4	0.007879	endogenous
ch_debt	$\alpha_{31}=0$	-862.7721	2.861026	4	0.581345	Weak exogenous
btrade	$\alpha_{41}=0$	-862.3348	1.986263	4	0.738286	Weak exogenous

[11] The value of the chi-squared statistic was $\chi^2(3) \approx 1.469$ with a p-value of 0.6895

Infl_gdpdefl	$\alpha_{51}=0$	-862.1094	1.535545	4	0.820327	Weak exogenous
lrgdp	$\alpha_{61}=0$	-862.9536	3.223876	4	0.521083	Weak exogenous

It is important to note that based on the restrictions, the VAR only comprises of the interest rate, the budget deficit and the GDP. However as is reported in the weak exogeneity tests of Table 10, the only variable that plays a significant role in the short-run behaviour of the cointegrating relationship is the budget deficit, since the null hypothesis of weak exogeneity (*the endogenous variable is weakly exogenous*) cannot be rejected for the treasury bill rate, the change in debt, the balance of trade, the inflation and the GDP. Reported below are the loading coefficients of the parsimonious VECM:

Table 11: Loading Matrix of the PVECM

Treasury bill equation

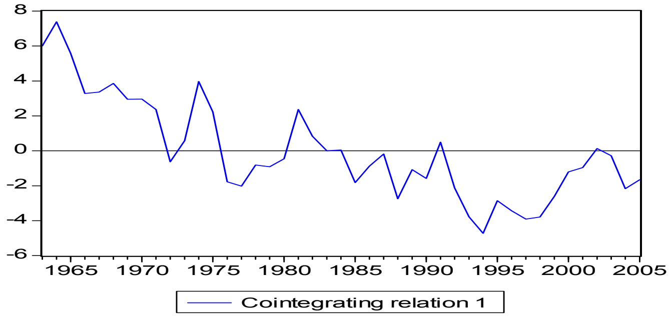
	D(TBR)	D(DEF_GDP)	D(CH_DEBT)	D(BTRADE)	D(INFL_GDPDEFL)	D(LRGDP)
CointEq1	0.000000	-0.456200 [-6.20911]	0.000000	0.000000	0.000000	0.000000

From the above we can see that the system is stable, in the sense, that the deficit as a percentage of the GDP would tend to bring the system back to equilibrium, in period *t+1*, following a discrepancy in period *t*.[12] Figure 2 depicts the cointegrating relationship. The graph indicates mean reverting residuals to the equilibrium.[13]

[12] All, the restrictions, i.e., both on the alpha and the beta matrix were found to be binding, since the value of the chi-squared statistic was $\chi^2(8) \approx 6.068$ with a p-value of 0.64.

[13] Diagnostic tests, reported in Appendix VIII, indicate the residuals of the cointegrating relationship are not normally distributed, but no evidence of autocorrelation and heteroscedasticity could be found.

Figure 2: Residuals for the cointegrating equation 1.



Finally, since we are interested in causality, we test if the coefficients of a particular lagged differentiated regressor are significantly equal to zero in the VECM, or in other words, we carry out the block causality tests of all the variables in the system. Table 12 reports the results of the Granger causality tests in the cointegrated system of the annual data. The results below, show that the null hypotheses of deficit does not Granger cause interest rate and interest rate does not Granger cause budget deficit cannot be rejected at the 10% level of significance, implying that the causal relationship between interest rate and budget deficit is non-existent for the annual data over the period of 1961 to 2005. Moreover, as can be seen from Panel A of Table 12, change in debt, balance of trade, inflation and GDP too, does not Granger cause the Treasury Bill rate. However, as shown in Panel B of Table 12, all the above set of variables tend to Granger cause deficit, at least the 10 percent level of significance. Moreover, all the variables in the system jointly cause deficit, but not the Treasury bill rate. So, in summary, based on annual data for the period of 1961 to 2005, we cannot obtain causality in any direction between budget deficit and interest rate, even though they are found to be cointegrated in a multivariate framework.

Table 12: VECM Granger Causality

Panel A: Dependent variable: D(TBR)

Excluded	Chi-sq	df	Prob.
D(DEF_GDP)	1.151444	1	0.2832
D(CH_DEBT)	0.000591	1	0.9806
D(BTRADE)	1.543314	1	0.2141
D(INFL_GDP DEFL)	0.378308	1	0.5385
D(LRGDP)	0.195232	1	0.6586
All	6.497557	5	0.2608

Panel B: Dependent variable: D(DEF_GDP)

Excluded	Chi-sq	df	Prob.
D(TBR)	0.025205	1	0.8739
D(CH_DEBT)	3.411693	1	0.0647
D(BTRADE)	16.97304	1	0.0000
D(INFL_GDP DEFL)	3.100980	1	0.0782
D(LRGDP)	20.45626	1	0.0000
All	30.40740	5	0.0000

5. Conclusions

This paper investigates the temporal causal relationship between government budget deficit and interest rate in South Africa, using a multivariate VECM estimated using Johansen’s (1991, 1995) MLE approach. Based on quarterly data over the period of 1961:02 to 2005:04, and then annual data for 1961 to 2005, the Johansen (1991, 1995) cointegration tests revealed that the government budget deficit and the measure of the interest rate are positively related in the long-run. In addition, block causality tests in the VECM, suggested a one way causal relationship between budget deficit and interest rate, with the causality running from budget deficit to interest rate, for the quarterly data. However, as in Akinbode (2004), using annual data, Granger causality tests on the VECM found no causal relationship between the budget deficit and the Treasury bill rate. Interestingly, exactly the same results were also obtained from simple Granger causality tests in a bivariate framework.

In summary, we can conclude that there is a positive relationship between government deficit and interest rate in South Africa, but the results on the causal relationship depends on the periodicity of the data. While, at the business cycle frequencies, higher deficit does tend to raise the Treasury bill rate, and might cause a downturn in economic activity, assuming that other relevant interest rates, capturing the cost of investment also follows the suite., in case of annual data, no such causality could be detected. Hence, based on our econometric framework estimated over the period of 1961 to 2005, a major implication is that chances of negative impact on long run growth via a fall in investment expenditures, due to rise in interest rates following higher deficit, is less likely to happen for the South African economy. But, besides this, our analysis once again reveals the importance of the frequency of data in the analysis of causality. The role of the econometric framework, however, does not seem to be of paramount importance.

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APPENDICES

QUARTERLY DATA

APPENDIX I: UNIT ROOTS TEST

Series	**Model**	**ADF**		**PP**	
		$\tau_\tau \tau_\mu \tau$	$\phi_3 \phi_1$	$\tau_\tau \tau_\mu \tau$	
TBR	τ_τ	-2.765521	17.25661***	-2.232081	*Non- stationary*
	τ_μ	-2.442270	24.74936***	-2.105981	
	τ	-1.021162		-0.874427	
D(TBR)	τ_τ	-8.239989***	33.94871***	-8.15219***	*Stationary*
	τ_μ	-8.235926***	67.83048***	-8.15862***	
	τ	-8.258374***		-8.18216***	
DEF_GDP	τ_τ	-3.499837**	110.8254***	-15.5226***	*Stationary*
	τ_μ	-3.464048**	129.5438***	-15.5362***	
	τ	-1.463851		-11.4922***	
CH_DEBT	τ_τ	-3.500533**	40.43940***	-15.5326***	*Stationary*
	τ_μ	-3.512288***	45.77629***	-15.5694***	
	τ	-3.165871***		-15.1344***	
BTRADE	τ_τ	-3.471574**	11.47918***	-4.67327***	*Stationary*
	τ_μ	-3.423680**	13.73836***	-4.50289***	
	τ	-3.358613***		-4.16427***	
INFL_GDPDEFL	τ_τ	-3.641835**	70.31857***	-14.9611***	*Stationary*
	τ_μ	-3.725230***	88.41730***	-14.9419***	
	τ	-1.249901		-11.0322***	
LRGDP	τ_τ	-3.453438**	59.33728***	-3.246970*	*Non- stationary*
	τ_μ	-2.647977*	62.96863***	-2.451648	
	τ	2.910625***		5.219730***	
D(LRGDP)	τ_τ	-3.951825**	171.0555***	-20.9387***	*Stationary*
	τ_μ	-3.779388***	191.5672***	-19.8644***	
	τ	-2.258519		-16.1741***	

*(**)[***] indicates statistical significance at 10(5)[1] percent level.

APPENDIX II: **THE APPROPRIATE NUMBER OF LAGS FOR THE VAR**

VAR Lag Order Selection Criteria
Endogenous variables: TBR DEF_GDP CH_DEBT BTRADE INFL_GDPDEFL LRGDP
Exogenous variables: C D_1 D_2 D_3
Sample: 1961Q2 2005Q4
Included observations: 167

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3900.429	NA	1.04e+13	46.99915	47.44725	47.18103
1	-3090.655	1522.569	9.83e+08	37.73240	38.85264*	38.18708
2	-3017.890	131.5869	6.35e+08	37.29210	39.08448	38.01959
3	-2961.781	97.43562	5.02e+08	37.05127	39.51579	38.05156
4	-2881.788	133.1614*	2.99e+08*	36.52441*	39.66107	37.79751*
5	-2850.189	50.33240	3.20e+08	36.57711	40.38592	38.12302
6	-2823.250	40.97171	3.65e+08	36.68563	41.16658	38.50435
7	-2800.054	33.61342	4.39e+08	36.83898	41.99207	38.93050
8	-2772.474	37.98439	5.05e+08	36.93981	42.76505	39.30415
9	-2741.546	40.37342	5.66e+08	37.00055	43.49793	39.63770
10	-2718.670	28.21896	7.08e+08	37.15772	44.32724	40.06767
11	-2690.350	32.89870	8.43e+08	37.24970	45.09136	40.43245
12	-2659.478	33.64420	9.93e+08	37.31112	45.82492	40.76668

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

APPENDIX III: DIAGNOSTIC STATISTICS OF THE REDUCED-FORM VAR

Roots of Characteristic Polynomial

Endogenous variables: TBR DEF_GDP CH_DEBT BTRADE INFL_GDPDEFL LRGDP

Exogenous variables: C D_1 D_2 D_3

Lag specification: 1 4

Root	Modulus
0.993490	0.993490
-0.960651	0.960651
0.936845 - 0.045188i	0.937934
0.936845 + 0.045188i	0.937934
-0.012940 - 0.899457i	0.899550
-0.012940 + 0.899457i	0.899550
0.837550 + 0.186363i	0.858034
0.837550 - 0.186363i	0.858034
-0.817686	0.817686
0.048494 - 0.792342i	0.793824
0.048494 + 0.792342i	0.793824
0.727326	0.727326
-0.682848 - 0.228475i	0.720058
-0.682848 + 0.228475i	0.720058
-0.650724	0.650724
0.042067 - 0.555100i	0.556691
0.042067 + 0.555100i	0.556691
0.363722 + 0.413647i	0.550815
0.363722 - 0.413647i	0.550815
-0.082850 - 0.527649i	0.534114
-0.082850 + 0.527649i	0.534114
0.113803 - 0.307104i	0.327512
0.113803 + 0.307104i	0.327512
-0.031829	0.031829

No root lies outside the unit circle.

VAR satisfies the stability condition.

APPENDIX IV: DIAGNOSTICS TEST FOR RESIDUALS

	test	t-statistic	P-value	Conclusion
Autocorrelation	LM(3)	40.50893	0.2781	No Autocorrelation
Multivariate Normality	Jarque-Bera(Joint)	561.7127	0.0000	The residuals are not normally distributed
Heteroscedasticity	Chi-square	1210.197	0.1262	No Heteroscedasticity

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APPENDIX V: UNIT ROOTS TEST

Series	**Model**	**ADF**		**PP**	
		$\tau_\tau \tau_\mu \tau$	$\phi_3 \phi_1$	$\tau_\tau \tau_\mu \tau$	
TBR	τ_τ	-2.747841	3.436858	-1.481315	*Non- stationary*
	τ_μ	-2.450668	3.944465	-1.780563	
	τ	-0.698147		-0.548952	
D(TBR)	τ_τ	-5.820345***	12.30758***	-7.52116***	*Stationary*
	τ_μ	-5.714165***	17.80090***	-5.34204***	
	τ	-5.763859***		-5.35405***	
DEF_GDP	τ_τ	-3.361384**	5.978242***	-3.174709	*Stationary*
	τ_μ	-3.346892**	11.20169***	-3.244639**	
	τ	-1.453124		-1.285536	
CH_DEBT	τ_τ	-6.200977***	19.22784***	-6.19999***	*Stationary*
	τ_μ	-6.274587***	39.37044***	-6.27376***	
	τ	-5.640293***		-5.70576***	
BTRADE	τ_τ	-3.372712*	4.080158	-2.590615	*Non- Stationary*
	τ_μ	-3.371679**	6.082396***	-2.334366	
	τ	-3.236348***		-2.399379**	
D(BTRADE)	τ_τ	-5.592865***	15.64012***	-5.63804***	*Stationary*
	τ_μ	-5.651754***	31.94232***	-5.73598***	

	τ	-5.653303***		-5.69074***	
INFL_GDPDEFL	τ_τ	-2.475390	3.584956	-2.198294	*Non- stationary*
	τ_μ	-2.698918*	7.284157***	-2.508345	
	τ	-1.071944		-0.892438	
D(INFL_GDPDEFL)	τ_τ	-7.252792***	32.44035***	-17.1224***	*Stationary*
	τ_μ	-9.071125***	82.28531***	-10.1986***	
	τ	-9.171533***		-9.90516***	
LRGDP	τ_τ	-3.079180	9.323281***	-3.561225**	*Non- stationary*
	τ_μ	-1.920475	9.220835**	-3.062083**	
	τ	2.806063***		5.31691***	
D(LRGDP)	τ_τ	-3.894229**	7.758418***	-3.827987**	*Stationary*
	τ_μ	-3.755852***	14.10643***	-3.65143***	
	τ	-2.225005**		-1.863596*	

*(**) [***]indicates statistical significance at 10(5)[1] percent level.

APPENDIX VI: THE APPROPRIATE NUMBER OF LAGS FOR THE VAR

VAR Lag Order Selection Criteria
Endogenous variables: TBR DEF_GDP CH_DEBT BTRADE INFL_GDPDEFL LRGDP
Exogenous variables: C
Sample: 1961 2005
Included observations: 42

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1060.878	NA	4.67e+14	50.80370	51.05194	50.89469
1	-844.9566	359.8685	9.04e+10	42.23603	43.97370*	42.87295*
2	-807.0726	52.31595*	9.20e+10	42.14631	45.37341	43.32917
3	-762.1342	49.21821	8.10e+10*	41.72068*	46.43721	43.44947

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

APPENDIX VII: DIAGNOSTIC STATISTICS OF THE REDUCED-FORM VAR

Roots of Characteristic Polynomial
Endogenous variables: TBR DEF_GDP CH_DEBT BTRADE INFL_GDPDEFL LRGDP
Exogenous variables: C
Lag specification: 1 1

Root	Modulus
0.990823	0.990823
0.862477	0.862477
0.658194	0.658194
0.533340 - 0.305493i	0.614636
0.533340 + 0.305493i	0.614636
-0.242025	0.242025

No root lies outside the unit circle.
VAR satisfies the stability condition.

APPENDIX VIII: DIAGNOSTICS TEST FOR RESIDUALS

	test	t-statistic	P-value	Conclusion
Autocorrelation	LM(2)	39.75864	0.3063	No Autocorrelation
Multivariate Normality	Jarque-Bera(Joint)	12.98166	0.3704	The residual are normally distributed
Heteroscedasticity	Chi-square	319.5823	0.1461	No Heteroscedasticity