Evidence of Structural Breaks in Kenya Macroeconomic Variables

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Abstract

This paper endogenously determines the timing of structural breaks in Kenya's macroeconomic variables covering 11 monthly (October 1997 to march 2013) and 17 annual series (1973 to 2011). The results show both mean shifts and breaks in trend in a number of variables. The identified structural breaks coincide with identifiable climatic, economic and political shocks. Given the evidence of structural breaks in many of the series, we apply unit root tests in the presence of breaks and find that the mean shifts in real GDP per capita and breaks in the trend in exports and imports bias the conventional tests towards non rejection of nonstationarity. The finding that there are structural breaks in key macroeconomic variables should be taken into account in econometric modelling and forecasting in Kenya; otherwise, ignoring them can lead to model misspecification and spurious results of model parameters.

Key words: *Structural Breaks, Parameter stability, Unit root test, Kenya*

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The views and opinions expressed in this paper are those of the authors and do not reflect the position of Central Bank of Kenya, Kenya School of Monetary Studies or the USAID/Kenya.

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1.0 Introduction

The subject of structural change is of considerable importance in the analysis of macroeconomic time series. Structural change occurs in time series data for a number of reasons, including economic crises, changes in institutional arrangements, policy changes and regime shifts among others. Most importantly, if structural changes are present in the data generating process but not incorporated in the unit root test specification, results may be biased towards flawed non-rejection of the non-stationarity hypothesis (Perron, 1989; Perron, 1997; Leybourne and Newbold, 2003). The consequence of such a result in turn implies that any shock – whether demand, supply, or policy-induced – to the variable will have effects on the variable into the very long run. This also may affect accuracy in forecasting.

Rich and growing literature on the theoretical underpinnings of structural breaks, estimation and practical application has been in existence for more than two decades. A brief scan of literature reveals that there is a dearth of empirical study on this issue within the African context. A few studies that focus on African countries include Allaro et al. (2011) for Ethiopia and Emerson, Jamie and Chihwa Kao (2006) that examine a sample of African countries. Emerson et al. (2006) use panel estimation to test for structural changes in GDP growth, consumption growth and productivity growth. One of the reasons for the scarcity of empirical studies on developing countries is unavailability of reliable long-term time series data. However, improvements in data compilation in recent years make the time series analysis and accompanying diagnostic tests possible.

The literature identifies two problems with structural break estimation. First is the difficulty of differentiating data that is subject to a structural break from data having a unit root. Second, although break locations in data can be estimated consistently, there is no efficiency condition for the limiting distribution of the estimates. Although consistency is a sufficient condition for the purpose of many empirical studies, efficiency could still be of interest if the aim is to obtain the smallest confidence intervals around the break dates. The stated reason behind these difficulties of estimating structural breaks is that the problem is nonstandard; a break date only appears under the alternative hypothesis, not under the null of no break. Perron (2005) makes a comprehensive review of both problems.

With regard to dating of breaks, conventionally, the dating of the potential break is assumed to be known *a priori*. Test statistics are then constructed by adding dummy variables representing different intercepts and slopes, thereby extending the standard Dickey-Fuller procedure (Perron, 1989). However, this standard approach has been criticized. For instance, Christiano (1992) argued that this approach invalidates the distribution theory underlying conventional testing. A number of studies have developed different methodologies for determining dates endogenously, including Zivot and Andrews (1992), Lumsdaine and Papell (1997, Vogelsand and Perron (1998),) and Bai and Perron (2003). They have shown that by endogenously determining the time of structural breaks, bias in the usual unit root tests can be reduced.

This paper applies single structural break test as developed by Zivot and Andrews (1992), Vogelsang and Perron (1998), and the multiple break point estimation of Bai and Perron (1998, 2003). We make use of these approaches on a set of monthly and annual data for Kenya. We then test for unit root allowing for structural breaks. These include the nominal effective exchange rate (NEER), real effective exchange rate (REER), inflation, exchange rate, consumer price index (CPI), current account balance (CAB) with and without oil component, lending rate, domestic credit and domestic credit growth, international reserves, money supply, stock market prices (SMP), 91days treasury bill (TB91) rate, Gross Domestic Product (GDP) real and nominal, GDP growth, GDP deflator, exports, imports, gross capital formation (GCF), gross fixed capital formation (GFCF), gross domestic savings (GDS), and consumption expenditure.

2.0 Literature Review

Macroeconomic data reflects different trends and pattern during different phases of an economic, social and political cycle. Changes in these phases, may affect economic relationship between variables and hence, stability of parameters over a period of analysis. These can lead to misspecification and misleading inferences due to inefficiency and lack of consistency of parameters (Yang, 2002). Therefore, adopting linear models whose functional forms assume relationship between variables is constant for all variables might not report robust results which may affect forecasting.

The literature depicts an intricate play between unit roots and structural breaks (Perron 1989, 2005). Most tests that attempt to distinguish between a unit root and a (trend) stationary process will favour the unit root model when the true process is subject to structural changes. However, the process could be (trend) stationary within regimes specified by the break dates. Also, most tests trying to assess whether a structural change is present will reject the null hypothesis of no structural change when the process has a unit root component. Accordingly, there is voluminous literature on testing for a unit root under structural break(s). The literature ranges from single arbitrarily determined break (Perron, 1989) to endogenously determined break (Zivot and Andrews, 1992; Perron, 1997; Vogelsang and Perron, 1998), to simultaneous two and multiple endogenous breaks (Lumsdaine and Papell, 1997; Lee and Strazicich, 2003; Bai and Perron, 1998, 2003: Maheu and Song, 2012).

Perron (1989) influential study tests a null hypothesis of unit root under the assumption of known (exogenous, pre-tested) break date in both null and alternative hypotheses. Later Christiano (1992) criticizes Perron's known date assumption by arguing that considering the timing of the break as an exogenously known event invalidates the distribution theory underlying conventional testing (Vogelsang and Perron, 1998). Since Perron's work, several studies have proposed different methodologies with an aim of determining the break date endogenously. Some of these include Banerjee, Lumsdaine and Stock (1992), Zivot and Andrews (1992), Perron and Vogelsang (1992), Perron (1997), Lumsdaine and Papell (1998) and Bai and Perron (1998, 2003). These studies have shown that bias in the usual unit root tests can be reduced by endogenously determining the time of structural breaks.

Zivot and Andrews (1992) proposed a unit root test based on sequential Dickey-Fuller test that treats the breakpoint as endogenous. They find less evidence against unit root hypothesis than Perron (1989). Zivot and Andrews (ZA) test utilizes the full sample and uses a different dummy variable for each possible break date. The break date is selected where the t-statistic from the ADF test of unit root is at a minimum. The critical values in Zivot and Andrews (1992) are different to the critical values in Perron (1989). The difference is due to the fact that selecting of the time of the break is treated as the outcome of an estimation procedure, rather than predetermined exogenously.

ZA work was extended by Perron and Vogelsang (1992) and Perron (1997) who proposed a class of test statistics that allows for two different forms of structural break allowing for changes in both level and trend in the series. These are: the Additive Outlier (AO) and Innovational Outlier (IO) models. The AO model allows for a sudden change in mean, while the IO model allows for changes that are gradual. Perron and Vogelsang (1992) argue that these tests are based on the minimal value of t statistics on the sum of the autoregressive coefficients over all possible breakpoints in the appropriate autoregression. Perron and Vogelsang (1992) applied these two models for non-trending data, while Perron (1997) modified them for use with trending data. Since the approach allows for identification of possible structural break date, then it avails valuable information for analysing whether a structural break on a certain variable is associated with particular political, economic, institutional or social occurrences such as government policy, economic crises, war, and regime shifts.

Lumsdaine and Papell (1997) extended the ZA test and introduced a new procedure to capture two structural breaks. They argued that unit root test that account for two structural breaks (if significant) is more powerful than those, which only allows for one single break. Bai and Perron (1998) developed tests for multiple structural changes. According to Lee and Strazicich (2001, 2003), minimum Lagrangian Multiplier (LM) unit root test assumes breaks in the null hypothesis and allows for more than one endogenously determined structural break in the unit root testing. Glynn et al. (2007) confirmed the LM test to be a superior estimation for structural breaks.

In a VAR system, Bai et al. (1998) used quasi likelihood estimation to show that precision of breaks across equations increase with the number of equations in the system. Perron and Qu (2007) using a multiple equation model developed a test of structural break that reduced the confidence intervals around a break date hence increased precision. Emerson and Kao (2006) covering the period 1970 to 1986 finds a common structural break for a sample of Africa countries in 1978 for GDP per capita and GDP per worker, and in 1979 for Consumption per capita.

Altinay (2005) investigated structural breaks in Turkish macroeconomic data using the sequential Dickey-Fuller type test and the minimum LM test for endogenous breaks. The author finds that Zivot and Andrews (1992) and Lumsdaine and Papell (1997) tests indicates the shocks are permanent contrary to Lee and Strazicich (2003 and 2004) minimum LM unit root tests. Waheed et al. (2006) using Pakistan data adopted the approach developed by Zivot and Andrews, which identifies endogenously the point of the single most significant structural break for a set of time series, finding presence of a structural break during the period 1972 to 1976.

Valadkhani et al. (2005) focusing on 10 Australian macroeconomic variables used the Lumsdaine and Papell test, and after incorporating two structural breaks they fail to reject the null hypothesis of unit root for four of the variables. Harvie and Pahlavani (2006), by applying the Innovational Outlier and Additive Outlier on Korean data show that after accounting for the two most significant structural breaks in the data impacting on both the intercept and trend, the Lumsdaine and Papell test results indicate that the null of at least one unit root is rejected for some of the variables under investigation.

In terms of forecasting, when the break points are identified, using the post-break data will give unbiased results (Pesaran et al. 2013). Bauwens et al. (2010) evaluated the performance of various forecasting models and concluded that how the structural breaks are treated will determine the results obtained. Eksi (2009) provides a comprehensive survey of literature on structural breaks. In the case of multiple breakpoint tests, Bai (1997) and Bai and Perron (1998, 2003) provided the theoretical background that extended the work on estimation of multiple unknown breakpoints. There are several criteria and/or formal tests suggested in the literature to determine the number of structural breaks. These test procedures have their own strengths and weaknesses. Prodan (2008) discusses the potential pitfalls of the widely-used multiple structural change tests suggested by Bai and Perron (1998, 2003, 2006).

Few studies have focused on developing countries. Allaro et al. (2011) using 1974 to 2009 annual data from Ethiopia applied the Chow test to determine the break dates and found that the break date occurred in 2003 eleven years after the regime shift through a policy change. Their results showed that some break points could occur with a lag for different variables. This paper aims to fill the gap for Kenya by attempting to identify break dates for monthly and annual data and provide the policy implications.

3.0 Methodology

The paper follows the methodology as described in Zivot and Andrews (1992) that treats the breakpoint as endogenous. As described in Perron (1990) and in Vogelsang and Perron (1998), we use the IO model, where a dummy for a break in the level is allowed along with a dummy for a break in the trend at an unknown period of time. Under the IO model, the break is modelled as evolving more slowly over time. We also use the AO model specification to test whether the break is characterized by a "crash" type of event in some specific Kenya's macroeconomic series.

The IO:

$$y_t = \hat{\mu} + \hat{\beta}_t + \hat{\gamma} DT_t(\hat{\lambda}) + \hat{\theta} DU_t(\hat{\lambda}) + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-i} + \hat{e}_t \qquad (1)$$

Where DU = 1 if $t>T_b$, and 0 otherwise

$DT = t-T_b$ if $t > T_b$, and 0 otherwise,

T_b = break date
k = number of lags according to the ADF general to specific methodology for lag selection.

We test two restricted models as given by Zivot and Andrews, when only a break in the level or a break in the trend is included.

$$y_t = \hat{\mu} + \hat{\beta}_t + \hat{\theta} DU_t(\hat{\lambda}) + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-i} + \hat{e}_t \qquad (2)$$

$$y_t = \hat{\mu} + \hat{\beta}_t + \hat{\gamma} DT_t(\hat{\lambda}) + \hat{\alpha} y_{t-1} + \sum_{i=1}^{k} \hat{c}_i \Delta y_{t-i} + \hat{e}_t \qquad (3)$$

If the error term is autocorrelated, enough lagged difference terms are to be included, so that the error term is serially independent. The AO involves a two-step procedure: in the first step the series are detrended by running OLS regressions (4) through (6) and testing for the significance of DT or DU, testing for break in the series in the level or the trend. The second step procedure under the AO model involves testing the hypothesis of unit root.[4]

$$y_t = \hat{\mu} + \hat{\beta}_t + \hat{\gamma} DT_t + \hat{\theta} DU_t + \tilde{y}_t^1 \qquad (4)$$

$$y_t = \hat{\mu} + \hat{\beta}_t + \hat{\theta} DU_t + \tilde{y}_t^2 \qquad (5)$$

$$y_t = \hat{\mu} + \hat{\beta}_t + \hat{\gamma} DT_t + \tilde{y}_t^3 \qquad (6)$$

Where *DU* = 1 if t >T_b and 0 otherwise,

DT = t -T_b if t > T_b and 0 otherwise,

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[4] The second step procedure in the additive outlier model, regressions 4.1 through 6.1 serve to test the hypothesis of unit root.

$$\tilde{y}_t^1 = \sum_{i=0}^{k} \omega_i D(T_b)_{t-i} + \hat{\alpha} \tilde{y}_{t-1}^1 + \sum_{i=1}^{k} \hat{c}_i \Delta \tilde{y}_{t-1}^1 + \hat{\mu}_t \qquad (4.1)$$

$$\tilde{y}_t^2 = \sum_{i=0}^{k} \omega_i D(T_b)_{t-i} + \hat{\alpha} \tilde{y}_{t-1}^2 + \sum_{i=1}^{k} \hat{c}_i \Delta \tilde{y}_{t-1}^2 + \hat{\mu}_t \qquad (5.1)$$

$$\tilde{y}_t^3 = \hat{\alpha} \tilde{y}_{t-1}^3 + \sum_{i=1}^{k} \hat{c}_i \Delta \tilde{y}_{t-1}^3 + \hat{\mu}_t \qquad (6.1)$$

Where *D* (T_b) = 1 (t=T_b + 1) and 0 otherwise,
T_b = break date
k = lag length of the autoregression.

T_b = break date

The Bai and Perron (1998, 2003) approach (hereafter referred to as the BP approach) to structural breaks considers a multiple linear regression with m breaks

$$y_t = x_t^{'}\beta + z_t^{'}\delta_j + \mu_t \qquad (t = Tj + 1, \ldots, Tj+1 + 1) \text{ For j=1,…,m+1.} \qquad (7)$$

Where y_t is the observed dependent variable at time t, $x_t(p\times 1)$ and $z_t(q\times 1)$ are vectors of covariates and β and δ_j are the corresponding vectors of coefficients μ_t is the disturbance term. The break points or indices ($T_1,...,T_m$) are treated as unknown. For the available data, the unknown regression coefficients and the break points are estimated. The parameter for the vector β is not subject to change since estimation covers the entire sample hence it is a partial structural change model. When $p = 0$ we obtain a pure structural change model where all the coefficients are subject to change. The variance of the disturbance term need not be constant and a break can occur so long as it coincides with the break of the parameter of the regression. The multiple linear regression system can also be expressed in matrix and the true values are represented with a superscript 0 such that $\overline{Z}^0$ is a matrix that diagonally partitions Z at the break points. The data generating process is then assumed to be

$$Y = X\beta^0 + \overline{Z}\delta^0 + U \qquad (8)$$

The method of estimation considered is the least square principle and for each m-partition the associated least-squares estimates of coefficients are obtained by minimizing the sum of squared residuals. In the case of multiple structural breaks, there are various ways of obtaining the test statistics breaks:

(i) A test of no break versus some fixed number of breaks. Requires a specification of the number of breaks under m

(ii) A double maximum test, which tests a null hypothesis of no structural break against an alternative hypothesis of unknown number of breaks given some upper bound.

(iii) Tests of L versus L+1 breaks. This considers a null hypothesis of L breaks against an alternative that additional break exists, the breaks obtained are obtained by global minimization of the sum of squared residuals.

(iv) Sequential estimation of break points

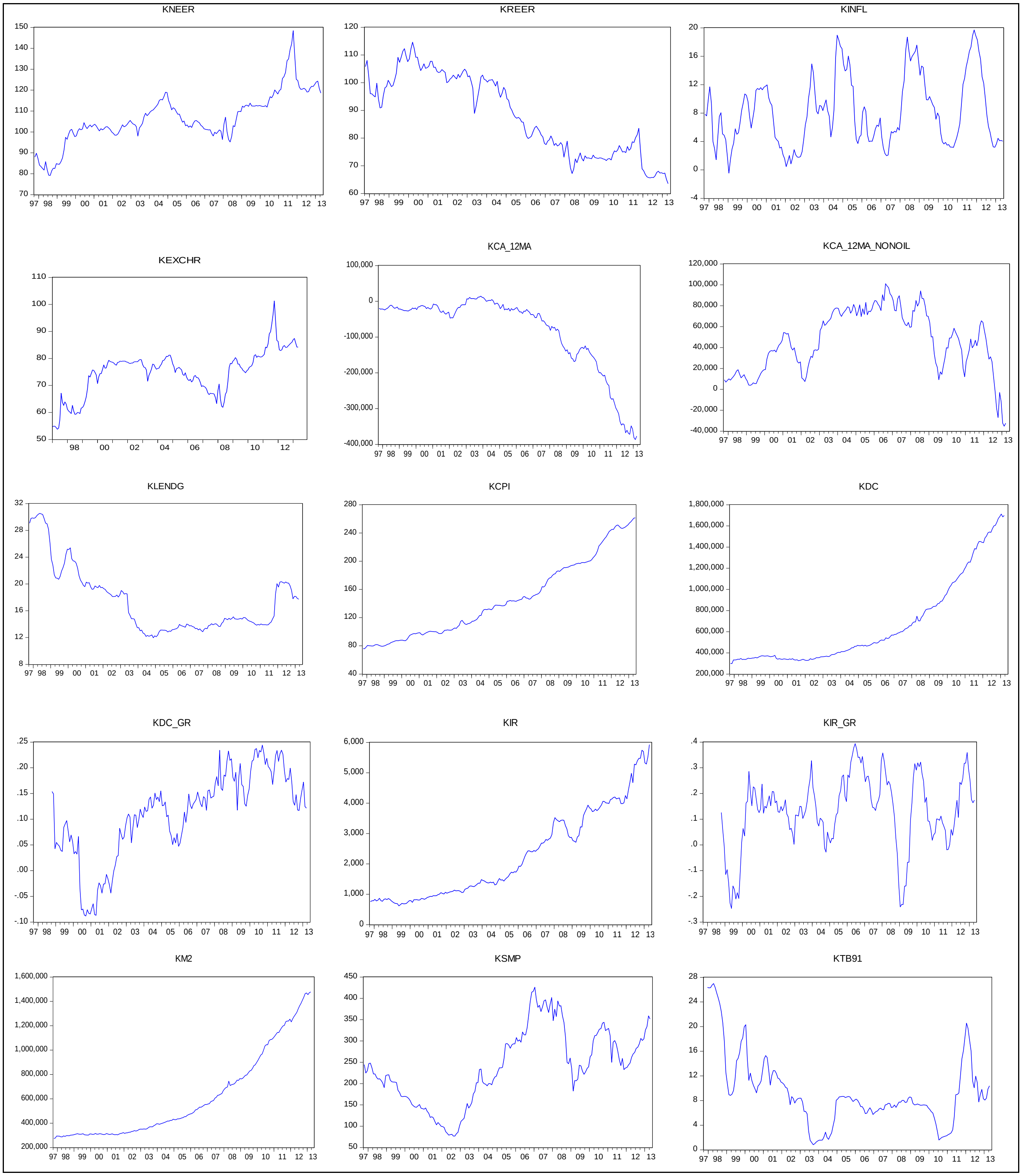
We apply the sequential estimation and global estimation criteria, then we adopt two information-based criteria to determine the appropriate number of breaks. These criteria are: Bayesian Information Criterion (BIC) as suggested by Yao (1988) and a modified Schwarz' criterion (LWZ) as suggested by Liu *et al*. (1997). According to Bai and Perron (2003), these two criteria perform reasonably well when there is no serial correlation in the errors. However, literature stipulates that the information criteria are biased downward and that the sequential procedure and the L vs L+1 breaks perform better in this case since it allows a specific to general modelling strategy to consistently determine the appropriate number of changes in the data (Bai and Perron, 2003). We acknowledge issues noted by Feng et.al (2009) related to sample size in multiple break point estimation as the subsample get smaller as well as Prodan (2008) issues on sequential estimation related to the use of the critical values that could cause size distortions if the series are persistent. We allow up to five breaks and used a trimming of 0.15 using Eviews 8 and apply break least square regression and multiple break points tests. Then we attempt to explain the break dates that are identified.

3.0 Results Discussion

3.1 Descriptive Evidence

Although the Kenyan economy has experienced significant changes in social, economic and political development since the early 1960s, unavailability of high frequency monthly data limits the analysis to the period of October 1997 to March 2013. Economic performance was on the downside at the beginning of this period with economic growth being only 0.5 percent in 1997. For the period 1997 and 2002, average economic growth was 1.8 percent compared to an average population growth rate of about 3 percent; thus, GDP per capita deteriorated by about 1.2 percent. Figure 1 shows the trend of some of the macro-economic variables of interest. These includes the nominal effective exchange rate (NEER), real effective exchange rate (REER), inflation rate (INFL), exchange rate (EXCR), current account balance 12 month cumulative (CA_12MA), current account balance 12 month cumulative excluding oil (CA_12MA_nonoil), lending rate (LENDG), consumer price index (CPI), domestic credit (DC), domestic credit growth rate (DC_GR), international reserves (IR), international reserves growth rate (IR_GR), money supply (M2), stock market prices (SMP), and 91 days treasury bills rate (Tb91). The graphs depict shifts in levels and trends.

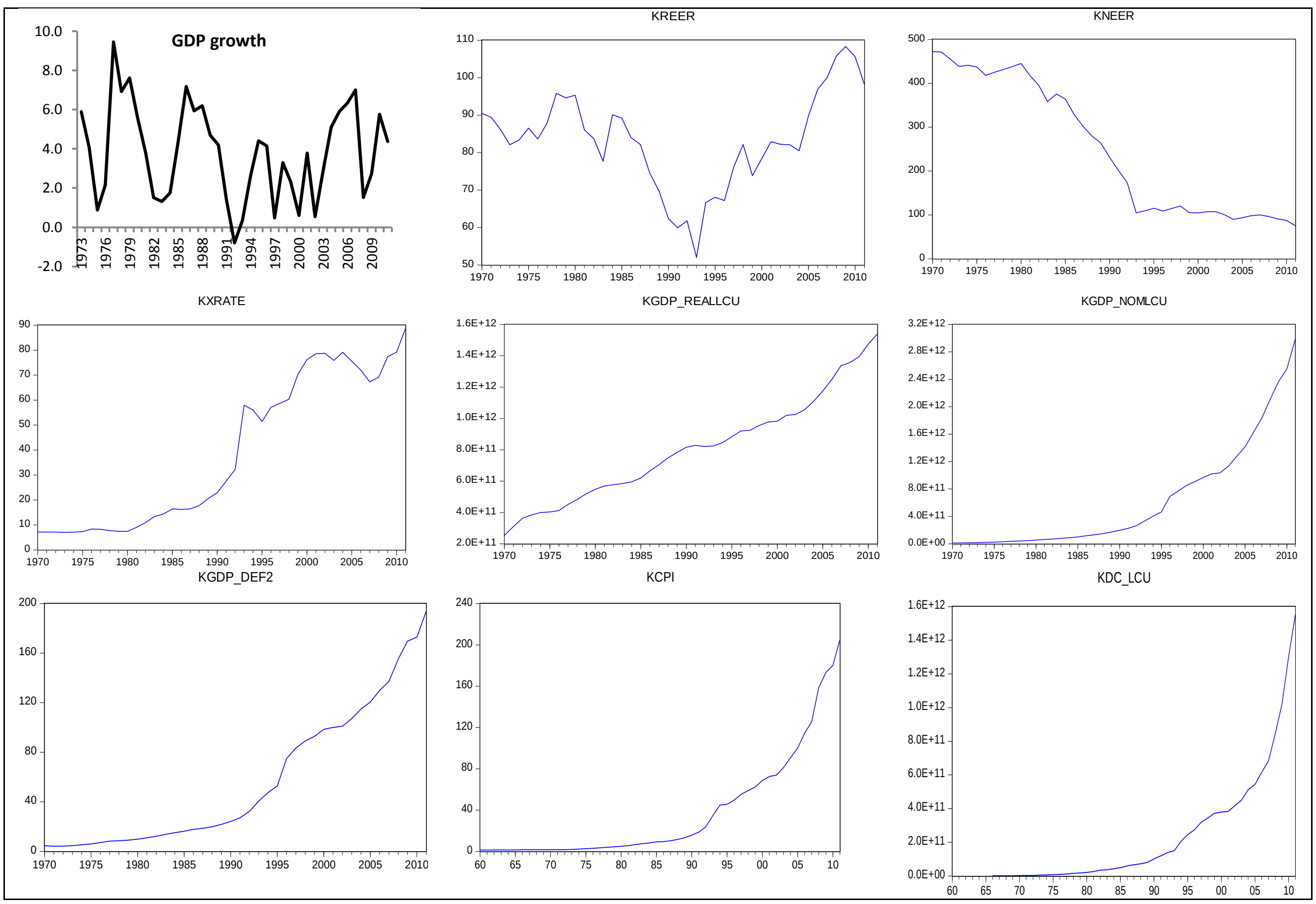
Figure 1: Trend of Monthly data

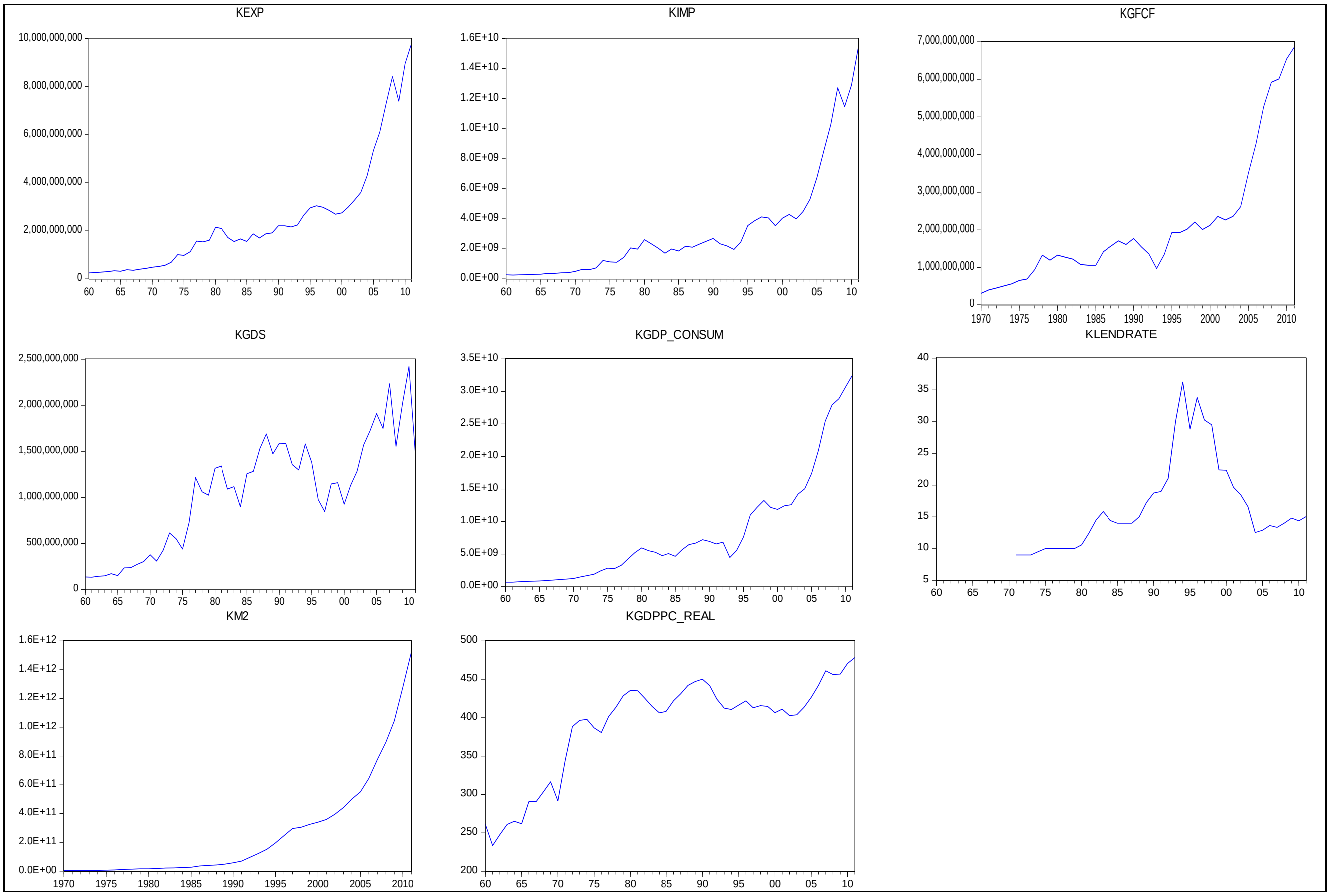


Source: KNBS, CBK

The annual data, covering the period 1973 to 2011 presents a relatively dynamic snapshot of the economy. The annual series shown in Figure 2 include GDP growth rate, nominal effective exchange rate, real effective exchange rate, real GDP in shillings (GDP_realLCU), nominal GDP in shillings (GDP_nomLCU) , GDP deflator (GDP_def), consumer price index (CPI), domestic credit in shillings (DC_LCU), exports (exp), imports (imp), gross fixed capital formation (GFCF), gross domestic savings (GDS), consumption expenditure part of GDP (KGDP_consum), lending rate (lendrate), money supply (M2) and real GDP per capita (GDPpc).

Figure 2**: Trend of Annual data**





Source: WDI

The data shows that the Kenyan macroeconomic variables have undergone large swings some of which may bring about a permanent shock such that the equilibrium path and/or position changes. Some of these changes can be seen in trend/mean, for instance the exchange rate, lending rate, GDP per capita and economic growth rate. The data shows that exchange rate, NEER and GDP deflator series change after 1993, which could have been due to economic, financial and trade reforms. The steepness of GDP and its constituents – consumption and investment, increased sharply in the period after 2000, a trend which is also replicated by money supply, exports and imports. Imports for instance seem to be trend stationary before mid-1990s and then drift sharply upwards thereafter. Real GDP per capita shows minimal improvement between 1980 and 2005 after which a sharp increase is experienced. This change can be explained by the higher economic growth rate achieved after 2005, an average over 4.5 percent.

To appreciate the dynamics in the data it is important to note that the growth pattern has been inconsistent overtime. Kenya economic growth rate has been on a swing as shown in Table 1.

Table 1: Economic Growth Dynamics

Period	**Average Growth**
1973-1980	5.3%
1981-1985	2.5%
1986-1990	5.6%
1991-2003	2.0%
2004-2011	4.8%

Source: Author's computation using WDI data

In 1977, economic growth rate rose to 9.5 percent from a low of 2.2 percent in 1976. The momentum was sustained for the following three years registering a growth of 6.9, 7.6 and 5.6 percent in 1978, 1979 and 1980 respectively. The coffee boom brought about by high coffee prices in the period 19765/76 to 1978/79 led to the increase in foreign exchange and this could be associated with the increase in Gross Domestic Savings (GDS) by more than US$ 0.5 billion between 1975 and 1977. Collier and Gunning (1989) noted that there was massive increase in public investment following the coffee boom and hence the significant change in Gross Fixed Capital Formation (GFCF) in the period 1978. Between 1980 and 1982 Kenya shillings depreciated by about 79 percent against the US$.

Further, in the period 1989 to 1993, Kenya shillings depreciated by about 182 percent and in 1999 a depreciation of about 17 percent was recorded after which a period of stability followed with only about 2 percent average annual depreciation in the period 2000 to 2011. In 1993, there were several devaluations –36 percent devaluation in March and in May – before finally establishing a floating exchange rate. The destabilization in prices in 1993 – inflation (46%), exchange rate (depreciation rate – 80%), lending rate (30% in 1993 and 36% in 1994) - brought about by the economic and trade liberalization process. In 1991, foreign aid was frozen which was then followed by the first multi-party election in 1992. Visual observation of these key variables in Figure 2 suggests that Kenya's economy seems to indeed have experienced structural changes. We present the econometrics results below.

3.2 Empirical estimation

The ZA AO and IO models are applied to test endogenously for existence of a single structural break for the period October 1997 to March 2013[5]. *K* represents the optimal lag length, the results are reported in levels but even when we take logarithms, a break point is identified within the same period. The AO and IO approach with the variables at levels provides significant structural breaks as presented in Table 2 at both mean and the trend.

Table 2: ZA Single Structural Break Results

Variable	K	Model	SB period	t stat
REER	2	AO2-DU	2004-10	10.78***
NEER	1	AO2-DU	2004-07	11.57***
CPI	8	A03-DT	2007-05	13.04***
International reserves	10	AO3-DT	2006-03	12.16***
Current Account balance	13	AO3-DT	2009-10	14.07***
Non-oil Current Account balance	12	AO2-DU	2007-12	18.43***
Lending rate	1	AO2-DU	2007-09	11.28***
Domestic credit	1	A03-DT	2009-01	18.26***
Domestic credit growth	12	AO2-DU	1999-12	4.51***
M2	1	AO3-DT	2008-12	18.68***
Stock market prices	4	AO2-DU	2003-12	12.53***
T-bills rate 91days	14	A02-DU	2010-03	8.76***
RM2	7	IO2-DU	2000-04	7.6***
RM2	7	IO3-DT	2001-12	4.95***

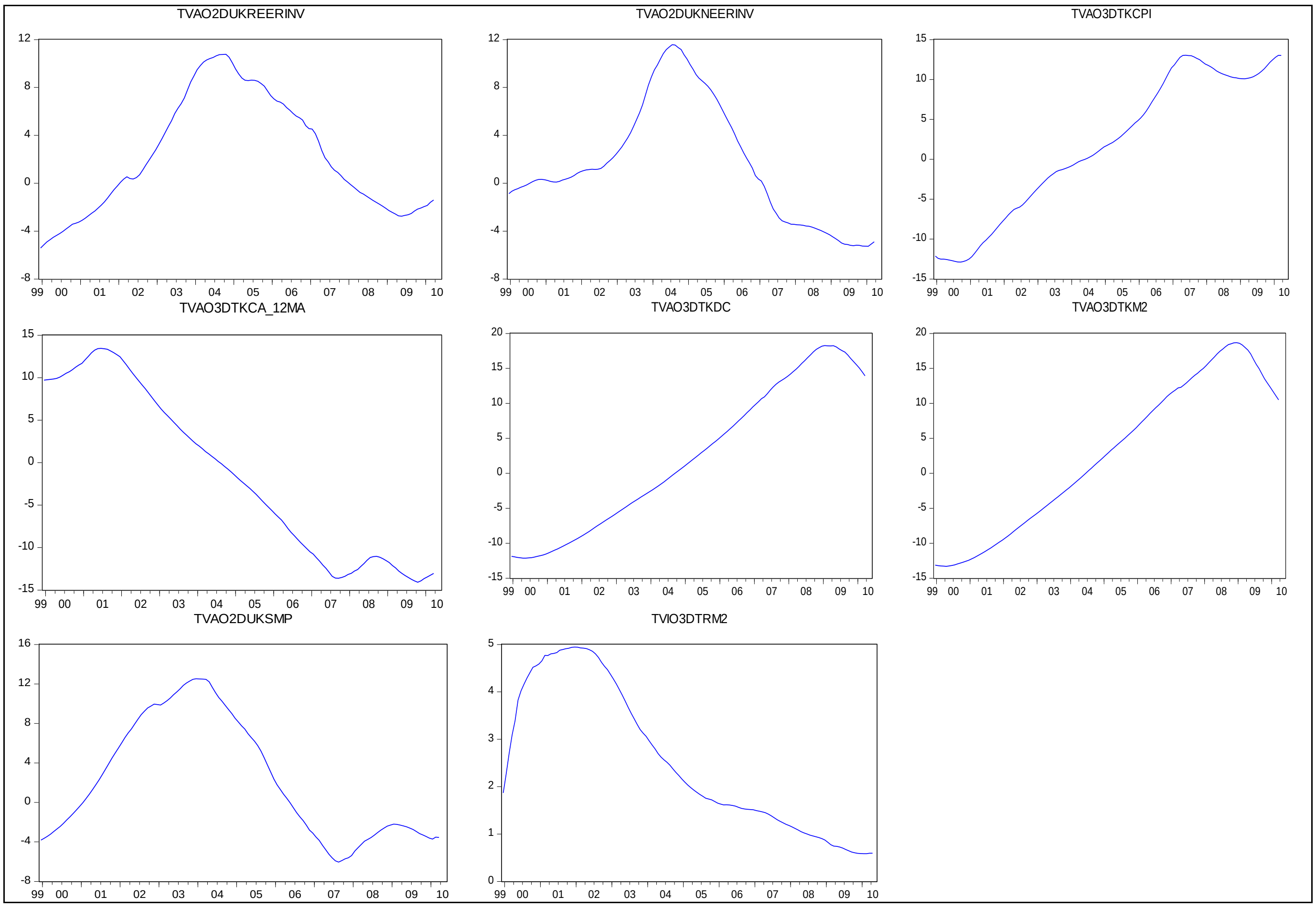
Source: Author's computations
*** Significance at 1 percent

ZA approach ignores other possible break points since ZA is a single break test. Zivot and Andrews (1992) and Perron (1997) tests capture only one (the most significant) structural break in each variable. The results point to breaks in the levels in the cases of REER, NEER, non-oil current account balance, lending rate, domestic credit growth, stock market prices, 91-

[5] The results using ZA model could not be obtained due the short period for the annual date and the trimming.

day Treasury bill rate, and M2 over reserves ratio. Breaks in the trend are found in the CPI, international reserves, CAB, domestic credit, M2 and M2 over reserves. The breaks were statistically significant at 1 percent level, per the AO break test in the case of most of the variables, and in this case the change takes effect instantaneously. M2 over reserves is the only variable where the change is gradual, per the IO break test. The selected charts from the ZA model indicating the optimal break points are shown in Figure 3.

Figure 3: Break points t-statistics results from ZA approach



***Source**: Author's computations*

Table **3** presents the structural break dates results from the BP model indicating breaks in trend or mean and the break date. Some results differ from the ZA ones, while others are similar or fall within the same period. Notable is the close coincidence of the points of significant t-values and the multiple break dates.

Table 3: BP model

	Break date	co-efficient	t-stat	S.E
NEER		101.2*	21.08	4.5
	2009-01	120.3*	28.4	4.23
REER		102.0*	52.17	1.96
	2005-03	82.2*	39.66	2.07
	2007-12	72.3*	39.98	1.81
Inflation	No break			
Exchange rate		73.3*	32.01	2.29
	2010-06	85.4*	46.62	1.83
		-324.8*	-38.11	8.52
CAB	2008-08	-1013.0*	-115.42	8.78
	2011-01	-1781.2*	-17.04	104.5
CAB-nonoil		11072.6*	5.45	2030.38
	2000-02	34610.7*	4.64	7459.35
	2003-01	76229.1*	25.36	3005.84
	2009-02	29255.2	1.39	20972.24
Lending rate		25.9*	13.12	1.98
	2000-07	19.3*	68.42	0.28
	2003-06	14.6*	12.41	1.17
CPI [trend]		4.59*	6.68	0.69
	2000-02	1.98*	49.56	0.04
	2003-07	1.50*	76.05	0.02
	2006-04	1.33*	324.49	0.004
	2011-02	1.40*	148.59	0.009
Domestic credit [trend] F-stat	2010-08	10.06	8.58	
DC growth		0.003	0.11	0.03
	2002-08	0.11*	8.71	0.01
	2007-08	0.18*	14.97	0.01
IR		811.6*	41.3	19.65
	2001-09	1224.5*	22.57	54.26
	2004-11	1964.3*	186.79	10.52
	2007-04	3285.2*	28.32	116.02
	2010-09	4649.9*	736.55	6.31
IR	2000-02	131.9	8.58	
[trend] F-stat	2002-07	16.9	10.13	
	2004-12	46.8	11.14	
	2009-08	22.3	11.83	
Money supply		17248.1*	6.54	2633.76
[trend]	2000-01	7173.3*	31.23	229.65
	2002-08	5100.5*	489.79	10.41
	2008-01	5892.8*	46.4	127.01
	2010-06	7415.7*	12775.97	0.58
RM2 (M2/IR)		5.91	33.2	0.18
	2000-08	3.90	59.3	0.07
	2005-07	3.28	105.9	0.03
Stock market		208.5*	20.86	9.99
	2000-02	143.7*	528.51	0.27
	2005-01	303.9*	20.72	14.67
91days TBs		18.5*	10.37	1.79
	2000-03	11.6*	28.26	0.41
	2002-06	6.0*	28.15	0.21
	2011-02	10.8*	9.13	1.19

Source: Author's computations

*Significance at 5%

For the monthly data, the results indicate that in the first quarter of 2000, Treasury bill, stock market, money supply, international reserves, CPI, lending rate and CAB without oil experienced a break in either the trend or the mean. This could be explained by the poor economic performance and the poor weather conditions occasioned by *el nino* in late 1990s. Stock market and the REER registers a break in 2005, which could be explained by the exemplary economic performance, at a 17-year high of 5.9 percent[6]. International reserves, exchange rate, money supply and domestic credit experienced a break in 2010 within third quarter probably due to the effect of exchange rate and inflation rate shocks. The graphic representation of the break points is presented in the appendix A1, while the corresponding *t* and/or *F- statistic* are presented in Table 4 using the BIC and LWZ approach[7]. The estimated mean shifts are significant at 5 percent level. When the break is on the trend, it's indicated in parenthesis.

The study applied break least square regression and multiple break points tests, and they showed similar results. The sequential L vs L+1 approach reports substantially large number of breaks compared to BIC and LWZ. Nevertheless, those reported by BIC and LWZ are also captured by sequential approach. BIC and LWZ approach reports similar break dates except for CPI, imports and GDS.

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[6] In 2005, there were also some changes in the national accounts compilation that could have affected the variables.

[7] The results where lags are included indicate more or less the same results and hence the results including lags are not included in the paper but can be availed on request. Also when we apply sequential approach with L vs L+1, many breaks coincide with those reported in Sequential break points are not reported but are available on request as well.

Table 4: BIC and LWZ structural break results

BIC - No lags

	Break date		coeff	t-stat
REER			87.1*	59.2
		1988	64.7*	25.7
		1997	80.9*	54.0
		2006	102.5*	48.7
NEER			443.0*	55.9
		1981	373.4*	27.2
		1987	242.1*	18.9
		1993	101.5*	47.4
Exchange rate			0.53*	52.5
[trend]		1987	0.78*	688.3
		1993	1.60*	46.7
		1999	1.84*	64.3
		2005	1.58*	33.7
GDP real	billion		26.5*	101.1
[trend]		1992	25.1*	168.6
		2006	28.7*	58.9
GDP nominal			63.2*	3.4
[trend]		1996	25.1*	32.8
		2006	46.5*	22.5
GDP deflator			0.59*	9.7
[trend]		1990	1.16*	22.4
		1996	2.44*	37.7
		2006	3.31*	26.0
CPI			0.40*	4.9
[trend]		1993	1.40*	15.7
		2000	1.92*	888.9
		2006	3.31*	14.9
Domestic credit			2750*	3.3
[trend]		1995	9750*	400.6
		2006	20900*	42.1
Exports	millions		79*	18.9
[trend]		2006	165*	18.8
Imports	millions		80*	15.5
[trend]		1995	110*	56.2
		2006	246*	14.6
GFCF	millions		632*	6.8
		1978	1630*	17.2
		1998	2440*	16.3
		2006	5800*	11.4
GCF			58*	20.4
[trend]		2006	120*	15.2
GDS			492*	8.5
		1977	1160*	24.9
		1987	1500*	34.3
		1996	1070*	18.5
		2003	1850*	20.6
GDP consumption			210*	17.7
[trend]		1996	327*	50.5
		2006	574*	18.4
Lending rate			9.95*	34.8
		1982	16.17*	40.7
		1993	31.42*	42.8
		1999	18.66*	36.4
		2005	14.01*	34.2
Money supply			2190*	2.9
[trend]		1996	9390*	24.4
		2006	21400*	24.4
GDPPC real			274.8*	23.6
		1971	385.1*	54.0
		1978	421.0*	96.4
		2005	455.9*	55.2

LWZ - No lags

	Break date		coeff	t-stat
REER			87.1*	59.2
		1988	64.7*	25.7
		1997	80.9*	54.0
		2006	102.5*	48.7
NEER			443.0*	55.9
		1981	373.4*	27.2
		1987	242.1*	18.9
		1993	101.5*	47.4
Exchange rate			0.53*	52.5
[trend]		1987	0.78*	688.3
		1993	1.60*	46.7
		1999	1.84*	64.3
		2005	1.58*	33.7
GDP real	billion		26.5*	101.1
[trend]		1992	25.1*	168.6
		2006	28.7*	58.9
GDP nominal			63.2*	3.4
[trend]		1996	25.1*	32.8
		2006	46.5*	22.5
GDP deflator			0.59*	9.7
[trend]		1990	1.16*	22.4
		1996	2.44*	37.7
		2006	3.31*	26.0
CPI			0.46*	4.2
[trend]		1994	1.72*	15.8
		2006	3.31*	15.1
Domestic credit			2750*	3.3
[trend]		1995	9750*	400.6
		2006	20900*	42.1
Exports	millions		79*	18.9
[trend]		2006	165*	18.8
Imports			97*	14.1
[trend]		2006	246*	14.8
GFCF	millions		632*	6.8
		1978	1630*	17.2
		1998	2440*	16.3
		2006	5800*	11.4
GCF			58*	20.4
[trend]		2006	120*	15.2
GDS			492*	8.7
		1977	1250*	15.4
		2003	1850*	21.2
GDP consumption			210*	17.7
[trend]		1996	327*	50.5
		2006	574*	18.4
Lending rate			9.95*	34.8
		1982	16.17*	40.7
		1993	31.42*	42.8
		1999	18.66*	36.4
		2005	14.01*	34.2
Money supply			2190*	2.9
[trend]		1996	9390*	24.4
		2006	21400*	24.4
GDPPC real			274.8*	23.6
		1971	385.1*	54.0
		1978	421.0*	96.4
		2005	455.9*	55.2

Source: Author's computation.

The structural break dates results obtained above seem to point to asymmetric transmission of policy related shocks, since some of the macroeconomic variables show the effects of the shocks immediately and some with a lag or lead: In the case of economic and trade liberalization in the early 1990s; Real GDP reflects a break in 1992, while NEER, exchange rate, CPI and lending rate (all monetary variables) register a structural change in 1993. Domestic credit and imports had a break in 1994 moreover nominal GDP, GDP deflator, consumption demand and savings had a break in 1995. Further, when the economic momentum is on the take-off around 2005, we realize that there are those variables that experience a break before 2005, for instance GDS experiences a break in 2003, those that experience a break in the same year includes, exchange rate and lending rate. All the other variables register a break in 2006.

In the post liberalization, period exchange rate and lending rate have same break dates contrary to the prior period – 1993, 1999 and 2005 for the annual data. However, varying break date for monthly data are reported; lending rate has July 2000 and June 2003 break dates while exchange rate reports June 2010 which corresponds with money supply, international reserves and domestic credit while CPI and Treasury Bill rate has a February 2011 break date

The empirical results would suggest that the liberalization in 1993 transmitted more rapidly upon primarily financial variables such as the exchange rate, CPI and Lending rate. Surprisingly the break date for money supply occurs in 1996, which could point to a weak monetary policy transmission mechanism in the prior period. In addition, another domestic shock, the post-election violence might be the explanation for money supply and CAB break dates in 2008, January and August respectively.

Note that the structural break dates identified above are not independent of the sample period or of the data frequency. Some of the breaks identified with monthly and annual data are close to each other for instance the period 2005 and 2006 reports break dates for both monthly and annual data.

3.3 Unit Root Tests and Structural Breaks

A well-known weakness of the Dickey–Fuller unit-root test with I(1) as a null hypothesis is its potential confusion of structural breaks in the series as evidence of nonstationarity. The mechanisms to addressing this has been to test for unit root incorporating identified and potential structural breaks. Given the findings of mean shifts and breaks in the trend, we apply two tests for stationarity in the presence of a single and double break. We apply the Zivot and Andrews unit root test for single breaks and the Clemente-Montanez-Reyes (1998) (CMR) unit root tests in the presence of two breaks in the mean. First we present the ADF unit root tests results for the monthly and annual data as shown in Table 5.

Table 5: ADF Unit root tests

Monthly data

	ADF		
	Levels	**1st Difference**	
CPI	3.458	-8.624***	*I(1)*
Exchange rate	-1.762	-10.156***	*I(1)*
TB91	3.097**		*I(0)*
DC	8.494	-10.78***	*I(1)*
Inflation	-2.372	-8.462***	*I(1)*
International reserves	2.272	-12.68***	*I(1)*
Money supply	7.826	-11.63***	*I(1)*
REER	-0.715	-11.34***	*I(1)*
SMP	-0.829	-13.23***	*I(1)*
NEER	-1.541	-10.98***	*I(1)*
Lending rate	-2.68*	-8.81***	*I(1)*

1%= -3.479
5%= -2.884
10%= -2.574

Annual Data

	ADF		
	Levels	**1st Difference**	Order
CPI	9.233	-2.351	*I(2)*
DC-shs	13.96	1.046	*I(2)*
Domestic Credit-US$	4.57	-4.078***	*I(1)*
Exports	3.596	-5.79***	*I(1)*
GCF	3.052	-5.096***	*I(1)*
GDP-consumption	4.288	-3.396**	*I(1)*
GDP-deflator	6.804	-2.812*	*I(1)*
GDP nominal	3.715	-3.51***	*I(1)*
GDP nominal-shs	14.19	0.226	*I(2)*
GDP real	4.089	-4.077***	*I(1)*
GDP real -shs	4.089	-4.078***	*I(1)*
GDPpc real	-1.485	-6.164***	*I(1)*
GDPpc nominal	0.814	-4.308***	*I(1)*
GDS	-1.919	-8.385***	*I(1)*
GFCF	3.511	-3.704***	*I(1)*
Imports	4.397	-4.22***	*I(1)*
Lending rate	-1.47	-5.984***	*I(1)*
Money supply -M2	20. 446	2.993	*I(2)*
NEER	0.552	-4.378***	*I(1)*
REER	-1.532	-6.566***	*I(1)*
Exchange rate	0.794	-5.819***	*I(1)*

Source: Author's computation

The results indicate that, for monthly data, all variables are I(1) except for Treasury bill rate which is I(0). Similarly, the annual data shows that all other variables are I(1) while CPI, money supply, domestic credit and nominal GDP in shillings are I(2).

The BP (LWZ) multiple break testing results for annual data reveals one significant break in the trend in exports, imports and gross capital formation. The results show three significant breaks in the mean for real GDP per capita and gross fixed capital formation, where we are able to test for two breaks once the sample accounts for a 10% trimming. Below we present unit root tests taking into account one and two breaks: Zivot and Andrews unit root tests in the presence of one break in the trend, constant or both; and Clemente Montanez and Reyes (1998) (CMR) unit root test in the presence of a shift in the mean in either an AO model and IO model. Baum et al. (1999) expanded CMR unit root tests to double shifts in the mean for both additive and innovational models.

Our results show that the ADF unit root tests in Table 5 are biased towards the non-rejection of nonstationarity in the cases of the annual series, exports, imports, and real GDP per capita. Once structural breaks are accounted for in the annual data, using the ZA and CMR unit root tests, Table 6 shows that these series follow an I(0) process.[8] A finding that the real GDP per capita is an I(O) process is in line with the existing literature (e.g. Zivot and Andrews,1992; Smyth and Inder, 2004).

Table 6: Unit root tests in the presence of breaks - annual and monthly series

	Multiple Break Results		ADF	Break dates	ZA	CMR AO		CMR IO	
	Year(s)	Break in							
Exports	2006	Trend	*I(1)*	2003	*I(0)*				
Imports	2006	Trend	*I(1)*	2003	*I(0)*				
GCF	2006	Trend	*I(1)*	2003	*I(1)*				
GDP pc real	1971, 1978, 2005	Mean	*I(1)*					*1975, 2005*	*I(0)*
GFCF	1978, 1998, 2006	Mean	*I(1)*			*1996, 2006*	*I(1)*	*1992, 2003*	*I(1)*

Note: Number of breaks per the multiple break results, LWZ criterion. In the case of gross capital formation (GCF), nonstationarity is rejected at 10% level , while for Exports and Imports, we reject at 1% level.
GFCF CMR unit root test sample 1974-2011.

[8] In the case of gross capital formation, nonstationarity is rejected at 10%, while for the other three variables we reject at 1% level.

With the caveat that the study uses only 14 years of monthly data, we also carried out the CMR unit root tests in variables where our multiple break results determined one or two breaks: namely, nominal exchange rate, domestic credit growth, REER, SMP, NEER and lending rate. The results did not reject unit root with the exception of REER under the CMR unit root test in the presence of one break. However, there are two significant breaks per the test and unit root cannot be rejected. It is worth highlighting that some of the estimated break dates are close to the multiple break estimation dates. The unit root results allowing for structural breaks show that it is imperative to account for structural break in time series for Kenya.

4.0 Conclusions

This paper uses monthly and annual data to endogenously determine structural breaks that could have occurred for macroeconomic variables in Kenya. We used Zivot and Andrews (1992) and Bai and Perron (1998, 2003) framework, and provide evidence of structural breaks, which are associated with unstable political, economic and trade liberalization and poor and erratic climatic conditions. The economy is susceptible to external shocks, and there are some structural breaks that correspond to international commodity price shocks and global financial crisis. The finding of structural breaks in the time series are useful for future empirical studies using macroeconomic variables in Kenya. Furthermore, the unit root tests in the presence of structural breaks for annual real GDP per capita, imports, and exports show that the ADF unit root tests without accounting for the breaks could lead to false non-rejection of unit root.

There are several criticisms that have been raised on the estimation of multiple structural breaks, among them the accuracy when the sample size is small, including the cases of multiple breaks estimation where the sub-sample sizes are reduced, and frequency of rejection distortions when the data is highly persistent, so further work to improve the date breaks estimations is necessary. Panel data estimation of structural breaks in Africa can aid in improving the estimation of breaks; furthermore, as regional blocks pursue integration and macroeconomic convergence assessing symmetry of shocks and common structural breaks becomes even more critical. Also, given that we observe structural breaks being associated with regime changes, we also see the potential for the use of regime switching models.

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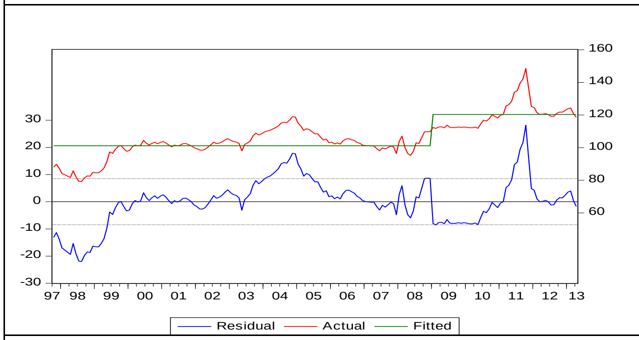
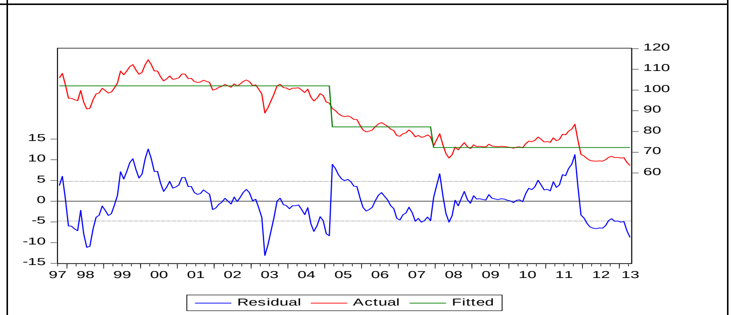
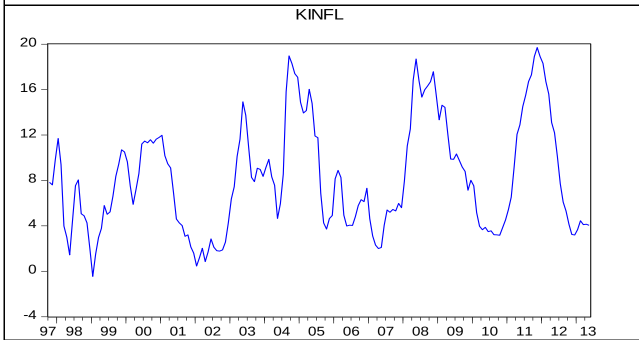
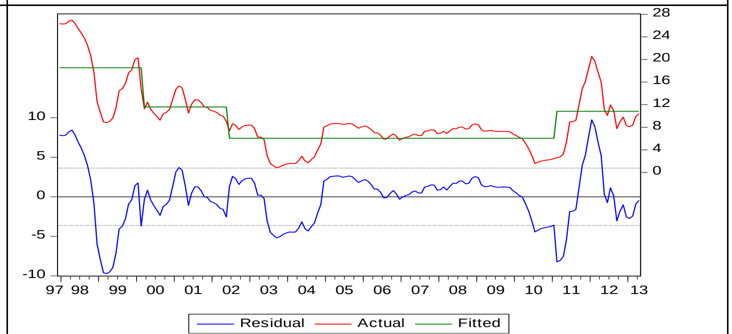
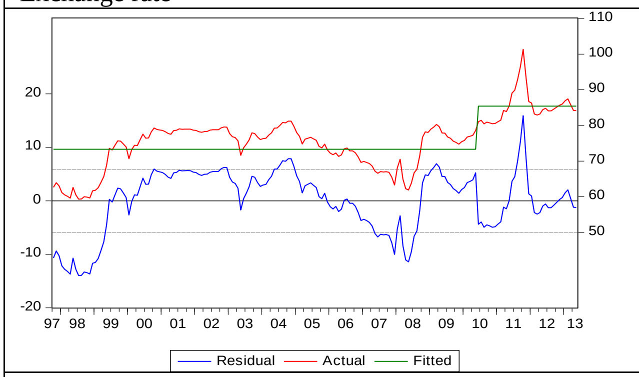
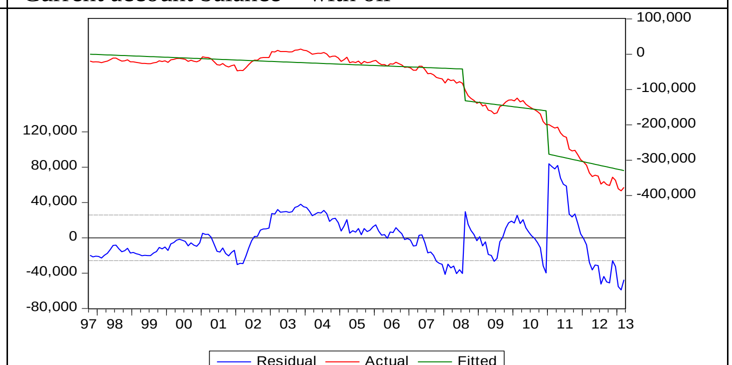
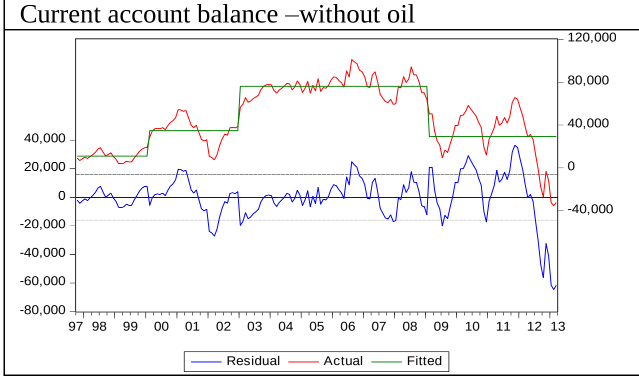
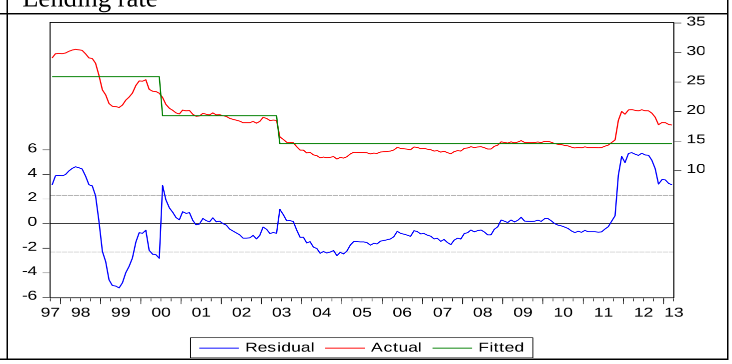
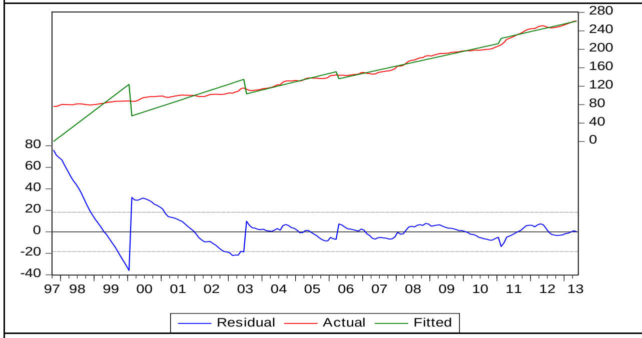
APPENDIX

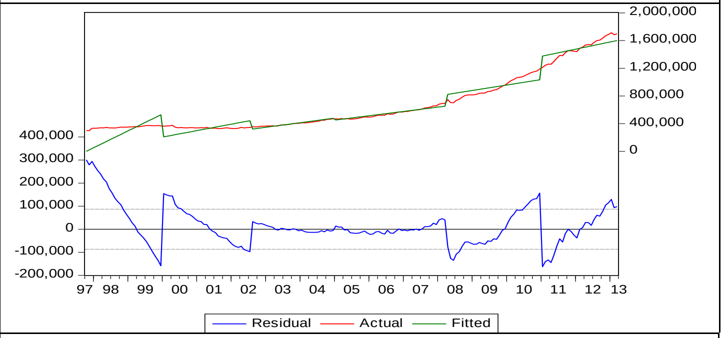
Figure A1: Monthly data break points

NEER	REER
	
Inflation no break	91day treasury bills rate
	
Exchange rate	Current account balance – with oil
	
Current account balance –without oil	Lending rate
	

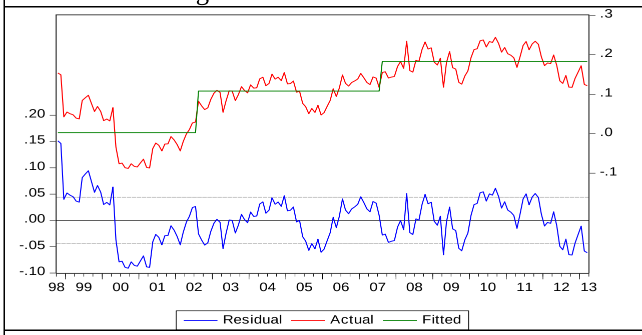
CPI -trend



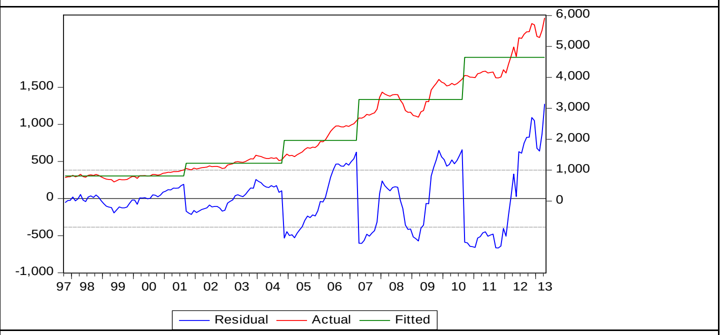
Domestic credit - trend



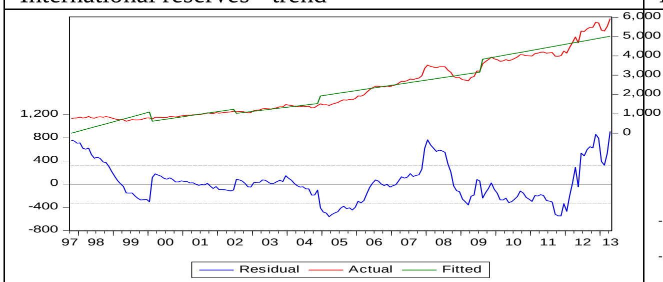
Domestic credit growth



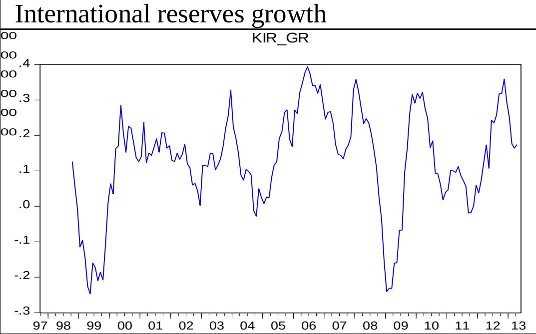
International reserves



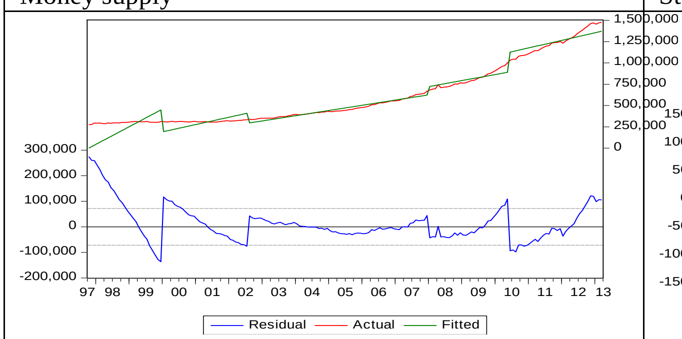
International reserves - trend



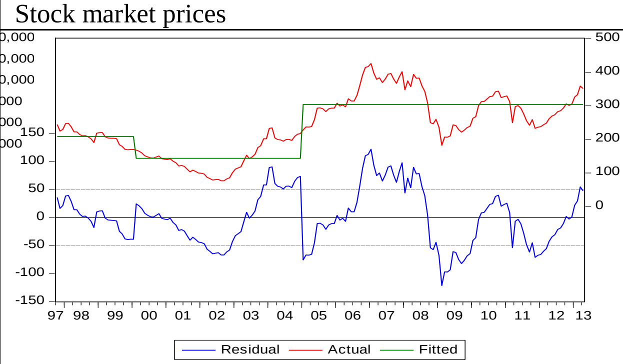
International reserves growth



Money supply

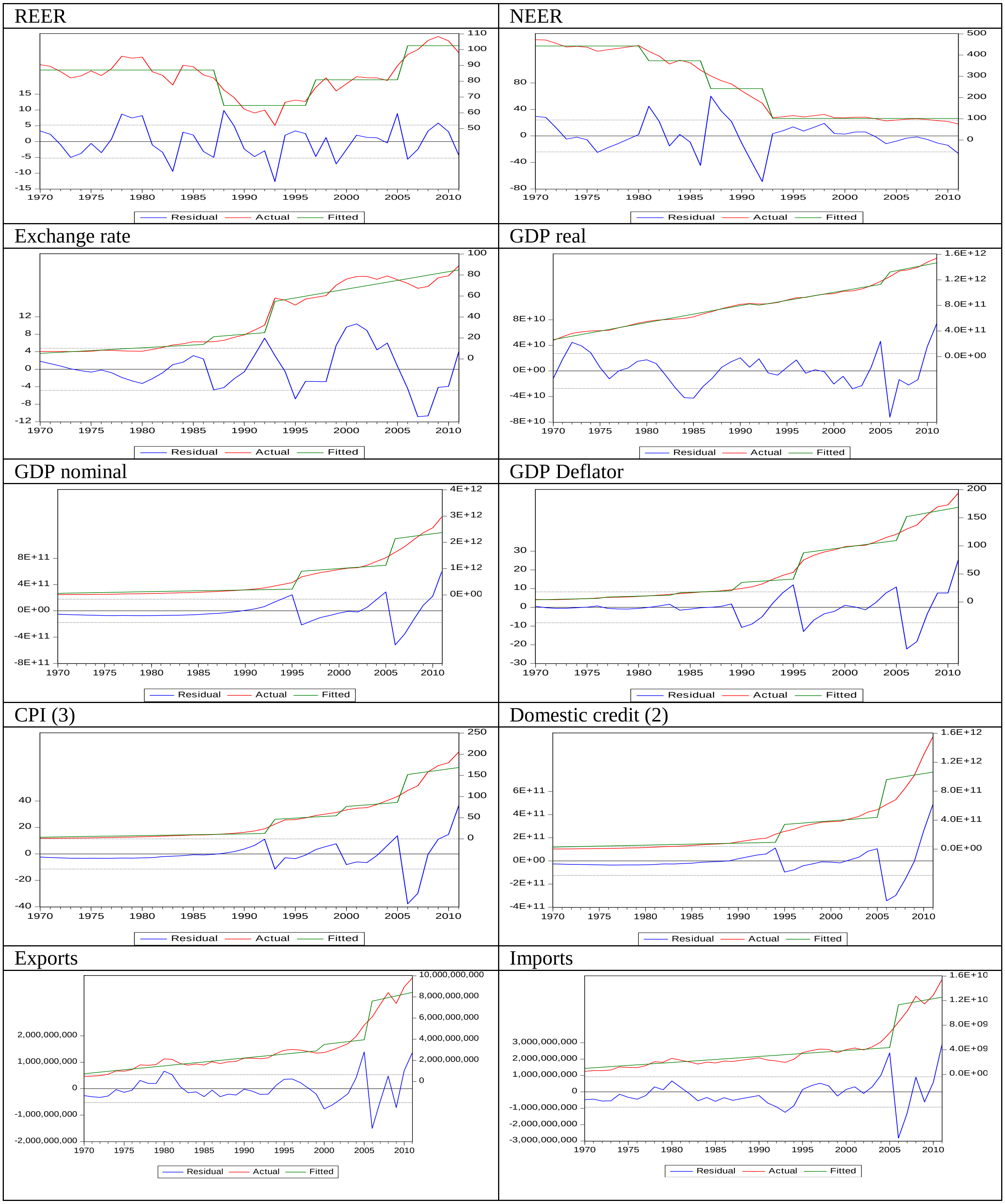


Stock market prices

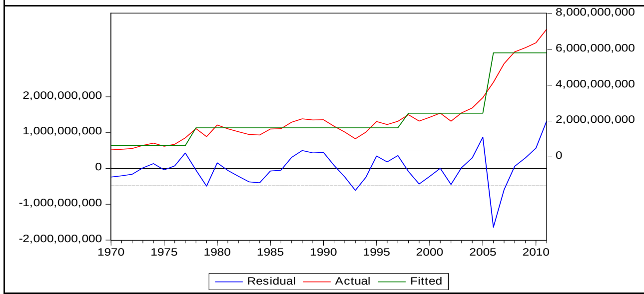


Source: Author's Computation

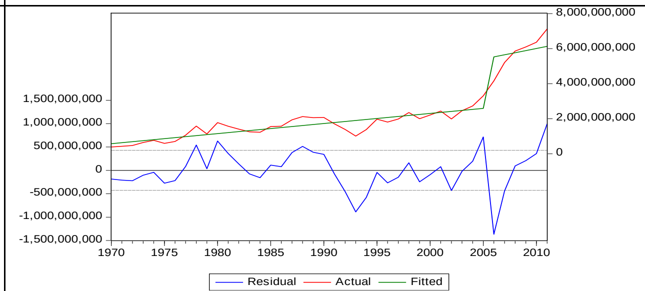
Figure A2: Annual data break points



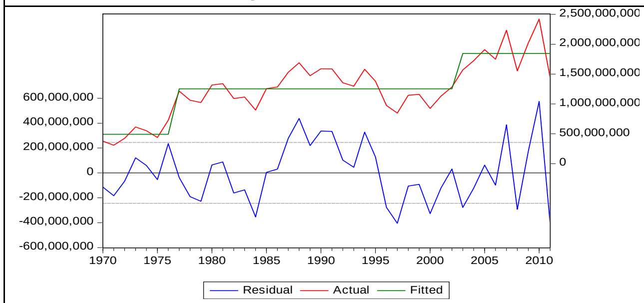
Gross fixed capital formation



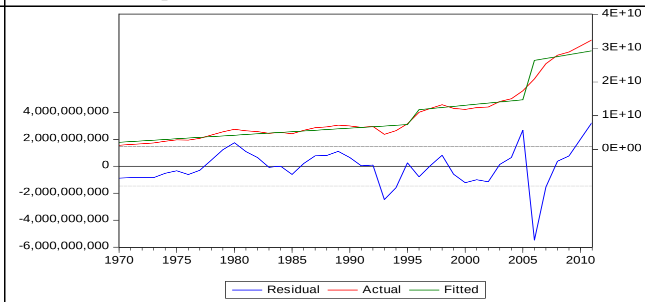
Gross capital formation



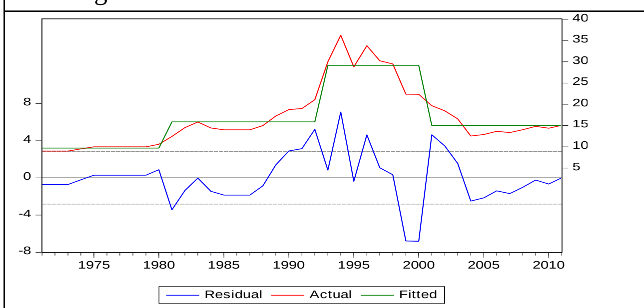
Gross domestic savings



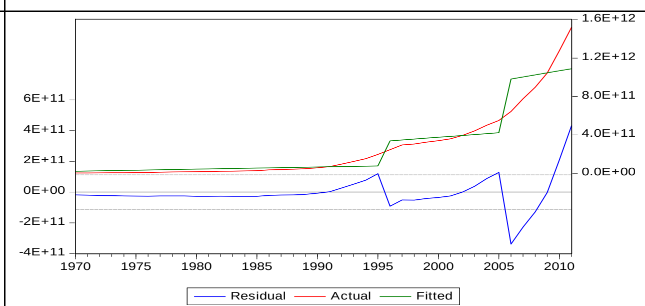
GDP consumption



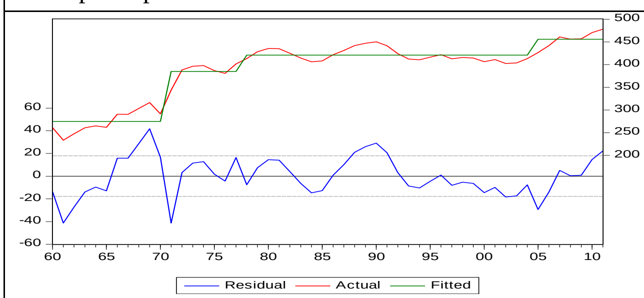
Lending rate



M2



GDP per capita



Source: Author's Computation.