



Fiscal regime changes and the sustainability of fiscal imbalance in South Africa; a smooth transition error-correction approach

Samuel S. Jibao, Niek Schoeman and Ruthira Naraidoo

Working paper 228

July 2011

Fiscal regime changes and the sustainability of fiscal imbalance in South Africa; a smooth transition error-correction approach

Samuel S. Jibao*, Niek Schoeman[†] and Ruthira Naraidoo[‡]

July 8, 2011

Abstract

In addition to the conventional linear cointegration test, this paper tests the asymmetry relationship between fiscal revenue and expenditure, by making a distinction between the adjustment of positive (budget surplus) and negative (budget deficit) deviations from equilibrium. The analysis uses quarterly data for South Africa. The paper reveals that government authorities in South Africa are more likely to react fast when the budget is in deficit than when in surplus, and that the stabilisation measures used by government are fairly neutral at low deficit levels; that is, at deficit levels of 4% of GDP and below. We conclude that an attempt to achieve fiscal sustainability via a reduction in expenditure on sectors conducive to economic growth might be prone to create social and political shocks, which could render such fiscal policy unsustainable. In South Africa the main fiscal challenge, therefore, is to find ways through which the recent gains in fiscal solvency can be consolidated.

Keywords smooth transition error correction model; nonlinearity; government intertemporal budget constraint; and fiscal sustainability.

JEL classification C22 C51 H62

1 Introduction

Developments which followed the sub-prime crisis have led to renewed debate on fiscal sustainability: The massive degree of fiscal intervention, with corresponding increases in deficits and debt, are a concern. From a fiscal perspective, maintaining a stable long-term relation between expenditures and revenues is one of the key requirements for a stable macroeconomic environment and a sustainable economy. Sustainability, in general, concerns current and expected policies. If economic agents do not expect current and future policies to operate within the inter-temporal budget constraint, then the fiscal process would be unsustainable and government insolvency possible.

Several of the empirical studies on fiscal sustainability, however, focus on the time series behaviour of tax revenues and expenditures, as well as debt series, to investigate whether the behaviour of these series is consistent with the inter-temporal budget balance. The empirical results of these studies vary depending on the sample period and the methodology used. In the United States, Cunado, Gil-Alana, and Perez de Gracia (2004), Hamilton and Flavin (1986), and Trehan and Walsh (1988) failed to reject the inter-temporal budget balance, whilst Hakkio and Rush (1991) Wilcox (1989)

*PhD Candidate, University of Pretoria, Department of Economics, Pretoria, 0002, South Africa; Phone: (012) 4204125. Email: samuel.jibao@up.ac.za.

[†]Professor/ Supervisor, University of Pretoria, Department of Economics, Pretoria, 0002, South Africa; Phone: (012)4203455. E-mail: niek.schoeman@up.ac.za.

[‡]Senior Lecturer/Co-Supervisor, University of Pretoria, Department of Economics Pretoria, 0002, South Africa; Phone: Tel (012)3625207. E-mail: ruthira.naraidoo@up.ac.za

and others, rejected it. Empirical investigations into government's inter-temporal fiscal solvency constraints in East Asia have also been documented (see for example, Baharumshah and Lau 2007). Based on time series analysis and quarterly data over three decades, Baharumshah and Lau (2007) found evidence of sustainable fiscal finances in Thailand and South Korea, whilst the Philippines and Malaysia demonstrated only 'weak sustainability'. Baharumshah and Lau (2007) showed that in Singapore, revenue was growing at a faster rate than government spending.

In South Africa, issues of fiscal sustainability received greater attention in the 1980s and 1990s following a growing public debt/GDP ratio. In the earlier and mid-1990s, several researchers argued that fiscal policy was unsustainable in South Africa (Roux 1993; Van der Merwe 1994; Schoeman 1994; Cronje 1995). Roux (1993) argued that the South African government would be able to finance higher social expenditure only if economic growth improved; otherwise, debt-financed increases in social expenditure would cause an increase in the public debt/GDP ratio. Van der Merwe (1994) argued that fiscal policy in South Africa is unsustainable due to the large gap between real interest rates and real economic growth as well as the relatively large size of the deficit. Schoeman (1994) also warned that as long as government runs a large deficit in the face of a real interest rate that exceeds the real economic growth, the public debt/GDP ratio would tend to explode.

Consistent with the findings of the various researchers in South Africa, the South African economy embarked on broadly three phases of fiscal reform since 1994.

From 1994 to 1996, following a period of recession and a rapid rise in the budget deficit, Government's Reconstruction and Development Programme was phased into departmental plans and budgets, and a comprehensive reprioritisation of public expenditure was undertaken (Manuel, 2004). The average budget deficit stood at 4.3% of GDP and government debt was approaching 50% of GDP by 1994.

A period of fiscal consolidation from 1997 to 2000 saw the introduction of medium term expenditure planning, substantial investment in tax reform and revenue administration capacity and efficient coordination of fiscal and monetary policy. The budget deficit declined to 3.0% of GDP, public debt relative to GDP declined from 49.7% in 1994 to 44.4% in 2000 and average borrowing costs decreased sharply, providing room for government to spend more on social services and infrastructure.

From 2001 to 2008, the government of South Africa adopted a more expansionary fiscal stance in support of its infrastructure investment and social welfare improvement drive. Despite this expansionary stance of government, the main budget revenue increased consistently from 22.5% of GDP in 2002 to 26.6% of GDP in 2007 and declined slightly to 26.3% of GDP in 2008. Expenditure remained around 26% of GDP and increased slightly to 26.9% of GDP in 2008. As a result, budget deficits declined from 2001 to 2005 and a budget surplus was recorded in 2006 and 2007. For 2008, the budget returned to a deficit of 0.6% of GDP (See fig.1).

Although government had achieved a substantial reduction in its budget deficit target, from 6.8% of GDP in 1993 to 0.6% in 2008, the scenario has meanwhile changed again (see Budget Review 2010), mainly due to the slowdown in the world economy which also affected the revenue base of the South African economy. However, the policy of fiscal prudence during the period 2003 to 2008 resulted in a substantial decline in real debt service cost, while the real growth rate of the economy increased considerably. Nevertheless, the former still exceeds the growth rate, resulting in a (r-g) gap¹. Furthermore, it appears that public debt and budget deficit reductions have been achieved at the expense of a relative reduction in service delivery expenditure, as is evident in the reduction in the ratio of education expenditure to GDP from an average of 6.21% during the period 1990-1999, to an average of 5.6% during the period 2000-2008; and a reduction in health expenditure relative to GDP from an average of 2.93% during 1990-1999 to 2.84% during 2000-2008².

In most of the studies recorded in the literature on fiscal measures to address the solvency condition, researchers have either tested for linear stationarity in the total government deficit series or tested for linear cointegration between total government spending and total tax revenues. To

¹See Burger, Philippe, 2003, Sustainable Fiscal Policy and Economic Stability, Theory and Practice.

²Although in nominal terms allocations have increased in the case of social services, like health and education.

the best of our understanding, few researchers have used non-linear techniques to quantify the adjustment process of fiscal and other macroeconomic variables towards the long-run equilibrium (see Van Dijk Dick & Franses and Philip Hans (1997), Hansen and Kim (1996), Kunst (1992, 1995) Dwyer (1996) Swanson(1996) and Cipollini (2001)). In South Africa in particular, no study has tested whether the error-correction process used in the respective studies is linear. Instead, previous studies have assumed that the adjustment process driving the variables toward equilibrium is linear; i.e. adjustment towards equilibrium is always present and of the same strength under all circumstances. In this study the authors want to point out that there are situations in which the validity of this assumption might be questioned (see Van Dijk et al. 1997).

The authors therefore apply an extension of the linear inter-temporal budget constraint rule of fiscal sustainability to a regime-switching framework, where the transition from one regime to the other occurs in a smooth way. The switching between regimes is controlled by the state of the fiscal balance. This feature of the smooth transition model allows us to test the ability of high against low budget deficits or surpluses to best describe the non-linear dynamics of fiscal policy in South Africa.

Following the introduction, Section II presents sustainability criteria as obtained from the literature. Section III provides the estimation procedures, with both linear and non-linear specifications; Section VI presents the results from the estimations and the last section summarises and concludes.

2 Sustainability Criteria

The most straightforward way to assess the fiscal sustainability position is to start from a government's inter-temporal budget constraint. The budget constraint looks at the long-run relationship between government revenue and expenditure (that covers the total government spending on goods and services, transfer payments and interest on debts). For simplicity, assume that budget deficits are financed using bonds with a maturity of one period. This implies that the government faces the budget constraint as shown in equation one:

$$G_t + (1 + r_t)B_{t-1} = R_t + B_t \quad (1)$$

Where G is government expenditure, r is the one-period real rate of interest, R is government revenue and B is the stock of debt. Iterating equation (1) forward yields the government's inter-temporal budget constraint:

$$B_t = \sum_{s=0}^{\infty} \prod_{i=1}^s (1 + r_t)^{-1} (R_{t+s} - G_{t+s}) + \lim_{s \rightarrow \infty} \prod_{i=1}^s (1 + r_{t+i})^{-1} B_{t+s} \quad (2)$$

We assume that the real interest rate is stationary with unconditional mean given by r and also that the growth rate of the real supply of bonds, on average, is equal to or lower than the average rate of interest[see Hamilton and Flavin (1986) and Haug (1995)]. With these assumptions, we can have the following expression:

$$\lim_{s \rightarrow \infty} (1 + r)^{-s} B_{t+s} = 0 \quad (3)$$

The above equation (3) states that the debt stock, when measured in present value terms, vanishes in the limit. By definition, it excludes Ponzi financing; that is, the government is not 'bubble'-financing its expenditure by issuing new debt to finance the deficit. This is equivalent to saying that the deficit is sustainable if and only if the stock of debt held by the public is expected to grow no faster than the mean real rate of interest, which is viewed as a proxy for the growth rate of the economy (Baharumshah 2007).

Following equation (3), the inter-temporal budget constraint, equation (2), can be re-written as;

$$G_t - R_t = \sum_{s=0}^{\infty} (1 + r)^{-s+1} (\Delta R_{t+s} - \Delta G_t + r \Delta B_{t+s-1}) \quad (4)$$

The inter-temporal budget constraint, under the no-Ponzi scheme rule, imposes restrictions on the time series properties of government expenditure and revenue given by the right hand side of equation 4. This will be stationary, as long as government expenditure, revenue and the stock of debt are all stationary in first differences. Specifically, if G_t are R_t I(1), they will be cointegrated, implying that there exists an error-correction mechanism pushing government finances towards the levels required by the inter-temporal budget constraint.

Assuming that the transversality condition for the budget constraint holds and the limit term in equation (3) is zero, we arrive at the following cointegrating relationship as shown in equation 5 (see Hakkio and Rush 1991);

$$R_t = \alpha + \beta G_t + \varepsilon_t \quad (5)$$

Following Martin (2000), the deficit is ‘strongly’ sustainable (strong solvency) if and only if the I(1) process of R and G are cointegrated and $\beta=1$. The deficit is only ‘weakly’ sustainable if R and G are cointegrated and $0 < \beta < 1$ (see Trehan and Walsh, 1988; Quintos, 1995). The linear model estimated in this paper, after eliminating insignificant lags, is specified as:

$$\begin{aligned} drev_t = & \alpha_0 + \alpha_1 drev_{-1} + \alpha_2 drev_{-2} + \alpha_3 drev_{-4} + \alpha_4 drev_{-5} + \alpha_5 drev_{-8} + \alpha_6 \exp_t \\ & + \alpha_7 d\exp_{-2} + \alpha_8 d\exp_{-4} + \alpha_9 d\exp_{-5} + \alpha_{10} d\exp_{-8} + \alpha_{11} ecm_{-1} \end{aligned} \quad (6)$$

3 Specification and Estimation Techniques

In this paper, our empirical estimation involves the following steps: i) testing for stationarity of the variables; ii) testing for cointegration and estimation of the cointegrating relation; iii) testing for non-linearity of the adjustment process; and IV) estimating and evaluating of the Smooth Transition Error Correction model.

3.1 Linear estimation techniques

We carry out three different tests for the order of integration which are: the Augmented Dickey-Fuller (1981), the Kwiatowski, Phillips, Schmidt and Shin (1992) and the Phillips-Perron (1990) tests. The Dickey-Fuller and Phillips-Perron tests have as their null hypothesis that the dynamics of the respective series are characterised by a unit root. The Kwiatowski, Phillips, Schmidt and Shin test, on the other hand, is based on the null of stationarity. The use of three tests is justified since Perron (1989, 1997) and Zivot and Andrews (1992) have demonstrated that the Augmented Dickey-Fuller test has low power in the presence of a structural break.

We consider those cointegration tests that are most popular among researchers: the residual-based test suggested by Engle and Granger (1987) and the Likelihood Ratio test introduced by Johansen (1988). Given a bi-variate case (for simplicity) with no deterministic regressors, the residual-based test for cointegration is performed via the two-step procedure of Engle and Granger (1987). That is, we first estimate the cointegration regression as specified in equation (6) using ordinary least square (OLS) and second, test for the presence of a unit root in the regression residuals.

$$y_t = -\beta x_t + u_t \quad (7)$$

Johansen (1988) advocates a test for cointegration by testing the rank r of π by applying likelihood ratio tests to test the significance of the squared partial canonical correlations between Δy_t and y_{t-1} denoted $\hat{\lambda}_1$ and $\hat{\lambda}_2$ which can be obtained by solving a generalised eigenvalue problem. The authors use trace tests to test $H_0 : r = r_0$ against the alternative hypothesis $H_1 : r \geq r_{0+1}$ for $r_0 = 0, 1$.

This paper considers both non-parametric and parametric tests for linearity. The non-parametric test follows Brock-Dechert-Scheinkman (1987). It tests the null hypothesis of independence and identically distributed variables against an unspecified alternative. The Brock-Dechert-Scheinkman

(1987) test cannot test chaos directly, but only non-linearity, provided that any linear dependence has been removed from the data (e.g. using traditional ARIMA-type models or using first differences). The Brock-Dechert-Scheinkman (1987) statistics are, therefore, different from other non-parametric test statistics since these focuses mainly on either the second- or third-order properties of x_2 . The basic idea of the Brock-Dechert-Scheinkman (1987) test is to make use of a ‘correlation integral’ popular in chaotic time series analysis. Given a k -dimensional time series and observations $\{x_t\}_{t=1}^{T_k}$, define the correlation integral as³.

$$C_k(\delta) = \lim_{T_k \rightarrow \infty} \frac{2}{T_k(T_k - 1)} \sum_{i < j} I_\delta(X_i X_j) \quad (8)$$

Where $I_\delta(u, v)$ is an indicator variable that equals one if $\|u-v\| < \delta$, and zero otherwise, and where $\|\cdot\|$ is sup norm. The null hypothesis of the BDS test is that the series is linear and the alternative hypothesis is that the time series is non-linear after removing any linear dependence from the data, either by using ARIMA-type models or taking the first difference of the series. This test statistic has a standard normal limiting distribution.

The parametric test for linearity follows Tervirta (1994) who suggests a method of approximating the transition function by a Taylor expansion about the null of linearity $\gamma = 0$. The linearity test involves estimating an auxiliary regression by OLS:

$$\Delta y_t = \phi' w_t + \phi'_1 \hat{w}_t z_{t-d}^2 + \phi'_2 \hat{w}_t z_{t-d}^2 + \phi'_3 \hat{w}_t z_{t-d}^3 + \varepsilon_t \quad (9)$$

Where

$$w_t = (1, \Delta y_{t-1}, \dots, \Delta y_{t-p}, \Delta x_{t-p}, z_{t-d})'$$

$$\hat{w}_t = (\Delta y_{t-1}, \dots, \Delta y_{t-p}, \Delta x_{t-1}, \dots, \Delta x_{t-p}, z_{t-d})$$

The original null hypothesis of linearity, $H_0: \gamma = 0$ is equivalent to the hypothesis that all coefficients of the auxiliary regressors $\hat{w}_t z_{t-d}^j$, $j = 1, 2, 3$ are zero i.e. $H_0: \phi_1 = \phi_2 = \phi_3 = 0$. For details on the LM-type test for this hypothesis, see Van Dijk et al. (1997). To select the most appropriate lag of z to use as transition variable, the test should be carried out for a number of different values of d , say $d = 1, \dots, D$. If the linearity is rejected for several values of d , the one with the smallest p-value is selected as the transition variable; see Van Dijk et al. (1997).

3.2 Non-linear estimation technique

If the linearity hypothesis is rejected, we can estimate a non-linear model using non-linear least squares (NLS). In this paper, we apply the smooth-transition threshold models (Granger and Tervirta, 1993; Tervirta, 1994; Tervirta, 1998) which allow for smooth transition between regimes of behaviour and thus generalise the threshold autoregressive model (TAR). The other strength of the smooth transition model is that it is theoretically more appealing than the simple TAR models that impose an abrupt switch in parameter values. An abrupt switch only happens if all agents act simultaneously. Additionally, the STR model allows different types of market behaviour depending on the nature of the transition function. In particular, the logistics function allows differing behaviour depending on whether deviations from equilibrium are positive or negative, whilst the exponential function allows differing behaviour to occur for large and small deviations regardless of sign (see McMillan, 2004). Following McMillan, the STR model is given by equation 9 below:

$$\Delta x_t = \delta_0 + \sum_{i=1}^p \Delta x_{t-i} + \rho_1 u_{t-1} + (\theta_i + \sum_{i=1}^p \theta_i \Delta x_{t-i} + \rho_2 u_{t-1}) F(u_{t-1}) + \varepsilon_t \quad (10)$$

³See Tsay (2005). Analysis of Financial Times Series, Second edition P. 210.

Where $F(u_{t-d})$ is the transition function and u_{t-d} the transition variable. The logistic function is given as follows, with the full model thus referred to as a logistic STR (or LSTR) model:

$$F(u_{t-1}) = \{1 + \exp[-\gamma(u_{t-1} - \tau)]\}^{-1} \quad \gamma > 0 \quad (11)$$

Which allows a smooth transition between the differing dynamics of positive and negative deviations, where γ is the smoothing parameter and τ the transition parameter. This function allows the parameters to change monotonically with u_{t-1} . As $\gamma \rightarrow \infty$, $F(u_{t-1})$ becomes a Heaviside function, $F(u_{t-1}) = 0, (u_{t-1}) \leq \tau, F(u_{t-1}) = 1, (u_{t-1}) \geq \tau$ and equation 9 reduces to a TAR model. As $\gamma \rightarrow 0$, equation 9 becomes a linear model of order p .

The second type of asymmetry, which distinguishes between small and large equilibrium errors, is obtained when is taken to be the exponential, with the resulting model referred to as the exponential STR (or ESTR) model and ESTECM for a bivariate model:

$$F(u_{t-1}) = 1 - \exp[-\gamma(u_{t-1} - \tau)^2] \quad (12)$$

Equation 9 results in gradual changing strength of adjustment for larger (both positive and negative) deviations from equilibrium. It implies that the dynamics of the middle ground differ from those of the larger deviations. This model is therefore only able to capture non-linear symmetric adjustment. A possible drawback of this choice for the transition function is that both if $\gamma \rightarrow 0$ or $\gamma \rightarrow \infty$, the model becomes linear. This can be avoided by using the ‘quadratic logistic function’ as proposed by Jansen and Tersvirta (1996).

$$F(u_{t-1}) = (1 + \exp\{-\gamma(u_{t-1} - \tau_1)(u_{t-1} - \tau_2)\})^{-1} \quad (13)$$

In this case, if $\gamma \rightarrow 0$, the model becomes linear, whilst if $\gamma \rightarrow \infty$, the function $F(\cdot)$ is equal to 1 for $u_{t-1} < c_1$ and $u_{t-1} > c_2$.

The STR model is estimated using the non-linear least squares; however in the LSTR model, a large γ results in a steep slope of the transition function at τ , thus a large number of observations is required to estimate γ accurately. Furthermore, convergence of γ may be slow, with relatively large changes in γ having only a minor effect upon the shape of the transition function. To get around this problem, Granger and Tersvirta (1993) and Tersvirta (1994) proffer scaling the smoothing parameter γ by the standard deviation of the transition variable, and by the variance of the transition variable in the case of ESTR (see McMillan, 2004).

4 Data Discussion

The data used to estimate the model suggested in this paper consists of the South African national government receipts and expenditures, expressed as ratios of GDP. The data, obtained from the Quarterly Bulletin published by the South African Reserve Bank, are quarterly, from 1960:1 to 2008:4. All variables have been expressed as a percentage of GDP and converted into their natural logarithmic form. We use revenue and expenditure ratios to GDP since government authorities are mainly concerned with the dynamics of the different budget items relative to the overall size of the economy (see Hakkio and Rush, 1991; Cipollini, 2001)

5 Empirical results

The Augmented Dickey-Fuller (1981) and Phillips-Perron (1988) unit root tests as well as the Kwiatkowski-Phillips-Schmidt-Shin (1992) stationarity tests for both series are reported in table 1. We note that the null of a unit root cannot be rejected on the basis of Augmented Dickey-Fuller (1981) and Phillips-Perron (1989) for both series. This result is supported by the Kwiatkowski-Phillips-Schmidt-Shin (1992) test as this test rejects the null of stationarity for both series. There

is no ambiguity in the order of integration; therefore we use the first differences of the series in our study. The Granger Causality test (see table 2) gives an indication of a unidirectional causality from expenditure to taxes, i.e. supports the expenditure dominance hypothesis, implying that in South Africa budget developments are mainly determined by government spending⁴. A residual-based test of cointegration as suggested by Engle and Granger (1987) and the likelihood ratio test introduced by Johansen (1991), show evidence of a long-run relation between the two variables of interest (see fig. 6). We test the hypothesis that the co-integrating vector is (1, -1). Since the ρ -value is not significant at the conventional levels we cannot reject the null hypothesis that the restrictions are binding (see table 3), implying that during the sample period, fiscal policy in South Africa, consistent with the inter-temporal condition of sustainability, was sustainable.

The fitted linear conditional error-correction model for revenue to GDP is shown in table 6, column 1. The linear model seems quite satisfactory, with the post-estimation residual tests indicating normality but with evidence of heteroscedasticity. The LM-tests reject the null of no serial correlation. It may be that these significant test values are caused by neglected non-linearity (Van Dijk et al. 2001).

5.1 Linearity testing and model selection

We carry out the Brock-Dechert-Scheinkman (1987) test on a series of estimated residuals to check whether the residuals are independent and identically distributed; i.e. whether the residuals from our linear model has any non-linear dependence in the series after the linear model has been fitted. Table 4 indicates that all the test statistics are significantly greater than the critical values. Thus, we should reject the null hypothesis of independent and identically distributed series/variables. The results strongly suggest that the time series in our model are non-linearly dependent, which is one of the indications of chaotic behavior.

We also consider a parametric test, the Escribano and Jorda (EJ hereafter) (2001) linearity LM test. The null hypothesis in this test, is that the series follows a stationary linear process. The computation of the test is carried out using the F- version, which is an asymptotic Wald test.

Computing the LM-type test statistics, and setting delay variable (d) equal to 1 through 8, it is seen that linearity is rejected for d=1, 2, 6 and 8 at the 5 percent level of significance. But given that d=6 has the smallest ρ -value, we select it as the delay variable (see table 5). This implies that in South Africa it takes 6 quarters or one and a half years for fiscal policy changes to be effective. This is not uncommon, as fiscal policy issues require legislature procedures, which take time. Deciding between the transition functions can be done by a short sequence of tests nested within. This testing is motivated by the observation that if a logistics alternative is appropriate, the second-order derivative in the Taylor expansion (8b) is zero (see Van Dijk, 1997). The null hypothesis to be tested is as follows:

$$H_{03} : \phi_3 = 0; H_{02} : \phi_2 = 0 \mid \phi_3 = 0; H_{01} : \phi_1 = 0 \mid \phi_3 = \phi_2 = 0$$

Granger and Teräsvirta (1993) suggest carrying out all three tests, independent of rejection or acceptance of the first or second test, and using the outcomes to select the appropriate transition function. The decision rule is to select an exponential STR function only if the p-value corresponding to H_{02} is the smallest, and select the logistic function in all other cases. Table 5 shows that at d=6, the logistic representation of the data is the most preferred.

⁴The authors recognise that Granger causality is different from a test for exogeneity (Enders, 2004). Whilst exogeneity of one variable, say, expenditure means that it is not affected by contemporaneous values of the remaining variables (taxes, debt etc), Granger causality refers only to the effects of past values of those variables on the current value of expenditure. Our causality result reported only gives an indication of the relationship which is not firmed because it is not the focus of the paper. Studies have shown that causality amongst variables are highly sensitive to the methodologies used, choice of variables, the frequency of the data, and also the sample period (see Ndahiriwe and Gupta 2007)

5.2 LSTECM estimation

Having established a non-linear relationship we now estimate the parameters of the LSTECM by using the non-linear least squares (NLS) technique. Two LSTECM models are fitted, one is general and the other is fitted after parameter reduction (see table 6, columns 3 and 4); this is obtained by removing the insignificant coefficients. The model estimated is specified as:

$$\begin{aligned}
 {}^{dl}rev_t = & \alpha_0 + \alpha_1 {}^{dl}rev_{-1} + \alpha_2 {}^{dl}rev_{-2} + \alpha_3 {}^{dl}rev_{-4} + \alpha_4 {}^{dl}rev_{-5} + \alpha_5 {}^{dl}rev_{-8} + \alpha_6 {}^{dl}rev_t \\
 & \alpha_7 {}^{dl}exp_{-2} + \alpha_8 {}^{dl}exp_{-4} + \alpha_9 {}^{dl}exp_{-5} + \alpha_{10} {}^{dl}exp_{-8} + \beta_{11} {}^{dl}ecm_{-1} + (1 - F)(\beta_0 + \beta_1 {}^{dl}rev_{-1} \\
 & \beta_2 {}^{dl}rev_{-2} + \beta_3 {}^{dl}rev_{-4} + \beta_4 {}^{dl}rev_{-5} + \beta_5 {}^{dl}exp_{-8} + \beta_6 {}^{dl}exp_t + \beta_7 {}^{dl}exp_{-2} + \beta_8 {}^{dl}exp_{-4} \\
 & \beta_9 {}^{dl}exp_{-5} + \beta_{10} {}^{dl}exp_{-8} + \beta_{11} {}^{dl}ecm_{-1})
 \end{aligned} \quad (14)$$

Where the weight F is modelled as follows:

$$F(ecm_{t-d}) \equiv F(ecm_{t-d}; \gamma, c) = \{1 + \exp[-\gamma(ecm_{t-d} - \tau)]\}^{-1} \quad \gamma > 0$$

The parameter γ which determines the smoothness of the transition regime is set at 10; and the threshold is computed to be at 0.04. As stated earlier, the delay variable (d) is computed to be at 6 quarters i.e. one and a half years. We also follow Granger and Tersvirta (1993) and Teräsvirta (1994) in making γ dimension-free by dividing it by the standard deviation of σecm_{t-d} . As the surplus grows larger, $ecm_{t-d} \rightarrow \infty$, $F \rightarrow 1$. As the budget deficit grows increasingly larger, $ecm_{t-d} \rightarrow -\infty$, $F \rightarrow 0$. When $F \rightarrow 0$ implying $(1 - F) = 1$, i.e. a budget deficit, the relevant parameters are a summation over α and β .

The results from estimating model equation (13) are presented in table 6. Table 6 columns 3 and 4 report the non-linear least square estimates of our models. Tests of the residuals show no residual autocorrelation, no serial correlation, no non-normality of residuals and, finally, no heteroscedasticity. The Akaike information criterion shows that the non-linear model (i.e. model 3) is a better fit than the linear model. The error-correction terms are of the expected signs and statistically significant and show that the adjustment process to equilibrium is faster when the government budget is in deficit than in surplus. In short, government authorities are likely to react faster when the budget deficit exceeds 4% of GDP, since it will create concern for the achievement of fiscal sustainability. The one-and-a-half-year reaction delay (i.e. $d = 6$) combined with a relatively smooth switch from one regime to the other $\gamma = 10$, can be explained in terms of the political-institutional processes (see Cipollini, 2001). Fiscal laws and regulations are drafted, through a budget document and tabled to parliament for approval before implementation, a process that could be time consuming. The empirical result shows that a 1% increase in the government budget deficit (the transition variable) implies variation in the transition function that is larger (i.e. a stronger policy maker reaction) than the corresponding 1% increase in a budget surplus⁵, showing that in this phase the South African government becomes more concerned about solvency or fiscal sustainability. However, it appears that fiscal sustainability in South Africa has been attained at the expense of a reduction in the ratio of expenditure to GDP on education, and a relatively constant ratio of expenditure to GDP on health, during the deficit and surplus fiscal regimes (see figures 2 and 4). Whilst the ratio of expenditure to GDP on these sectors were declining both during the budget deficit and surplus regimes, expenditure to GDP on social protection and public order and safety increased in both regimes (see figures 3 and 5). This result is supported by the negative correlation between the thresholds (i.e. budget deficit and surplus regimes) and the trend of education and health expenditure to GDP (see tables 7a and b). A priori one would expect that such a decline in the allocations to sectors which could stimulate growth and which in turn could generate future revenue, may pose a threat to the accumulated fiscal space.

⁵Figures 7 and 8 shows the state dependent speed of adjustment over time

6 Summary and Conclusion

This paper has tested the asymmetry relationship between revenue and expenditure, by making a distinction between adjustment of positive (budget surplus) and negative (budget deficit) deviations from equilibrium. It uses quarterly data on South Africa. Our findings suggest that fiscal policy over the sampled period has been sustainable, since the historical processes in South Africa are consistent with the intertemporal government budget constraint. Of more importance, our findings show that the assumption that adjustment towards equilibrium is always present and of the same strength under all circumstances, is not valid in the case of fiscal data on South Africa.

Results from the study also reveal that government authorities are likely to react faster when the budget is in deficit than when in surplus, implying that the South African government becomes more concerned about solvency or fiscal sustainability in the case of the former. This adjustment could be prone to social shock, as trend expenditure on education and health to GDP has been on a decline over this period of fiscal solvency. The paper therefore supports the view that sustainability is more than fiscal accounting to include social and political context, especially for emerging economies like South Africa where the role of government is socially and politically important⁶. It concludes that the attempt to achieve fiscal sustainability via a reduction in the expenditure/GDP ratios on sectors which could be potentially growth enhancing and therefore expand the revenue base, may be socially, politically and economically unsustainable.

7 Future Research

Future research requires estimating the revenue gap in the South African economy to ascertain whether there is potential for revenue growth, in order to reduce the backlog in service provision – a situation which is identified as a potential threat to current fiscal stability.

References

- [1] Alesina A. & Perotti R. 1995. The Political Economy and Budget Deficits, IMF Staff papers, March 1-31. Washington, D.C.: International Monetary Fund.
- [2] Baharumhah, A.Z. & Lau E. 2007. Regime changes and the sustainability of fiscal imbalance in East Asian countries, *Economic Modelling* 24 878-89; available online at: www.sciencedirect.com.
- [3] Boateng, A., Naraidoo, R. & Uddin, M.M. 2009. An analysis of the inward cross-border mergers and acquisitions in the UK: a macroeconomic perspective, Department of Economics, of Pretoria, working paper, 2009-24.
- [4] Brock, W. A., Dechert W. & Scheinkman J. 1987. A test for independence based on the correlation dimension, working paper, University of Wisconsin at Madison, University of Houston, and University of Chicago.
- [5] Bravo, A.B.S. & Silvestre, A.L. 2002. Intertemporal sustainability of fiscal policies: some tests for European countries. *European Journal of Political Economy* 18, 517-528.
- [6] Braum M. 2007. Fiscal policy in Latin America a paper prepared for the Consulta de San Jose, a joint IDB-Consensus Center Project.
- [7] Burger, P. & Fourier, F.C. 2004. *Sustainable Fiscal Policy and Economic Stability, Theory and Practice*. Edward Elgar Publishing 2004.

⁶See Adelzadeh (199:2); Burger and Fourie (2004).

- [8] Cipollini, A. 2001. Testing for government intertemporal solvency, a smooth transition error correction model approach. *The Manchester School* 69, 643-655.
- [9] Cronje, A. 1995. Deficit financing and the public debt in South Africa, Discussion paper series, Discussion Paper No.2, the Budget Project. Cape Town: University of Cape Town, School of Economics
- [10] Cunado, J., Gil-Alana, L., A. & Perez de Gracia, F. 2004. Is the US fiscal deficit sustainable? A Fractionally integrated approach, *Journal of Economics and Business*, Elsevier, 56(6), 501-526
- [11] Dickey, D. A. & Fuller, W.A. 1981. Likelihood ratio tests for autoregressive time series with a unit root. *Econometrica*, 49,1057-1072.
- [12] Dwyer, G. P., Locke P. & Yu. W. 1996. Index arbitrage and nonlinear dynamics between the S&P 500 futures and cash, *Review of Financial Studies*, 9, 301-332.
- [13] Engle, R.F. & Granger, C.W.J. 1987. Co-integration and Error Correction: Representation, Estimation and Testing. *Econometrica* 55,251-276.
- [14] Escribano, A. & Jorda, O. 2001. Testing nonlinearity: Decision rules for selecting between logistic and exponential STAR models, *Spanish Economic Review*, 3(3) 193-209.
- [15] Granger, C. & Terasvirta, T. 1993. *Modelling Nonlinear Economic Relationships*, London, Oxford Economic Press.
- [16] Feve, P. & Henin, P.Y. 2000. Assessing Effective Sustainability of Fiscal Policy within the G-7, *Oxford Bulletin of Economics and Statistics* 62,175-195.
- [17] Hakkio, C.S. & Rush, M. 1991. Is the budget deficit 'Too Large'? *Economic Inquiry* 29,425-429.
- [18] Hamilton, J.D., & Falvin, M.A., 1986. On the limitations of government borrowing: a framework for empirical testing. *American Economic Review* 76, 808-819.
- [19] Hansen, G. & Kim J. R. 1996. Nonlinear cointegration analysis of German unemployment, mimeo, Institute of Statistics and Econometrics, Christian Albrecht University.
- [20] Hatemi J.A. 2002. Fiscal policy in Sweden: effects of EMU criteria convergence. *Economic Modelling* 19, 121-136.
- [21] Johansen, S. 1991. Estimation and hypothesis testing of Cointegration vectors in Gaussian Vector Autoregressive models, *Econometrica* 59, 1551-1580.
- [22] Jansen, E. S., & Teräsvirta, T.,1996. Testing Parameter Constancy and Super Exogeneity in Econometric Equations, *Oxford Bulletin of Economic and Statistics*, 58 (4), 735-765.
- [23] Kunst, R. M. 1992. Dynamic patterns in interest rates: threshold cointegration with ARCH, working paper, Institute of Advanced Studies, Vienna.
- [24] Kunst, R. M. 1995. Determining long-run equilibrium structures in bivariate threshold autoregressions: a multiple decision approach, working paper, Institute of Advanced Studies Vienna.
- [25] Kwiatkowski, Phillips, P.C.B., Schmidt, P., & Shin, Y. 1992. Testing the null hypothesis of stationary against alternative of a unit root; how sure are we that economic time series have a unit root? *Journal of Econometrics* 54, 159-178.
- [26] Makrydakis, S., Tzavalis, E., & Balfoussias, A. 1999. Policy regime changes and long-run sustainability of fiscal policy: an application to Greece. *Economic Modelling* 16, 71-86.

- [27] Marfan M. 2008. Fiscal Policy and Economic cycles: The Chilean fiscal rule, presentation prepared for the G-20 workshop, Buenos Aries, June 19-20, 2008.
- [28] Martin, G.M., 2000. US deficit sustainability: a new approach on multiple endogenous breaks. *Journal of Applied Econometrics* 15, 83-105.
- [29] Manuel, T. 2004. Longer term fiscal policy issues in South Africa. Paper presented at the Bureau for Economic Research 60th anniversary conference Somerest West, 18 November 2004.
- [30] McMillan D. G. 2004. Non-Linear Error Corrections: Evidence for UK Interest Rates, the *Manchester School* Vol. 72 No. 5 September 2004, 1463-6786 626-640.
- [31] Minford, P. & Peel, D. 2002. *Advance Macroeconomics: a primer*, Northampton MA: Edward Elgar. Chapter 5.
- [32] National Treasury Secretariat, 2004. Fiscal Policy in Brazil and Japan, what can be learned? Seminar on Economic Policies, Policy Research Institute, Ministry of Finance and the Japanese Government.
- [33] Ndahiriwe, K. & Gupta, R. 2007. Temporal Causality between Taxes and Public Expenditures: The Case of South Africa. University of Pretoria Working Paper: 2007-09.
- [34] Phillips, P.C.B. & Perron, P. 1988. Testing for Unit Root in Time Series Regression, *Biometrika*, 75, 335-346.
- [35] Phillips, P. C. B. & Outliers. 1990. Asymptotic properties of residual based tests for cointegration; *Econometrica* ,58 165-193.
- [36] Quintos, C.E. 1995. Sustainability of the deficit process with structural shifts, *Journal of Business and Economic Statistics* 13, 409-417.
- [37] Rogoff, K. & Sibert A. 1988. Elections and Macroeconomic Policy Cycles, NBER Working Paper No. 1838.
- [38] Roux, A. 1993. The public debt: A medium-term perspective. *The South African Journal of Economics* 61(4), 324-333.
- [39] Schoeman, N.J. 1994. Public Debt and the economy, Paper presented at the EBM Conference at RAU-28-29 November 1994.
- [40] Swanepoel, & Schoeman, N. 2002. Tax revenue as an automatic fiscal stabilizer: a South African perspective. *South African Journal of Economic and Management Sciences*, 5(4): 566-588.
- [41] Swanson, N.R. 1996. Finite sample properties of a simple LM test for neglected nonlinearity in error correction regression equations, Working Paper, University of Pennsylvania.
- [42] Teräsvirta, T. 1998. Modelling Economic relationships with Smooth Transition Regressions, in A. Ullah and D.E.A Gilles (eds), *Handbook of Applied Economic Statistics*, New York, Marcel Dekker.
- [43] Teräsvirta, T. 1994. Specification, estimation, and evaluation of smooth transition autoregressive models, *Journal of the American Statistical Association*, 89, 2008-218.
- [44] Tsay, R. S. 2005. *Analysis of Financial Time Series*, 2nd(ed). University of Chicago, Graduate School of Business.
- [45] Trehan, B., Walsh, C.E. 1988. Common Trends, the Government Budget Constraint and Revenue Smoothing, *Journal of Economic Dynamics and Control* 12, 425-444.

- [46] Van Dijk, D., Franses P.H. 1997. Nonlinear error-correction models for interest rates in Netherlands. In W.A. Barnett, D.F. Henry, S. Hylleberg, T. Terasvirta, D. Tjostheim and A.H. Wurtz (eds), *Nonlinear Economic Modelling of Time Series*, Cambridge, Cambridge University Press.
- [47] Van Dijk, D., Teräsvirta, T. & Franses P.H. 2002. Smooth Transition Autoregressive Models-a survey of recent developments. *Econometric Reviews*, 21(1), 1-47(2002).
- [48] Van der Merwe, E. 1994. Is South Africa in a debt trap? EPSG Occasional paper No.6, Economic Policy Study Group. Johannesburg: Economic Policy Group Study.

Table 1: Unit Roots Tests

Panel A: in Levels	ADF	PP	KPSS
Revenue-GDP	1.42	-0.598	1.599***
Expenditure-GDP	0.906	-0.300	1.307***
Panel B: first difference			
Δ Revenue-GDP	-9.665***	-9.998**	0.095
Δ Expenditure-GDP	-10.132***	-7.528***	0.092

Note *(**)(***) denotes significance at 10, 5, and 1% levels respectively.

Table 2: Granger Causality Test

Null hypothesis	Obs	F-Statistic	Prob.
Dlrevgdp does not Granger cause Dlexpgd	188	1.34	0.25
Dlexpgdp does not Granger Cause Dlrevgdp		2.17	0.054

Table 3: Binding Restrictions

B(1,1)=1, B(1,2)=-1					
Hypothesied no. of Cointegration	Restricted Likelihood	LR Statistics	Degree of freedom	of	Probability value
1	452.0105	0.219771	1		0.639215

Table 4: BDS Test

	Embedding Dimensions(m)	BDS Statistics
2	2	0.014***(0.0045)
2	3	0.024***(0.0071)
2	4	0.040***(0.0085)
2	5	0.046***(0.0087)
2	6	0.046***(0.0085)

Note: *(**)(***) denotes significance at 10, 5 and 1% respectively

Table 5: LM-Type for non-linearity and model selection

Transition Variable	LM	H ₀₁	H ₀₂	H ₀₃
Ecm. ₁	0.018	0.018	0.043	0.025
Ecm. ₂	0.706	0.706	0.240	0.558
Ecm. ₃	0.448	0.448	0.140	0.680
Ecm. ₄	0.113	0.113	0.205	0.446
Ecm. ₅	0.144	0.144	0.068	0.090
Ecm. ₆	0.000	0.000	0.001	0.0012
Ecm. ₇	0.421	0.421	0.507	0.957
Ecm. ₈	0.001	0.0011	0.0010	0.124

Note: ρ -values of F variants of the LM-type tests used in the specification procedure of Escribano and Jorda(2001).

In-sample estimates of linear and nonlinear models

$$\begin{aligned}
 Dl\ rev_t = & \alpha_0 + \alpha_1 dl\ rev_{-1} + \alpha_2 dl\ rev_{-2} + \alpha_3 dl\ rev_{-4} + \alpha_4 dl\ dlrev_{-5} + \alpha_5 dl\ rev_{-8} + \alpha_6 dl\ exp_t \\
 & \alpha_7 dl\ exp_{-2} + \alpha_8 dl\ exp_{-4} + \alpha_9 dl\ exp_{-5} + \alpha_{10} dl\ exp_{-8} + \beta_{11} dl\ ecm_{-1} + (1-F)(\beta_0 + \beta_1 dl\ rev_{-1} \\
 & \beta_2 dl\ dlrev_{-2} + \beta_3 dl\ rev_{-4} + \beta_4 dl\ rev_{-5} + \beta_5 dl\ exp_{-8} + \beta_6 dl\ exp_t + \beta_7 dl\ exp_{-2} + \beta_8 dl\ exp_{-4} \\
 & \beta_9 dl\ exp_{-5} + \beta_{10} dl\ exp_{-8} + \beta_{11} ecm_{-1})
 \end{aligned}$$

Table 6: Model Estimates, 1960: Q1- 2008: Q4

Parameter	Linear model	Non-linear (General)	Non-linear (Specific)
α_0	0.002 (0.005)	0.009 (0.008)	0.005 (0.008)
α_1	-0.28*** (0.081)	-0.424*** (0.109)	-0.469*** (0.081)
α_2	0.102** (0.047)	0.100* (0.058)	
α_3	0.478*** (0.068)	0.507*** (0.088)	0.510*** (0.069)
α_4	0.227*** (0.062)	0.334*** (0.089)	0.284*** (0.067)
α_5	0.199** (0.060)	0.154** (0.075)	0.173*** (0.059)
α_6	0.153** (0.059)	0.136* (0.078)	0.093** (0.046)
α_7	-0.082** (0.041)	-0.132** (0.056)	-0.108** (0.054)
α_8	-0.145** (0.070)	-0.1534* (0.087)	
α_9	-0.213*** (0.054)	-0.253*** (0.079)	-0.127* (0.066)
α_{10}	0.008 (0.054)	0.023 (0.075)	
α_{11}	-0.214*** (0.061)	-0.165** (0.077)	-0.121* (0.072)
β_0		-0.058*** (0.021)	-0.058*** (0.019)
β_1		0.399** (0.171)	0.326*** (0.019)
β_2		-0.085 (0.106)	
β_3		-0.073 (0.151)	
β_4		-0.111 (0.142)	
β_5		0.126 (0.131)	
β_6		0.103 (0.135)	
β_7		0.148* (0.089)	0.138* (0.078)
β_8		-0.184 (0.160)	-0.220** (0.094)
β_9		-0.131 (0.144)	-0.269** (0.125)
B_{10}		0.018 (0.112)	
β_{11}		-0.342** (0.144)	-0.332*** (0.124)
$\alpha_6 + \beta_6$		0.239*** (0.012)	
$\alpha_{11} + \beta_{11}$		-0.507*** (0.0147)	-0.453*** (0.011)
τ		-0.04	-0.04
γ		10	10
	0.90	0.91	0.92
T	184	184	184
AIC	-2.35	-2.34	-2.37
ARCH	[0.0066]	[0.52]	[0.30]
LM	[0.001]	[0.108]	[0.402]
DW	2.10	2.09	2.06

Note: (**)(***) denotes significance at 10, 5 and 1% respectively; T- No. of observations, ARCH- Autoregressive conditional heteroscedasticity, AIC-Akaike info criterion ,DW- Durbin Watson stat. [] are probability values. The Delta method is used to calculate the standard errors of $(\alpha_6 + \beta_6)$ and $(\alpha_{11} + \beta_{11})$

Table 7a: Correlation between expenditure Items GDP and Deficit Regime

	Deficit	Defence	Education	Health	Social protection	Public order & Safety	Housing
Deficit	1.0000	-0.1398	-0.475	-0.2373	0.1149	-0.0564	-0.2423
Defence	-0.1398	1.0000	-0.5009	-0.5387	-0.9051	-0.9047	0.7138
Education	-0.475	-0.5009	1.0000	0.7637	-0.4592	0.6585	-0.3971
Health	-0.237	-0.5387	0.7637	1.0000	0.5580	0.6582	-0.2009
Social Protection	0.1149	-0.9051	-0.4592	0.5580	1.0000	0.8987	-0.5650
Public order &safety	-0.0564	-0.9047	0.6585	0.6582	0.8987	1.0000	-0.5861
Housing	-0.242	0.7138	-0.3971	-0.20092	-0.5650	-0.5861	1.0000

Table 7b: Correlation between expenditure Items GDP and Surplus Regime

	Surplus	Defence	Education	Health	Social protection	Public order & Safety	Housing
Surplus	1.0000	-0.4803	-0.2655	-0.0099	0.4964	0.4303	-0.1847
Defence	-0.4803	1.0000	-0.5009	-0.5387	-0.9051	-0.9047	0.7138
Education	-0.2655	-0.5009	1.0000	0.7634	-0.4592	0.6585	-0.3971
Health	-0.0099	-0.5387	0.7634	1.0000	0.5580	0.6582	-0.2009
Social Protection	0.4964	-0.9051	-0.4592	0.5580	1.0000	0.8987	-0.5650
Public order &safety	0.43030	-0.9047	0.658	0.6582	0.8987	1.0000	-58615
Housing	-0.1847	0.7138	-0.3971	-0.2009	-0.5650	-0.5861	1.0000

Appendix 1: Description of the variables and sources

Variables	Description
Revenue	National government revenue as a percentage of gross domestic product
Expenditure	National government expenditure as a percentage of gross domestic product
Education	National government expenditure on education as a percentage of gross domestic product
Health	National government expenditure on health as a percentage of gross domestic product
Socialprotection	National government expenditure on social protection as percentage of gross domestic product
Public order and safety	National government expenditure on public order and safety as percentage of gross product product
Housing	National government expenditure on housing as a percentage of gross domestic product
Deficit	Expenditure greater tha revenue as a percentage of gross domestic product

Source: South African Reserve Bank (<http://www.reservebank.co.za>)

Figure 1: Selected macroeconomic variables of South Africa

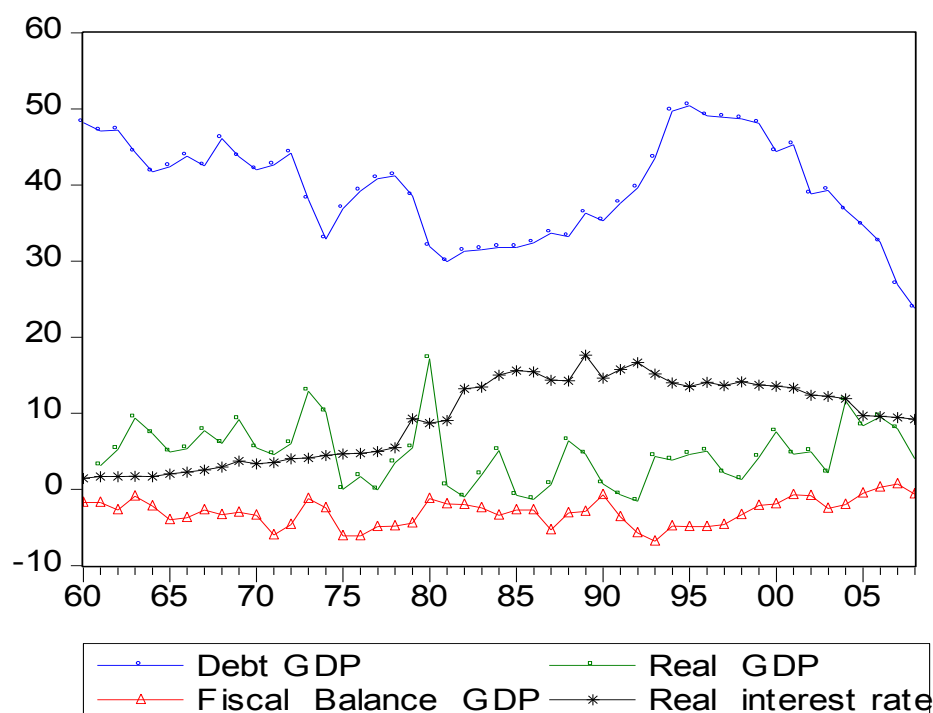


Figure 2: Expenditure on growth enhancing sectors during deficit regime

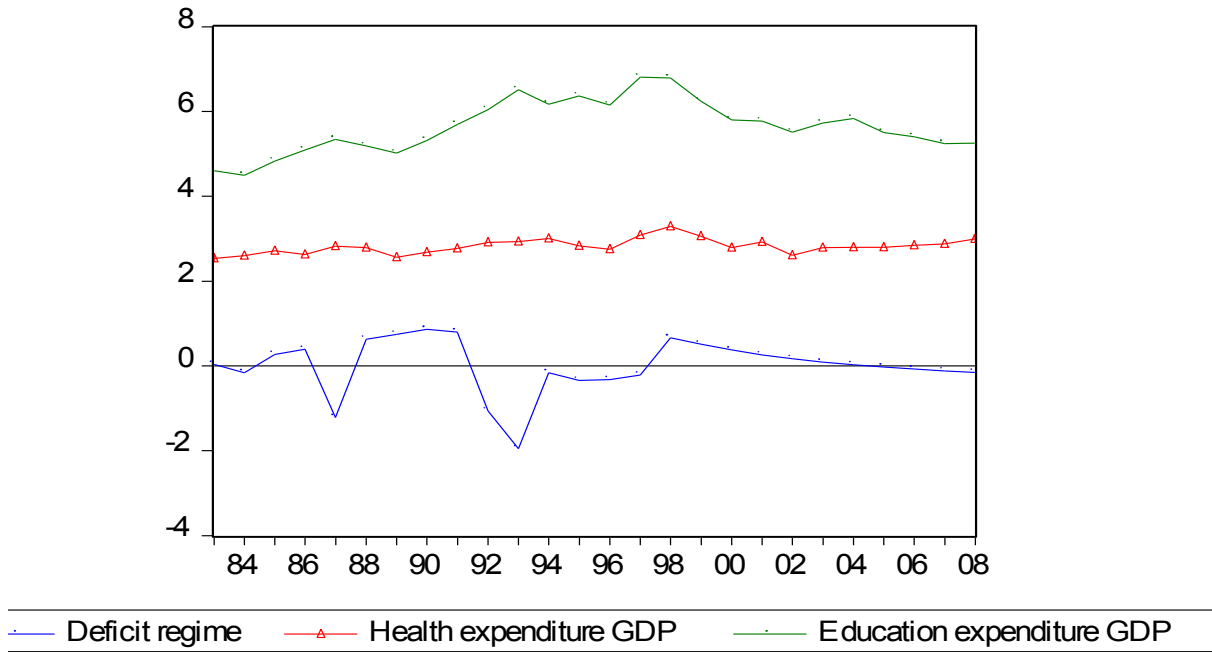


Figure 3: Deficit vs some non-productive sectors

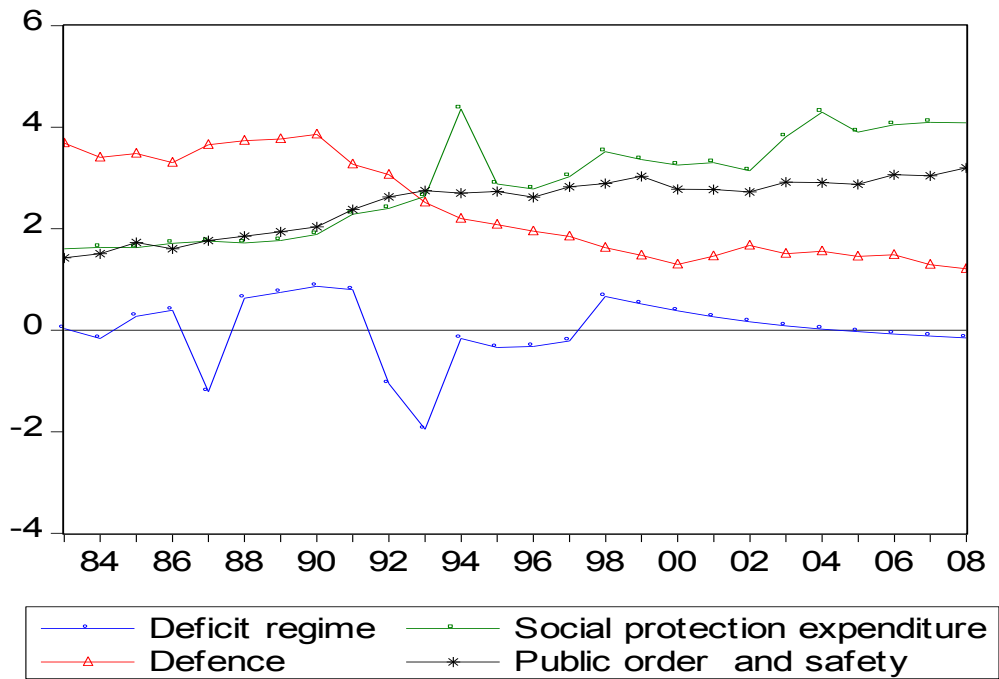


Figure 4: Surplus regime vs growth enhancing sectors

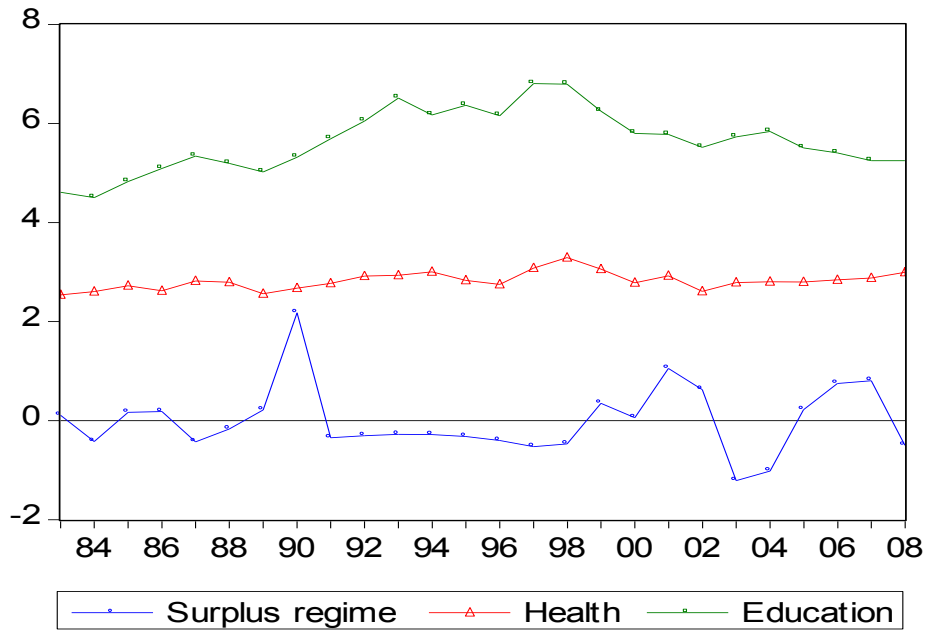


Figure 5: Surplus regime vs non productive sectors

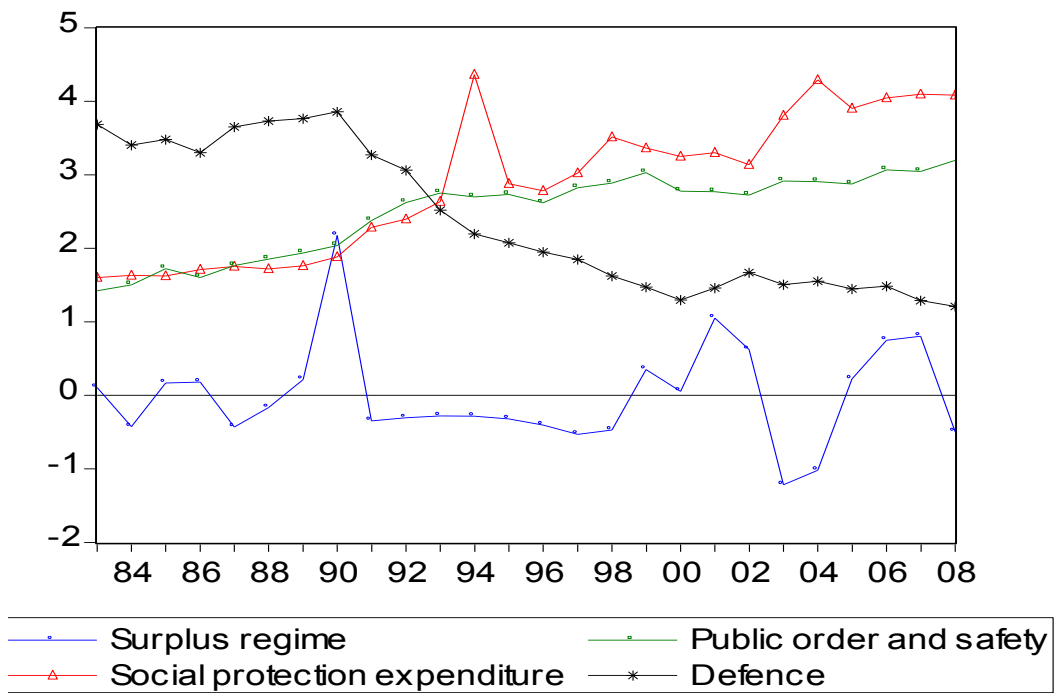


Figure 6: Cointegrating relationship between series

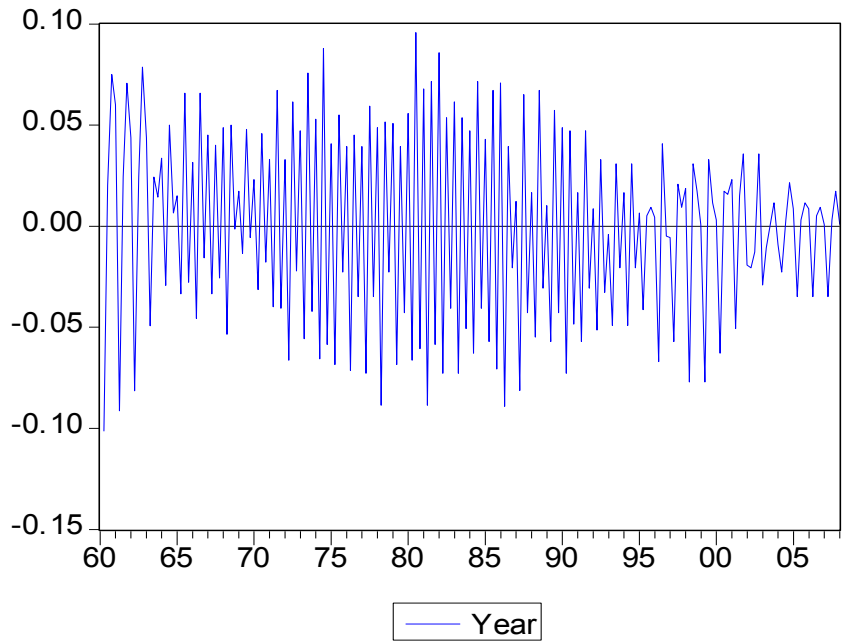


Figure 7: Time varying parameter, budget deficit regime

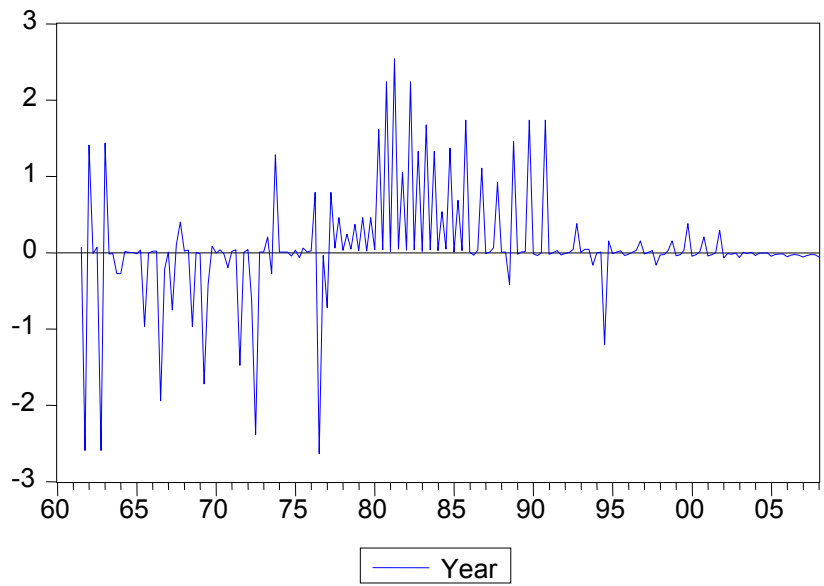


Figure 8: Time varying parameter, surplus regime

