

# Exchange Rates and International Reserves: A Threshold Cointegration Analysis

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## Abstract

This paper models the long-run relationship between exchange rates and international reserves in a sample of African countries over the period of 1980:01 - 2004:04. The empirical methodology uses threshold cointegration technique that considers the possibility of a non-linearity. The results have indicated that a long-run dynamics exist between the series. Cointegration occurs when the divergence between the two is above the threshold point estimate. The threshold point estimate varies from country to country, reflecting the country's exchange rate regimes. The floating regimes seem to have higher threshold than the peg regimes and the exchange rates adjust more than the reserves.

*Key Words:* Exchange Rates, International Reserves, Threshold Cointegration

*JEL Classification:* F31, F33, C22

# 1 Introduction

Foreign exchange interventions were not considered as an economic policy option at the beginning of the floating era in the 1970s as the consensus then was in favour of zero intervention or pure floating. However, the floating industrialized currencies had experienced a high degree of volatility in both nominal and real exchange rates, which prompted a shift by both economists and policy makers to the one that favours intervention (Sarno and Taylor, 2001). Foreign exchange interventions are found across regimes in developed, emerging, and developing economies. Monetary authorities intervene in the exchange rate transaction to alter the direction of the exchange rates or to dampen the exchange rate volatility that is normally associated with floating exchange rate regimes. Foreign exchange interventions were part of the Bretton Wood's system in which they were carried out whenever the exchange rate was considered to have deviated from the parity bands. However, after the collapse of the system in the early 1970s, interventions are carried out at the discretion of the monetary authorities. By 1977 the IMF Board issued three main guiding rules for intervention policies for its member-countries, which are:

- countries should not use the exchange rate as an instruments to obtain greater competitive advantages than others, or to prevent balance of payment adjustments;
- interventions should be done with the intention of smoothening out excessive volatility or to address 'disorderly market conditions'; and,
- while intervening, countries should consider other countries' exchange rate interests.

Calvo and Reinhart (2001) observe that developing countries seem to be more tolerant of foreign reserve fluctuations than exchange rate volatility. This means that as a country experiences exchange rate fluctuations, the authorities use their reserve stock to intervene in the foreign exchange market with the purpose of dampening the exchange rate volatility. This therefore, suggests that the two series may seem to have a long-run relationship. Many empirical works, for example Levy-Yeyati and Sturzenegger (2004) and Calvo and Reinhart (2002) have used reserve volatility as a proxy for intervention. However, this approach has being criticized on the ground that reserve volatility in developing countries cannot be solely attributed foreign exchange transactions, but a number of other factors can cause reserves fluctuations<sup>1</sup>. It is against this background that this paper sets

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<sup>1</sup>Ghosh *et al* (2003) argue that payment for bulk purchases (like oil and airplane) and foreign debt servicing can result into significant movement in developing countries' reserves.

to investigate the relationship between exchange rates and the foreign reserves using sample of African countries. The specific aim of this paper, therefore, is to empirically investigate the relationship between the two, with specific reference to appropriateness or otherwise of using reserve volatility as an indicator of interventions, more especially, in developing countries. The main contributions are, empirical investigation of relationship between exchange rate and reserves in developing countries where there is acute problem of sourcing data on intervention; secondly, effects of reserve changes on exchange rate and vice versa and thirdly the interventions pattern of African countries.

The rest of the paper is organized as follows. The next section discusses exchange rate regimes and foreign reserves. Section 3 sets out the econometric framework of the model. Section 4 discusses the estimated results and section 5 concludes.

## 2 Exchange Rate Regimes and the Reserves

The relationship between exchange rate and reserves is well established in the textbook expositions as the latter is used to stabilize a given exchange rate. There are many empirical works that used reserve volatility as determinant of exchange rate. The IMF in 1999 started incorporating reserves volatility among the exchange rate determinants. Other works that have linked the exchange rate and the reserves are Levy-Yeyati *et al* (2003), Berg, Borensztein and Patillo (2004) and Bordo, Eichengreen, Klingebiel and Soledad-Martinez (2001).

During the pre-floating era, the contributions and the discussion, on the reserves were limited to the relationship between the reserve and the global liquidity, but the introduction of the flexible exchange rates in the 1970s and the development of the capital markets resulted in discarding the opinion on the adequacy of international reserves vis a vis the global liquidity. However, the financial crises of the 1990s rekindled the discussion, but rather on country level and concentrated on what is the appropriate reserve level a country should hold in order to protect itself from currency crises. Currently, the trend in the developing countries is accumulation of reserves, particularly in the Asian countries. As Fisher (2001), rightly points out that, reserves are among the determinants of a country's capability of preventing economic and financial crises. He further elaborates that reserves are important to countries, but is more pertinent to the emerging and developing countries that generally experience volatile international capital flows.

Other related arguments in the literature include that reserves holdings reduce possibility of currency crises or 'sudden stop' of capital inflow. Secondly, high reserves tend to lead to low costs of external borrowing. These effects come from improved confidence, which is regarded as direct effects and through credit rating

or sovereign currency debt as risks for likely default has reduced with the accumulation of the foreign reserves. The latter is known as indirect effects. Hviding *et al* (2004) studying 28<sup>2</sup> emerging countries, find a strong non-linear effects of high reserves to exchange rate volatility. This means that a country with high reserves stock would experience less exchange rate volatility. Flood, Perraudin and Vitale (1998) have also found relationship between reserves loss, balance of payment crises and subsequent devaluations in the Latin American countries in the 1990s.

### 3 The Econometric Framework of the Model

Since the work of Hamilton (1989), two groups of literature on modeling economic variables defines different states of the regimes, and to allow for the likelihood that the dynamic behaviour of economic variables depend on the regime that occurs at any time developed. The first group is the Markov-switching models, which assumes that the regime cannot actually be observed but is determined by an underlying stochastic process. This means that although, probabilities on the occurrence of the different regimes can be assigned, it would be difficult to ascertain which particular regime has occurred at a given point in time. These were extended into Markov-Switching Vector Error Correction (MS-VECM) models. The second group views modeling the regime, explicitly as a continuous function of an observable variable like in threshold autoregressive (TAR) models, introduced by Tong and Lim (1980). As a result, both the past and the present regimes are known with the use of statistical techniques. Thus, giving the TAR models an edge over the Markov-switching models.

Modeling exchange rates and reserve within the threshold context can be motivated by the fact that the transition mechanism is controlled by official interventions in the market. For instance, it allows for distinguishing between the impact of the interventions on the exchange rates when there is a large reserves and their impact on exchange rates during which the reserve is small. An important feature of threshold models is their ability to capture persistent behaviour while remaining stationary. For example, it is argued that variables like unemployment and interest rates should be stationary. However, the conventional tests for unit roots fail to reject the null of non-stationarity. This resulted in argument that threshold models would better explain the dynamics of such series. A classical case cited is that of the real exchange rates, which have been documented to possess unit root, which implies non-existence of international arbitrage and therefore, violation of the PPP hypothesis. However, when threshold models were utilized, effects

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<sup>2</sup>The countries in their sample included 5 African countries.

of transaction costs are captured and the series appear globally stationary (Bec, Ben-Salem and Carrasco, 2004). Movements towards equilibrium could not take place due to the presence of adjustments cost on the side of the economic agents. There is therefore a persistent deviation from the equilibrium until such deviations exceed a critical threshold thereby resulting in a higher benefit to adjust than the cost.

The threshold cointegration was introduced by Balke and Fomby (1997) that combines non-linearity with cointegration. Models that have cointegrating variables can be typified by an error correction model (ECM) that explains how the variables respond to equilibrium in the face of deviations in such a way that the ECM represents an adjustment process through which long-run equilibrium is achieved. Balke and Fomby (1997) explain that it is not possible that movement back to or along the equilibrium takes place at every time period because of the existence of adjustment costs on the side of the economic agents. In the same vein, interventions with the purpose of altering the exchange rate level, or to dampen volatility do not occur within a given band. Thus, interventions of this nature occur only when the exchange rate is outside the band or approaching the edge of the band. The threshold cointegration maintains that the cointegrating relationship does not hold within a certain band, but only when the system is far away from the equilibrium, exceeding a certain threshold. Such adjustment is useful in explaining the behaviour of monetary authorities. The authorities would intervene when the exchange rate deviates too far from what they consider to be the equilibrium. The threshold cointegration would capture a possible non-linear relationship between the exchange rate and the foreign reserves in such a way that a mean-reverting dynamic behaviour of the exchange rate can be expected after exceeding a given threshold.

Based on Balke and Fomby the threshold vector of set of two endogenous variables, log of exchange rates and log of reserves is given as:

$$x_t = (e_t, r_t)' \quad (1)$$

which is a 2-dimensional  $I(1)$  time series where  $e_t$  and  $r_t$  as defined above. The model assumes that there is a long-run relationship between the series with a cointegrating scaler of  $\beta$ . A linear VECM of order  $l + 1$  takes the following:

$$\Delta x_t = A' X_{t-1} + u_t \quad (2)$$

where

$$X_{t-1} = \begin{pmatrix} 1 \\ w_{t-1} \\ \Delta x_{t-1} \\ \Delta x_{t-2} \\ \vdots \\ \Delta x_{t-l} \end{pmatrix} \quad (3)$$

where  $\Delta$  represents the first order difference operator, the regressor  $X_{t-1}$  is  $k \times 1$  and  $A$  is  $k \times 2$  and  $k = 2l + 4$ . The error term,  $u_t$  is assumed to be a  $(2 \times 1)$  with finite covariance matrix  $\Sigma = E(u_t, u_t')$ .  $A$  is a coefficient matrix that describes the dynamics in each of the regimes. If log of exchange rate  $e_{p,t}$ , is nonstationary  $I(1)$ , i.e. stationary on first differenced, then equation (1) represents a cointegrated system where  $w_{t-1} = e_{t-1} - \beta r_{t-1}$  is a stationary error correction term.

Based on Hansen and Seo (2002)<sup>3</sup> model in equation (2) could be extended as:

$$\Delta x_t = \begin{cases} A'_1 X_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) \leq \gamma \\ A'_2 X_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) > \gamma \end{cases} \quad (4)$$

where  $\gamma$  is the threshold parameter. Equation (4) above can be alternatively written in the following form:

$$\Delta x_t = A'_1 X_{t-1} d_{1t}(\gamma) + A'_2 X_{t-1} d_{2t}(\gamma) + u \quad (5)$$

where

$$\begin{aligned} d_{1t}(\gamma) &= I(w_{t-1}(\beta) \leq \gamma), \\ d_{2t}(\gamma) &= I(w_{t-1}(\beta) > \gamma) \end{aligned} \quad (6)$$

where  $I(\cdot)$  represents the indicator function.

The threshold model in (5) has two regimes, defined by the value of the error-correction term. The coefficient matrices  $A_1$  and  $A_2$  manage the dynamics in the regimes. Model (5) allows all coefficients, apart from the cointegrating vector, to switch between these two regimes. In some cases, constraint may be placed on  $A_1$  and  $A_2$  to obtain a special case of the mode, which allows some coefficients to shift between the regimes. For instance, a specific interest it may make sense to impose greater parsimony on the model, by only allowing some coefficients to switch between regimes. This is a special case where constraints are placed on  $(A_1; A_2)$ . For example, a model of particular interest only lets the coefficients on the con-

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<sup>3</sup>I am grateful to Hansen, who allowed a free download of his codes that are used here.

stant and the error correction  $w_t - 1$  to switch, constraining the coefficients on the lagged  $x_{t-j}$  to be constant across regimes. The threshold effect only has content if  $0 < P(w_{t-1} \leq \gamma) < 1$ , otherwise the model simplifies to linear cointegration. A constraint is imposed by assuming that

$$\pi_0 \leq p(w_{t-1} \leq \gamma) \leq 1 - \pi_0 \quad (7)$$

where  $\pi_0$  is a trimming parameter and positive.

The threshold model in equation (5) has two-regimes which is defined by the value of the error correction term. As long as the deviations from the equilibrium are lower or equal to the threshold, it would remain unlikely that the variables  $x_t$  would adjust towards the equilibrium. In other words, the variables would not be cointegrated. However, if the deviations are greater than the threshold, there is possibility of the variables would adjust towards equilibrium, meaning that the variables would be cointegrated.

If equation (5) is represented in the following form

$$\Delta x_t = A(w_{t-1})X_{t-1} + u_t \quad (8)$$

where  $A(w_{t-1}) = A_1 d_{1t}(\gamma) + A_2 d_{2t}(\gamma)$ , it could be seen that the threshold VECM can be interpreted as a linear VECM but time varying parameter.

Hansen and Seo (2002) also developed two LM test statistics to assess the evidence for threshold effects, a linear cointegration against the presence of threshold effects. The LM statistic is:

$$SupLM = SupLM_{\gamma L \leq \gamma \leq \gamma U}(\tilde{\beta}, \gamma) \quad (9)$$

where  $\tilde{\beta}$ , is the estimated  $\beta$  and  $\gamma L$  and  $\gamma U$  represent the search is set so that  $\gamma L$  is the  $\pi_0 = 0.05$  and  $\gamma U$  is the  $1 - \pi_0 = 0.95$  percentile.

The model results in one threshold if the adjustment parameter differs significantly between the two-regimes. If the adjustment parameter for the inner regime is not different from zero, one could interpret the threshold as transaction cost that needed to be high so that adjustment can be worthwhile.

## 4 The Estimated Results and Discussions

The estimation started by subjecting the series, the log of exchange rates and the log of reserves, to the unit root test. Table 1 presents the unit root test results where ADF, PP and KPSS tests were reported. In all the series non presence of unit root was rejected in favour of non-stationarity at the level and the opposite on the first difference, indicating that the series are all non-stationary  $I(1)$ .

The results for all the countries estimated rejected the presence of linear cointegration in favour of threshold cointegration. The  $p$ -values for both fixed regressor and the residual bootstrap are all zero. The thresholds are summarized in Tables 2 and 3.

In Algerian two-regime threshold cointegration, the estimated threshold parameter is 21.30. The first regime has 39% of the observations and the second regime has 61%. The latter is the usual regime. The error correction effects, in both  $e_t$  and  $r_t$  models, are significant. The size of the coefficients points to the fact that more adjustment takes place in the reserves in the first regime whereas the exchange rate adjusts more in the second regime. This is consistent with the floating exchange rate regime operated by the country. Figure 1 plots the error correction effects, which further illustrate this point, as there is a very small positive error correction effects for the reserves and strong negative effects for the exchange rate equations on left side of the estimated threshold. Strong negative error effects continued for the exchange rate while the reserves equations have a slight negative error on the right side of the estimated threshold.

The Botswana's results indicate an estimated threshold of 1.74. The first regime is the usual or typical regime as 89% of the observations are included while the unusual or extreme regime has only 11% of the observations is included. The error correction effects are only significant in the first regime and  $e_t$  model of the second regime. In the typical regime, the response of the reserves is more than the exchange rates. Botswana is on a peg regime, so the results seem to concur with that. The estimated parameters of the differenced terms reflect the transitory effects in the first period and the next period. The error correction effects are plotted in figure 2, in which a near zero effects for the reserves and moderate negative effects for the exchange rate equations on the right side of the threshold. The reserves and the exchange rate equations record slight and strong negative effects on the right side of the threshold with an implication that exchange rate beyond the threshold would result in an appreciation with an accompanying reduction in the reserves. But the rate of the appreciation seems to be higher than the reduction level in reserves.

The estimated two-regime threshold cointegration for Ghana has an estimated threshold of 0.46 with the first regime as the unusual regime, as only 13% of the observations whereas the second regime, the usual regime has 87% of the observations. The error corrections effects are significant in both regimes. The coefficients of the error correction effects suggest that more adjustment takes place in the reserve, in both the first and the second regimes. The error correction effects, as plotted in figure 3 show that the exchange rate equations recorded a near zero effects on both the left and the right side of the threshold whereas the reserves equations have contrasting recorded strong positive and negative effects on the left

and right side of the threshold, respectively. The exchange rates remain somewhat stable after the threshold but the reserves declined sharply after the threshold.

Kenyan two-regime threshold VECM reveals a threshold of 0.9. The first regime, which is the unusual or extreme regime, has 22% of the observations and the usual or the typical regime, which includes 78% of the observations. The error correction effects are more significant in the second regime, which is the usual regime. The size of the coefficients indicates that more adjustment occurs in the exchange rate than in the reserve. This is consistent with flexible exchange rate regimes, which Kenya runs. Figure 4.4 represents the error correction effects with both the exchange rates and the reserves equations having strong positive effects on the right side of the threshold and near zero effects after the threshold.

The estimated two-regime threshold cointegration for Morocco shows an estimated threshold of  $-0.28$ . The first regime is the unusual regime, consisting of 34% of the observations while the usual or second regime, which is the usual regime including 66% of the observations. The error correction effects are significant in both regimes and the size of the coefficients suggests that there is more adjustment in the exchange rate in the first regime and the adjustments in the second regime do not significantly differ in the second regime. The results do not deviate much from the expected one, as Morocco has a managed float regime. The error correction effects, as in figure 5 show a slight negative effect and a near zero effects for the exchange rate and the reserves equations on the left side of the estimated threshold. While the exchange rate recorded moderate positive effects, the reserves exhibited a strong positive one on the right side of the estimated threshold. The reserves rose considerably after the threshold with a slight appreciation of the currency.

The estimated two-regime threshold for Nigeria has a threshold of 0.97%. The first regime is the unusual or extreme regime, including 40% of the observations included while the second and the usual regime has 60% of the observation. The adjustment in the second regime seems to be placed on the reserve than in the exchange rate. The error correction effects are significant in both the regimes. Figure 6 plots the error correction effects, which shows that the reserve has more positive effects than the exchange rate on the left side of the threshold whereas the reserve has a slight positive effect while the exchange rate has negative effects on the right side of the threshold.

The estimated two-regime threshold VECM for the South Africa shows a threshold of 4.12, and the first regime is the usual regime as 79% of observations are included. The second and unusual regime is when the exchange rate includes 21% of the observations. The error correction effects are significant in both the regimes. The error correction term allows analysis of the behaviour of the gap between the exchange rate and the reserves. The size and the magnitude of the

coefficients tell us about the processes of how the long-run equilibrium between the exchange rate and the reserves is maintained. The coefficients on the error correction term suggest that the response of reserves is higher than the response of the exchange rate. A value of gap above 4.1% in one month would result in downward pressure on the exchange rate in the following month whereas a value of gap below 4.1% in one would result in upward pressure in the subsequent month. The exchange rate revealed a near zero effects at both the left and right sides of the estimated threshold. The reserves equations on the other hand, have negative effects at both the left and the right side of the estimated threshold.

The Ugandan two-regime threshold VECM has with an estimated threshold -0.15. The first regime is the usual regime, as 79% of the observations are included. The second and the unusual regime has 21% of the observations included. The error correction effects are significant in both regimes. The exchange rate equation has small negative effects while the reserves equations have a slight positive effect at the left side of the threshold. But both equations display strong negative effects with the exchange rate more negative than the reserves on the right side of the estimated threshold. This means that both the exchange rate and the reserves would drastically decline after the threshold.

## 5 Conclusion

This paper uses the threshold cointegration technique to investigate the relationship between exchange rates reserves in some African countries. The results have shown that threshold cointegration exist between the series, meaning that a long-run dynamic relationship between them exists. This means that, as it is done in empirical work, the use of reserves volatility as a proxy for intervention could be valid. The error correction effects have shown how changes and adjustments take place within and between the series. In some cases, adjustments are higher in the exchange rate and in some cases is the reverse. The threshold varies from in to 0.28 in Morocco to 4.12 in South Africa. This is a reflection of degree of tolerance that the countries have for exchange rate volatility. In general, countries that have float regimes seem to have higher threshold and the exchange rates appear to adjust more than the reserves.

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**Table 1**  
**Unit Root Tests**

Series	ADF		PP		KPSS	
	Level	1 <sup>st</sup> Difference	Level	1 <sup>st</sup> Difference	Level	1 <sup>st</sup> Difference
lkenres	-0.89*	-17.25**	-1.04*	-26.56**	1.96 <sup>a</sup>	0.16 <sup>b</sup>
lkenexc	-0.92*	-12.87**	-0.90*	-12.90**	2.02 <sup>a</sup>	0.06 <sup>b</sup>
lalgres	-0.15*	-23.51**	-0.34*	-29.03**	1.89 <sup>a</sup>	0.08 <sup>b</sup>
lalgexc	0.20*	-15.50**	-0.02*	-16.10**	2.01 <sup>a</sup>	0.25 <sup>b</sup>
lbotsres	-0.52*	-11.00**	-1.28*	-50.15**	1.97 <sup>a</sup>	0.15 <sup>b</sup>
lbotsex	-1.87*	-16.13**	-1.98*	-16.09**	0.23 <sup>a</sup>	0.21 <sup>b</sup>
lghnres	-0.56*	-25.3**	-0.50*	-27.95**	2.03 <sup>a</sup>	0.07 <sup>b</sup>
lghnexc	0.60*	-4.40**	1.61*	-12.33**	1.63 <sup>a</sup>	0.68 <sup>bc</sup>
luganres	-1.36*	-16.09**	-1.45*	-26.03**	1.97 <sup>a</sup>	0.35 <sup>b</sup>
Luganexc	-2.19*	-17.05**	-2.29*	-18.02**	1.74 <sup>a</sup>	0.09 <sup>b</sup>
lsares	1.76*	-5.90**	0.23*	-32.78**	2.00 <sup>a</sup>	0.24 <sup>b</sup>
lsaexc	-2.26*	-16.37**	-2.27*	-16.36**	2.00 <sup>a</sup>	0.41 <sup>bd</sup>
lnigres	-1.04*	-10.74**	-1.29*	-16.49**	1.19 <sup>a</sup>	0.33 <sup>b</sup>
lnigexc	-1.07*	-16.67**	-1.07*	-16.69**	2.00 <sup>a</sup>	0.12 <sup>b</sup>
lmorres	-1.46*	-16.63**	-1.23*	-27.21**	1.92 <sup>a</sup>	0.14 <sup>b</sup>
lmorex	-2.54*	-15.94**	-2.53*	-15.92**	0.38 <sup>a</sup>	0.11 <sup>b</sup>

bc significant at 1% level of significance

bd significant at 1% and 5% level of significance

\* Failed to reject the null that the series has unit root

\*\* Rejected the null that the series has unit root

<sup>a</sup> Rejected the null that the series is stationary

<sup>b</sup> Failed to reject the null that the series is stationary

**Table 2a**  
**Threshold VECM**

Country	Variables	1st Regime		2nd Regime	
		e <sub>t</sub> model	r <sub>t</sub> model	e <sub>t</sub> model	r <sub>t</sub> model
<b>Algeria</b>	Intercept	-1.86 (0.05)	0.45 (0.03)	-2.26 (0.08)	-0.33 (0.01)
	W <sub>t-1</sub>	-43.25 (04.71)	84.91 (2.13)	-26.32 (8.18)	8.55 (2.25)
	e <sub>t-1</sub>	1.37 (0.04)	-0.04 (0.02)	0.01 (0.04)	0.00 (0.00)
	r <sub>t-1</sub>	-3.16 (0.3)	0.93 (0.1)	0.11 (0.13)	0.14 (0.04)
	Threshold Parameter	21.3			
	Cointegration Vector	3.91			
	% of obs		39		61
	<b>Botswana</b>	Intercept	-0.44 (0.06)	0.1 (0.06)	-1.97 (0.46)
W <sub>t-1</sub>	0.75 (0.07)	-0.75 (0.05)	1.83 (0.78)	-0.18 (0.69)	
e <sub>t-1</sub>	0.74 (0.04)	0.15 (0.03)	1.23 (0.23)	0.5 (0.32)	
r <sub>t-1</sub>	0.16 (0.07)	-0.34 (0.06)	3.58 (1.34)	4.22 (1.42)	
Threshold Parameter	1.74				
Cointegration Vector	1.23				
% of obs		89		11	
<b>Ghana</b>	Intercept	0.29 (0.10)	21311.8 (1321.48)	-0.09 (0.01)	-199.46 (95.12)
	W <sub>t-1</sub>	-2.39 (0.02)	-5694.78 (513.97)	0.56 (0.03)	2112.64 (162.46)
	e <sub>t-1</sub>	-0.12 (0.02)	-20781.1 (1303)	-0.12 (0.02)	-624.84 (127.05)
	r <sub>t-1</sub>	-0.00 (0.00)	0.46 (0.07)	-0.00 (0.00)	0.3 (0.03)
	Threshold Parameter	0.46			
	Cointegration Vector	0.97			
% of obs		13		87	
<b>Kenya</b>	Intercept	4.56 (0.49)	2.78 (0.26)	0.22 (0.05)	0.16 (0.04)
	W <sub>t-1</sub>	2.86 (0.41)	1.97 (0.21)	0.24 (0.02)	0.18 (0.01)
	e <sub>t-1</sub>	-5.5 (0.51)	-2.66 (0.28)	-0.14 (0.04)	-0.01 (0.01)
	r <sub>t-1</sub>	11.53 (0.94)	4.91 (0.54)	0.23 (0.06)	0.08 (0.02)
	Threshold Parameter	0.9			
	Cointegration Vector	2.70			
	% of obs		22		78

**Table 2b**  
**Threshold VECM**

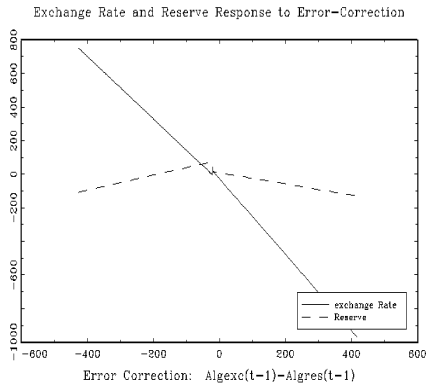
Country	Variables	1st Regime		2nd Regime	
		$e_t$ model	$r_t$ model	$e_t$ model	$r_t$ model
<b>Morocco</b>	Intercept	-1.04 (0.10)	-0.36 (0.26)	1.27 (0.23)	5.77 (0.78)
	$w_{t-1}$	-0.28 (0.03)	0.04 (0.07)	0.32 (0.06)	1.55 (0.21)
	$e_{t-1}$	0.68 (0.09)	2.56 (0.25)	1.07 (0.12)	2.70 (0.31)
	$r_{t-1}$	-0.35 (0.03)	-1.26 (0.09)	0.00 (0.13)	-0.11 (0.05)
	Threshold Parameter	0.28			
	Cointegration Vector	0.29			
	% of obs		34		66
<b>Nigeria</b>	Intercept	0.24 (0.08)	1.21 (0.14)	-0.31 (0.04)	0.22 (0.03)
	$w_{t-1}$	-0.35 (0.11)	-2.09 (0.18)	0.73 (0.09)	-0.07 (0.06)
	$e_{t-1}$	-1.13 (0.07)	-1.14 (0.11)	-0.35 (0.12)	0.17 (0.05)
	$r_{t-1}$	0.33 (0.16)	2.00 (0.23)	0.03 (0.03)	0.18 (0.02)
	Threshold Parameter	0.97			
	Cointegration Vector	1.45			
	% of obs		40		60
<b>South Africa</b>	Intercept	-0.10 (0.11)	-1.23 (0.10)	0.21 (0.19)	-1.5 (0.16)
	$w_{t-1}$	0.72 (0.34)	4.25 (0.35)	-1.35 (0.95)	7.13 (0.77)
	$e_{t-1}$	0.08 (0.04)	0.30 (0.05)	0.12 (0.08)	0.25 (0.12)
	$r_{t-1}$	0.03 (0.02)	0.23 (0.04)	-0.11 (0.10)	0.44 (0.12)
	Threshold Parameter	4.12			
	Cointegration Vector	-0.90			
	% of obs		46		54
<b>Uganda</b>	Intercept	0.32 (0.01)	0.32 (0.01)	-17.23 (0.92)	-17.23 (0.92)
	$w_{t-1}$	0.62 (0.07)	0.62 (0.07)	-2.48 (0.33)	-2.48 (0.33)
	$e_{t-1}$	0.33 (0.05)	0.33 (0.05)	7.37 (1.25)	7.37 (1.25)
	$r_{t-1}$	-0.31 (0.04)	-0.31 (0.04)	-3.59 (2.06)	-3.59 (2.06)
	Threshold Parameter	0.15			
	Cointegration Vector	0.72			
	% of obs		79		21

**Table 3**  
**Threshold VECM**  
**Diagnostics**

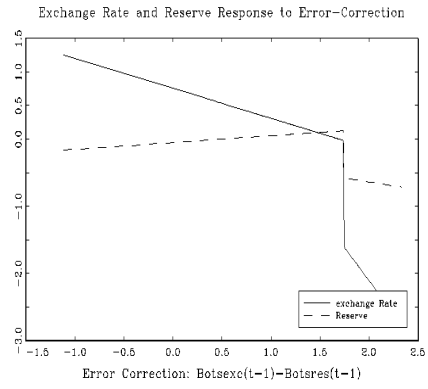
Country	Test Statistics	Fixed Regressor p-Value	Bootstrap p-Value
<b>Algeria</b>	193.55	0.00	0.00
<b>Botswana</b>	102.31	0.00	0.00
<b>Ghana</b>	254.77	0.00	0.00
<b>Kenya</b>	193.62	0.00	0.00
<b>Morocco</b>	163.55	0.00	0.00
<b>Nigeria</b>	90.43	0.00	0.00
<b>South Africa</b>	151.52	0.00	0.00
<b>Uganda</b>	125.82	0.00	0.00

**Logs of Exchange Rate and Reserves Response to Error-Correction**

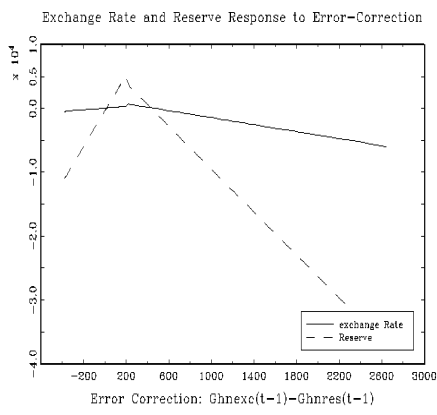
**Figure 1: Algeria**



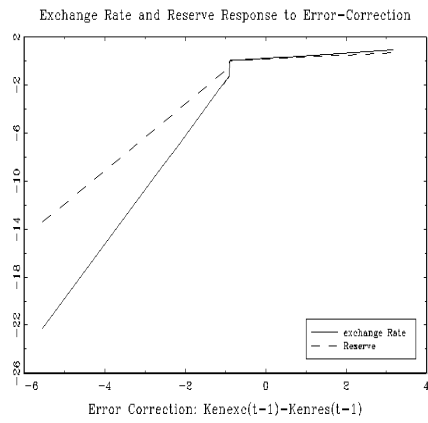
**Figure 2: Botswana**



**Figure 3: Ghana**

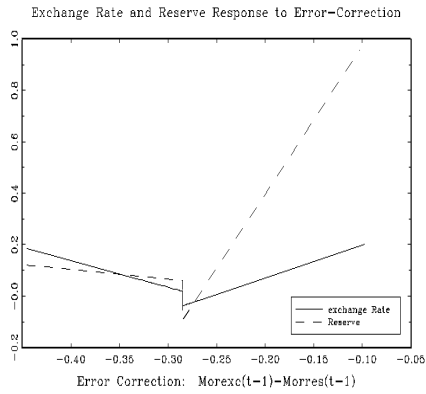


**Figure 4: Kenya**

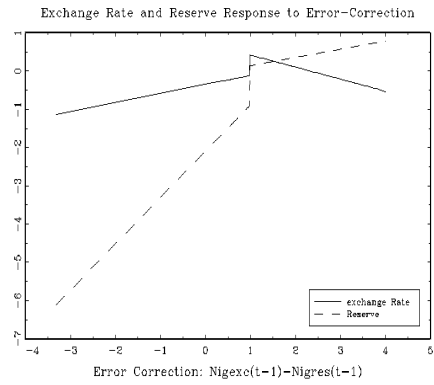


**Logs of Exchange Rate and Reserves Response to Error-Correction**

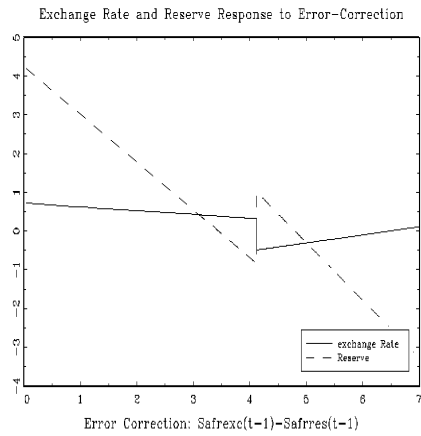
**Figure 5: Morocco**



**Figure 6: Nigeria**



**Figure 7: South Africa**



**Figure 8: Uganda**

