Economic Growth and Electricity Consumption in Africa and Asia: MS-VAR and MS-GRANGER Causality Analysis

Bildirici, Melike

Yildiz technical University

29 January 2012

ECONOMIC GROWH AND ELECTRICITY CONSUMPTION IN AFRICA and ASIA: MS-VAR and MS-GRANGER CAUSALITY ANALYSIS

Prof. Dr. Melike E BILDIRICI
Yildiz Technical University, Department of Economics
Barbaros Bulvarı, 34349 Beşiktaş / ISTANBUL
Phone: 90-212-3832527 Fax : 90-212-2366423 E-mail: melikebildirici@gmail.com

Abstract

Knowledge of the direction of the causality between electricity consumption and economic growth is of primary importance if appropriate energy policies and energy conservation measures are to be devised. This study estimates the causality relationship between electricity consumption and economic growth by Markov Switching Vector Auto Regression (VAR) and Markov Switching Granger Causality methods for some countries in Africa (7 Countries) and Asia(Brunei); Brunei, Cameron, Côte d'Ivoire, Nigeria, South Africa, Togo and Zimbabwe. The results from MS-VAR models show that in regime one, two and three, Electricity Consumption (EC) is the Granger cause of the Gross Domestic Product (GDP) and GDP is the Granger cause of the EC. In sum, we find some evidence of bidirectional GC between the EC and the GDP.

Key Words: Economic Growth, Electricity Consumption, MS-VAR, MS-Granger Causality

JEL Codes: C13, C22, O40, Q41, Q43

1. Introduction

The relationship between the energy consumption and the economic growth is important for both developed and developing countries, because energy consumption increases with economic development and the consumption of energy sources improve living standards (Darmstadter, et al., 1979; Schurr, 1982; and Rosenberg, 1983), a higher level of socio-economic development is associated with a well developed energy consumption (Kebede, Kagochi, Jolly; 2011). Increasing energy consumption and/or electricity consumption has been identified as an important source of productivity improvement.

Energy consumption has been used as a measure of economic development in some papers and energy consumption is a key factor of production in addition to capital, labor and other factors (raw materials, technology). Rasche and Tatom (1977) specified a production function for the United States. Some papers had been focused to income elasticity and price elasticity of electricity demand as Houthakker (1951), Fisher and Kaysen (1962), Baxter and Ress (1968), Houthakker and Taylor (1970), Wilson (1971), Cargil and Mayer (1971), Anderson (1973), Mount et al (1973), Bakırtaş, Karbuz and Bildirici (2000). However, many papers have accepted electricity consumption as a measure of economic development or growth and these papers have focused on the causality relation. Kraft and Kraft (1978) found the relation between energy consumption and GNP for the 1947-1974 period as one way - from GNP to energy consumption by using Sims causality analysis. Akarca and Long (1980) continued the analysis by eliminating the data of 1973 and 1974. Yu and Choi (1985) found no causality relationship between gross national product and energy consumption for the USA, UK, and Poland. Yu, et. al. (1988), found no relationship between energy consumption and GNP, and also no relationship between energy and employment. In pursuit of these pioneer studies, the other studies have expanded and become diversified.

Following the literature, one may construct four different hypotheses: (1) The *neutrality hypothesis* states that there is no causality between economic growth and energy consumption. Under the neutrality hypothesis, the policies aimed at conserving energy resources fail to retard economic growth (Asafu-Adaye, 2000; Jumbe, 2004). (2) *The feedback hypothesis* states that, there exists a bi-directional causality running between economic growth and energy consumption. Energy consumption and economic growth are complementary, and that an increase in energy consumption stimulates economic growth, and vice-versa. (3) *The conservation hypothesis* determines the unidirectional causality running from economic growth to energy consumption. When causality runs from economic growth to energy consumption, an economy is less energy dependent, and thus energy conservation policies, such as phasing out energy subsidies, may not adversely affect economic growth (Mehrera, 2007). (4) The *growth hypothesis* evaluates the existence of the unidirectional causality running from energy consumption to economic growth (Narayan and Smyth, 2005; Ghosh, 2002). According to the growth hypothesis, a country's economy is energy dependent; in this case, the reduction of energy consumption will lead to a fall in economic growth because energy consumption is a prerequisite for economic growth, energy is a direct input in the production process and/or an indirect input that complements labor and capital inputs (Ebohon, 1996; Toman and Jemelkova, 2003). This implies that a negative shock to electricity consumption leads to higher electricity prices or electricity conservation policies has a negative impact on GDP (Narayan and Singh, 2007).

In these papers, conventional analysis is used: ARDL, Johansen and Engle Granger Cointegration tests etc., but these methods are not suitable in states of structural break and business cycle. One of the shortcomings of these studies is the avoidance of the nonlinear structure of the time series under consideration, especially GDP series which has been extensively evaluated as a measure of economic performance under business cycles. the parameters are assumed to be constant over the sample period in these models, but the world has experienced many crises that affected economic growth.

Esso (2010) used the Gregory and Hansen (1996a, 1996b) testing approach to threshold cointegration for 7 African countries. Kebede, Kagochi, Jolly (2011) estimated dates of structural breaks for African countries. Their results stated that the first structural breaks appeared between 1974 and 1979 (in Libya and Nigeria, the first structural breaks occurred in 1989 just after the stock market crash in the United States and just prior to the Gulf War). Gregory and Hansen's threshold cointegration analysis is not suitable in case of multiple structural breaks.

One way to overcome these problems is to divide the sample into sub-samples, based on the structural breaks; but the exact date of these changes is not known and the researcher must determine it endogenously based on the data. However, there is no guarantee that the relationship between real GDP and electricity consumption changes at the same date of the break dates of the variables (Falahi, 2011; 4165-4170). In this paper, Markov Switching VAR (MS-VAR) model is used to analyze the relationship between electricity consumption and economic growth. This study can be defined as complementary to the previous empirical papers. However, it differs from the existing literature in some aspects. First, it employs MS-VAR method. Second, it uses Markov Switching Granger Causality analysis. MS-Granger causality approach allows the analysis of causality in different regimes of GDP.

In the next section of the paper, literature review will be presented. In the third section of the paper, the econometric theory will be presented. The fourth section consists of the empirical results. The last section includes conclusions and policy implications.

2. Literature Review

Although in recent times, some papers about energy economics have focused on African countries, the literature focusing on African countries are relatively rare vis-a-vis papers on European and Asian countries. Lee (2005) analyzed the relationship between energy consumption and GDP by panel estimation techniques for 18 developing countries including sub-Saharan African countries, Kenya and Ghana, and determined the causality running from energy consumption to GDP.. Wolde-Rufael (2005) investigated the long run relationship between per capita energy consumption and per capita real gross domestic product for 19 African countries over the period 1971–2001. The paper also used the ARDL methods and Toda-Yamamoto test for causality and the empirical results suggested that there was a long run relationship for only eight countries, whereas causality exists for only 10 countries. De Vita et. al. (2006) examined the determinants of electricity demand in Namibia. Wolde-Rufael (2009) analyzed the relationship between energy consumption and economic growth for 17 African countries by taking into account labor and capital as additional variables. Odhiambo (2010) assessed the causal relationship between energy consumption and economic growth in three sub-Saharan African countries. Esso (2010) examined the relationship between energy consumption and economic growth for seven sub-Saharan African countries during the period 1970–2007 by using threshold cointegration approach. He found that energy consumption is cointegrated with economic growth in Cameroon, Ivory Coast, Ghana, Nigeria and South Africa. His results of causality tests suggest bidirectional causality between energy consumption and real GDP in Ivory Coast and unidirectional causality running from real GDP to energy use in Congo and Ghana (Kebede, Kagochi, Jolly, 2011).

The results of the studies on African countries in the literature are presented in Table 1.

Table 1: Causality Literature on Energy Economics in Some Countries

Author(s)	Country	Period	Methodology	Main Variables	causality
Conservation hypothesis					
Wolde-Rufael (2006)	Cameroon, Gabon, Ghana, Nigeria, Senegal, Zambia, Zimbabwe	1971-2001	ARDL (Toda Yamamamoto)	GDP, Electricity consumption	Y → EC
Wolde-Rufael (2005)	Algeria, Democratic Republic of Congo, Egypt, Ghana and Ivory Coast	1971-2001	ARDL (Toda Yamamamoto)	GDP, Electricity consumption	Y → EC
Esso (2010)	Congo Ghana	1970-2007	Threshold cointegration approach	GDP, Electricity consumption	Y → EC
Growth Hypothesis					
Lee (2005)	Sub-Saharan Africa Kenya and Ghana	1971-2001		GDP, Electricity consumption	EC → Y
Wolde-Rufael Y.(2006)	Benin, Congo, Tunisia	1971-2001	ARDL (Toda Yamamamoto)	GDP, Electricity consumption	EC → Y
Odhiambo (2009)	Tanzania	1971-2006	ARDL)-bounds testing approach	GDP, Electricity consumption	EC → Y
Belloumi, 2009	Tunusia	1971–2004	Granger causality, VECM	GDP, Electricity consumption	EC → Y (in SR)
Ozturk, A. Acaravci (2011)	Egypt Saudi Arabia		ARDL	GDP, Electricity consumption	EC → Y(in LR)
Quedraogo (2010)	Burkina Faso	1968-2003	ARDL	GDP, Electricity consumption	EC→Y
Kebede, Kagochi, Jolly (2010)	20 Sub-Saharan Africa	1980-2004	Atomic Energy Agency Energy Demand Projection (MAED) model	GDP, Electricity consumption	EC→Y
Feedback hypothesis					
Ebohon (1996)	Nigeria, Tanzania	1960-1984 1960-1981	Granger Causality	GDP, Electricity consumption	EC←→Y
Belloumi, 2009	Tunisia	1971–2004	Granger causality, VECM	GDP, Electricity consumption	EC←→Y (in LR)
Ouedraogo (2010)	Burkina-Faso	1968-2003	Bound test	GDP, Electricity consumption	EC←→Y
Esso (2010)	Ivory Coast	1970-2007	Threshold cointegration approach	GDP, Electricity consumption	EC←→Y
Nondo et.all (2010)	19 African countries (COMESA)	1980-2005	Panel VEC, Granger Causality Tests	GDP, Electricity consumption	EC←→Y (in LR)
Jaunky(2006)	16 African countries		Panel VEC, Granger Causality Tests	GDP, Electricity consumption	EC←→Y
Neutrality hypothesis					
Wolde-Rufael (2006)	Kenya	1971-2001	Bound test (Toda Yamamamoto)	GDP, Electricity consumption	none
Wolde-Rufael (2006)	Sudan	1971-2001	Bound test (Toda Yamamamoto)	GDP, Electricity consumption	none
Huang, Hwang, Yang(2008)	in the low income group	1972-2002	Panel VAR, GMM-SYS	GDP, Electricity consumption	none
Esso (2010)	Cameroon, Nigeria, Kenya, South Africa	1970-2007	Threshold cointegration approach	GDP, Electricity consumption	none

3. **Data and Methodology**

3.1. Data

In this study, the relationship between electricity consumption (EC) and economic growth (Y) is investigated by the MS-VAR method with annual data. This study involves seven countries in Africa and one country in Asia for the period 1970–2010. The eight countries covered in the study are Brunei, Cameron, Côte d'Ivoire, Nigeria, South African, Togo, and Zimbabwe. The choice of countries included in the work was based on the availability of data on the variables incorporated. The data is taken from World Bank, IEA, OECD, and U.S. Energy Information Administration.

3.2. Methodology

Hamilton (1989) model, which allows positive and negative shocks, is

$$y_t - \mu_{st} = \phi(y_{t-1} - \mu_{st-1}) + u_t \quad (1)$$

where μ_{s_t} is $\mu_1 \leq 0$ when $s_t = 1$, and $\mu_2 > 0$ when $s_t = 2$, and where $u_t \sim iid\, N(0,\sigma^2)$ when $|\phi| < 1$ s_t is a discrete variable that takes on the values of 1 or 2.

The Markov chain is ergodic and irreducible; a two-state Markov chain with transition probabilities p_{ii} has unconditional distribution given by

$$\Pr(s_t = 1) = \frac{1-p_{22}}{2-p_{11}-p_{22}}, \Pr(s_t = 2) = \frac{1-p_{11}}{2-p_{11}-p_{22}} \quad (2)$$

As Krolzig (1997; 2000) demonstrated, obtaining the impulse response functions in MS-VAR model which has autoregressive dynamics that are independent from the regime are indicated below for a MS(M)-VAR(1) model. Impulse-response function for $MS(M)-VAR(1)$, where $y_t = \left(y_t', \ldots, y_{t-p+1}'\right)'$, $y_t = \mathrm{H}\xi_t + Ay_{t-1} + u_t$. If $\{u_t, \xi_t, Y_{t-1}\}$, the conditional expectation of y_{t+h} is $y_{t+h|t} = \mathrm{H}\xi_{t+h|t} + Ay_{t+h-1|t}$, and $\xi_{t+h|t} = \mathrm{F}^h \xi_t$ and $\mathrm{F{=}P'}$. In this situation, impulse-response function is:

$$ET_{\nabla\xi}(h) = J(\sum_{\mathrm{k=0}}^{\mathrm{h}} \mathrm{A^k H F^{h-k}})\nabla\xi \quad (3)$$

where $J = [\mathrm{I_K} \quad 0 \quad \cdots \quad 0] = \iota_1' \otimes \mathrm{I_K}$,

In $MSIA(M)-VAR(1)$ model; if γ_t is $\gamma_t = \xi_t \otimes y_t$,

$$\gamma_{\mathrm{t}} = \mathrm{M}\xi_{\mathrm{t-1}} + \Pi\gamma_{\mathrm{t-1}} + \varepsilon_{\mathrm{t}}$$
$$\xi_{\mathrm{t}} = \mathrm{F}\xi_{\mathrm{t-1}} + \eta_{\mathrm{t}}$$

In matrix form, it is

$$\underbrace{\begin{bmatrix}\gamma_t \\ \xi_t\end{bmatrix}}_{\gamma_t^*} = \underbrace{\begin{bmatrix}\Pi & \mathrm{M} \\ 0 & \mathrm{F}\end{bmatrix}}_{\Pi^*} \underbrace{\begin{bmatrix}\gamma_{t-1} \\ \xi_{t-1}\end{bmatrix}}_{\gamma_{t-1}^*} + \underbrace{\begin{bmatrix}\varepsilon_t \\ n_t\end{bmatrix}}_{\varepsilon_t^*} \quad (4)$$

the conditional expectation of γ_t is $E\left[\gamma_{t+h}^* \middle| \gamma_t^*\right] = \Pi^{*h}\gamma_t^*$ when $y_t = \sum_{i=1}^{M} \xi_{it} y_t$, the conditional expectation of y_{t+h},

$$E\left[y_{t+h} \middle| y_t, \xi_t\right] = \sum_{i=1}^{M} E\left[\xi_{it+h} y_{t+h} \middle| y_t, \xi_t\right] = (1_{\mathrm{M}}' \otimes \mathrm{I_K} : 0_{\mathrm{K,M}}) E\left[\gamma_{t+h}^* \middle| \gamma_t^*\right]$$

$$=\begin{bmatrix} 1'_M \otimes I_K & 0_{K,M} \end{bmatrix} \begin{bmatrix} \Pi & M \\ 0 & F \end{bmatrix}^h \begin{bmatrix} \gamma_t \\ \xi_t \end{bmatrix} = \begin{bmatrix} 1'_M \otimes I_K & 0_{K,M} \end{bmatrix} \Pi^{*h} \begin{bmatrix} \gamma_t \\ \xi_t \end{bmatrix} \tag{5}$$

The impulse response function is given by

$$ET_{\nabla u}(h) = \begin{bmatrix} 1'_M \otimes I_K & 0_{K,M} \end{bmatrix} \Pi^{*h} \begin{bmatrix} \xi_t \otimes \nabla u \\ 0_{M,1} \end{bmatrix}$$

and

$$ET_{\nabla \xi}(h) = \begin{bmatrix} 1'_M \otimes I_K & 0_{K,M} \end{bmatrix} \Pi^{*h} \begin{bmatrix} \nabla \xi_t \otimes y_t \\ \nabla \xi_t \end{bmatrix} \tag{6}$$

The Markov chain is ergodic, irreducible and there does not exist an absorbing state, i.e.,

$\bar{\xi}_p \in (0, 1)$ for all m=1, . . . , M, where $\bar{\xi}_p$ is ergodic or unconditional probability of regime q.

3.2.1. Markov Switching Granger Causality

Warne (2000) and Psaradakis et al. (2005) determined different definitions of causality based on Grangers causality in the context of Markov switching VAR model. Falahi (2011) used Granger causalities for GDP and energy consumption. Based on the coefficients of the lagged values of LY and LEC in the equation for LEC and LY where L represents the logarithm of the variables, we could determine the existence of causalities between these two variables. In the equation for LEC, if any of the coefficients of LY_t be significantly different from zero, in any of the regimes,

$$\begin{bmatrix} LY_t \\ LEC_t \end{bmatrix} = \begin{bmatrix} \mu_{1,st} \\ \mu_{2,st} \end{bmatrix} + \sum_{k=1}^{q} \begin{bmatrix} \phi_{11,st}^{(k)} & \phi_{12,st}^{(k)} \\ \phi_{21,st}^{(k)} & \phi_{22,st}^{(k)} \end{bmatrix} \begin{bmatrix} LY_{t-k} \\ LEC_{t-k} \end{bmatrix} + \begin{bmatrix} e_t \\ \varepsilon_t \end{bmatrix} \tag{7}$$

it is concluded that LY (LEC) is a Granger cause of LEC(Y) in that regime. Granger causalities are detected by testing $H_0 : \phi_{12}^{(k)} = 0$ and $H_0 : \phi_{21}^{(k)} = 0$.

4. Empirical Results

The tests proposed by Elliott et al. (1996) and Ng and Perron (2001) were used to determine the order of integration of the logarithm of real GDP and electricity consumption. The results from unit root tests are shown in Table 1. The results indicate that the null hypothesis of unit root cannot be rejected at 5% level of significance for these variables; however, the first difference of LY and LEC appears to be stationary. It can be concluded that the LY and LEC are integrated of order one, I(1). Since the variables are integrated of same order, the maximum likelihood procedure of Johansen can be used to examine the possible existence of cointegration between LY and LEC. The null hypothesis of no cointegration was not rejected. If the variables are I(1) and are not cointegrated, the first difference or innovations of the variables, DLY and DLEC, can be used to test for MS- Granger.

Table 2. Results from unit root tests

	MZa	MZt	MSB	MPT	Elliott-Rothenberg-Stock test statistic
Brunei					
Y	-3.55688	-1.25554	0.35299	6.87739	11.54296
DLY	-15.4753	-2.78150	0.17974	1.58376	1.591563
EC	0.10981	0.07128	0.64910	28.0918	26.1173
DLEC	-13.6724	-2.60975	0.19088	1.81059	1.969124
Cameron					
Y	-2.11538	-0.01370	0.88996	5.20629	10.24038
DLY	-14.08044	-2.41687	0.24723	2.01719	1.867435
EC	-0.174365	-0.11329	0.77522	15.1745	12.91266
DLEC	-16.0262	-2.60051	0.16227	2.35301	2.114669
Côte d'Ivoire					
Y	-0.62618	-0.32203	0.51427	17.5174	71.06964
DLY	-15.2291	-2.75721	0.18105	1.61719	0.027398
EC	1.20707	1.22040	1.01104	73.7232	196.1853
DLEC	-17.9163	-2.99255	0.16703	1.36918	1.527426
Nigeria					
Y	-5.10763	-1.00239	0.33173	5.35116	0.003698
DLY	-25.0170	-3.41424	0.13648	1.37662	2.216993
EC	1.18349	1.02624	0.86713	55.7899	166.4172
DLEC	-15.8242	-2.77631	0.17545	1.68408	1.145021
South Africa					
Y	-4.90696	-1.18356	0.33347	5.91110	4.289740
DLY	-13.9958	-2.63518	0.18828	1.78938	1.817332
EC	1.31626	2.16748	1.64669	188.338	13.12355
DLEC	-12.6120	-2.19876	0.17434	3.07855	2.239174
Togo					
Y	-4.31891	-1.37718	0.31887	5.81185	6.016389
DLY	-17.8610	-2.98097	0.16690	1.39871	1.694243
EC	0.12782	0.07211	0.56419	22.9675	37.16966
DLEC	-17.9447	-2.99392	0.16684	1.37066	1.374975
Zimbabwe					
Y	-3.9915	-0.9313	0. 63256	5.86575	11.05394
DLY	-14.2775	-2.62298	0.18371	1.90004	2.413181
EC	0.96336	0.83486	0.86661	53.4779	10.8753
DLEC	-13.7844	-2.61710	0.18986	6.65750	1.7543
ERS Test CV: 1% level (1.870000), 5% level(2.970000), 10% level (3.910000)					
Asymptotic critical values 1% level	-13.8000	-2.58000	0.17400	1.78000	1.870000
5 % level	-8.10000	-1.98000	0.23300	3.17000	2.970000
10 % level	-5.70000	-1.62000	0.27500	4.45000	3.910000
Johansen Cointegration Result					
Brunei	r=0 9.18 r≤1 1.334	Cameron	r=0 07.034 r≤1 0.27	Côte d'Ivoire	r=0 5.789 r≤1 1.745
Nigeria	r=0 3.783 r≤1 1.128	South Africa	r=0 6.746 r≤1 0.1736	Togo	r=0 3.651 r≤1 1.620
Zimbabwe	r=0 29.98 r≤1 1.114				

Business Cycle Characteristics

MSIA(p)-VAR(q) models were selected for Brunei, Côte d'Ivoire , Togo and Zimbabwe and MSIAH(p)- VAR(q) models for Cameron, Nigeria and South-Africa.

The first difference or innovations of the variables is used to Markov Switching- Granger Causality analysis. MS models were selected as Akaike Information Criteria (AIC) and Likelihood Ratio (LR) test. In all models, in order to determine the number of regimes, a linear VAR is tested against a MSVAR with 2 regimes, and the null hypothesis, which hypothesizes linearity, was rejected by using the LR test statistics. Since it was observed that two regime models overruling the linear model are insufficient in explaining the relationships between the mentioned variables, 3 regime models are considered. Therefore, a MSVAR model with 2 regimes is tested against a MSVAR model with 3 regimes; H_0 hypothesis, which specifies that there are 2 regimes, was rejected and MSVAR with 3 regimes was accepted as the optimal model because of the LR statistic was greater than the 5% critical value of The first regime show recession phase in all model and second regime is moderate growth. High growth phase is regime 3.

The estimated models show strong business cycle characteristics. The persistence of regimes is observed to change from country to country. The models track fairly well the oil price crisis of 1974-75, 1979-1980, 1989-1991 and the recent 2008 crisis in Table 2 (but according to our model's result, Nigeria, Togo and Cameron don't track the 2008 crisis).

Table 3. Regime 1 Dating analysis

Nigeria	Zimbabwe	SAF	Togo
1975:1 - 1975:1 [0.9998] 1978:1 - 1979:1 [0.9998] 1981:1 - 1981:1 [0.9987] 1983:1 - 1985:1 [0.9999] 1987:1 - 1987:1 [0.9093]	1977:1 - 1978:1 [1.0000] 1982:1 - 1982:1 [0.9998] 1986:1 - 1986:1 [0.9958] 1992:1 - 1993:1 [0.9995] 1995:1 - 1995:1 [1.0000] 1997:1 - 2004:1 [0.9991] 2006:1 - 2008:1 [0.8594]	1975:1 - 1975:1 [0.9998] 1979:1 - 1980:1 [0.9987] 1985:1 - 1985:1 [0.9999] 1989:1 - 1992:1 [1.0000] 1997:1 - 1998:1 [0.9998] 2008:1 - 2008:1 [0.9998]	1979:1 - 1982:1 [1.0000] 1991:1 - 1993:1 [0.8573] 1999:1 - 1999:1 [0.9852]
Côte d'Ivoire	Brunei	Cameron	
1979:1 - 1980:1 [1.0000] 1982:1 - 1984:1 [0.8436] 1987:1 - 1987:1 [0.9532] 2009:1 - 2009:1 [1.0000]	1977:1 - 1978:1 [0.9812] 1985:1 - 1986:1 [1.0000] 1988:1 - 1991:1 [0.9981] 1998:1 - 2002:1 [0.9995] 2005:1 - 2009:1 [1.0000]	1976:1 - 1976:1 [0.9991] 1979:1 - 1980:1 [0.9991] 1987:1 - 1995:1 [0.9966]	

As expected, the total time length of expansion period (Regime 2 and Regime 3) is longer than the total time length for recession (Regime 1).

The transition probability matrix is ergodic and cannot be irreducible because the maximum eigenvalues of the matrix of transition probabilities related to MS-VAR models is one and the other two eigenvalues are less than one, the transition probability matrix is ergodic and cannot be irreducible.

It was determined to MSIAH(3)-VAR(4) for South Africa in Table A1. As the first regime characterizing the periods, 1970, 1975, 1981 are approximate dates of recessions. The first regime economy tends to last 2.01 years on average, while regime 2 is persistent (2.59 years). High growth periods tend to last 2.56 years on average. $\text{Prob}(s_t = 1|s_{t-1}=1)=0.5020$, $\text{Prob}(s_t = 2|s_{t-1}=2)= 0.6145$ and $\text{Prob}(s_t = 3|s_{t-1} = 3)= 0.6087$ suggest the persistence of moderate growth. The computed probability i.e. $\text{Prob}(s_t= 3|s_{t-1}=1) = 0.09217$ reflects the low chance that a recession is followed by a period of high growth but $\text{Prob}(s_t= 2|s_{t-1}=1) = 0.4058$ reflects the high chance that a recession is followed by a period of moderate growth. Ergodic probabilities shown that dominant regime is the first and transition probabilities, $p_{11}=0.3007$, $p_{22}=0.3165$, and p33=0.3828 report important asymmetries in business cycle.

In Table A2, MSIAH(3)-VAR(1) model that presents the best econometric performance for Nigeria was established. The transition probabilities, $\text{Prob}(s_t = 1|s_{t-1}=1)=0.6454$, $\text{Prob}(s_t = 2|s_{t-1}=2)= 0.9302$ and $\text{Prob}(s_t = 3|s_{t-1} = 3)= 0.5167$ suggest the persistence of high growth. Ergodic probabilities have shown that dominant regime is the first and transition probabilities, $p_{11}=0.1554$, $p_{22}=0.6332$ and $p_{33}=0.2115$ report important asymmetries in business cycles.

The MSIA(3)-VAR(4) model that is describe important change determined to important results for Togo in Table A3. The first regime economy tends to last 2.60 years on average, while regime 2, moderate growth regime, is persistent (17.43 years). Regime 3, which corresponds to the high growth tends to last 4.17 years on the average. The result of $\text{Prob}(s_t = 1|s_{t-1} = 1)=0.6160$, $\text{Prob}(s_t = 2|s_{t-1} = 2)= 0.9426$ and $\text{Prob}(s_t = 3|s_{t-1} = 3)= 0.7599$ have shown persistence of regimes.

In Table A4, MSIA(2)-VAR(4) model that presents the best econometric performance for Zimbabwe was established. Prob(s_t = 1|s_{t-1}=1)=0.6074, Prob(s_t = 2|s_{t-1}=2)= 0.5475 suggest the persistence of recession phase. The regime 2 tends to last 2.21 years on average; the average duration of recession phase is 2.55 years.

In Table A5 for Brunei, MSIA(2)-VAR(2) model was accepted. Regime 1 approximates the dates of recessions. Regime 2 shows growth regime. Dominant regime is the first regime. The first regime of the economy tends to last 19.0 years on average. Prob(s_t = 1|s_{t-1}=1)=0.7663, Prob(s_t = 2|s_{t-1}=2)= 0.6809 suggest the persistence of growth. Ergodic probabilities have shown that dominant regime is the first and transition probabilities, p_{11}=0.5772 and p_{22}=0.4228 report to important asymmetries in business cycles.

MSIAH(2)-VAR(4) modal established to Cameron in Table A6. Prob(s_t = 1|s_{t-1}=1)=0.8423, Prob(s_t = 2|s_{t-1}=2)= 0.9490 suggest the persistence of growth regime. The regime 2 is determined to last on average 19.62 years, the average duration of crisis phase is 6.34 years.

The MSIA(3)-VAR(1) model for Côte d'Ivoire described to important results in Table A7. The first regime economy tends to last 1.68 years on average, while regime 2 is persistent (17.35 annual). Regime 2 is found to be the most persistent, which is also confirmed by the average duration of each regime. Ergodic probabilities have shown that transition probabilities, p_{11}=0.1828, p_{22}=0.5170 and p_{33}=0.3002 report to important asymmetries in business cycles.

MS-VAR and MS- Granger Causality Result

In MSIAH(3)-VAR(4) for South Africa, the estimated coefficients of electricity consumption innovations (DLEC), and economic growth innovations (DLY) are statistically significant at conventional level in regimes except of DLEC(-4) in equation 1 in regime 2 and DLY(-3) in equation 1 and DLEC(-2) in equation 2 in regime 3. In equation 1 and 2 in regime 1, the coefficients of electricity consumption and DLY are statistically significant at conventional level. There are Granger causality from DLEC towards DLY for equation 1 and Granger causality from DLY towards DLEC for equation 2. According to the first equation, that is the equation for DLY, the DLEC appears to be Granger cause of DLY in regimes and in the second equation, that is the equation for LEC, the DLY appears to be Granger cause of electricity consumption in regimes. In sum, there are bi-directional Granger causality between the electricity consumption and the DLY in regimes.

In Table A2, in MSIAH(3)-VAR(1) model for Nigeria, the estimated coefficients of DLY innovations (DLY) are statistically significant both in the first, second, and third regime. The estimated coefficients of electricity consumption innovations (DLEC) are statistically significant at conventional level in all regimes. However, DLEC(-1) in equation 2 both in regime 1 and in regime 2, and DLY(-1) in equation 1 in regime 3 are statistically insignificant at conventional level. It is found to bi-directional causality. It is appered to be Granger causality from DLEC towards DLY for equation 1 in regimes and Granger causality from DLY towards DLEC for equation 2 in regimes. In sum, we found some evidence of bi-directional Granger causality between the electricity consumption and the DLY in the first, second and third regime.

The MSIA(3)-VAR(4) model for Togo determined that the estimated coefficients of economic growth innovations (DLY) and electricity consumption innovations (DLEC) are statistically significant in equations 1 and 2 in regimes. According to the first equations of the first, second, and third regime, that is, the equation for DLY, the DLEC appears to be Granger cause of DLY and in second equation of the first, second and third regime, the DLY appears to be Granger cause of electricity consumption. In sum, we found some evidence of bidirectional Granger causality between the electricity consumption and the DLY in recessions, moderate growth and high growth periods.

In Table A4, it was established MSIA(2)-VAR(4) model for Zimbabwe. The coefficients of distributed-lag component of EC variable are statistically significant except of DLEC(-3) in equation 1 in regime 1. The first equations of the first and the second regime, that is, for the equation of LY, the DLEC appears to be Granger cause of economic growth. It is determined that Granger Causality exists from EC to DLY in equation 1 in Regime 1 and 2. According to the second equation obtained for the first and the second regime, that is, the equation for LEC, DLY appears to be Granger cause of energy consumption, and the direction of causality is from DLY to DLEC for Equation 2. In sum, we found some evidence of bidirectional Granger Causality between the energy consumption and the DLY in recessions and moderate growth periods.

In MSIA(2)-VAR(2) model for Brunei in Table A5, the estimated coefficients of DLEC and DLY are significant both in the first regime and in the second regime. In the first and second regimes, the electricity consumption appears to be the Granger cause of DLY in equation 1 and DLY appears to be the Granger cause of electricity consumption in equation 2. In sum, we found some evidence of bidirectional GC between the energy use and the DLY in all of the regimes estimated.

According toMSIAH(2)-VAR(4) model for Cameron in Table A6, all coefficients are statistically significant. The estimated coefficients of the innovations for the energy consumption (DLEC) are statistically significant in Equation 1 for the first, second and third regimes. DLY coefficients are statistically significant at the conventional significance levels in Equation 2 for regimes. In sum, we found some evidence of bi-directional GC between the electricity consumption and the DLY in all of the regimes estimated.

The MSIA(3)-VAR(1) model that describes important changes, implies important results for Côte d'Ivoire. The estimated coefficients of electricity consumption innovations (DLEC) are significant both in the first regime, in the second regime, and in regime 3. In the first equations in all regimes, i.e. the equation for DLY, the EC is determined to be the Granger cause of economic growth. In the second equations in regimes, i.e. the equation for DEC, the DLY is determined to be the Granger cause of electricity consumption. In sum, there is some evidence of bidirectional Granger Causality between the electricity consumption and economic growth.

Traditional Granger Causality Result

For comparison, the standard Granger causality test was tested for same data sets. The results are reported in Table 5. There is evidence to support the growth hypothesis for Brunei. There is a unidirectional relationship from electricity consumption to real GDP, which means that electricity consumption acts as a stimulus to economic growth. There is evidence to support the conservation hypothesis for Togo, Zambia and Zimbabwe. Bi-directional causality was confirmed for Nigeria, South Africa.

Table 5. Results of Linear Granger Causality

Countries	$\Delta EC \rightarrow \Delta Y$ $\Delta Y \rightarrow \Delta EC$ *F statistic for SR- GC*
Nigeria	72.5018 59.3389
South Africa	306.8788 16.6168
Togo	0.3526 66.145
Zambia	0.27891 234.51
Zimbabwe	2.2590 184.594
Brunei	0.1568 1.47893
Cameron	0.578 1.14587
Côte d'Ivoire	0.2345 15.15236

5. Conclusion

To analyze the Granger causality between electricity consumption and economic growth in some African and Asia countries, Markov Switching VAR method is used. It is possible to detect the changes in the behavior of the variables with MS-VAR models. Different MS-VAR models are estimated and the best model is selected based on AIC and LR test. The first difference of these variables is used in the modeling process. The results from these models show that in regime one, two, andthree, EC is the Granger cause of the GDP and GDP is the Granger cause of the EC. In sum, we found some evidence of bidirectional Granger Causality between the EC and the GDP.

The results highlight the importance of electricity consumption policies on economic growth, economic development and welfare. The current energy policy and the electricity sector restructuring process should be designed to meet this goal. The energy policies aimed at improving the energy infrastructure in the context of our findings regarding the MS-VAR method suggest that increasing the energy supply lies ahead as an appropriate option for economic growth.

As Nondo, Kahsai, Schaeffer (2010) stated, it is reasonable to conclude that, one factor explaining African countries' poor economic growth is the lack of investments in energy infrastructure and services. Thus, the current low investment in energy infrastructure may be an obstacle that may prevent some African countries from reaching the Millennium Development Goals. The energy related problems are and will be crucial policy issues for African countries.

References

Adebola,S.S., 2011. Electricity Consumption and Economic Growth: Trivariate investigation in Botswana with Capital Formation, *International Journal of Energy Econ. Pol.* 1(2);32-46

Akarca, A.T., Long, T. V., 1980. On the relationship between energy and GNP: a re-examination, *Journal of Energy and Development*. 5; 326-331.

Akinlo AE., 2009. Electricity consumption and economic growth in Negeria: Evidence from cointegration and co-feature analysis. *Journal of Policy Modelling*, 31, 681-693

Amusa, H., Amusa, K., Mabugu, R., 2009. Aggregate demand for electricity in South Africa: An analysis using the bounds testing approach to cointegration. Energy Policy. 37, 4167-4175.

Asafu-Adjaye, J., 2000. The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries, *Energy Economics*, 22; 615-625

Babatunde M.A. Shuaibu M.İ., 2009. The Demand for residential electricity in Nigeria: A bound testing approach, http://www.africametrics.org/documents/conference09/papers/Babatunde_Shuaibi.pdf

Belloumi, M., 2009. Energy consumption and GDP in Tunisia: cointegration and causality analysis. *Energy Policy*, 37(7), 2745-2753.

De Vita, G., Endresen, K., Hunt, L.C., 2006. An empirical analysis of energy demand in Namibia. Energy Policy, 34, 3447–3463

Ebohon, O.J., 1996. Energy, economic growth and causality in developing countries: a case study of Tanzania and Nigeria. *Energy Policy*, 24, 447–453

Elliott G, Rothenberg TJ, Stock JH. Efficient tests for an autoregressive unit root. *Econometrica* 1996;64:813-36.

Erol,U., Yu, E.S.H.1987. On the relationship between electricity and income for industrialized countries. *Journal of Electricity and Employment*, 13, 113–122.

Falahi F. 2011. Causal relationship between energy consumption (EC) and GDP: A Markov-switching (MS) causality. Energy. 36(7): 4165–4170.

Fatai, K., Oxley, L., Scrimgeour, F.G., 2004. Modeling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia., The Philippines and Thailand. *Math. Comput. Simul.* 64, 431–445.

Ghosh, S., 2002. Electricity consumption and economic growth in India. Energy Policy. 30, 125–129

Hamilton, J. D. 1989. "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," *Econometrica*, 57(2), 357-84,

Hamilton, J. D. 1990. Analysis of Time Series Subject to Changes in Regime," *Journal of Econometrics*, 45; 39-70.

Huang B.N., Hwang M.J., Yang, C.W., 2008. Causal relationship between energy consumption and GDP growth revisited: A dynamic panel data approach. *Ecological Economy*. 6 7, 4 1 – 5 4

Jaunky, C. Vishal., 2006. Income Elasticities of Electric Power Consumption: Evidence from African Countries. *Reg. Sec. Econ. Stud*. 7, 25-50.

Jefferis. K., (2008), Summary of Economic Developments. BIFM Economic Review 1st Quarter, 2008

Jumbe, Charles B. L., 2004. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Economics. 26(1), 61-68.

Kebede, E., Kagochi, J., Jolly, C. M., 2010. Energy consumption and economic development in Sub-Sahara Africa. Energy Economics, 32(3), 532–537.

Kouakou A.K., (2011), Economic Growth and Electricity Consumption in Côte d'Ivoire: Evidence from Time Series Analysis. Energy Policy, 39, 3638-3644

Kraft, J., Kraft A., 1978. On the Relationship between Energy and GNP. Journal of Energy and Development, 401-403.

Krolzig H-M. 1997. Markov-Switching Vector Autoregressions: Modelling, Statistical Inference, and Application to Business Cycle Analysis. Lecture Notes in Economics and Mathematical Systems No. 454.

Krolzig H-M. 2000. Predicting Markov-switching vector autoregressive processes. Unpublished manuscript, Nuffield College, University of Oxford

Lee, C.C., 2005. Energy consumption and GDP in developing countries: a cointegrated panel analysis. *Energy Economics,* 27, 415-427.

Mehrara, M., 2007. Energy consumption and economic growth: The case of oil exporting countries. *Energy Policy*, 35 (5), 939-2945.

Narayan PK., 2005. The saving and investment nexus for China: evidence for cointegration tests. *Applied Economics*, 37,1979–1990

Narayan P.K, Smyth R., 2005. Electricity consumption, employment, and real income in Australia: evidence from multivariate Granger causality tests. *Energy Policy*, 33,1109–16.

Narayan, P.K. Smyth,R., 2005/b. Residential demand for electricity in Australia: an application of the bounds testing approach to cointegration. *Energy Policy*, 33, 467–474.

Narayan, P.K. and Singh,B., 2007. The electricity consumption and GDP nexus for the Fiji Islands. *Energy Economics*, 29,1141–1150.

Ng S, Perron P. Lag length selection and the construction of unit root tests with good size and power. *Econometrica* 2001;69:1519-54.

Nondo C., Kahsai Mulugeta S., Schaeffer Peter V.,2010. Energy Consumption and Economic Growth: Evidence from COMESA Countries. Research Papers 2010-1

Odhiambo, N.M., 2009. Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach. *Energy Policy*, 37, 617–622.

Odhiambo N. M., 2009. Electricity consumption and economic growth in South Africa: A trivariate causality test. *Energy Economics*, 31(5), 635–640.

Ouédraogo Idrissa M., 2010. Electricity consumption and economic growth in Burkina Faso: A cointegration analysis. *Energy Economics*, 32, 524–531

Rasche, R.H., Tatom, J.A., 1977. The effects of the new energy regime on economic capacity, production, and prices. Fed. Reserve Bank of St. Louis, May, 2-12

Rosenberg N., 1998. The role of electricity in industrial development. *The Energy Journal,* 19 ,7–24.

Squalli J.(2007), Electricity consumption and economic growth: bounds and causality analyses of OPEC countries, *Energy Economics*,29:1192–205.

Warne A. 2000.Causality and Regime Inference in a Markov Switching VAR, December 5,

Psaradakis, Ravn M. Sola M. 2005. Markov switching causality and the money–output relationship, *Journal of Applied Econometrics*, 20(5); 665–683.

Wolde-Rufael Y W., 2005. Energy demand and economic growth: The African experience. *Journal of Policy Modelling* 27, 891–903

Wolde-Rufael Y., 2006. Electricity consumption and economic growth: a time series experience for 17 African countries. *Energy Policy*, 34,1106–14.

Toman, M., Jemelkova, B., 2003. Energy and Economic Development: An Assessment of the State of Knowledge. *Energy Journal,* 24, 93-112.

Toman, M., 2003. The Roles of the Environment and Natural Resources in Economic Growth Analysis. Discussion Papers -02-71.

Yu, E. S. H., Choi, J. Y., 1985. The Causal Relationship between Energy and GNP : An International Comparison. *Journal of Energy and Development.* 10, 249-272.

Ziramba E., 2008. The demand for residential electricity in South Africa. *Energy Policy*, 36,3460–3466.

APPENDIX

Table A1. SAF MSIAH(3)-VAR(4) model, Estimation sample: 1969 - 2010

	Reg 1			Reg 2			Reg 3	
	DLEC		DLY	DLEC		DLEC		EC
C	0.031001 (6.14)	-0.051201 (-3.91)	C	0.025871 (5.1239	0.015939	c	0.022363 (0.4437)	0.037509 (2.86)
DLY _1	1.006579 (19.93)	-0.655491	DLY _1	0.427225 (8.544)	0.448936	DLY _1	0.123854 (2.4530)	-0.274388 (-2.09805)
DLY _2	-0.023311 (-4.61)	-0.176231 (2.8261)	DLY _2	0.246258 (3.8789)	0.163129 (4.877)	DLY _2	0.306410 (6.0638)	-0.619903 (-4.7441)
DLY _3	-0.033194 (-6.57)	0.550971 (4.21425)	DLY _3	0.324607 (6.445)	-0.524266 (-4.009)	DLY _3	0.062399 (1.2458)	0.625919 (4.7889)
DLY _4	-0.326838 (-6.47)	-0.728346 (-5.57094)	DLY _4	-0.385105 (-7.627)	-0.216817 (-6.583)	DLY _4	-0.062641 (-2.40661)	-0.509286 (-3.895)
DLEC_1	-0.809436 (-16.03)	1.293836 (9.8995)	DLEC_1	-0.236950 (-4.693)	-0.387806 (-2.9662)	DLEC_1	0.032344 (6.4062)	0.392414 (3.00148)
DLEC _2	0.104793 (2.7551)	0.269384 (2.06047)	DLEC _2	-0.293891 (-5.8207)	0.354491	DLEC _2	-0.181750 (-3.5997)	-0.245969 (1.8813)
DLEC _3	0.326926 (6.475)	-0.159431 (-1.219)	DLEC _3	-0.094899 (-1.879)	0.359971 (2.753)	DLEC _3	-0.049016 (-9.70806)	-0.139215 (-10.648)
DLEC _4	-0.376906 (-7.4648)	0.360491 (2.7573)	DLEC _4	-0.006956 (-1.3778)	0.318373 (2.4334)	DLEC _4	0.201482 (3.99053)	0.436181 (3.3362)
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2	Regime 3	
Regime 1	10.5	0.3007	2.01	Regime 1	0.5020	0.4058	0.09217	
Regime 2	10.8	0.3165	2.59	Regime 2	8,07E-10	0.6145	0.3855	
Regime 3	12.8	0.3828	2.56	Regime 3	0.3912	5,86E-02	0.6087	

log-likelihood : 206.3896 linear system : 165.6000 , AIC criterion : -8.4347 linear system : -8.5059; LR linearity test: 81.5792 Chi(36) =[0.0000] ** Chi(42)=[0.0002] ** DAVIES=[0.0011] **

StdResids: Vector portmanteau(9): Chi(20)= 32.5308 [0.0124] *, StdResids: Vector normality test : Chi(4)= 9.0422 [0.0601], StdResids: Vector hetero test: Chi(48)= 40.1758 [0.7816] F(48,21) = 0.3121 [0.9996], PredError: Vector portmanteau(9): Chi(20)= 22.1476 [0.3326], PredError: Vector normality test : Chi(4)= 12.5988 [0.0134] *, PredError: Vector hetero test: Chi(48) = 62.2354 [0.0813] F(48,21)= 0.8197 [0.7218] ,VAR Error: Vector portmanteau(9): Chi(20)= 23.3649 [0.2712] VAR Error: Vector normality test : Chi(4)= 3.0898 [0.5429], VAR Error: Vector hetero test: Chi(48)= 44.9525 [0.5985] F(48,21) = 0.3780 [0.9973]

Table A2. Nigeria, MSIAH(3)-VAR(1) model of (Y, EC) Estimation sample: 1973-2010

	Reg 1			Reg 2			Reg 3	
	DLEC		DLY	DLEC		DLY	DLEC	EC
c	-0.05418 (-1.1436)	0.096609 (0.51954)	c	0.004538 (0.25913)	0.003725 (0.5102)	c	0.017456 (0.574)	0.194363 (1.5963)
DLY _1	-0.68019 (3.965)	1.411527 (7.5928)	DLY _1	0.65157 (3.832)	1.8845 (2.546)	DLY _1	-0.04438 (-1.464)	-0.82913 (6.796)
DLEC_1	-0.13918 (-2.9421)	-0.45379 (0.24523)	DLEC_1	-0.03016 (-7.543)	-0.53649 (-1.724)	DLEC_1	0.10839 (2.4587)	-0.39413 (-2.7853)
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2	Regime 3	
Regime 1	7.9	0.1554	1.55	Regime 1	0.6454	0.001536	0.3531	
Regime 2	19.0	0.6332	14.32	Regime 2	0.010	0.9302	0.04983	
Regime 3	10.0	0.2115	1.46	Regime 3	0.3754	0.1080	0.5167	

log-likelihood : 113.8127 linear system : 75.3041, AIC criterion : -4.3683 linear system : -3.5840, LR linearity test: 77.0173 Chi(18) =[0.0000] ** Chi(24)=[0.0000] ** DAVIES=[0.0000] **

StdResids: Vector portmanteau(5): Chi(16)= 18.4508 [0.2982], StdResids: Vector normality test : Chi(4)= 5.3940 [0.2492], StdResids: Vector hetero test: Chi(12)= 11.2666 [0.5062] F(12,74)= 0.8254 [0.6240], StdResids: Vector hetero-X test: Chi(15)= 17.2973 [0.3014] F(15,74)= 1.1019 [0.3700], PredError: Vector portmanteau(5): Chi(16)= 22.0079 [0.1429], PredError: Vector normality test : Chi(4)= 8.6791 [0.0696], PredError: Vector hetero test: Chi(12) = 14.3501 [0.2789] F(12,74)= 1.0861 [0.3842], PredError: Vector hetero-X test: Chi(15) = 14.5490 [0.4844] F(15,74)= 0.8492 [0.6213], VAR Error: Vector portmanteau(5): Chi(16) = 25.0175 [0.0695], VAR Error: Vector normality test : Chi(4)= 7.4082 [0.1158], VAR Error: Vector hetero test: Chi(12) = 21.9931 [0.0376] * F(12,74)= 1.9650 [0.0398] * , VAR Error: Vector hetero-X test: Chi(15)= 22.3106 [0.0999] F(15,74) = 1.5316 [0.1161]

Table A3. Togo, MSIA(3)-VAR(4) model of (Y,EC) Estimation sample: 1976 - 2009

	Reg 1			Reg 2			Reg 3	
	DLY	DLEC		DLY	DLEC	DLY	DLEC	
c	-0.035868 (2.7787)	0.010779 (0.375)	c	-0.012201 (1.0012)	0.038693 (1.3569)	c	-0.032953 (-2.538)	0.164505 (5.714)
DLY _1	0.155715 (1.206)	-0.986069	DLY _1	-0.106970 (-8.2236)	0.023444 (0.816)	DLY _1	-0.255459 (-2.00123)	-2.198808 (-7.582)
DLY _2	0.582501 (4.83)	-1,01829 (-3.636)	DLY _2	0.034453 (2.65)	0.240537 (2.67)	DLY _2	-0.455021 (-3.507)	0.741232 (2.5551)
DLY _3	1.322715 (10.285)	5,59705 (5.9014)	DLY _3	-0.279444 (2.146)	-0.970489 (-3.381)	DLY _3	-0.493336 (3.8076)	-1.018256 (-3.546)
DLY _4	-0.218372 (-1.891)	3,43505 (11.986)	DLY _4	0.200364 (2.0986)	0.056906 (1.896)	DLY _4	-0.999730 (-8.325)	0.535206 (18.818)
DLEC_1	-0.311238 (2.60012)	-0.553029 (-0.1256)	DLEC_1	0.136094 (10.79)	-0.146160 (-5.2685)	DLEC_1	0.063743 (4.887)	0.694534 (2.413)
DLEC _2	0.054843 (4.57)	0.043131 (1.535)	DLEC _2	-0.131815 (-10.76)	-0.015448 (-5.34)	DLEC _2	0.275166 (2.756)	-0.845406
DLEC _3	-0.248021 (-1.9226)	-1,23466 (-4.0945)	DLEC _3	0.031421 (0.2458)	0.088984 (3.0681)	DLEC _3	1.357119 (10.4685)	0.700539 (2.142)
DLEC _4	-0.206265 (-17.180)	-0.868346 (-1.2825)	DLEC _4	0.71729 (5.5538)	-0.175035 (-6.0685)	DLEC _4	0.321829 (1.2458)	-1.009976 (-0.7896)
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2	Regime 3	
Regime 1	8.0	0.1709	2.60	Regime 1	0.6160	0.2438	0.1402	
Regime 2	18.4	0.7293	17.43	Regime 2	0.03738	0.9426	0.010	
Regime 3	7.6	0.0998	4.17	Regime 3	0.2381	0.001962	0.7599	

log-likelihood : 163.0701 linear system : 82.2293, AIC criterion : -5.8865 linear system : -3.6017, LR linearity test: 161.6815 Chi(36) =[0.0000] ** Chi(42)=[0.0000] ** DAVIES=[0.0000] **

StdResids: Vector portmanteau(9): Chi(20)= 24.9259 [0.2043], StdResids: Vector normality test : Chi(4)= 17.8478 [0.0013] **, StdResids: Vector hetero test: Chi(48)= 43.9172 [0.6408] F(48,21)= 0.3690 [0.9978], Vector hetero-X test: Chi(99)=102.0000 [0.3981] F(99,-29)= -0.1692 [0.0000] ** PredError: Vector portmanteau(9): Chi(20)= 34.0968 [0.0255] *, PredError: Vector normality test : Chi(4) = 31.3581 [0.0000] **, PredError: Vector hetero test: Chi(48) = 86.9373 [0.0005] ** F(48,21)= 3.3773 [0.0018] ** , Vector hetero-X test: Chi(99) =102.0000 [0.3981] F(99,-29) = 0.2933 [0.0000] **, VAR Error: Vector portmanteau(9): Chi(20)= 21.9605 [0.3427], VAR Error: Vector normality test : Chi(4)= 15.4012 [0.0039] **, VAR Error: Vector hetero test: Chi(48)= 50.4264 [0.3777] F(48,21)= 0.5084 [0.9732], Vector hetero-X test: Chi(99) =102.0000 [0.3981] F(99,-29)= 0.2933 [0.0000] **

Table A4. Zimbabwe, MSIA(2)-VAR(4) model of (Y, EC) Estimation sample: 1976 - 2010

	Reg1			Reg 2		
	DLY	DLEC		DLY	DLEC	
c	-0.025883 (-0.987)	0.011510 (0.4045)	c	0.029745 (1.142)	0.031515 (1.523)	
DLY _1	-0.221042 (-8.25)	0.518973 (8.025)	DLY _1	0.381306 (4.148)	-0.739676 (-2.645)	
DLY_2	0.265618 (7.245)	-0.17142 (-4.652)	DLY_2	-0.034091 (-1.311)	-0.74158 (-3.52)	
DLY_3	-0.045239 (-6.4256)	-0.0108 (-0.3856)	DLY_3	0.421853 (6.264)	-0.23931 (-8.356)	
DLY_4	0.44279 (1.666)	-0.30202 (5.145)	DLY_4	-0.365900 (-5.0123)	0.026966 (0.936)	
DLEC_1	0.148001 (5.5521)	-0.13365 (3.642)	DLEC_1	0.750739 (2.62)	-0.046558 (-2.238)	
DLEC_2	1.287795 (4.067)	-0.19966 (-0.135)	DLEC_2	-0.881678 (-3.085)	0.714527 (2.536)	
DLEC_3	-0.29073 ((-1.536)	-0.01096 (-0.8236)	DLEC_3	-0.408765 (-2.7895)	-0.442691 (-1.5571)	
DLEC_4	-0.885284 (-3.826)	0.12062 (4.307)	DLEC_4	-0.051569 (-1.907)	0.049393 (1.689)	
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2
Regime 1	17.6	0.5355	2.55	Regime 1	0.6074	0.3926
Regime 2	15.4	0.4645	2.21	Regime 2	0.4525	0.5475
log-likelihood : 137.9320 linear system : 114.4792, AIC criterion : -5.8747 linear system : -5.6654, LR linearity test: 46.9054 Chi(18) =[0.0002] ** Chi(20)=[0.0006] ** DAVIES=[0.0072] **						
StdResids: Vector portmanteau(9): Chi(20) = 22.4051 [0.3189], StdResids: Vector normality test : Chi(4) = 14.6649 [0.0054] **, StdResids: Vector hetero test: Chi(48) = 36.4280 [0.8892] F(48,18)= 0.2444 [1.0000], Vector hetero-X test: Chi(96)= 99.0000 [0.3965] F(96,-29)= -0.0996 [0.0000] **, PredError: Vector portmanteau(9): Chi(20)= 29.5392 [0.0777], PredError: Vector normality test : Chi(4)= 0.8040 [0.9379], PredError: Vector hetero test: Chi(48)= 59.6213 [0.1212] F(48,18)= 0.6569 [0.8764], Vector hetero-X test: Chi(96)= 99.0000 [0.3965] F(96,-29)= 0.3025 [0.0000] ** , VAR Error: Vector portmanteau(9): Chi(20)= 26.0665 [0.1636], VAR Error: Vector normality test : Chi(4)= 12.2172 [0.0158] *, VAR Error: Vector hetero test: Chi(48)= 39.9649 [0.7887] F(48,18)= 0.2793 [0.9998], Vector hetero-X test: Chi(96) = 99.0000 [0.3965] F(96,-29) = 0.3025 [0.0000] **						

Table A5. Brunei, MSIA(2)-VAR(2) model Estimation sample : 1973-2010

	Reg 1			Reg 2		
	DLY	DLEC		DLY	DLEC	
c	-0.000313 (0.020)	0.012655 (0.44)	c	0.081552 (5.12)	0.111452 (1.82)	
DLY-1	0.454980 (3.032)	-0.042076 (2.502)	DLY-1	-0.637770 (3.98)	0.351346 (2.473)	
DLEC-1	0.110258 (2.1536)	0.105142 (3.755)	DLEC-1	0.829220 (5.187)	0.441590 (5.5102)	
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2
Regime 1	19.0	0.5772	4.28	Regime 1	0.7663	0.2337
Regime 2	15.0	0.4228	3.13	Regime 2	0.3191	0.6809
log-likelihood : 100.0018 linear system : 86.6227, AIC criterion : -4.8825 linear system : -4.5660, LR linearity test: 26.7581 Chi(6) =[0.0002] ** Chi(8)=[0.0008] ** DAVIES=[0.0039] **						
StdResids: Vector portmanteau(5): Chi(16)= 17.9282 [0.3281], StdResids: Vector normality test : Chi(4)= 13.6378 [0.0085], StdResids: Vector hetero test: Chi(12)= 16.8301 [0.1561] F(12,66)= 1.4640 [0.1607], StdResids: Vector hetero-X test: Chi(15)= 26.3808 [0.0342] * F(15,66)= 2.5027 [0.0055] **, PredError: Vector portmanteau(5): Chi(16)= 20.5676 [0.1957], PredError: Vector normality test : Chi(4)= 10.2170 [0.0369] *, PredError: Vector hetero test: Chi(12)= 26.8893 [0.0080] ** F(12,66)= 2.8879 [0.0029] **, PredError: Vector hetero-X test: Chi(15)= 31.4264 [0.0077] ** F(15,66)= 2.5785 [0.0043] **, VAR Error: Vector portmanteau(5): Chi(16)= 14.6660 [0.5492], VAR Error: Vector normality test : Chi(4)= 17.5599 [0.0015] **, VAR Error: Vector hetero test: Chi(12)= 28.1585 [0.0052] ** F(12,66)= 3.1341 [0.0014] **, VAR Error: Vector hetero-X test: Chi(15)= 35.2385 [0.0023] ** F(15,66) =						

Table A6. Cameron, MSIAH(2)-VAR(4) model Estimation sample :1976 - 2009

	Reg 1			Reg 2			Reg 3	
	DLY	DLEC		DLY	DLEC		DLY	DLEC
c	-0.0268 (1.928)	-0.0136 (0.755)	c	0.023218 (1.714)	0.050856 (2.822)	c	0.004995 (0.357)	0.154583 (8.88)
DLY-1	-2.744705 (-1.9965)	6.078346 (3.377)	DLY-1	0.277373 (2.0012)	0.348708 (1.9445)	DLY-1	0.251331 (1.9857)	0.612150 (3.52)
DLEC-1	2.345 (6.78)	2.868 (5.931)	DLEC-1	-0.076332 (5.452)	0.079906 (4.444)	DLEC-1	0.559936 (4.011)	-0.449456 (2.569)
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2		
Regime 1	12.0	0.2443	6.34	Regime 1	0.8423	0.1577		
Regime 2	12.0	0.7557	19.62	Regime 2	0.0510	0.9490		
log-likelihood : 142.9899 linear system : 99.0073, AIC criterion: -5.8229 linear system : -4.5887 , LR linearity test: 87.9653 Chi(21) =[0.0000] ** Chi(23)=[0.0000] ** DAVIES=[0.0000] **HQ								
StdResids: Vector portmanteau(5): Chi(16) = 25.8103 [0.0568] , StdResids: Vector normality test : Chi(4)= 5.3610 [0.2522] , StdResids: Vector hetero test: Chi(12)= 10.7119 [0.5538] F(12,74)= 0.7845 [0.6644] , StdResids: Vector hetero-X test: Chi(15)= 15.2032 [0.4369] F(15,74)= 0.9280 [0.5378], PredError: Vector portmanteau(5): Chi(16)= 6.6390 [0.9796] , PredError: Vector normality test : Chi(4)= 42.6151 [0.0000] **, PredError: Vector hetero test: Chi(12)= 24.8735 [0.0154] * F(12,74)= 2.5883 [0.0063] ** , PredError: Vector hetero-X test: Chi(15) = 28.8434 [0.0168] * F(15,74)= 2.2949 [0.0099], VAR Error: Vector portmanteau(5): Chi(16)= 11.4574 [0.7804] , VAR Error: Vector normality test : Chi(4)= 39.3376 [0.0000] ** , VAR Error: Vector hetero test: Chi(12)= 38.1563 [0.0001] F(12,74)= 4.4077 [0.0000] ,VAR Error: Vector hetero-X test: Chi(15)= 43.4429 [0.0001] , F(15,74)= 4.1226 [0.0000] **								

Table A7. Cote d'Ivoire, MSIA(3)-VAR(1) model of (Y, EC) Estimation sample: 1973 - 2009

			Reg 1			Reg 2		
	DLY	DLEC		DLY	DLEC		DLY	DEC
c	-0.037207 (1.407)	0.082154	c	-0.014125 (0.55)	0.051580 (0.912)	c	0.021880 (0.814)	0.134233 (2.5001)
DLY-1	0.657027 (2.44)	3.513985 (5.866)	DLY-1	0.413918	0.437693	DLY-1	0.342349 (2.962)	0.480106 (8.596)
DLEC-1	-0.430939 (6.66)	-0.1917 (3.363)	DLEC-1	0.182827	-0.301070	DLEC-1	-0.074285 (2.74)	-0.32850 (5.78)
	nObs	Prob.	Duration	Transition probabilities	Regime 1	Regime 2	Regime 3	
Regime 1	6.7	0.1828	1.68	Regime 1	0.5939	0.100	0.3061	
Regime 2	19.6	0.5170	17.35	Regime 2	0.05709	0.9424	0.0005380	
Regime 3	10.7	0.3002	2.76	Regime 3	0.2633	0.09922	0.6375	
log-likelihood : 129.0714 linear system : 106.5419, AIC criterion : -5.5174 linear system : -5.2725, LR linearity test: 45.0591 Chi(12) =[0.0000] ** Chi(18)=[0.0004] ** DAVIES=[0.0004] **								
StdResids: Vector portmanteau(5): Chi(16) = 13.4903 [0.6366], StdResids: Vector normality test : Chi(4) = 12.6118 [0.0133] *, StdResids: Vector hetero test: Chi(12) = 6.1391 [0.9089] F(12,74) = 0.4172 [0.9522], StdResids: Vector hetero-X test: Chi(15)= 6.6043 [0.9677] F(15,74)= 0.3489 [0.9871], PredError: Vector portmanteau(5): Chi(16)= 16.0762 [0.4477] , PredError: Vector normality test : Chi(4) = 19.0308 [0.0008] **, PredError: Vector hetero test: Chi(12)= 31.2422 [0.0018] ** F(12,74) = 3.5261 [0.0004] **, PredError: Vector hetero-X test: Chi(15)= 33.4436 [0.0041] ** F(15,74) = 2.9063 [0.0012] **, VAR Error: Vector portmanteau(5): Chi(16)= 12.5387 [0.7061], VAR Error: Vector normality test : Chi(4)= 16.9443 [0.0020] **, VAR Error: Vector hetero test: Chi(12)= 21.2896 [0.0463] * F(12,74) = 1.9740 [0.0388] *, VAR Error: Vector hetero-X test: Chi(15)= 24.0379 [0.0645] F(15,74) = 1.7761 [0.0546]								