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Regime changes and fiscal sustainability in Kenya with comparative non-linear Granger causalities across East-African countries

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Abstract:

This study seeks to investigate the nature of fiscal policy regime in Kenya, and the extent to which fiscal policy is sustainable in the long run by taking into account periodic regime changes. Markov switching models were used to determine fiscal policy regimes endogenously. Regime switching tests were used to test whether the No-Ponzi game condition and the debt stabilizing condition were met. The results established that the regime-switching model was suitable in explaining regime sustainable and sustainable cycles. An investigation of fiscal policy regimes established that both sustainable and unsustainable regimes were dominant and each lasted for an average of four years. There was evidence to suggest the existence of procyclical fiscal policy in Kenya. Regime switching tests for long-run sustainability suggested that the No-Ponzi game condition weakly holds in the Kenyan economy. Regime-based sensitivity analysis suggests that the persistence of unsustainability regime for more than four years could threaten long-run fiscal sustainability. Sensitivity tests are conducted by resorting to (i) Self-Exciting Threshold Autoregressive Models at the country-level, and (ii) non-linear Granger causalities across a Feed-Forward Artificial Neural Network composed of East-African countries (Burundi, Kenya, Rwanda, Tanzania and Uganda).

JEL Codes : E62; F30; H61

Keywords: Fiscal policy; Markov-switching; No-Ponzi game condition; SETAR; Non-linear Granger causality; Feed-Forward Artificial Neural Network

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1. Introduction

Fiscal policy sustainability has dominated the scholarly debate in both developed and developing countries. One popular approach to the assessment of sustainability is to use non-increasing debt to GDP ratio as a benchmark (Chalk & Hemming, 2000). However, economies undergo periods of unfavorable macroeconomic conditions which prompts fiscal spending to counter adverse macroeconomic shocks (Chalk and Hemming, 2000; Aldama & Creel, 2016). Therefore, the practical question is whether the fiscal policy may periodically violate unsustainability condition without disrupting long-run fiscal sustainability.

Developing countries, particularly in Africa, use debt to finance large and persistent fiscal deficits and infrastructural development. Despite the inherent growth prospects, overreliance on debt increases the susceptibility to prolonged periods of unsustainability. Also, empirical evidence shows that fiscal policy tends to be procyclical among developing countries, particularly in Sub Saharan Africa (SSA). This limits not only the ability of fiscal policy to stabilize the economy during bad times but also the ability for policy makers to pursue fiscal consolidation hence threatening fiscal sustainability (UNCTAD, 2015; UNEC, 2016).

The ongoing preparations towards the formation of the East African Monetary Union (EAMU) have culminated in a set of agreed convergence criteria to guarantee regional fiscal coordination (Mauro & Joly, 2015).¹ There exists a need to back up this set of convergence criteria with some similar regional fiscal empirical work. However, the scarcity of comparative studies informing this process can be attributed to numerous reasons including: *(i)* The observed heterogeneity of fiscal policy drivers among the five-member EAMU countries; *(ii)* Differences in coverage, timeliness

¹ Burundi, Kenya, Rwanda, Tanzania and Uganda are the five signatory nations to the formation of the East African Community (EAC), and the process involves among other protocols, the adoption of a Monetary union protocol.

and quality of fiscal data across the countries and; *(iii)* Differences in the strength of the Public Financial management institutions which impacts the conduct of fiscal policy across the five countries (Mauro & Joly, 2015). Table A3 in the Appendix captures the summary of descriptive statistics which elaborates the variance in the fiscal policy dynamics and public debt drivers among the five EAC member countries.

The motivation of this study is to characterize the nature of fiscal policy and understand shifts between sustainable and unsustainable regimes in Kenya. Existing literature applies linear approaches to evaluating fiscal policy sustainability but fails to consider the time-varying nature of fiscal policy. This study assumes that fiscal policy switches between sustainable and unsustainable regimes and therefore adopt a Markov-switching model to characterize the periodic shifts between sustainable and unsustainable fiscal policy regimes and trace out the extent to which cyclical and persistence of periodic unsustainable regimes pose a threat to long-run fiscal sustainability.

Kenya presents a unique case study for evaluating fiscal sustainability among developing African countries, particularly in SSA, for two reasons: First, the economy does not rely on resources such as oil or mineral exports to finance its fiscal policy. According to UNEC (2016) and Konuki & Villafuerte (2016), non-resource based low-income economies provide an opportunity to study the effect of reallocation of resources from private to government sector without the bias from external factors and large fiscal allocations generated from oil and mineral exports. Secondly, Kenya is one of the few SSA countries that did not benefit debt relief initiative under the Heavily Indebted Poor Countries (HIPC) program. It, therefore, provides a unique opportunity to study the evolution of

fiscal policy and understand the nature of fiscal sustainability in the long run (Bova et al., 2014; UNEC, 2016).

Annual time series data from 1964 to 2014 was used for the analysis. The methodology hinges on a two-stage analysis. First, Markov-Switching Model was used to identify fiscal and policy regimes. Having identified the regimes, regime switching model-based tests are applied to test whether Kenya fiscal policy is sustainable in the long run. The results show that regime changes are significant in explain fiscal policy sustainability in Kenya. It was further established that both sustainable and unsustainable regimes are equally persistent. The regime cycle shifts after approximately four years. Regime switching model-based tests provide weak evidence of unsustainability. However strict conditions show that if the expected duration of unsustainable last for more than four years, the long run sustainability is violated.

The remainder of the study is organized as follows: Section 2 reviews the theoretical and empirical literature and introduces the methodology and variables used in the study. Section 3 discusses the empirical results. Section 4 provides additional robustness checks by establishing non-linear Granger causalities across EAC countries (specifically, the panel dimension is addressed by means of a feed-forward artificial neural network). Lastly, Section 5 provides conclusions with policy recommendations.

2. Methodology and Data

This section introduces the theoretical and empirical literature review. Theoretical literature introduces the transversality condition and No-Ponzi game condition. To optimize space, Table A1 (in the Appendix) provides a summary of the relevant empirical studies on the sustainability of fiscal policy.

2.1 Theoretical Literature

The theoretical literature on fiscal policy sustainability is primarily pegged on transversality condition. The government budget is either financed by taxes or by issuing debt at an interest rate r (Bohn, 1995; Chalk & Hemming, 2000). It follows that debt consumed in period t is issued in period $t-1$. Then at period t , the static budget constraints holds that:

$$(1 + r)D_{t-1} + G_t = T_t + D_t \quad \text{Eqn (1)}$$

$T_t - G_t$ represents the primary surplus (PS). Using an iterative method, the intertemporal budget constraint for T periods ahead is given as

$$D_{t-1} = \sum_{t=0}^T \frac{PS_t}{(1+r)^t} + \sum_{t=1}^T E_t \left[\frac{D_t}{(1+r)^t} \right] \quad \text{Eqn (2)}$$

Where $(1 + r)^t$ is the discounting factor. Equation (2) represents the present value budget constraint (PVBC). This identity equation becomes a constraint after introducing the transversality condition. It holds that solvency is attained if the present value of primary surpluses exceeds or is equal to initial debt stock D_t . Note that it is not feasible for the government to hold debt by using newly acquired debt to service old debt (that is playing Ponzi games) because it will hold debt at some infinite point which ought to have been terminated. This means that rolling debt continuously will discourage private agents from lending to the government. Therefore for the no-Ponzi game (NPG) condition to hold, transversality condition must apply that is the limit of expected future debts must be equal to zero $\lim_{T \rightarrow \infty} \sum_{t=1}^T E_t[D_t] = 0$ (Bohn, 1995; Chalk & Hemming, 2000).

Therefore, the PVBC is constrained if NPG condition holds;

$$D_{t-1} \leq \sum_{t=0}^T \frac{PS_t}{(1+r)^t} \quad \text{Eqn (3)}$$

The policy implication of the PVBC in Equation (3) means that regardless of the level of primary deficit or the level of debt, PVBC can still hold if the future primary surpluses are sufficient to cover debt stock. The PVBC condition forms the basis of the theoretical framework derived in the next section

The theoretical framework articulating the rationale used in estimation was presented². Next, under the empirical model specification, regime switching model-based tests were used to evaluate the sustainability of fiscal policy in the long run. Lastly, the data types, measurements, and variables description are introduced.

2.2 Theoretical framework

Using the static equation (1), the identity can be presented as a ratio of output such that:

$$\frac{D_t}{Y_t} = (1 + r) \frac{D_{t-1}}{Y_t} - \frac{PS_t}{Y_t} \quad \text{Eqn (4)}$$

Equation (4) shows that change in debt in any given period should be equal to previous debt plus interest payable plus primary deficit (or less primary surplus). Previous debt as a ratio of previous output as follows:

$$\frac{D_t}{Y_t} = (1 + r) \frac{D_{t-1}}{Y_t} \frac{Y_{t-1}}{Y_{t-1}} - \frac{PS_t}{Y_t} = (1 + r) \frac{Y_{t-1}}{Y_t} \frac{D_{t-1}}{Y_{t-1}} - \frac{PS_t}{Y_t} \quad \text{Eqn (5)}$$

Note that $\frac{Y_{t-1}}{Y_t} = \frac{1}{1+g}$ where g is equal to real growth rate. Let d_t represent debt to output ratio and p_t represent primary surplus-to output ratio. Then it follows that:

² Notice itw as possible to derive an alternative theoretical framework for studying fiscal policy. For instance, Jawadi et al. (2016) implement a Panel Vector Auto-Regressive (PVAR) model for five key emerging market economies — Brazil, Russia, India, China and South Africa (BRICS).

$$d_t = \left[\frac{1+r}{1+g} \right] d_{t-1} - p_t \quad \text{Eqn (6)}$$

Note that $\frac{1+r}{1+g}$ can be normalized to $\frac{1+r}{1+g} \approx 1 + r - g$. Equation (6) can be expressed as:

$$d_t = (1 + r - g)d_{t-1} - p_t = d_{t-1} + (r - g)d_{t-1} - p_t \quad \text{Eqn (7)}$$

Expressing equation (7) regarding the change in debt yields

$$\Delta d_t = (r - g)d_{t-1} - p_t \quad \text{Eqn (8)}$$

From equation (8) if $r > g$, then the ratio of debt to GDP increases. Therefore, for debt to remain bounded, debt stabilization policy must respond by increasing expected primary surplus. This can be shown using a basic fiscal reaction function, where the fiscal policy reaction must react positively to rise in debt.

Therefore, assuming transversality holds, the fiscal policy reaction function can be presented as $P_t = \alpha d_{t-1} + \Delta d_t$ where $\alpha = (r - g)$ (Chalk & Hemming, 2000; Burnside 2004). No-Ponzi games (NPG) condition holds iff $\alpha > 0$, i.e if a change in debt is bounded. Given the cyclical nature of output and real interest rates, transversality condition maybe violated (Bohn, 1995; Chalk & Hemming, 2000). The need to test whether the NPG condition holds in developing countries is based on the observation that they often run large primary deficits and increasing debts.

NPG and stabilizing conditions as opposed to the traditional non-increasing debt to GDP ratio may be more practical in analyzing long-run sustainability based on macroeconomic conditions and prevailing fiscal characteristics of each country (Chalk & Hemming, 2000; Davig 2005; UNEC, 2016). Therefore, based on Leeper (1991) as quoted in Aldama and Creel (2016), this study

introduces a stabilizing condition which is based on introducing growth-adjusted real interest rate. This condition is more restrictive because it tests for $\alpha > r - g$ which accounts for the fiscal limits and cyclicity of the fiscal rule in the country.

For estimation purposes, it is logical to assume that changes in debt Δd_t is dependent on the state of the economy such that $\Delta d_t = \rho Z_t + \varepsilon_t$ where Z vector of macroeconomic and ε_t is a random component such that $\varepsilon_t \sim i.i.d(0, \sigma_\varepsilon^2)$. The basic fiscal policy reaction is given as:

$$p_t = \alpha d_{t-1} + \rho Z_t + \varepsilon_t \quad \text{Eqn (9)}$$

In the short run, fiscal reaction function stochastically shifts between the sustainable regime and unsustainable regimes. Markov switching Model is introduced to capture the state or regimes adopted by the policy agents.

Notably, Markov-Switching model was chosen among the family of nonlinear models namely Threshold Autoregressive (TAR), Self-Exciting Threshold Autoregressive (SETAR), and Smooth Transitional Autoregressive (STAR) models because transition variables need be identified in the later models – a process that may prove difficult. Secondly, TAR and STAR are restrictive as they assume that regimes are dependent on the lagged values of the dependent variable as opposed to being endogenous (Tsay, 2005; Hamilton, 2010). According to Hamilton (2010), Markov-switching method assumes that the transition from one regime to another is endogenous which means that policy regimes are determined from within the model. Based on the condition outlined in equations (2) and (3), a regime is considered unsustainable if fiscal balance does not respond or responds by $\alpha \leq 0$ with a rise in primary debt. Therefore, Let S represent the regimes such that:

$$S_t = \begin{cases} 1, & \text{sustainable fiscal policy regime is observed at period } t \\ 0, & \text{unsustainable fiscal policy regime is observed at period } t \end{cases}$$

Markov-switching model estimates both the transition probabilities and time-varying transition probability. Transition probability measures the probability that policy regime switches from state

i to $j \forall i, j = 0,1$ and are assumed to be constant and defined by the matrix $\begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix}$

Time-varying probabilities were used to identify sustainable and unsustainable policy regimes as the probability that state i was observed at period t (Hamilton, 2010; Davig, 2005; Khalid & Marwan, 2012; Aldama & Creel, 2016). Based on equation (9) a two-state Markov-switching model for fiscal policy reaction function is presented as:

$$Fb_t = \alpha_0(S_t) + \alpha_1(S_t)Debt_{t-1} + \alpha_2(S_t)\theta_t^* + \alpha_3(S_t)RINT_t + (S_t)\mu_t \quad \text{Eqn (10)}$$

Where Fb_t refers to fiscal balance as a ratio of GDP, $Debt$ refers to total debt as a ratio of GDP and $RINT$ refers to the real interest rate. θ^* represents the other control variables including the output gap ($OGAP$) and the government expenditure gap ($GAPGE$). μ_t represents the disturbance term for the fiscal reaction functions respectively where $\mu_t \sim I.I.D(0, \sigma_{fd}^2)$ (Aldama & Creel 2016).

Equation (10) stipulates that reaction of the current level of fiscal balance (Fb_t) is based on the previous period level of debt ($Debt_{t-1}$). The output gap and government expenditure gap capture the fiscal policy reaction that can be attributed to cyclical changes in the economy. Given the fiscal reaction function in equation (10), fiscal policy regime is considered sustainable if the coefficient of previous debt to output ratio is significant and positive. This means that government reacts by

increasing the primary surplus given rise in previous debt and therefore the NPG condition holds (Hamilton, 2010; Davig, 2005; Khalid & Marwan, 2012, Aldama & Creel, 2016). Fiscal policy regime is considered unsustainable if the coefficient of debt is negative or zero which means that the NPG condition is violated.

Having established sustainable and unsustainable policy regimes. The next objective is to determine whether a sustainable fiscal policy holds in the long run. According to Aldama & Creel (2016), fiscal policy is sustainable in the long run if unsustainable regimes are balanced by sustainable regimes such that the net effect is even though there exist periods of unsustainability. NPG holds because longer duration and accumulation of primary surplus offset the deficit acquired during the unsustainable period. To establish long-run estimates, the regime results are used based on ergodic probabilities and expected the duration of a given state. Ergodic probability refers to the likelihood of observing a sustainable state (S) and unsustainable state (NS) $\pi_{ii} : i \in \{S, NS\}$. Estimation of ergodic probability, and expected duration are given by equations (1) and (2) (see the Appendix).

2.3 Estimation Procedure

The following procedure was used to address the objectives. Markov switching model was estimated as specified by equation (10). To determine whether long-run sustainability holds, long run coefficient and standard deviation were computed as specified by equations (3) and (4) (see the Appendix). For robustness, Self-Exciting Threshold Autoregressive model (SETAR) was used to complement the Markov-switching model. SETAR model has an advantage over the traditional autoregressive model because it estimates the threshold value based on the lagged dependent variable which is used as transition variables (Tsay, 2005; Hubrich & Terasvirta, 2013).

To test for long-run sustainability, the NPG and debt stabilizing conditions were evaluated based on equations (5) and (6) (see the Appendix). Point estimates from the Markov switching model were used to evaluate the different scenarios. Scenarios were created by imposing different expected duration for unsustainability regimes (Bohn, 1995; Hamilton, 2010; Adam & Creel 2016).

The model was estimated using annual time series data from 1963 to 2014. Table 1 summarizes the description and measurement of variables used for investigation. Government expenditure gap and output (GDP) gap were estimated using Hodrick-Prescot filter. The use of output and expenditure was informed by the need to capture the effect of deviation of these variables from the long run path on primary surplus.

Table 1: Description and Measurement of Variables

Variable	Unit	Description	Source
Fiscal balance/GDP	Ratio	Fiscal balance is calculated as the difference between Government revenue and Government expenditure as a ratio of GDP	WDI & Economic Surveys
Total Debt/GDP	Ratio	The ratio of total debt which included domestic and external debt as a ratio of GDP	WDI & Economic Surveys
Real Interest Rate	Ratio	Estimated as the inflation-adjusted lending rate	WDI
Government expenditure/GDP	Ratio	The ratio of government total consumption as a ratio of GDP	WDI
Govexp gap	Ratio	Estimated as the deviation of actual Government expenditure from long-run Path. The long-run path is estimated using Hodrick-Prescott filter	Estimated

GDP growth	Ratio	Annual GDP growth	WDI
GDP Gap	Ratio	Estimated as the deviation of actual GDP from long-run Path. The long-run path is estimated using Hodrick-Prescott filter	Estimated

WDI represents World Bank Database
Kenya's Economic Survey (various issues)

Data used for analysis was sourced from the World Bank and Kenya's Economic surveys. Data on domestic debt and fiscal deficit were sourced from Economic surveys. Data on the inflation rate and interest rate were sourced from the World Bank. The next section presented the study findings.

3. Empirical Results

3.1. Stationarity tests

Stationarity conditions for all variables under investigation were tested using the Augmented Dickey-Fuller (ADF) test and Kwiatkowski-Philip-Schmidt and Shin (KPSS) test. Table 2 shows the stationarity test results with critical values at 5 percent level of significance.

Table 2: Stationarity Tests Results

Variable	Type of the Test and Test Statistics				Conclusion	
		ADF Test		KPSS Test		
		Test statistic	Critical value	Test statistic		Critical value
Fiscal Balance/GDP	Level	-4.899	-2.924	0.1829	0.4630	StationaryI(0)
Total debt/GDP	Level	-2.089	2.929	0.54***	0.7300	Stationary I(0)
GDP Gap	Level	-6.11	-2.929	0.4350	0.4630	StationaryI(0)
Real Interest rate	Level	-3.969	-2.92	0.405	0.4630	StationaryI(0)
Government Exp. Gap	Level	-5.18	-2.92	0.033	0.4630	Stationary I(0)

*Note: Critical values at 5 percent significant level...***Significant at 1 % based on KPSS*

Stationarity test presented in Table 2 shows that except the total debt to GDP ratio, all variables are stationary as shown by both ADF and KPSS tests. Based on KPSS results, total debt was stationary at 1 percent level. Given that ADF is restrictive, the total debt was treated as stationary.

The next section presents the empirical findings. The first objective seeks to identify and characterize the nature of fiscal regimes in Kenya. To address the objective, equations (9) was estimated, and both transition probabilities and time-varying probabilities were interpreted.

3.2 Estimation of Fiscal Policy Reaction Function Regimes

Table 3: Markov Switching Model: Fiscal Policy Reaction Function

<i>Dependent Variable: Fiscal Balance/GDP</i>			
Regimes	Unsustainable	Sustainable	Long Term
Total Debt: Lag 1	-0.104 (-1.48)	0.145*** (9.71)	0.02 (0.46)
Output GAP	-0.131 (-0.46)	0.01 (0.177)	0.069 (0.34)
Real Interest Rates	0.483*** (3.00)	-0.01 (-0.32)	0.23** (2.04)
Temporary Government Expenditure	1.29 (1.39)	-1.09*** (-4.65)	0.083 (0.12)
Constant	-3.04 (-0.96)	-11.04*** (-17.97)	-7.12*** (-3.15)
Log(Sigma)	1.23*** (6.28)	-0.272*** (-2.99)	0.932*** (2.26)
Transition Probability ($P(S_t = i/S_{t-1} = j)$)			
i=1	j=1 0.77	j=2 0.23	
i=2	0.22	0.78	
Ergodic Probabilities	0.49	0.51	
Expected duration (Years)	4.35	4.58	
Diagnostics			
Durbin-Watson		1.77	
Normality Test (Jarque-Bera)		40.08 (0.00)***	
Key: *** Significant at 1%, **Significant at 5%, *Significant at 10%			

Table 3 shows that the null hypothesis of normality as per the Jarque-Bera's test was rejected at 10 percent. Scrutiny of the residual graph (see Figure 1A in the Appendix) shows that for the most part, residuals were within the acceptable band.

The results in Table 3 shows that a sustainable regime was identified by the coefficient of lagged total debt of 0.145 which was significant at 1 percent. In contrast, the unsustainable regime was identified by the non-significant coefficient of the previous level of initial debt of 0.104. Expected duration shows that the probability of observing unsustainable and sustainable regimes is almost equal. Each of the regimes is expected to last for approximately 4.5 years.

There are several interesting findings. First, the positive and significant coefficients of real interest rate during the unsustainable regime and in the long run demonstrate that fiscal rule reacts prudently to changes in real interest rate, especially during the unsustainable regime. Second, the constant coefficient for an unsustainable period of -3.04 is not significant which implies that debt-to-output ratio does not exhibit a mean-reverting characteristic and is therefore explosive. Third, primary balance is nonresponsive to the output gap as indicated by non-significant output gap coefficients in both regimes and consequently in the long run³. Lastly, a temporary rise in government expenditure tends to worsen fiscal balance during the sustainable period.

Figure 1 below shows the probability of observing a sustainable fiscal regime.

³ Notably, SETAR estimation and other variations of the regime switching estimation such, as assumption of common variance across regimes, confirm that output gap has significant and positive coefficients in both regimes suggesting procyclicality of fiscal rule in Kenya.

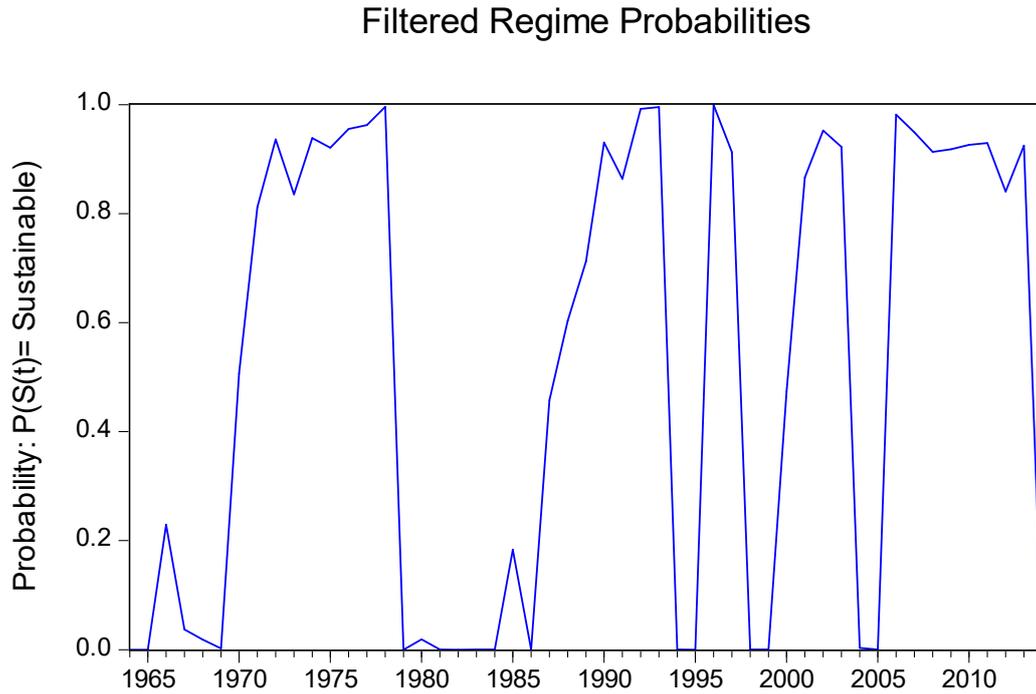


Figure 1: Trending Sustainable fiscal regime from 1963 to 2015

Figure 1 shows that marked decades of sustainable regimes were witnessed from the 1970's to 1980 and from 2004 to 2015. In contrast, public finances were unsustainable for most of the 1980's owing to the debt crisis in Africa. The period of sustainability witnessed from 1987 to 1992 and from 2004 to 2013 may support the supposition that comprehensive reforms (structural adjustment program in 1986 and Economic recovery plan in 2003) improved macroeconomic management in Kenya. Therefore, the above results suggest that the Markov-switching model explains fiscal policy regimes and is consistent with the comprehensive and historical analysis of Kenya's fiscal policy.

We need to evaluate whether the persistence of periodic unsustainable regime poses a threat to long-run fiscal sustainability. To do so, a scenario analysis was conducted by estimating long-run estimates under different transition probabilities (or different expected duration). NPG condition

was tested given different scenarios. Transition probabilities of observing sustainable regime were imposed from the most likely to the least likely. Two scenarios were imposed. First, scenario one focuses on categorically decreasing the expected duration of a sustainable regime as shown in column five in Table 4. Secondly, scenario two focuses on categorically decreasing the expected duration of the unsustainable regime as shown in column five in Table 5. Having computed the long-term point estimates (see Table 3), NPG condition and stability condition arguments were based on equations (5) and (6) in the Appendix respectively.

Table 4: Scenario One: Test based on decreasing duration of Sustainable Regime

Imposed	Estimate	Ergodic Prob		Duration		Coeff.	NPG	Stability
P_S	P_{NS}	π_S	π_{NS}	DU_S	DU_{US}	α	Condition	Condition
0.90	0.80	0.67	0.33	10.00	4.96	0.06	TRUE	FALSE
0.75	0.76	0.49	0.51	4.25	4.00	0.02	TRUE	FALSE
0.50	0.7	0.36	0.64	2.0	3.74	-0.01	FALSE	FALSE
0.30	0.88	0.15	0.85	1.40	8.60	-0.07	FALSE	FALSE
0.10	0.86	0.13	0.87	1.11	7.01	-0.07	FALSE	FALSE

Table 5: Scenario Two: Test based on decreasing duration of Unsustainable Regime

Imposed	Estimate	Ergodic Prob		Duration		Coeff.	NPG	Stability
P_{NS}	P_S	π_{NS}	π_S	DU_{NS}	DU_S	α	Condition	Condition
0.90	0.78	0.31	0.69	4.74	10.00	-0.03	FALSE	FALSE
0.75	0.76	0.51	0.49	4.25	4.00	0.02	TRUE	FALSE
0.50	0.78	0.64	0.36	3.74	2.0	0.06	TRUE	FALSE
0.30	0.70	0.70	0.30	3.25	1.42	0.07	TRUE	FALSE
0.10	0.86	0.87	0.13	8.46	1.11	0.11	TRUE	TRUE

The initial investigation sought to establish whether long-run sustainability manifests given periods of unsustainability. Table 4 and 5 show that in the event average periodic unsustainability regime lasts for more than four years, the NPG condition is violated. Notably, the estimated expected duration remains fairly symmetrical given the two scenarios.

Stabilizing condition is more restrictive as it factors in changes in market interest rates and growth rate in the determination of sustainability. Stability condition was violated for all scenarios in Table 4 but is maintained if the probability of unsustainable regime reduces to 10 percent.

These results imply that debt-to-output ratio becomes explosive if unsustainable regime persists for more than four years. More importantly, after accounting for cyclicity by introducing growth-adjusted real interest rates (specified in equation (5) in the Appendix), the debt-to-output ratio in Kenya becomes unsustainable. These results support the assertion that if Kenya's fiscal policy rule continues as estimated by the Markov-switching model, long-run sustainability is maintained provided the short run unsustainable regime does not last for more than four years. However, as shown by the stabilizing condition, running a procyclical fiscal policy rule tends to worsen the adverse effects of unsustainable fiscal policy regime even if the duration of pursuing sustainable regime is increased.

In conclusion, while the government remains dedicated to public investment plan to drive the economy towards inclusive and sustainable growth, there is a need for such expansionary periods to be followed by a commitment to fiscal consolidation over the medium term. The empirical literature further shows that economies are experiencing a fiscal unsustainability threat, ought to address this issue first at the expense of economic growth in the short run (LLedo & Ribiero-Poplowski, 2013; UNCTAD, 2015). Given the existence of procyclical fiscal rule and limited fiscal space in developing countries, the persistence of unsustainable regimes could cause debt overhang, crowding out effect and ultimately threaten growths (Cotarelli, C & Mohgadam, R. 2011; UNEC, 2016). Therefore, the following policy implications hold:

First, the study provides evidence that the regime-switching model effectively explains fiscal policy response, and the maximum duration for pursuing unsustainable policies without threatening long-run sustainability is four years. The historical analysis confirms the persistence of fiscal deficits and increasing debt to GDP ratio trends (see Figures 2A and 3A in the Appendix). Therefore, unsustainable regimes must be countered by consolidation policies geared towards improvement in PB within a four-year period to ensure a mean-reverting debt path.

Secondly, the results confirm evidence of the procyclical nature of fiscal policy in both sustainable and unsustainable regimes. The rise in temporary spending tends to worsen fiscal balance while the output gap is nonresponsive to fiscal balance and this characteristic tends to be more pronounced during the unsustainable regime. Also, analysis of stabilizing condition results proves that pursuance of procyclical fiscal rule tends to worsen fiscal sustainability. In this regard, there is need to adopt prudent fiscal policy management with emphasis on countercyclical fiscal policy is vital in enhancing fiscal sustainability in Kenya. Consolidating during the good years will help create a fiscal buffer which will help cushion the country during the inevitable bad years.

Developing countries have high growth potential; however, empirical evidence suggests that interest rates are likely to increase faster than the growth rate in the foreseeable future (Reinhart & Rogoff, 2010; Cotarelli & Mohgadam 2011; UNCTAD, 2015; UNEC, 2016). This implies an increased vulnerability of stability condition in the long run. Therefore, in the future, a widening gap between real interest and the growth rate increases the risk of unsustainability and would require a stronger commitment to an improvement in Primary balance to ensure that the transversality condition holds.

3.3 Sensitivity analysis based on the class of SETAR models

To gauge the robustness of the results, the Self –Exciting Autoregressive Threshold (SETAR) model (Cryer and Chan, 2008) was used to capture the nonlinear relationship between the variables:

$$Y_t = \phi_{1,0} + \phi_{1,1}Y_{t-1} + \dots + \phi_{1,p_1}Y_{t-p_1} + \sigma_1 e_t \Leftrightarrow Y_{t-d} \leq r \quad \text{Eqn. (11)}$$

$$Y_t = \phi_{2,0} + \phi_{2,1}Y_{t-1} + \dots + \phi_{2,p_2}Y_{t-p_2} + \sigma_2 e_t \Leftrightarrow Y_{t-d} > r \quad \text{Eqn. (12)}$$

where the Φ are the autoregressive parameters, the σ 's are noise standard deviations, r is the threshold parameter, and $\{e_{ij}\}$ is a sequence of i.i.d. random variables with zero mean and unitary variance.

In Table A2 of the Appendix, the SETAR model shows that at 5 percent significance level, the threshold value of the fiscal budget is -7.2. Seven observations lie below the threshold value, and 41 observations lie above the threshold. The range of the coefficient of the lagged value of debt is relatively equal to the results obtained by the Markov-switching model. Notably, the most parsimonious SETAR model had four lags proving that fiscal policy reaction function responds with a lag.

4. Comparative Analysis of Nonlinear Granger Causalities across East-African Countries

This section develops a comparative analysis among East-African countries. More precisely, we seek to document the existence of fiscal responsibility, i.e., the response of primary balance towards external debt, in this region. To that end, we investigate the inter-relations between and external debt and primary balance based on nonlinear Granger causality tests. The panel dimension

is addressed by creating a feed-forward artificial neural network across Burundi, Kenya, Rwanda, Tanzania and Uganda⁴.

4.1. Statistical Testing Procedure for Establishing Nonlinear Granger Causalities

Hiemstra and Jones (1994) have introduced the concept of nonlinear Granger causality in economics and finance. Recent empirical applications include Caporin et al. (2018) for measuring sovereign contagion in Europe, Lundgren et al. (2018) for establishing a connectedness network among green investments, or Wen et al. (2018) for documenting interactions between oil and US dollar exchange rates.

To test for nonlinear Granger causality between two series denoted $\{X_t\}$ and $\{Y_t\}$, the following specification is applied to the two estimated residual series $\{U_{x_t}\}$ and $\{U_{y_t}\}$ originating from a VAR model :

$$\sqrt{(n)} \left(\frac{C1(m + Lx, Ly, e, n)}{C2(Lx, Ly, e, n)} - \frac{C3(m + Lx, e, n)}{C4(Lx, e, n)} \right) \sim \mathcal{N}(0, \sigma^2(m, Lx, Ly, e))$$

Eqn. (13)

for given values of m , Lx , and $Ly \geq 1$ and $e > 0$, under the assumptions that $\{X_t\}$ and $\{Y_t\}$ are strictly stationary, with n is the number of observations. The null hypothesis is that $\{Y_t\}$ does not nonlinearly strictly Granger cause $\{X_t\}$.

$C1(\dots) / C2(\dots)$ denotes the ratio of joint probabilities corresponding to the conditional probability that two arbitrary m -length lead vectors of $\{X_t\}$ are within a distance e of each other, given that the

⁴ Table A3 captures the summary of descriptive statistics which elaborates the variance in the fiscal policy dynamics and public debt drivers among the five EAC member countries. One major problem when using this type of data lies in the presence of extreme observations, owing to political unrest in the region (e.g., genocide in Rwanda). Indeed, issues associated with data gaps and the non-disclosure of debt experienced in many developing countries can limit the effectiveness of comparative studies.

corresponding L_x -length lag vectors of $\{X_t\}$ and L_y -length lag vectors of $\{Y_t\}$ are within e of each other.

$C3(\dots) / C4(\dots)$ denotes the ratio of joint probabilities corresponding to the conditional probability that two arbitrary m -length lead vectors of $\{X_t\}$ are within a distance e of each other, given that their corresponding L_x -length lag vectors are within a distance e of each other.

Critical values for the test, as well as details on the variance estimator, are given in the Appendix of the original paper by Hiemstra and Jones (1994).

Formally, the panel dimension constitutive of the EAC countries in our sample is addressed by applying a Feed-Forward Artificial Neural Network (ANN) into the process of modeling the time series. Feed-Forward ANN is especially helpful in modelling non-linear processes (Hornik, 1993; Hornik et al., 1989; Maciel and Ballini, 2008). Resorting to such techniques is also justified when the system of relations is complex to describe (Darbellay and Slama, 2000).

Precisely, the perceptron network was used (White, 1988). In what follows, we build on the notations by Falat and Marcek (2014). Let F be a function defined as:

$$F: x_t \in \mathbb{R}^k \rightarrow y_t \in \mathbb{R}^1 \quad \text{Eqn. (14)}$$

This representation assigns one value y_t to any k -dimensional input given a period t . Let G be a restriction of F defined as:

$$G(x_t, w_t): x_t \in \mathbb{R}_{\text{train}}^k \rightarrow y_t \in \mathbb{R}_{\text{train}}^1 \quad \text{Eqn. (15)}$$

where R_{train} is a complement of R_{val} to R . The ANN is a mathematical model defined by finding the values w_t so that the function of an ARMA(p, q) process would be minimal:

$$E(w_t) = \sum_{x_t y_t \in R_{\text{train}}^k} (G(x_t, w_t) - y_t)$$

Eqn. (16)

Whenever the distance E is reported as being minimal by the Feed-Forward ANN algorithm, then $G(x, w_t)$ is considered to be a good candidate to approximate the initial function F .

In our empirical application to the network of nonlinear Granger causalities running among EAC countries: the input layer is composed of the input vector; the output layer is represented originally by one neuron that contains the network output. As is common practice, we represent additional hidden layers between inputs and outputs.

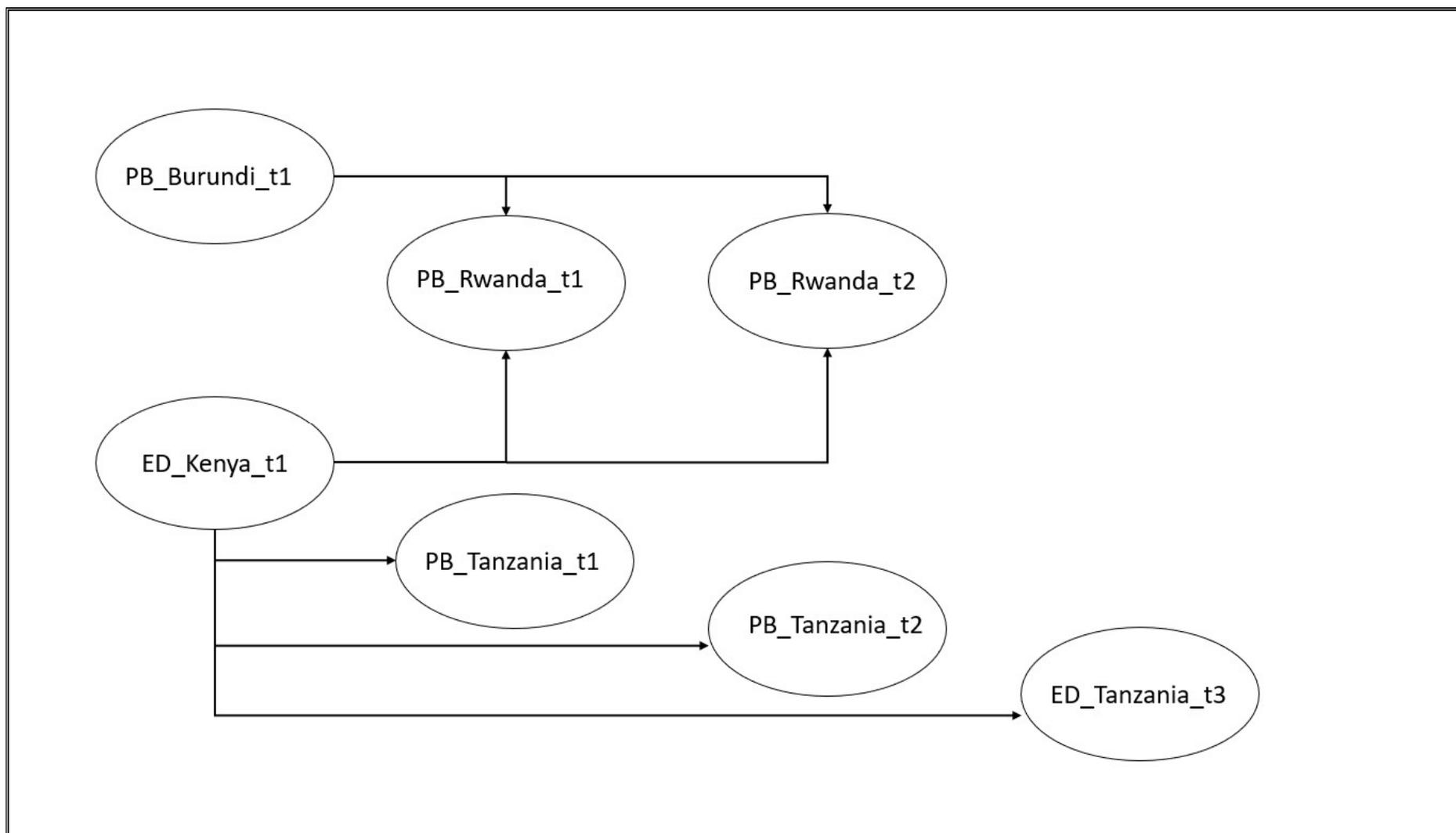
Regarding the number of neurons in the i -th hidden layers : (i) The length of the integer vector that contains the size of hidden layers of the univariate model is equal to two. (ii) The length of the integer vector that contains the size of hidden layers of the bivariate model is fixed to four. The number of iterations is fixed to 500 for each node of the Feed-Forward ANN under consideration. According to the theorem by Cybenko (1989), this network specification with more than one hidden layer can approximate any continuous function. Layers are interconnected via synapses (also called weights), which represent parameters of the neural network model.

Table 6: Nonlinear Granger Causalities in EAC countries

	Node	Lag 1	Lag 2	Lag 3
EXTERNAL_DEBT_BURUNDI	PRIMARY_BALANCE_BURUNDI	-	-	-
EXTERNAL_DEBT_BURUNDI	EXTERNAL_DEBT_KENYA	-	-	-
EXTERNAL_DEBT_BURUNDI	PRIMARY_BALANCE_KENYA	-	-	-
EXTERNAL_DEBT_BURUNDI	EXTERNAL_DEBT_RWANDA	-	-	-
EXTERNAL_DEBT_BURUNDI	PRIMARY_BALANCE_RWANDA	-	-	-
EXTERNAL_DEBT_BURUNDI	EXTERNAL_DEBT_UGANDA	-	-	-
EXTERNAL_DEBT_BURUNDI	PRIMARY_BALANCE_UGANDA	-	-	-
EXTERNAL_DEBT_BURUNDI	EXTERNAL_DEBT_TANZANIA	-	-	-
EXTERNAL_DEBT_BURUNDI	PRIMARY_BALANCE_TANZANIA	-	-	-
PRIMARY_BALANCE_BURUNDI	EXTERNAL_DEBT_KENYA	-	-	-
PRIMARY_BALANCE_BURUNDI	PRIMARY_BALANCE_KENYA	-	-	-
PRIMARY_BALANCE_BURUNDI	EXTERNAL_DEBT_RWANDA	-	-	-
PRIMARY_BALANCE_BURUNDI	PRIMARY_BALANCE_RWANDA	3.15444*	2.87235*	-
PRIMARY_BALANCE_BURUNDI	EXTERNAL_DEBT_UGANDA	-	-	-
PRIMARY_BALANCE_BURUNDI	PRIMARY_BALANCE_UGANDA	-	-	-
PRIMARY_BALANCE_BURUNDI	EXTERNAL_DEBT_TANZANIA	-	-	-
PRIMARY_BALANCE_BURUNDI	PRIMARY_BALANCE_TANZANIA	-	-	-
EXTERNAL_DEBT_KENYA	PRIMARY_BALANCE_KENYA	-	-	-
EXTERNAL_DEBT_KENYA	EXTERNAL_DEBT_RWANDA	-	-	-
EXTERNAL_DEBT_KENYA	PRIMARY_BALANCE_RWANDA	13.8182***	9.53237***	-
EXTERNAL_DEBT_KENYA	EXTERNAL_DEBT_UGANDA	-	-	-
EXTERNAL_DEBT_KENYA	PRIMARY_BALANCE_UGANDA	-	-	-
EXTERNAL_DEBT_KENYA	EXTERNAL_DEBT_TANZANIA	-	-	6.26984***
EXTERNAL_DEBT_KENYA	PRIMARY_BALANCE_TANZANIA	16.7763***	9.24083***	-
PRIMARY_BALANCE_KENYA	EXTERNAL_DEBT_RWANDA	-	-	-
PRIMARY_BALANCE_KENYA	PRIMARY_BALANCE_RWANDA	-	-	-
PRIMARY_BALANCE_KENYA	EXTERNAL_DEBT_UGANDA	-	-	-
PRIMARY_BALANCE_KENYA	PRIMARY_BALANCE_UGANDA	-	-	-
PRIMARY_BALANCE_KENYA	EXTERNAL_DEBT_TANZANIA	-	-	-
PRIMARY_BALANCE_KENYA	PRIMARY_BALANCE_TANZANIA	-	-	-
EXTERNAL_DEBT_RWANDA	PRIMARY_BALANCE_RWANDA	-	-	-
EXTERNAL_DEBT_RWANDA	EXTERNAL_DEBT_UGANDA	-	-	-
EXTERNAL_DEBT_RWANDA	PRIMARY_BALANCE_UGANDA	-	-	-
EXTERNAL_DEBT_RWANDA	EXTERNAL_DEBT_TANZANIA	-	-	-
EXTERNAL_DEBT_RWANDA	PRIMARY_BALANCE_TANZANIA	-	-	-
PRIMARY_BALANCE_RWANDA	EXTERNAL_DEBT_UGANDA	-	-	-
PRIMARY_BALANCE_RWANDA	PRIMARY_BALANCE_UGANDA	-	-	-
PRIMARY_BALANCE_RWANDA	EXTERNAL_DEBT_TANZANIA	-	-	-
PRIMARY_BALANCE_RWANDA	PRIMARY_BALANCE_TANZANIA	-	-	-
EXTERNAL_DEBT_UGANDA	PRIMARY_BALANCE_UGANDA	-	-	-
EXTERNAL_DEBT_UGANDA	EXTERNAL_DEBT_TANZANIA	-	-	-
EXTERNAL_DEBT_UGANDA	PRIMARY_BALANCE_TANZANIA	-	-	-
PRIMARY_BALANCE_UGANDA	EXTERNAL_DEBT_TANZANIA	-	-	-
PRIMARY_BALANCE_UGANDA	PRIMARY_BALANCE_TANZANIA	-	-	-
EXTERNAL_DEBT_TANZANIA	PRIMARY_BALANCE_TANZANIA	-	-	-

Notes: value of the *F*-test given alongside statistical significance at 1% (***), 5% (**), 10% (*) levels. Lag 1 critical value at 5% of risk: 4.414. Lag 2 critical value at 5% of risk: 3.682. Lag 3 critical value at 5% of risk: 3.49.

Figure 2: Nonlinear Feed-Forward Neural Network in EAC countries



Notes: EB stands for External Debt, PB for Primary Balance. t1 to t3 denote the lag of the nonlinear Granger causality tests.

4.2. Identifying a Network of Fiscal Responsibility Interactions within EAC Countries

We investigate the transmission of monetary and fiscal policies across several years, typically one to three years⁵ in the results reproduced below. In Table 6, the null hypothesis that $\{Y_t\}$ does not nonlinearly strictly Granger cause $\{X_t\}$ is rejected seven times across four pairs:

1. [Primary Balance of Burundi ↔ Primary Balance of Rwanda];
2. [External Debt of Kenya ↔ Primary Balance of Rwanda];
3. [External Debt of Kenya ↔ External Debt of Tanzania];
4. [External Debt of Kenya ↔ Primary Balance of Tanzania].

Except for the first pair, notice that we register the highest statistical significance (at the 1% level) concerning the F -test critical values tabulated by Hiemstra and Jones (1994).

These nonlinearities in the Granger sense result in the feed-forward neuronal network with hidden layers pictured in Figure 2, whereby each statistically significant node is drawn with its connection. The strongest links appear visually to be originating from the Primary Balance of Burundi and the External Debt of Kenya, with repercussions across the network to other EAC countries (at lags 1, 2, 3) such as Rwanda (Primary Balance) and Tanzania (both Primary Balance and External Debt).

This network might become more complex as time passes by, and fiscal responsibility becomes more pronounced among the constituents of the EAC region.

The non-linear Granger causalities and Feed-Forward ANN results presented in Table 6 and Figure 2 support the idea that the ongoing fiscal convergence among EAC countries is an endogenous

⁵ Notice lag 4 did not yield any additional significant results.

process as proposed by Buti and Sapir (1998). Concerning policy implications and economic interpretations of the present work, we may cautiously advance the following arguments.

To summarize the gist of our results, the motivation of this study is to characterize the nature of fiscal policy and understand shifts between sustainable and unsustainable regimes in Kenya. Further to this, the study examines for any traces of fiscal convergence among EAC countries. To do so, the study probes for fiscal convergence among EAC countries by adopting a nonlinear Granger causality tests to investigate for inter-relations between external debt and primary balance in a panel dimension.

The need to ensure a coordinated and converging fiscal policy stems from risks associated with uncoordinated fiscal policies. To name a few, we highlight the risks of weakening the monetary policy's capacity in ensuring price stability, therefore undermining the stability of the single currency. In addition, there exist risks of fiscal free riding where the pursuance of unsustainable fiscal policy by a member country could lead to an increase in the interest rates for the region as a whole leading to dampened investment and weak growth (Gupta and McHugh, 2015).

In order to strengthen convergence going forward, while committing to meeting the proposed list of comprehensive macroeconomic targets remains a necessity, this article supports the proposal by Gupta and McHugh (2015). To guarantee regional fiscal stability and sustainability, EAC countries will need to enhance convergence by establishing permanent fiscal rules, and a multilateral fiscal surveillance regime to oversee and enforce the operation of those rules.

5. Conclusion and Policy Recommendations

This study utilizes a Regime-Switching model to characterize the nature of fiscal regime cycles in Kenya and the extent to which periodic violation of sustainability condition affect long-run sustainability. The findings show that the regime switching model fits well to the data and adequately traces out fiscal policy cycles witnessed in Kenya. Notably, sustainable and unsustainable regimes are both dominant, and the average expected duration for each regime was four years. Further, the introduction of comprehensive reforms played a crucial role in promoting the sustainability of Kenya's fiscal policy. Additional results across EAC countries allow establishing a complex neural network of non-linear Granger causalities, with the main nodes being Burundi and Kenya, whereas the main synapses are Tanzania and Rwanda.

Evaluation of regime-switching based stability test shows evidence of weak NPG and instability of fiscal policy. Debt to output ratio was unstable in the long run when accounting for potential fiscal limits. These results suggest that despite prudent fiscal policy reaction during a sustainable period, procyclical nature of fiscal rule especially during unsustainable regimes tends to worsen fiscal sustainability, especially in the long-run.

The following recommendations were made: First, the results show that fiscal regimes matter in sustainability analysis whereby the persistence of unsustainable fiscal policy regime beyond four years could threaten long-run sustainability. Therefore, while the government remains dedicated to public investment plan to drive the economy towards inclusive and sustainable growth, there is a need for such expansionary periods to be followed by a commitment to fiscal consolidation.

Secondly, the results suggest that Kenya's long-run fiscal position fails to satisfy the debt stabilizing conditions especially because the fiscal rule is procyclical. Therefore, the evaluation of

debt buildup and composition should be informed by a stable debt-to-output ratio and the appropriate fiscal policy response. Also, adoption of prudent fiscal policy management with emphasis on countercyclical fiscal policy is critical in ensuring fiscal sustainability in Kenya. Consolidating during the good years would help create a fiscal buffer which will help cushion the country during the inevitable bad years.

Lastly, an in-depth understanding of long-run fiscal sustainability warrants further research on the estimation of the causes and nature of procyclicality which special consideration to the influence of the political economy on fiscal sustainability. Also, exploring the extent to which monetary policy and fiscal policy interact and their possible effect on overall macroeconomic sustainability is vital in monitoring macroeconomic stability.

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APPENDIX

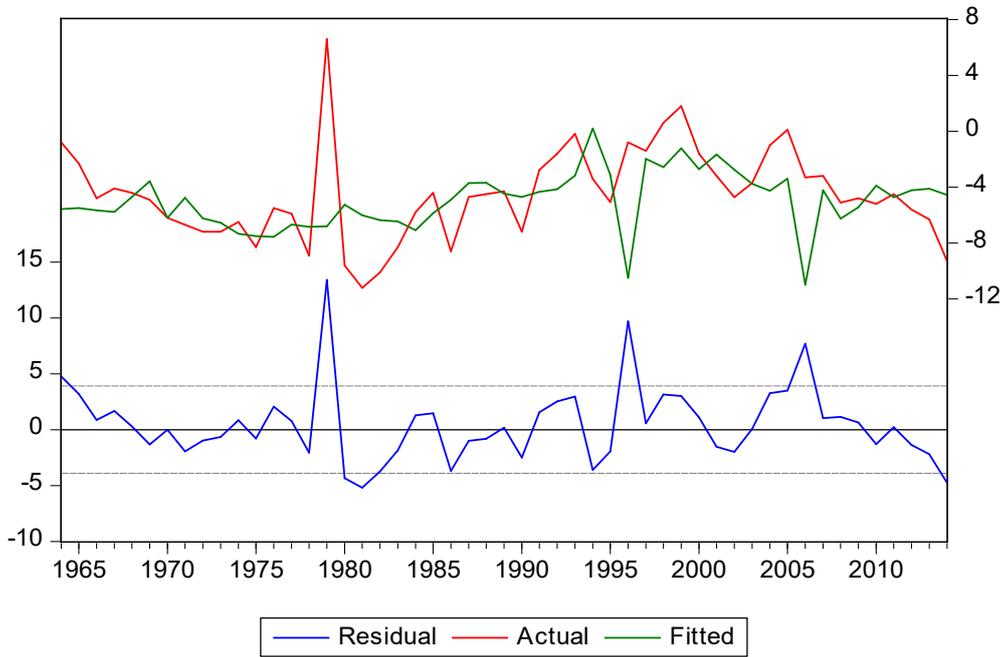


Figure 1A: Residual for Markov-Switching Regression Model

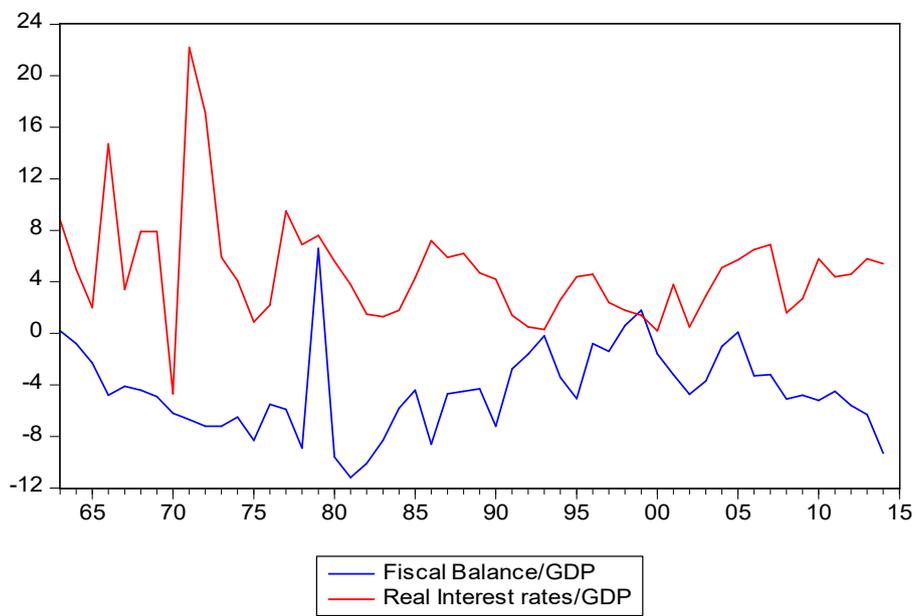


Figure 2A: Trending ratio of Fiscal balance to GDP and Interest rate from 1963 to 2015

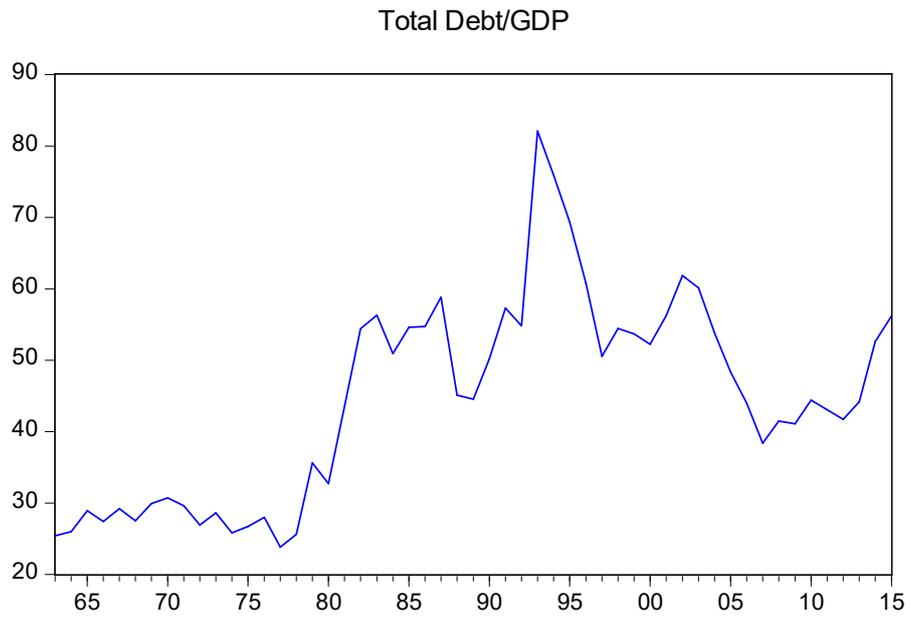


Figure 3A: Evolution of Total Public Debt from 1963 to 2014

Derivation of Ergodic Probability, Expected regime duration, and long run Parameters

Ergodic probabilities are estimated as follows:

$$\pi_{ii} = \frac{1-p_{jj}}{(1-p_{ii})+(1-p_{jj})} \quad \text{Eqn (1)}$$

Moreover, the expected duration (Du) for a given fiscal regime $\forall i \in \{S, NS\}$ is determined by

$$\left[Du_i = \frac{1}{1-p_{ii}} \right]. \quad \text{Eqn (2)}$$

The long run (ergodic) coefficients are therefore computed as follows:

$$\alpha = \alpha_S \pi_S + \alpha_{NS} \pi_{NS} \quad \text{Eqn (3)}$$

Moreover, the standard deviation is given as:

$$\sigma_{\alpha_i} = \sqrt{\sigma_{\alpha_S} \pi_S + \sigma_{\alpha_{NS}} \pi_{NS} + 2 \times \pi_S \times \pi_{NS} \times \text{cov}(\sigma_{\alpha_S}, \sigma_{\alpha_{NS}})} \quad \text{Eqn (4)}$$

Aldama and Creel (2016) show that given periods of unsustainability, NPG holds if:

$$\alpha_S > |\sigma_{NS}| \times \frac{Du_{NS}}{Du_S} \quad \text{Eqn (5)}$$

Where $\alpha = \alpha_S \pi_S + \alpha_{NS} \pi_{NS}$

Also, the public debt is stabilized if

$$\alpha_S > |\sigma_{NS}| \times \frac{Du_{NS}}{Du_S} + (r - g) \times \frac{Du_S + Du_{NS}}{Du_S} \quad \text{Eqn (6)}$$

Where $(r - g)$ represents the difference between the real interest rate and growth rate.

Table A1: Summary of Empirical Literature

Summary of Empirical Analysis				
Authors	Sample	Objective	Methodology	Remarks
Favero and Monacelli (2005)	Quarterly data from 1961 Q1 to 2002 Q4.	To characterize the U.S fiscal policy regarding a fiscal function.	The study allowed the fiscal regime to vary over time by adopting Markov-switching regression methods to estimate fiscal policy feedback rules in the U.S.	The study established three main findings: (i) Fiscal policy can be characterized as active from 1960 through 1980's switching gradually to passive in the early 1990's and back to active in early 2001. (ii) Regime - switching fiscal rules can track the time series behavior of the US primary deficit better than rules based on a constant parameter specification; (iii) Regime-switches in monetary and fiscal policy rules do not exhibit any form of synchronization.
Sirengo (2008)	Annual data from 1975 to 2006	Determinants of Fiscal balance in Kenya	The study used an error correction model to determine the determinants of fiscal balance in the long run. The key independent variables used in the analysis include interest rate	It was established that fiscal balance was positively influenced by the growth of real GDP but negatively influenced by trade openness and interest rates. The study also showed that liberalization

			measured by the treasury bill rate, real GDP, trade openness and dummy representing liberalization	policies had a negative influence on the fiscal balance
Harvard & Bleaney (2011)	Panel data from 85 developed and developing countries from 1980 to 2004	Explaining procyclicality of Fiscal Policy in developing countries	The study used panel data analysis to evaluate the effect of cyclical variables which include output gap and political economy which include political structure, social inequality, and international credit constraint.	The results established that social inequality, democracy, and corruption were essential determinants of procyclicality of fiscal policy.
Burger and Marinkov (2012)	Quarterly data for the period 1972Q1 to 2010Q4.	The study explored various models of fiscal policy reaction function to articulate South Africa's fiscal policy behavior.	In order to allow for a time-varying reaction to the Debt/GDP ratio, the study adopted a Markov, switching model.	The results showed that historically the South African government ran a passive fiscal policy. Also, the fiscal activism observed between 2008 and 2010 presents a case for the establishment of fiscal rules.
Guinigundo (2012)	Quarterly data from 1995Q1 to 2010Q2	Fiscal policy, Public debt management, and the governments bond market:	The study used the Vector Error Correction Model to evaluate the fiscal health of the Philippines. Key variables include government expenditure, domestic liquidity as measured by M3	The study established that the economy responded more to monetary policy than fiscal policy. It was also established that some degree of coordination existed in a bid to prevent sterilization.

		The case for the Philippines	and financial market volatility	
Khalid, N. & Marwan, F. (2012)	Annual time series data from 1971 to 2009 for three countries namely Thailand, Malaysia and Singapore	Examined the effect of fiscal and monetary policy regime changes on economic growth	The study used a Markov-switching (MS) model to characterize fiscal and monetary policy regime changes and an Autoregressive Distributed Lag Model (ARDL) to measure the short run and long run effect of regime changes on growth	The study provided for stochastic changes in policy regime and further provided for regime changes in examining the short-run and long-run models. It was established that fiscal policy was active for all times in Malaysia which monetary policy was dominant in Singapore. It was also shown that fiscal and monetary policy were critical in sustaining long-run growth in Thailand
Afonso and Toffano (2013)	Panel data for 18 OECD countries for the period 1970-2010.	Assessed the sustainability of fiscal policy in OECD countries by employing an indirect test on the solvency of public finances.	The study used unit root and cointegration analysis while controlling for endogenous breaks to evaluate fiscal sustainability by examining three channels: (i) First-differenced debt ratios; (ii) Government revenues and expenditures and; (iii) Primary balances and debt.	The study results suggest that the existence of one cointegrating relationship between government revenues and expenditures in only six countries. The overall fiscal policy appears unsustainable portraying fiscal sustainability to be somewhat elusive.

Lledo, V. Poplawski-Ribiero (2013)	Consists of two Panel data sets. One for 171 countries from 2004 to 2010 and the other for 31 Sub-Saharan (SSA) Countries from 2004 to 2010	Economic and institutional constraints affecting fiscal policy implementation in Sub-Saharan Africa	Using two sets of panel data analysis, the study estimated determinants of fiscal policy implementation gap for 171 countries and this model was compared to the model for SSA countries.	The study shows that there is no difference between susceptibility to fiscal policy implementation in SSA compared to the rest of the world. However, large fiscal plans are less likely to be implemented in SSA. This study is essential to the extent that it highlights main challenges that govern implementation of fiscal policy in SSA
Mutuku (2015)	Annual time series data from 1970 to 2013 for the Kenyan economy	Determine whether the fiscal policy in Kenya is on a sustainable path	Used Vector Autoregressive Model. The study sought to establish whether cyclical nature is consistent with long-run sustainability. Key variables include debt to output ratio, Consumer price index (CPI), Real exchange rate, primary balance as a ratio of GDP and interest rates and total revenue to GDP and political dummy	The study established that fiscal debt was acyclical and stabilization policy was not effective in the long run. It was also noted that election cycles expenditure had an adverse impact on fiscal policy sustainability. Though informative, the study uses linear models and therefore does not adequately address the cyclical nature of fiscal policy
Chibi <i>et al.</i> , (2015)	Quarterly time series Q4 1964 to Q4 2012	The study sought to examine fiscal sustainability factoring in	The study utilized the Smooth Transition autoregressive model. Key variables include government	The study established that linear model was rejected in favor of a transition model. The threshold was estimated at

		nonlinear behavior of the fiscal balance	debt, government revenue, and government expenditure. The threshold was based on fiscal dependency on oil price	\$ 83.3 per barrel. It was established that there was active debt management when deviation from equilibrium budget path was witnessed
Aldama & Creel (2016)	Annual time series data from 1963 to 2013	The study sought to establish long-run sustainability of fiscal policy in France	This study used a Markov switching model to estimate sustainable and unsustainable regimes in the short run and further use regime switching model-based tests to evaluate whether the Fiscal policy is sustainable in the long run	The study shows that regime-switching models capture the periods of unsustainable and sustainable fiscal regimes. The study further demonstrated weak evidence that France's fiscal policy is sustainable in the long run.
Konuki & Villafuerte (2016)	Panel data comprising of 43 SSA countries from 2000 to 2014	The study sought to find out the nature of cyclicity of fiscal policy among SSA countries	The study utilized a deterministic approach where cyclically adjusted primary balance from resource-based (such as oil-dependent countries) and non-resources based countries were excited using the output gap to account for the cyclical component.	It was established that SSA countries generally run procyclical fiscal policy and this characteristic was more pronounced in resource-rich countries
Nguyen <i>et al.</i> (2017)	Annual time series from 1916 to 2012	The study examined how primary surplus to gross domestic product ratio responds to	While controlling for the level of government spending and business cycle fluctuations, Bohn's time-varying fiscal reaction function was used, and both	The study found evidence that the U.S public debt was sustainable until 2005, from which date the primary surplus

		changes in debt to GDP ratio over time in a time-varying parameter model	GVAR and YVAR estimated.	appears to react negatively to the debt to GDP ratio.
Wesselbaum (2014)	Quarterly data from 1994 to 2014.	To characterize the interactions between fiscal and monetary and policy in New Zealand.	A multivariate Markov switching model was used to document the different policy changes.	The results map out two regimes: (i) A non-accommodative monetary policy regime, where monetary policy does not respond to changes in public debt and (ii) an accommodative monetary policy regime where monetary policy responds to changes in public debt.
Tarawalie, <i>et al.</i> , (2013)	Annual data for the period 1980-2011.	To examine the level of coordination between fiscal and monetary authorities in the Western African Monetary Zone (WAMZ) countries and its implications for the attainment of the inflation and	The paper uses the Set Theoretic approach (STA) and the Vector autoregressive (VAR) estimation techniques.	The results reveal weak policy coordination in all WAMZ countries during the period which contributes to the non-compliance concerning inflation and fiscal deficit criteria. The results of the STA models show that explicit policy coordination scores in the WAMZ countries are less than 50 percent. The study recommends that WAMZ should strengthen policy coordination by putting in place formal coordination

		fiscal deficit criteria.		platforms and institutional arrangements.
Lambertini and Rovelli (2003)	European Monetary Union (EMU).	To investigate the relationship between monetary and fiscal policy in the process of macroeconomic stabilization within a Stackelberg equilibrium framework.	The study proposes a game theory framework and analyzes the interaction of the fiscal and monetary policies in a Nash equilibrium.	The study concluded that the superior and most probable outcome is the one where the fiscal authority takes the lead in the macroeconomic policy game. The conclusions, however, support the idea that the setting of fiscal policies by member countries needs to be disciplined, and in some instances possibly over-ruled, by the EC authorities.
Leith and Lewis (2000)	European Monetary Union (EMU).	To identify the conditions under which either fiscal and monetary policy alone determines the price level.	The study uses simulation analysis to establish policy regimes under the EMU fiscal policy pact.	The results conclude that the central bank does not need to seek the level of debt stabilizing level implied by the fiscal stability pact.
Chuku C.A (2012)	Quarterly data from 1970 to 2008.	To examine the nature of monetary and fiscal policy interactions in Nigeria.	The paper used vector autoregression and a State Space model with Markov-switching.	The results indicated that monetary and fiscal policies in Nigeria have interacted in a counteractive manner, establishing some evidence of weak coordination.

Fialho and Portugal (2009)	Monthly data from 1995 to 2003.	To verify the predominance of a monetary or fiscal dominance regime in Brazil in the post-Real period.	To study the interactions between monetary and fiscal policies in Brazil using a Markov-switching vector autoregression model while applying the fiscal theory of price level.	The results can be summarized in two parts. (i) That there is a relationship between public debts and their measure of monetary policy, and (ii) The nature of macroeconomic coordination in Brazil follows a substitution approach with a dominant monetary regime.
Semmler and Zhang (2003)	Quarterly data from 1967 to 1998.	To investigate the interaction over time between monetary and fiscal policies in France and Germany in the 70s, 80s, and 90s.	The paper started by undertaking some tests of fiscal regimes with a VAR model, then conducted Granger- Causality tests to check whether fiscal policy granger-causes inflation. Finally, the paper applied a state space model with Markov switching to estimate the time-varying vector of parameters of a simple model.	The results can be summarized as follows: A non-Ricardian fiscal policy applies in this case; Fiscal policy does not seem to Granger-cause inflation, but Inflation does Granger-cause fiscal policy to some extent; Finally, there seem to be some regime changes in the monetary and fiscal policy interactions in the two countries but somehow different in the two countries.
Dungey and Fry (2009)	Quarterly data from 1983 to 2006.	To trace out the interaction between monetary policy shocks, fiscal shocks and other	The paper uses a structural VAR to disentangle monetary, fiscal policy and other shocks. The methodology combines identification via sign restrictions, cointegration,	The results show that the influence of fiscal policy stance is sometimes substantial to the extent that it outweighs the contribution of monetary policy shocks.

		economic shocks in New Zealand	and traditional exclusion restrictions.	
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Table A2: Regression Analysis using Self-Exciting Threshold Autoregressive Model

<i>Dependent Variable: Fiscal Balance/GDP</i>		
	Regime I	Regime II
Total Debt: Lag 1	0.1*** (2.94)	-0.61*** (-7.78)
Output GAP	-0.008 (-0.18)	0.828*** (3.09)
Real Interest Rates	0.05 (0.59)	1.98*** 4.96
Government expenditure Gap	-0.50 (-0.93)	-5.77*** (-4.65)
Constant	-9.329*** (6.51)	14.39*** (5.25)
Diagnostics		
Adjusted R-Square		0.43
J-Statistics		0.846 (0.655)
Threshold value		-7.200
No of observation below the threshold		7**
Key: *** Significant at 1%, **Significant at 5%, *Significant at 10%		

Table A3: Summary of Descriptive Statistics among EAC countries

	Δd_{it}	g_{it}	Pb_{it}	$RInt_{it}$	$DRexch_{it}$
Mean	-0.026899	4.6323	-3.4314	1.06609	51.37258
Median	-0.008749	5.39	-2.9511	0.8405	9.954578
Maximum	0.806352	35.224	0.97959	3.74031	1374.232
Minimum	-0.513629	-50.248	-11.5	0	-103.4125
Std. Dev.	0.157604	7.066	2.76995	0.75117	154.0035
Skewness	0.674661	-3.368	-0.8381	1.667	6.254393
Kurtosis	10.10477	34.358	3.4517	6.039	50.90026
Jarque-Bera	250.5968	5142.93	15.07	101.96	11743.92
Probability	0	0	0.00053	0	0
Sum	-3.093434	555.872	-409.64	127.37	5907.846
Sum Sq. Dev.	2.831635	5942.65	923.265	67.148	2703748
Observations	115	120	120	120	115

Note: The 5 EAC countries are composed of Burundi, Kenya, Rwanda, Tanzania, and Uganda.