University of Pretoria
Department of Economics Working Paper Series

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Kasai Ndahiriwe
University of Pretoria
Rangan Gupta
University of Pretoria
Working Paper: 2007-09
July 2007

Department of Economics
University of Pretoria
0002, Pretoria
South Africa
Tel: +27 12 420 2413
Fax: +27 12 362 5207

TEMPORAL CAUSALITY BETWEEN TAXES AND PUBLIC EXPENDITURES: THE CASE OF SOUTH AFRICA

Kasai Ndahiriwe[†]

and

Rangan Gupta[‡]

[†] Graduate Student, Department of Economics, University of Pretoria, South Africa. Contact details: E-mail: kasaind@yahoo.fr, Phone: +27 787 434 335, +250 08 825 932

[‡] 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 3625207

ABSTRACT

This paper investigates the direction of causal relationship between taxes and expenditure in South Africa, using quarterly data for the period 1960:1-2006:2, and annual data for 1960 to 2005. For both frequencies, gross domestic product and government debt are included in the VAR system as control variables. For quarterly data, the Johansen's (1991, 1995) methodology suggest two cointegrating equations among the four variables. Our findings support the fiscal synchronisation hypothesis, since Granger causality tests in a Vector Error Correction framework suggests bi-directional causality between taxes and expenditure for the period under study. In contrast to the VECM for quarterly data, the VECM for annual data disprove any possibility of Granger causality between taxes and expenditure. The apparent ambiguity is indication of the fact that causality, among other factors, depends on the frequency of data.

JEL Classification: C01; C32; H20 and H50.

Keywords: Granger causality, Cointegration, Error correction, Vector error correction model and Vector autoregressive model.

1. Introduction

In economics, it is agreed that expenditure depends on policy and on resources that include tax revenue and the proceeds of borrowing. Harvey (2005:15) suggests that taxes are usually viewed as the only source of government revenue. Regarding public spending and taxation, economists have analysed not only their effect on the economic activity, but also their causal relationship. The basic research question of this study is to determine the direction of the causal relationship between tax and public expenditure in South Africa. The answer to this key question requires answering the following sub-question: Is there long-run relationship between tax and public spending in South Africa?

In developed countries, especially in the United States, there exist a large number of studies analyzing the causal relationship between government spending and tax. However, it is important to recognize that conclusions regarding the economic behavior of critical variables cannot be generalized for the developing world. As a result, economic researchers should be motivated to gauge the causal relationship between public expenditure and tax in developing countries. For the South African economy, the motivation to estimate the causal relationship between public spending and tax is extremely important, since the government is expected to increase its expenditure for the preparation of 2010 soccer world cup.

To the best of our knowledge, there exists no recent research for the South African economy dealing specifically with analysing the causal relationship between taxes and expenditure. However, we must point out two recent, more or less related, studies concerned with the causality between revenues and public spending. Within a multivariate framework, Paresh and Seema (2006) modelled government revenue and government expenditure together with gross domestic product for 12 developing countries. The paper supported the evidence of neutrality between government revenue and government expenditure in South Africa. In contrast, using the Johansen cointegration framework, Nyamongo *et al.* (2006) reports a unidirectional Granger causality running from government expenditures to government revenues.

Bearing in mind that taxes form the dominant part of total government revenues, the purpose of this study is to analyse the nature of the relationship between public expenditure and taxes in South Africa. Since, being solely interested in tax, this paper is different from the works of Paresh and Seema (2006) and, by Nyamongo *et al.* (2006) both of which considers aggregate revenue. In this regard, once it is agreed that public expenditures and taxes are co-integrated, a determination of the causal relationship will be a pragmatic consideration for those using macroeconomic models for forecasting purposes. More precisely, our findings on temporal causality between taxes and spending will provide information on how fiscal policies should be implemented and/or to predict the path of government growth.

The rest of the paper is organised as follows: Section 2 presents an elaborate literature review, reporting empirical evidences on the tax-expenditure causality. Section 3 lays out the basics behind the Granger methodology of causality using co-integration and error correction modelling, used in this study besides a discussion of the data. Section 4 reports the empirical results and finally, Section 5 contains conclusions.

2. Literature review

Concerning the relationship between public spending and taxes, economic evidences from countries can be categorised into four alternatives: First, some economists support the fiscal synchronisation view which suggests bidirectional causality between taxes and spending. Second, there exists a host of evidence supporting the tax-and-spend hypothesis. This is likely to "occur in tax regimes restricted from running budget deficits or regimes facing temporary budget surpluses" (Joulfaian and Mookerjee, 1990). Third, there are also evidences supporting the spend-and-tax hypothesis, indicating that government expenditure causes government tax. Fourth, some studies indicate the independence of spending and tax, which imply a non-causal relationship between the two variables. Since cointegration is a sufficient condition of the presence of at least one-way causality, the last case may occur when the variables are not cointegrated.

For studies dealing with the US economy, there exists different views on the causal relationship between tax and spending. The results have been found to be dependant on the frequency of the data, included variables, period of study and/or the approach used by the authors. A study by Anderson *et al.* (1986) found that higher spending causes higher taxes. Miller and Russek (1990) reported a different conclusion. They used various cointegration and error correction models, based on quarterly data, to suggest bidirectional causality between government taxes and spending, both for federal and local fiscal finance. However, for annual data, the evidence was mixed with some supporting unidirectional causality, while the others hinted at the bidirectional causality obtained with the quarterly data. Hoover and Sheffrin (1992), reported two distinct causal relations depending on the period. Before the mid-1960's, taxes were found to cause spending, while after the late 1960's, taxes and spending were independent of each other. Using an error-correction model for forty-eight contiguous states, Payne (1998) reported the tax-spend hypothesis for twenty-four states, the spend-tax hypothesis for eight states, and fiscal synchronization for eleven states, with the remaining five states failing the diagnostic test for the error correction modeling.

Based on cointegration and error-correction methodology for the G7 economies, Owoye (1995) showed the existence of bidirectional causality between government taxes and expenditures in all countries, except for Japan and Italy, where causality was found to run from taxes to expenditures. On the other hand, the study by Kollias and Paleologou (2006) developed a Vector Error Correction Model (VECM) for 15 members of the European Union, and reported evidences of fiscal synchronisation for Denmark, Greece, Ireland, The Netherlands, Portugal and Sweden. Non causal relationship was reported for Austria, Belgium and Germany. Unidirectional causality from revenue to expenditure was pointed out for Italy and Spain, while, the causality ran in the reverse direction (from expenditure to revenue) for Luxembourg. Examining data for Greece, Spain, Ireland, and Portugal, based on tests of cointegration and causality, Kollias and Makrydakis (2000) indicate that in the case of Greece and Ireland, tax and spending decisions are taken simultaneously by the fiscal authority. For Spain, the tax-and-spend hypothesis was supported, while, no causal ordering between government expenditure and tax revenues was obtained for Portugal.

A study by Cheng (1999) for Latin American Countries, reported findings of bidirectional causality between taxes and expenditures in Chile, Panama, Brazil, and Peru. The study also detected a one-way causality from taxes to expenditures in Columbia, the Dominican Republic, Honduras, and Paraguay. Overall the spend-and-tax hypothesis was rejected.

Using a VECM, Chang and Ho (2002) reported the tax-and-spend hypothesis for Taiwan. In their study Fuess *et al.* (2003) supported the same hypothesis despite substantial fiscal synchronization. Unidirectional causality pattern running from tax to expenditure was found in both Lebanon and Tunisia by Darrat (2002), using a Granger-type short-run causality test and an ECM. Based on the cointegration and vector autoregression approach on annual time series data over the period 1951 to 1996 for ten countries, including South Africa, Chang (2002), suggested a "spend and tax" hypothesis for South Africa.

So, in summary, we can conclude, from the above discussion, that all the four possibilities, namely fiscal synchronisation, the tax-and-spend hypothesis, the spend-and-tax hypothesis, and the independence of spending and tax has been observed in the data across and within economies. Moreover, these results are sensitive to the methodologies used, choice of variables, the frequency of the data, and also the sample period, besides, other factors.

3. Data and Methodology

3.1 Data discussion

In this paper all the data have been obtained from the Quarterly Bulletin of the South African Reserve Bank. To check for the robustness of our results, the paper uses two different frequencies to test for Granger causality between taxes and expenditure. The quarterly data spans from the first quarter of 1961 (1960:1) to the second quarter of 2006 (2006:2), while the annual data covers the period 1960 to 2005. In addition to tax and expenditure, Gross Domestic Product (GDP) and public debt have been included in the VAR as control variables. All the variables have been measured in real terms and have been converted into their natural logarithmic form.

3.2 Granger causality, cointegration analysis and error correction model

At times the term function has been *a priori* used to indicate a causal relationship, in the sense that variation in one or more variables would have caused variation in some other variable[1]. However, the dependence of one variable on another or many other variables does not necessarily imply causation. Expenditure is said to be Granger-caused by taxes if taxes help in the prediction of expenditure, or equivalently, if the coefficients on the lagged taxes are statistically significant. For this example, taxes should precede expenditure, since the future cannot predict the past. In fact, there is four possibility of causal relationship between two variables *x* and *y*:

- Unidirectional causality from *x* to *y*;
- Unidirectional causality from *y* to *x*;
- Bidirectional causality when *x* causes *y* and vice versa;
- Independence when there is no causal relationship between *x* and *y*.

It is important to notice that when *x* and *y* are cointegrated, the Granger causality test will find at least one direction of causality. But, this is not the main reason to use cointegration techniques amongst variables; the most important reason is to avoid the problem of spurious regression when variables are nonstationary. Cointegration exists when a linear combination of two or more nonstationary time series is stationary. Harris (1995:22) argued that "the economic interpretation of cointegration is that if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (i.e., be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (i.e., stationary)". The presence of cointegration between variables implies the existence of an error correction model.

A vector error correction (VEC) model is a restricted vector autoregression (VAR), designed for using two or more cointegrated nonstationary series. Gujarati (2003: 830) argued that the error correction mechanism (ECM) developed by Engel and Granger (1987) is a means of reconciling the short-run behaviour of an economic variable with its long-run behaviour. Emphasising further, one can say, that the error correction model serves to restore the information about the sensible long-run relationships thrown away by the differencing process. Thus, the ECM contains both the short-run and long-run properties of the model.

In this study, we use the Johansen (1988, 1995) full information maximum likelihood approach (FIML) to estimate the long-run relationship between the chosen variables along with their adjustment process captured by the their short-run behavior. A VAR of order *p* can be represented as follows:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \ , \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2) \qquad (1)$$

with y_t being a k vector of non-stationary I(1) variables, x_t a d vector of deterministic variables, and ε_t a vector of innovations. This VAR can be rewritten as,

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \qquad (2)$$

where:

$$\Pi = \sum_{i=1}^{p} A_i - I \quad \text{and} \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j \qquad (3)$$

Following the Granger's representation theorem, with four variables (k = 4) in the VAR system we expect at most three cointegrating equations ($r < k$) and it can be represented as follows.

$$\begin{bmatrix} \Delta \ln\_\exp end_t \\ \Delta In\_taxes_t \\ \Delta \ln\_gdp_t \\ \Delta \ln\_debt_t \end{bmatrix} = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} \\ \gamma_{22} & \gamma_{22} & \gamma_{23} & \gamma_{24} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} \end{bmatrix} \begin{bmatrix} \Delta \ln\_\exp end_{t-1} \\ \Delta \ln\_taxes_{t-1} \\ \Delta \ln\_gdp_{t-1} \\ \Delta \ln\_debt_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} \\ \beta_{13} & \beta_{23} & \beta_{33} & \beta_{43} \end{bmatrix} \begin{bmatrix} \ln\_\exp end_{t-1} \\ \ln\_taxes_{t-1} \\ \ln\_gdp_{t-1} \\ \ln\_debt_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \qquad (4)$$

If any of the cointegrating equations deviate from the long run relationship, an adjustment will be made gradually by its associated elements of the α matrix, known as loading matrix of the Parsimonious VECM. Note the above matrix assumes that there is no constant, trend or seasonal dummies.

4. Empirical results

To avoid the problem of spurious results, we begin with the detection of unit roots based on the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests as shown in Appendixes 1 and 2. Both tests reveal that all the variables are integrated of order one I(1) for both the quarterly and annual data. Since all the four variables are found to be non-stationary in levels, they have to be cointegrated and, hence, the use of a VECM is justified.

4.1 Quarterly data

Before we resort to the multivariate approach, we investigate below the simple pair-wise Granger causality tests between taxes and expenditure, mainly to obtain a preliminary idea. Note, as the two variables are I(1), we use their first differences for the Granger causality test.

Table 1: Pair-wise Granger causality (lag length: 2)

Null Hypothesis:	F-Statistic	Probability
D_LN_TAXES does not Granger Cause D_LN_EXPEND	13.7729	0.0000
D_LN_EXPEND does not Granger Cause D_LN_TAXES	15.8413	0.0000

Table1 shows that the null of taxes does not Granger cause expenditures, is rejected at one percent level of significance, and so is the null that expenditures do not Granger causes taxes. All in all, the tests reveal feedback Ganger causality between taxes and expenditures.

With us now having a preliminary idea, it is important to verify the causal relationship using a multivariate framework. Moreover, the Johansen's (1991, 1995) methodology, helps us in checking whether the results obtained above, based on the pair-wise Granger causality, is robust when allowed for more than two variables in the econometric model. Note this methodology, in contrast to the single equation approach of Engel and Granger (1987), avoids the risk of considering only one cointegrating relationship when there may be more than one. In this subsection, before we perform the tests of cointegration, a test for stability has been performed. The estimated VAR satisfies the stability condition with no root lying outside the unit circle. Using four lags[2] ($p = 4$) in the VAR, and allowing for linear trends in each variable and in the cointegrating relations, we perform the Johansen and Juselius (1990) cointegration test to determine the number of cointegrating vectors. The results are shown in Table 2.

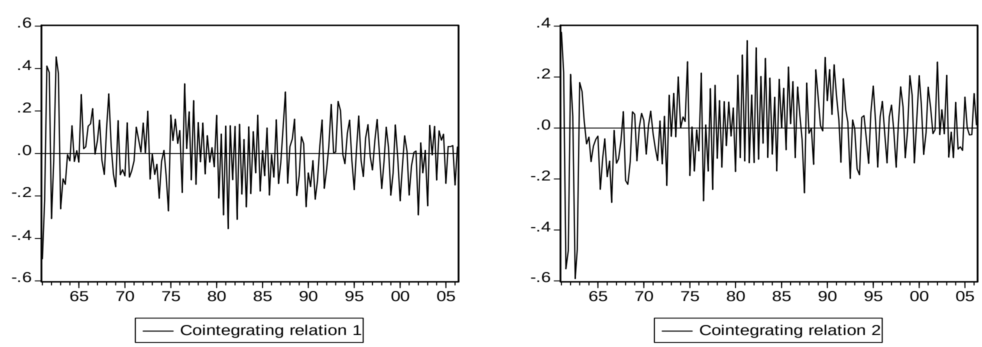
Table 2: Johansen cointegrating tests

Test	Statistic	Critical value	P-value	No of CE's
Trace	90.79396	63.87610	0.0001	None *
	50.42725	42.91525	0.0075	At most 1 *
	24.35023	25.87211	0.0764	At most 2
	7.043581	12.51798	0.3400	At most 3
Maximum Eigenvalue	40.36671	32.11832	0.0039	None *
	26.07702	25.82321	0.0463	At most 1 *
	17.30665	19.38704	0.0978	At most 2
	7.043581	12.51798	0.3400	At most 3

* denotes rejection of the hypothesis at the 0.05 level

Using the Pantula Principle, both the Trace and Maximum-Eigen Value tests show that there are two stationary relations in the data ($r = 2$) at the 5 percent level of significance. This is a sufficient condition for using the Johansen methodology. 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.

Figure 1: Plot of the cointegrating relations



From the above information we can now visualise the VECM of the two cointegrating vectors and loading matrices in the cointegrating space as follows:

$$\begin{bmatrix} \Delta \ln\_expend_t \\ \Delta ln\_taxes_t \\ \Delta \ln\_gdp_t \\ \Delta \ln\_debt_t \end{bmatrix} = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \\ d_{41} & d_{42} & d_{43} \end{bmatrix} \begin{bmatrix} D1 \\ D2 \\ D3 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} \\ \gamma_{22} & \gamma_{22} & \gamma_{23} & \gamma_{24} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} \end{bmatrix} \begin{bmatrix} \Delta \ln\_expend_{t-1} \\ \Delta \ln\_taxes_{t-1} \\ \Delta \ln\_gdp_{t-1} \\ \Delta \ln\_debt_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} & \beta_{52} & \beta_{62} \end{bmatrix} \begin{bmatrix} \ln\_expend_{t-1} \\ \ln\_taxes_{t-1} \\ \ln\_gdp_{t-1} \\ \ln\_debt_{t-1} \\ C \\ \delta \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \quad (5)$$

The unrestricted results from the Johansen cointegration procedure is reported below in Table 3.

Table 3: Unrestricted cointegrating results

Unrestricted Cointegrating Coefficients				
Ln_expend	Ln_taxes	Ln_GDP	Ln_debt	Trend
22.08494	-19.7953	0.554102	-4.881777	0.061859
4.891476	5.963815	-10.86192	0.847095	-0.034733
-3.772314	-10.4756	33.42188	-0.967274	-0.04888
-2.646065	-0.99878	5.122937	9.813911	-0.057767
Unrestricted Adjustment Coefficients				
D(LN_EXPEND)	-0.00969	-0.017751	0.000993	-0.009586
D(LN_TAXES)	0.016186	-0.009413	0.014528	0.002582
D(LN_GDP)	0.001752	-0.004035	-0.002232	0.001377
D(LN_DEBT)	0.007742	-0.003222	-0.003665	-0.00255

If all elements of the loading matrix (α) are non-zero, then the two cointegrating vectors enter into each of the four equations as follows:

$$\Delta \ln\_expend = \alpha_{11}\left[\beta_{11} \ln\_expend_{t-1} + \beta_{21} \ln\_taxes_{t-1} + \beta_{31} \ln\_gdp_{t-1} + \beta_{41} \ln\_debt_{t-1}\right] + \alpha_{12}\left[\beta_{12} \ln\_expend_{t-1} + \beta_{22} \ln\_taxes_{t-1} + \beta_{32} \ln\_gdp_{t-1} + \beta_{42} \ln\_debt_{t-1}\right] \quad (6)$$

$$\Delta \ln\_taxes = \alpha_{21}\left[\beta_{11} \ln\_expend_{t-1} + \beta_{21} \ln\_taxes_{t-1} + \beta_{31} \ln\_gdp_{t-1} + \beta_{41} \ln\_debt_{t-1}\right] + \alpha_{22}\left[\beta_{12} \ln\_expend_{t-1} + \beta_{22} \ln\_taxes_{t-1} + \beta_{32} \ln\_gdp_{t-1} + \beta_{42} \ln\_debt_{t-1}\right] \quad (7)$$

$$\Delta \ln\_gdp = \alpha_{31}\left[\beta_{11}\ln\_expend_{t-1} + \beta_{21}\ln\_taxes_{t-1} + \beta_{31}\ln\_gdp_{t-1} + \beta_{41}\ln\_debt_{t-1}\right] + \alpha_{32}\left[\beta_{12}\ln\_expend_{t-1} + \beta_{22}\ln\_taxes_{t-1} + \beta_{32}\ln\_gdp_{t-1} + \beta_{42}\ln\_debt_{t-1}\right] \quad (8)$$

$$\Delta \ln\_debt = \alpha_{41}\left[\beta_{11}\ln\_expend_{t-1} + \beta_{21}\ln\_taxes_{t-1} + \beta_{31}\ln\_gdp_{t-1} + \beta_{41}\ln\_debt_{t-1}\right] + \alpha_{42}\left[\beta_{12}\ln\_expend_{t-1} + \beta_{22}\ln\_taxes_{t-1} + \beta_{32}\ln\_gdp_{t-1} + \beta_{42}\ln\_debt_{t-1}\right] \quad (9)$$

Note, the coefficient α_{ij} measures the degree to which a variable in a particular equation responds to the deviation from the long-run equilibrium relationship.

Table 4: Long-run restrictions (standard errors in parenthesis)

	Ln_expend	Ln_taxes	Ln_GDP	Ln_debt	Trend
CE¶ I	1.000000	-0.873751	0.000000	-0.218828	0.002714
	(0.00000)	(0.03177)	(0.00000)	(0.07042)	(0.00062)
CE II	-0.873751	1.000000	-0.253370	0.218828	-0.003362
	(0.03177)	(0.00000)	(0.12162)	(0.07042)	(0.00074)

¶ Cointegrating equation

Since we are more interested in the relationship between expenditure and taxes, both the variables have been restricted to be equal to unity respectively, in the cointegrating equations I and II. To have binding restrictions, significant statistics and identified parameters, a number of restrictions were imposed on the VAR. First, the parameter of GDP in the first cointegrating equation was restricted to be equal to zero in long run. Second, the coefficient of taxes in the expenditure equation is set equal to the coefficient of expenditure in the second equation. Finally, the coefficient of government debt in the expenditure equation is restricted to be equal to the negative of the debt's coefficient in the taxes equation since the two coefficients were close to each other in absolute values. Based on the above set of restrictions, the cointegrating equations in table 4 can be rewritten as follows:

$$\ln\_expend = 0.87\ln\_taxes + 0.22\ln\_debt + 0.003trend \quad (10)$$

$$\ln\_taxes = 0.87\ln\_expend + 0.25\ln\_gdp - 0.22\ln\_debt + 0.001trend \quad (11)$$

In Table 4 the values in parenthesis indicate the standard errors. The LR statistic test [χ^2 (1) = 0.3932] for binding restrictions is found to be significant as the p-value is 0.53. The results show that a 1% change in taxes will lead to 0.87% change in government expenditure and vice versa.

At this stage, it is important to investigate the variables which enter significantly into the adjustment process, following a short-run disequilibrium. For that purpose, we carried out weak exogeneity tests, which have in turn been reported in Table 5 below.

Table 5: Exogeneity test

Variable	Restriction	Restricted Log-likehood	LR statistic	Df ¶	Probability	Conclusion
Ln_expend	$\alpha_{11}=\alpha_{12}=0$	1406.991	11.27375	3	0.010334	Endogenous
Ln_taxes	$\alpha_{21}=\alpha_{22}=0$	1406.437	12.38197	3	0.006183	Endogenous
Ln_GDP	$\alpha_{31}=\alpha_{32}=0$	1409.067	7.122277	3	0.068101	Endogenous
Ln_debt	$\alpha_{41}=\alpha_{42}=0$	1406.495	12.26638	3	0.006524	Endogenous

¶ 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 rejected for all the variables, included in the VAR system. As far as the parameters of the cointegrating relationships are concerned, as none of the variables is weakly exogenous in the system, it means that information can be lost by not modeling explicitly the process determining one particular variable jointly, with that determining other endogenous variables. At this stage, we must keep in mind that the i^{th} endogenous variable is said to be weakly exogenous, if the i^{th} row of the α matrix is entirely zero. However, this does not imply that a particular α_{ij} cannot be zero. Thus, if an individual element of α is zero, as it is the case in the loading matrix reported in Table 6[3], 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) are reported in Table 6 below.

Table 6: Loading matrix of the PVECM with t-values in brackets

	Ln_expend	Ln_taxes	Ln_GDP	Ln_debt
CE[¶] I	-0.904605	0.000000	-0.139574	0.000000
	[-3.94962]	[NA]	[-2.85651]	[NA]
CE II	-0.686004	-0.371902	-0.179365	-0.168431
	[-3.24162]	[-3.62044]	[-3.97496]	[-4.20931]

¶ Cointegrating equation

As seen in the above table, 90 per cent of the deviation from the long run equilibrium in the expenditure in quarter *t*, is corrected in quarter *t + 1* by expenditure itself, and 13 per cent is corrected by the GDP. For the second cointegrating equation, the results reveal that 69 per cent of the deviation from the long run equilibrium in taxes in quarter *t*, is corrected in quarter *t + 1* by expenditure, 37 per cent by taxes itself, 18 per cent is corrected by the GDP, and 17 per cent is corrected by the government debt. The bigger the adjustment coefficients the quicker is the adjustment process. Since the adjustment coefficients of taxes and government debts are zero in the expenditure equation, they do not help in the adjustment process for that particular equation.

It is worth noting that Granger causality is quite different from a test for exogeneity (Enders, 2004: 283). While exogeneity of one variable, for example taxes, means that it is not affected by contemporaneous values of the remaining variables (expenditures, GDP and debts), Granger causality refers only to the effects of past values of those variables on the current value of taxes. That is, the adjustment coefficient of taxes which is zero in the expenditure equation (CE I) does not automatically imply the absence of causality running from taxes to expenditure. 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 7: Granger causality test

Panel A: D(LN_EXP) as dependent variable

Excluded	Chi-sq	Df	Prob.
D(LN_TAXES)	11.6057	4	0.0205
D(LN_GDP)	7.79406	4	0.0994
D(LN_DEBT)	2.14825	4	0.7085
All	26.2735	12	0.0098

Panel B::D(LN_TAXES) as dependent variable

Excluded	Chi-sq	Df	Prob.
D(LN_EXPEND)	12.9364	4	0.0116
D(LN_GDP)	6.68237	4	0.1537
D(LN_DEBT)	18.9351	4	0.0008
All	36.0838	12	0.0003

With the information provided above, it is not surprising to obtain causality that had not been detected within the loading matrix. In the case of the VECM under study, taxes and government debt had zero adjustment coefficient in the expenditure equation (CE I). However, it is not a sufficient condition to suggest that none of the two variables Granger causes the expenditure. Table 7 depicts the results of the Granger causality in the cointegrated system. The test is based on the hypothesis that the coefficients of the lagged differences of a particular regressor (or all variables for joint causality) are equal to zero.

The results in panel A reveal that taxes Granger cause government expenditure, since the null hypothesis of *taxes does not Granger cause expenditure* is rejected at the five percent level of significance. This means that the lagged differences of taxes cannot be excluded jointly in the differentiated expenditure equation. In the same panel, it is suggested that GDP Granger causes expenditure at the 10 percent level of significance, while, government debt do not Granger cause expenditure. For the block causality, we find that taxes, GDP and government debt jointly Granger cause expenditure. On the other hand, panel B shows that expenditure Granger causes taxes, as the null hypothesis of *expenditure does not Granger cause taxes* is rejected at five percent level of significance. As above, this means that the lagged differences of the expenditures cannot be excluded jointly in the differentiated taxes equation. Government debt is also found to Granger cause taxes, while GDP does not. Furthermore, it is important to point out that expenditure, GDP and government debt jointly Granger cause taxes at the one percent level of significance. Coming back to our main concern of causality between taxes and expenditure, the VECM, as with the Bivariate Granger causality tests, supports the fiscal synchronization view for quarterly data and, thus, suggests bidirectional causality between taxes and expenditure.

4.2 Annual data

As with the quarterly data, we start off for the annual data by performing a pairwise Granger causality. Based on the results reported bellow we find no causal relationship between taxes and expenditure.

Table 8: Pairwise Granger causality (lag length: 1)

Null Hypothesis:	Obs	F-Statistic	Probability
D_LN_TAX does not Granger Cause D_LN_EXPEND	44	0.60770	0.44013
D_LN_EXPEND does not Granger Cause D_LN_TAX		2.15943	0.14933

Moving onto the Johansen methodology, we find the VAR to satisfy the stability condition, since no root lies outside the unit circle. In the VAR, which allows for linear trends in each variable and in the cointegrating relation, one lag[4] ($\rho = 1$) is found to be appropriate. The Johansen and Juselius (1990) cointegration test determine the number of cointegrating vectors. The results are reported in Table 9.

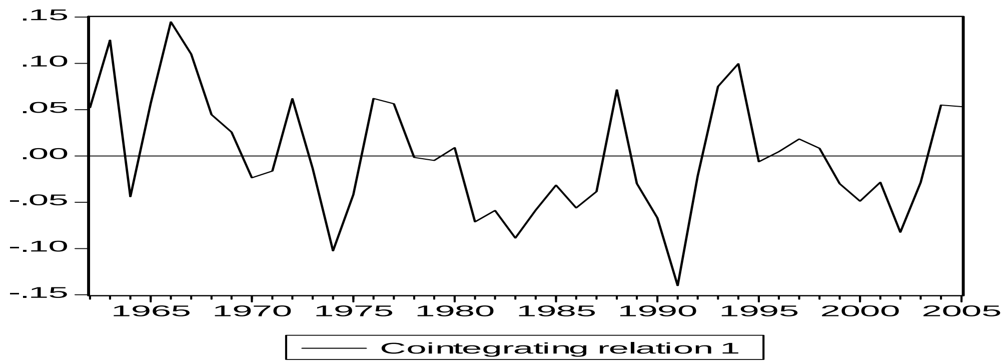
Table 9: Johansen cointegrating tests

Test	Statistic	Critical value	P-value	No of CE's
Trace	79.92641	63.87610	0.0013	None *
	35.01127	42.91525	0.2446	At most 1
	15.89939	25.87211	0.5006	At most 2
	6.301714	12.51798	0.4230	At most 3
Maximum Eigenvalue	44.91514	32.11832	0.0008	None *
	19.11188	25.82321	0.2978	At most 1
	9.597674	19.38704	0.6618	At most 2
	6.301714	12.51798	0.4230	At most 3

* denotes rejection of the hypothesis at the 0.05 level

Both the Trace and Maximum-Eigen Value tests show that there is one stationary relation in the annual data at the 5 percent level of significance. Since this is not a sufficient condition to proceed using the Johansen methodology, we will be cautious while using the exogeneity tests. If all the right hand side variables are found to be exogenous, we will then move to a single equation analysis. The figure bellow depicts the cointegrating relation which shows mean-reverting residuals to the equilibrium.

Figure 2: Plot of the cointegrating relation



The cointegrating vector and loading matrices in the cointegrating space can be visualised as follows:

$$\begin{bmatrix} \Delta \ln\_taxes_t \\ \Delta In\_\exp end_t \\ \Delta \ln\_gdp_t \\ \Delta \ln\_debt_t \end{bmatrix} = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \\ d_{41} & d_{42} & d_{43} \end{bmatrix} \begin{bmatrix} D1 \\ D2 \\ D3 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} \\ \gamma_{22} & \gamma_{22} & \gamma_{23} & \gamma_{24} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} \end{bmatrix} \begin{bmatrix} \Delta \ln\_taxes_{t-1} \\ \Delta \ln\_\exp end_{t-1} \\ \Delta \ln\_gdp_{t-1} \\ \Delta \ln\_debt_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \\ \alpha_{41} \\ \alpha_{51} \\ \alpha_{61} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} \end{bmatrix} \begin{bmatrix} \ln\_taxes_{t-1} \\ \ln\_\exp end_{t-1} \\ \ln\_gdp_{t-1} \\ \ln\_debt_{t-1} \\ C \\ \delta \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \quad (12)$$

The unrestricted results from the Johansen cointegration procedure is reported in Table 10 below.

Table 10: Unrestricted cointegrating results

Unrestricted Cointegrating Coefficients				
Ln_taxes	Ln_expend	Ln_GDP	Ln_debt	Trend
-24.44020	25.77301	-3.176159	-8.102654	0.489812
6.240599	-14.70882	4.006896	3.561325	-0.022008
16.73971	-0.539596	35.62000	-3.186466	-0.061114
0.667188	2.848957	-4.858890	-10.28493	0.243029

Unrestricted Adjustment Coefficients				
D(LN_TAXES)	0.013276	0.002669	0.018310	-0.000161
D(LN_EXPEND)	-0.003949	0.023497	0.002513	0.011892
D(LN_GDP)	0.010610	0.007886	0.001401	-0.002806
D(LN_DEBT)	0.017000	-0.001449	-0.007852	0.018625

If all elements of the loading matrix (α) are non-zero, the cointegrating vector enters into each of the four equations as follows:

$$\Delta \ln\_taxes = \alpha_{11}\left[\beta_{11} \ln\_taxes_{t-1} + \beta_{21} \ln\_\exp end_{t-1} + \beta_{31} \ln\_gdp_{t-1} + \beta_{41} \ln\_debt_{t-1}\right] \quad (13)$$

$$\Delta \ln\_\exp end = \alpha_{21}\left[\beta_{11} \ln\_taxes_{t-1} + \beta_{21} \ln\_\exp end_{t-1} + \beta_{31} \ln\_gdp_{t-1} + \beta_{41} \ln\_debt_{t-1}\right] \quad (14)$$

$$\Delta \ln\_gdp = \alpha_{31}\left[\beta_{11} \ln\_taxes_{t-1} + \beta_{21} \ln\_\exp end_{t-1} + \beta_{31} \ln\_gdp_{t-1} + \beta_{41} \ln\_debt_{t-1}\right] \quad (15)$$

$$\Delta \ln\_debt = \alpha_{41}\left[\beta_{11} \ln\_taxes_{t-1} + \beta_{21} \ln\_\exp end_{t-1} + \beta_{31} \ln\_gdp_{t-1} + \beta_{41} \ln\_debt_{t-1}\right] \quad (16)$$

Table 11: Long-run restrictions (Standard errors in parenthesis)

	Ln_taxes	Ln_expend	Ln_GDP	Ln_debt	Trend
Tax equation	1.000000 (0.00000)	-0.985519 (0.03585)	0.00000 (0.0000)	0.320482 (0.05040)	-0.018843 (0.00180)

Restructuring taxes to be equal to unity and GDP to be equal to zero we find that all the coefficients are identified and restrictions are binding for the cointegrating equation[5]. Results show that a change in government expenditure will lead to 0.99 percent change in taxes, while a change in government debt will lead to 0.3 percent negative change in taxes.

$$\ln\_taxes = 0.99 \ln\_\exp end - 0.32 \ln\_debt + 0.02 trend \quad (17)$$

At this stage, it is important to note that since the GDP was restricted to be equal to zero in long run, the VAR in first differences has taxes, expenditure and government debts as long-run elements. However, as it is shown in Table 12, GDP affects the short-run behavior of the cointegrating equation.

Table 12: Exogeneity test for Expenditure equation

Variable	Restriction	Restricted Log-likehood	LR statistic	Df ¶	Probability	Conclusion
Ln_taxes	$\alpha_{11}=0$	346.7393	5.406265	2	0.066995	Endogenous
Ln_expend	$\alpha_{21}=0$	349.1679	0.548980	2	0.759960	Exogenous
Ln_GDP	$\alpha_{31}=0$	344.1569	10.57111	2	0.005064	Endogenous
Ln_debt	$\alpha_{41}=0$	347.6160	3.652851	2	0.160988	Exogenous

¶ Degree of freedom equal to the number of restrictions

Although the coefficient of GDP was restricted to be equal to zero in the long run equation, its role in the adjustment process is obvious. The null hypothesis of weak exogeneity (*the endogenous variable is weakly exogenous)* is rejected for the taxes and the GDP respectively at 10% and 1% level of significance, while the government expenditure and debt are found to be weakly exogenous. This means that government expenditure and debt do not respond to the discrepancy from a long-run equilibrium for the taxes equation.

Below are the loading coefficients of the parsimonious VECM:

Table 13: Loading matrix of the PVECM with t-values in brackets

Taxes equation			
Ln_taxes	Ln_expend	Ln_GDP	Ln_debt
-0.481304	0.000000	-0.366642	0.000000
[-3.16753]	_	[-7.41343]	_

Table 13 shows that 48 per cent of the deviation from the long run equilibrium in the tax equation in a given year is corrected in the following year by tax itself, and 37 percent is corrected by GDP. Since we are interested in causality, we test if coefficients of a particular differenced lagged regressor are significantly equal to zero in the VECM.

Table 14: Granger causality test

Panel A: D(LN_TAX) as dependent variable

Excluded	Chi-sq	Df	Prob.
D(LN_EXP)	0.552668	1	0.4572
D(LN_GDP)	7.588777	1	0.0059
D(LN_DEBT)	0.003559	1	0.9524
All	10.66516	3	0.0137

Panel B::D(LN_EXP) as dependent variable

Excluded	Chi-sq	Df	Prob.
D(LN_TAX)	0.616332	1	0.4324
D(LN_GDP)	4.051636	1	0.0441
D(LN_DEBT)	3.929977	1	0.0474
All	15.42199	3	0.0015

Table 14 reports the results of the Granger causality in the cointegrated system resulting from the annual data. The results in panel A reveal that government expenditure do not Granger cause taxes, since the null hypothesis of *expenditure does not Granger cause taxes* is not rejected. This means that the lagged difference of expenditure can be excluded in the differenced tax equation. In the same equation, it is suggested that GDP Granger causes taxes, while Government debt does not. The block causality test reveals that expenditure, GDP and government debt jointly Granger cause taxes.

On the other hand, panel B also reports that tax does not Granger causes expenditure, as the null hypothesis of *tax does not Granger cause expenditure* is not rejected. In the same panel, however, it is reported that GDP and government debt Granger cause expenditure at the five percent level of significance. For the block causality test, we find that taxes, GDP and government debt jointly Granger cause expenditure at the one percent level of significance. In contrast to the VECM for quarterly data, the VECM for the annual data disprove any possibility of Granger causality between taxes and expenditure. This controversy supports the view that the results of a VECM might depend on the frequency of data, besides many other factors.

5. Summary and conclusion

Using the Johansen (1991, 1995) methodology, with GDP and government debt as control variables, this study finds that the causal relationship between taxes and expenditure in

South Africa depends on the frequency of the data. Using quarterly data, the causality tests suggest bidirectional causality between taxes and expenditure for the period 1960:1-2006:2. Based on this frequency, we can thus, accept the fiscal synchronization hypothesis for South Africa, and we can conclude that expenditure decisions are not made in isolation from taxes decisions. The same diagnostic test was performed on annual data but, the analysis, unlike the findings from the quarterly data, suggests neutrality between taxes and government expenditure for the period of 1960 to 2005.

Note, our results disapprove the findings of Chang (2002) and Nyamongo *et al.* (2006), which suggested the spend-and-tax hypothesis. However, our conclusions with the annual data do not differ from those of Paresh and Seema (2006) that supported the evidence of neutrality between government revenue and government expenditure. However, we must bear in mind that the frequency of the data, the sample period, and variables included in the VAR are different. Furthermore, these authors were comparing total revenues to expenditure, while we focused on expenditure and taxes. Our study, thus, once again confirms that causality amongst variables are highly sensitive to the methodologies used, choice of variables, the frequency of the data, and also the sample period, besides, other factors.

References:

Anderson, W., Wallace, M.S. and Warner, J.T. 1986. "Government Spending and Taxation: What Causes What?" *Southern Economic Journal* 52, no.3: 630-639.

Box, G.E. P. and Jenkins G. M.1976. *Time Series Analysis: Forecasting and Control*. Revised Edition, Oakland: CA: Holden-Day.

Carneiro, F.G., Faria, J.R. and Barry, B.S. 2005. "Government Revenues and Expenditures in Guinea-Bissau: Causality and Cointegration." *Journal of Economic Development* 30, no.1:107-117.

Chang, T. and Ho, Y. 2002. "Tax or Spend, What Causes What: Taiwan's Experience." *International Journal of Business and Economics* 1, no.2: 157-165

Chang, T., Liu W.R. and Caudill, S.B. 2002. "Tax-and-spend, spend-and-tax, or fiscal synchronization: new evidence for ten countries." *Applied Economics* 34, no.12: 1553 – 1561.

Cheng, B.S.1999. "Causality between Taxes and Expenditures: Evidence from Latin American Countries." *Journal of Economics and Finance* 23, no.2:184-192

Darrat, A.F. 2002. "Budget balance through spending cuts or tax adjustments?" *Contemporary Economic Policy* 20, no.3: 221-233.

Engle, R. F. and Granger, C. W. J. 1987. "Co-integration and Error Correction: Representation, Estimation, and Testing". *Econometrica* 55, no.(-): 251–276.

Eviews. 2004. *Eviews 5 User's Guide*. USA: Quantitative Micro Software, LLC

Fuess, S.M. Jr. , Hou J. W. and Millea M. 2003. "Tax or Spend, What Causes What? Reconsidering Taiwan's Experience." *International Journal of Business and Economics* 2, no.2: 109-119.

Gujarati, D. N. 2003. *Basic econometrics*. US: McGraw-Hill.

Harris, R. 1995. *Using cointegration analysis in econometric modeling*. London: Prentice Hall.

Hoover, K.D and Sheffrin. S.M. 1992. "Causation, Spending, and Taxes: Sand in the Sandbox or Tax Collector for the Welfare State?" *The American Economic Review* 82, no.1: 225-248.

James D.E. and Throsby C.D. 1973. *Introduction to quantitative methods in economics*. New York: John Wiley & Sons Australasia.

Johansen, S. 1991. "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica* 59, no.(-): 1551–1580.

Johansen, S. 1995. *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford: Oxford University Press.

Johansen, S. and Juselius, K. 1990. "Maximum Likelihood Estimation and Inferences on Cointegration-with applications to the demand for money." *Oxford Bulletin of Economics and Statistics* 52, no.(-): 169–210.

Joulfaian, D. and Mookerjee, R. 1990. "The intertemporal relationship between state and local government revenues and expenditure: evidence from OECD countries." *Public Finance* 45, no.1: 109-117

Kollias, C. and Makrydakis, S. 2000. "Tax and spend or spend and tax? Empirical evidence from Greece, Spain, Portugal and Ireland." *Applied Economics* 32, no.(-): 533-546.

Kollias, C. and Paleologou, S-M. 2006. "Tax and spend, spend and tax, fiscal synchronisation or institutional separation?" *Journal of Economic Studies* 33, no.2: 108-120

Miller, S.M. and Russek, F.S. 1990. "Co-integration and Error-Correction Models: The Temporal Causality between Government Taxes and Spending." *Southern Economic Journal* 57, no.1: 221-229.

Nyamongo, E. Morekwa, MT. D. and Sichei, M. 2006. "Government revenue and government expenditure nexus in South Africa." *Working paper*, University of Pretoria, Department of Economics.

Owoye, O.1995. "The causal relationship between taxes and expenditures in the G7 countries: cointegration and error-correction models." *Applied Economics Letters* 2, no.1:19 - 22

Paresh, K.N. and Seema, N. 2006. "Government revenue and government expenditure nexus: evidence from developing countries." *Applied Economics* 38, no.(-): 285–291.

Payne, J.E. 1998. "The tax-spend debate: Time series evidence from state budgets." *Public Choice* 95, no.3: 307-320.

Footnotes:

[1] James and Throsby (1973) wrote that "in economics the term function is used mainly to indicate a causal relationship".

[2] To decide on the lag of the VAR we used the lag length criteria, and the test suggested that both 4 lags and 5 lags were appropriate. We, however, decided to avoid a higher lag length and hence chose 4 lags. For the VECM we used the lag exclusion tests which suggested the use of 3 lags.

[3] α_{21} and α_{41} are not significantly different from zero.

[4] Both the lag length criteria for the VAR and the lag exclusion tests for the VECM indicated the choice of 1 lag.

[5] The p-value for the binding restriction is equal to 0.5306, and the LR statistic test for binding restrictions $[\chi^2(1)] = 0.3932$.

Appendices

Appendix I: Unit root test for quarterly data

Panel A: Levels

Series	**Model**	**ADF**		**PP Test**
		$\tau_\tau, \tau_\mu, \tau$	ϕ_3, ϕ_1	$\tau_\tau, \tau_\mu, \tau$
Ln_Taxes	Intercept & Trend	-2.091	326.201**	-12.512***
	Intercept	-2.132	387.949**	-2.037
	None	3.856		2.139
Ln_Expenditure	Intercept & Trend	-2.567	166.986***	-11.831***
	Intercept	-2.801*	197.428***	2.296
	None	3.836		2.753
Ln_GDP	Intercept & Trend	-3.092	63.129***	-2.859
	Intercept	-2.256	67.606**	-2.444
	None	2.924		5.552
Ln_Debts	Intercept & Trend	-2.400	14.891***	3.756**
	Intercept	-1.434	16.721*	-2.026-
	None	1.768		2.253

Panel B: First differences

Series	**Model**	**ADF**		**PP Test**
		$\tau_\tau, \tau_\mu, \tau$	ϕ_3, ϕ_1	$\tau_\tau, \tau_\mu, \tau$
D(Ln_Taxes)	Intercept & Trend	-8093***	1412.134***	-79.176***
	Intercept	-7.902***	1749.410***	-70.405***
	None	-6.521***		-47.629***
D(Ln_Expenditure)	Intercept & Trend	-9.284***	788.7123***	-74.639***
	Intercept	-8.968***	966.7680***	-68.562***
	None	-7.711***		-51.267***
D(Ln_GDP)	Intercept & Trend	-5.426***	201.715***	-21.773***
	Intercept	-3.802***	205.954***	-20.260***
	None	-2.870***		-16.508***
D(Ln_Debts)	Intercept & Trend	-6.290***	93.585***	-18.503***
	Intercept	-6.293***	117.167***	-18.150***
	None	-6.008***		-17.263***

*, ** and *** respectively 10%, 5% and 1% level of significance.

Appendix II: Unit root test for annual data

Panel A: Levels

Series	Model	ADF		PP Test
		$\tau_{\tau}, \tau_{\mu}, \tau$	ϕ_3, ϕ_1	$\tau_{\tau}, \tau_{\mu}, \tau$
Ln_Taxes	Intercept & Trend	-1.754460	3.741	-1.745292
	Intercept	-2.498671	6.243***	-3.127738**
	None	3.639450		5.226864
Ln_Expenditure	Intercept & Trend	-2.213059	4.634973	-2.417670
	Intercept	-2.655670*	7.052585***	-4.79486***
	None	4.310278		4.255114
Ln_GDP	Intercept & Trend	-3.188292*	10.11069***	-3.031389
	Intercept	-2.264621	10.31603**	-3.080352**
	None	2.850718		5.403337
Ln_Debts	Intercept & Trend	-1.831425	1.960308	-2.038585
	Intercept	-1.249321	1.560803	-1.249321
	None	2.644093		2.644093

Panel B: First differences

Series	Model	ADF		PP Test
		$\tau_{\tau}, \tau_{\mu}, \tau$	ϕ_3, ϕ_1	$\tau_{\tau}, \tau_{\mu}, \tau$
D(Ln_Taxes)	Intercept & Trend	-5.61994***	13.66042***	-6.007672***
	Intercept	-5.39328***	29.08753***	-5.405648***
	None	-3.26308***		-3.263084***
D(Ln_Expenditure)	Intercept & Trend	-6.03913***	15.91942***	-6.829840***
	Intercept	-5.16177***	18.20349***	-6.027139***
	None	-4.39886***		-4.423641***
D(Ln_GDP)	Intercept & Trend	-3.98525**	7.988752***	-4.036999**
	Intercept	-3.69095***	13.62311***	-3.699952***
	None	-2.05114**		-1.654951*
D(Ln_Debts)	Intercept & Trend	-5.83319***	17.02225***	-5.835478***
	Intercept	-5.82373***	33.91593***	-5.825302***
	None	-5.18110***		-5.187232***

*, ** and *** respectively 10%, 5% and 1% level of significance.

Appendix III: Test for stability of the VAR (quarterly data)

Roots of Characteristic Polynomial
Endogenous variables: LN_EXPEND LN_TAXES
LN_GDP LN_DEBT
Exogenous variables: C D_1 D_2 D_3
Lag specification: 1 2
Date: 03/06/06   Time: 10:50

Root	Modulus
0.986718	0.986718
0.948914	0.948914
0.756564	0.756564
-0.704402	0.704402
0.041265 - 0.476133i	0.477918
0.041265 + 0.476133i	0.477918
-0.297359	0.297359
-0.216113	0.216113

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

Appendix IV: Test for stability of the VAR (annual data)

Roots of Characteristic Polynomial
Endogenous variables: LN_EXPEND LN_TAX
LN_GDP LN_DEBT
Exogenous variables: C
Lag specification: 1 2
Date: 03/27/07   Time: 10:02

Root	Modulus
0.965459	0.965459
0.874619 - 0.167890i	0.890587
0.874619 + 0.167890i	0.890587
0.280049 - 0.286099i	0.400350
0.280049 + 0.286099i	0.400350
-0.032199 - 0.384307i	0.385653
-0.032199 + 0.384307i	0.385653
0.170581	0.170581

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