Regime Switching Monetary Policy and Nonlinear Taylor Rule in African Open Economies

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Abstract- The study is theoretical, entitled the 'Regime Switching Monetary Policy and Nonlinear Taylor Rule in African Open Economies Explore'. The essay examined the responses of the monetary policy authorities to the volatility of their exchange rate. The study employed a baseline methodology, and the empirical specifications revealed the linearised objective function of the sample countries' central banks, which is consistent with theoretical the theory of the Taylor rule, and presented the relation of the central banks that targets deviation of the actual output from its potential level and the deviation of the actual inflation from the expected inflation. Further, the test for nonlinearity conducted in this study aligns with Franses and van Dijik's (2000; 2003) procedure. The study concluded that the smoothing parameter (i_{t-1}) is the transition variable in Botswana and Morocco. In the cases of Egypt and South Africa, inflation is the primary variable that causes regime switch; hence it represents the transition variable in both countries. Finally, the monetary policy in the high exchange rate regime Botswana and South Africa are faced with much higher inflation than Egypt and Morocco. Therefore, the monetary policy response is tightening to reduce the effects of the higher inflation experienced in an exchange rate depreciating regime. Output gap increases across all the countries under the exchange rate depreciating regime. This suggests instability in output which is accompanied by significant falls in the exchange values of all the currencies. However, the results showed that Egyptian pounds are not depreciating significantly compared to the other currencies.

I. INTRODUCTION

Following the advent of the Nixon shock of the 1970s, monetary policy's mandate of achieving intermediate targets has increasingly become more critical. Concerns about exchange rate management now rest more on the monetary authorities. In recent times, complexity in the exchange rate management appears to be increasing. Two critical factors might be attributed to the increasing challenges in managing exchange rates, especially in developing, open economies.

Firstly, over the years, it appears structural adjustments across most developing countries, accompanied by an opening up and deregulation of the capital account, have forged a significant watershed on monetary policy in many countries. Informed by the need to mitigate instability in domestic currency, monetary authorities in these countries seem to have been conducting monetary policy to either improve capital inflows or curtail excessive capital outflows. This is in line with Fornaro (2015) and Ottonello (2015).

Secondly, amplified by increased market integration and sophistication of financial instruments, which allows for easy capital mobility, capital movements across markets are ever becoming volatile[1]. This evidence has recently been documented in several studies by Forbes, Hjortsoe, Nenova (2017), Forbes, Fratzscher, Kostka and Straub (2016; 2015), and Forbes, Carrasco, Gokarn and Mukhopadhyay (2014). Evidence of these capital flow volatilities and their spillover[2] Effect on the exchange rate of domestic currency is likely to pose more significant macroeconomic policy challenges.

Consequently, compelled by these factors, many African countries appear to have adopted diverse strategies of managing the exchange rate of their domestic currencies in the face of volatile capital flows in line with the trilemma of achieving independent monetary policy with open capital account and a stable exchange rate. The ability to meet the intermediate target becomes increasingly challenging.

For instance, Botswana has abandoned the Rand Monetary Area (R.M.A.) to establish an independent domestic currency using a fixed exchange regime in sub-Saharan Africa. However, the central bank discarded the fixed regime and adopted the crawling exchange rate regime. This was necessary because of the pressure imposed by the exchange rate basket. Similarly, the South African reserve bank abandoned its initial fixed exchange rate regime and pursued an independent managed floating exchange rate regime.

In the same vein, open economies in the northern part of Africa appeared unshielded from the vagaries of exchange rate fluctuation associated with capital volatility spillover. Thus, they are equally compelled to changes in exchange rate regimes to maintain domestic currency stability. For example, both the Moroccan and Egyptian central banks appeared to have gone through significant departures from their initial exchange rate regimes.

In the case of the Moroccan dirham, it was first pegged using the fixed exchange regime but abandoned in favour of a flexible exchange rate regime. Meanwhile, the Egyptian central bank followed an adjustable fixed exchange rate regime. Subsequently, a managed exchange rate regime replaced the initial fixed regime. These departures in exchange rate regimes experienced in open African economies attest to the challenges confronting the monetary authorities in managing the exchange rate value of the domestic currencies. However, this general transition to a more flexible exchange rate regime by these countries, to allow for greater independence of monetary policy for targeting domestic targets, presents additional challenges by increasing exchange rate volatility.

As found in the previous chapters, capital flows volatility in the selected countries has significantly affected the exchange rate volatility. Given the high pass-through effects of the exchange rate on domestic inflation, the conduct of monetary policy in these countries may also be responsive to changes in capital flows, in addition to the exchange rate changes themselves. This implies that the monetary policy reaction functions of the central banks of these countries may also include some measures of capital flows and exchange rate volatilities. Thus, this chapter provides empirical evidence of how the central banks within the selected African countries manage their short and intermediate terms targets, given the potentially destabilising effects of capital flows and exchange rate volatilities.

Recognising the potential nonlinearities in their reaction situates a regime-switching model within the Taylor rule framework. The regime-switching model in this study follows a smooth transition regression model (STAR), which is also consistent with research by Naraidoo and Paya (2010). The assumption in this model is that central banks' attempt to smooth their interest rate path to dampen policy rate uncertainties (Bello and Sanusi, 2016). The study tested and found evidence of nonlinearities in the monetary policy rules for each of the central banks.

The behaviours of the monetary authorities in setting the policy rate in the central banks are characterised as logistic functions. This means the response of the monetary policy rate of each bank smoothly.[3] Thus, the switch between two different regimes depends on some transition variable's value. In the case of Botswana and Morocco, this transition variable is found to be the lagged interest rate, while the inflation rate was found to be the transition variable in Egypt and South Africa.

However, the monetary policy target that causes regime switch differs among the central banks. This means, in the case of Botswana and Morocco, regime switch in monetary policy is triggered by the margin of the differential between the previous level interest rate and the current interest rate. In contrast, the regime switch in monetary policy rule in the Egyptian central bank and that of the South African reserve bank is triggered by the threshold of domestic inflation.

The rest of the chapter presents a review of the related literature, methodology and description of the data used. The last part of the chapter presents the estimated empirical result of the nonlinear Taylor rule.

II. LITERATURE REVIEW

Since the resurgence of the New Keynesian model, the Taylor rule (monetary policy rule) has become a dominant framework in monetary policy analysis. The concentration and early evidence are found in advanced economies but developing, and emerging economies are increasingly embracing the framework as a tool for analysing monetary policy.

One of the early estimations of the Taylor rule reveals the evidence of advanced economies. The study was advanced by Clarida, Gali and Gertler (1997), and the result reveals that monetary policy success achieved by the central banks in Germany, Japan and the U.S. was down to applying forward-looking, inflation targeting framework the banks. Conversely, the central banks of the UK, France and Italy, perhaps including other European countries, are heavily influenced by Germany's central bank (Bundesbank). To a large extent, monetary policy in these countries is aggressively keeping higher interest rates (Clarida, Gali & Gertler, 1997). The external influence that the Bundesbank has on other European central banks could be due to the influence of capital flow and its net effect on the exchange rate, primarily because of the interconnectivity of financial markets across Europe and responsiveness of capital flow to the changes in the monetary policy. Therefore, this strongly indicates the relevance of the external sector in stabilising the domestic economy.

However, a study by Castro (2008) points out that in addition to exchange rate consideration in monetary policy reaction, the European Central Bank (E.C.B.) and Bank of England also consider financial conditions in the conduct of monetary policy. The financial condition includes but unrestricted to asset prices. The study applies the Smooth Transition Autoregression (STAR) model in the estimation of the nonlinear monetary policy reaction function[4].

An interesting finding that emanates is the distinctiveness in the behaviour between the two central banks in terms of how they react. The E.C.B. was found to react to asset prices, whereas the Bank of England did not. The non-responsiveness of the bank to asset prices means it is shy of capital flow movement in and out of the economy. Hence, this might make such an economy vulnerable to financial crises spillover from other markets.

Carvalho and Moura (2008) apply the Taylor rule in analysing the monetary policy in Latin American counties. The study results show that for the period under review, the central banks of the countries follow the Taylor rule. The finding reveals that central banks in these countries consider domestic inflation a significant target, and less importance is placed on stabilising output and exchange rate. However, only Brazil, Chile and Mexico follow the Taylor rule to some degree. The study also indicates the prominence of the backwards-looking monetary policy rule over the forward-looking rule.

Recently, empirical evidence (Coulibaly, 2018) has shown the great relevance of monetary policy under capital account control. The study emphasises the radical effect capital control has on monetary policy. Coulibaly (2018) argues that monetary policy will be near-optimal under a liberalised capital account regime only when the monetary authority is committed to keeping inflation low. The study maintains that economies with controlled capital accounts are better shielded from financial crises, even when higher inflationary pressures. Procyclicality and the attendant adverse welfare effect are mitigated under a control capital account regime.

It is in line with the issue of monetary policy performance under capital account control that Ottonello (2015), as well as Vegh and Vuletin (2012), shed some light on the effect of capital account liberalisation, which many countries in Sub-Saharan Africa embarked on after the financial crises of the early 1980s. To a large degree, the integration of the capital markets has increased the exposure of many countries to the spillover effect of financial crises. Hence, this indicates that economic stability in countries with liberalised capital accounts is at significant risk, and monetary policy may struggle to stabilise the exchange rate whenever financial crises hit the economy.

Similarly, Fornaro (2015) provides support to Ottonello (2015) who argues that under optimal capital control, exchange rate management tends to provide better welfare than monetary policy targeting inflation. These studies prove that an optimal exchange rate policy can eliminate inefficiencies that arise from nominal rigidities.

Furthermore, Coulibaly (2018) substantiates this finding and reports that monetary policy under capital control can improve the potency and efficacy of monetary policy in emerging economies. In contrast, optimal monetary policy under capital controls is better used whenever capital inflow into the domestic economy experiences a sudden stop, as suggested by Devereux *et al.* (2016). Coulibaly (2018) argues that capital controls are only complementary tools that can be applied to either discretionary or monetary policy rules. However, Devereux *et al.* (2016) maintain that capital control is essentially used to cushion the effect of a sudden stop in capital inflows associated with the inefficiency of capital market dynamics. This argument is also at variance with the position of Bianchi (2011), who is of the view that capital control is primarily used for the stabilisation of external accounts and to mitigate against excessive risk exposure.

Therefore, the current study hopes to add to the ongoing debate by estimating a monetary policy reaction function that responds to exchange rate regimes when capital volatility spillovers to the domestic exchange rate in developing economies.

Other strands of the literature that focus on the framework for monetary policy analysis are predominantly centred on the New Keynesian policy model. The appropriateness and suitability of the Taylor-type rule have been substantiated in many studies. One of the pieces of empirical evidence reported by Carvalho and Nechio (2014) is the consistency of the Taylor rule with how economic agents form expectations. This shows the framework's relevance in managing how monetary policy can better be anchored on expectation. Similarly, Orphanides (2007) considers the role of the Taylor rule for both positive and normative monetary policy. The study stressed that the framework illuminates how the interest rate adjusted systematically to the development[5] in the economy.

In support of this view, Kahn (2012) buttressed the significance of the Taylor rule in revealing the success or failure of ex-post monetary policy. Recent studies have attempted to estimate different variants of a Taylor-type rule in both developed and emerging economies. Bennani (2018), Aguanno (2018), Skumsnes (2013) Hayat and Mishra (2010). Other studies in developing economies include Saghir and Malik (2017) Bello and Sanusi (2016), Naraidoo and Raputsoane (2013) Naraidoo and Paya (2012) have all applied the New Keynesian Taylor rule in estimating monetary policy reaction function.

Aron and Muellbauer (2007) estimated a simple interest rate rule and an extended monetary policy rule for the South Africa Reserve Bank (S.A.R.B.) under the capital liberalisation regime. The study pointed out that the S.A.R.B. follows a money growth rate against inflation targeting. Under this rule, the bank places less weight on output stability. Also, the study reports aggressive behaviour in the bank when changing the interest rate. In contrast, Naraidoo and Paya (2012) report that the S.A.R.B. reacts to asset prices in its monetary policy rule and the bank follows inflation targeting monetary policy rule.

Unlike Aron and Muellbauer (2007), which limits their study to analysing the Taylor rule's linear estimation, Naraidoo and Paya (2012) estimated both linear and nonlinear variants of the Taylor rule. The outcome of the models in terms of forecast, the nonlinear models did better in the out-of-sample forecast. In support of the relevance of the capital market dynamic in the conduct of monetary policy, Naraidoo and Raputsoane (2013) provide evidence that suggests that the South African market is marked by volatility which accounts for uncertainties in the financial market. The study reveals that the S.A.R.B. is less aggressive in adjusting the nominal interest rate to weaken the tendency of any instability that might result in abrupt changes in the monetary policy. This monetary policy posture is consistent with the Central Bank of Nigeria (CBN) as well as the State Bank of Pakistan (S.B.P.) as reported by Bello and Sanusi (2016) and Saghir and Malik (2017), respectively.

The current research study sought to estimate a nonlinear Taylor-type monetary policy rule to align the monetary policy changes with the theoretical, empirical and practical justification. Theoretically, the nonlinear behaviour of inflation in the New Keynesian Philips Curve (N.K.P.C.) is expected to be matched by a corresponding nonlinear monetary policy rule. Empirically, the justification for nonlinearity in monetary policy rule has been established in Dolado, Maria-Dolores and Naveira (2003), who show the implication of nonlinear Philips cure on monetary policy rule. Other studies that have provided empirical evidence include those by Qin and Enders (2007), Cukierman and Muscatelli (2008), Catro (2008), Moura and Cavalho (2009), Hayat and Mishra (2010), Naidoo and Paya (2010; 2012) Bennani (2018). Hence, this study builds on the existing premise established theoretically, empirically, and practically, which presumes that optimal monetary policy is nonlinear. The practical justification rests on the assumption that, in practice, policymakers adjust interest rates more when inflation and output deviate further away from the target than when the deviation from the target is minor.

Furthermore, an optimal monetary policy that has evolved over the years is expected to reflect the diverse exchange rate regime associated with changes in capital account liberalisation. Hence, periods of stops and starts in capital flow are expected to be transmitted to the exchange rate. Thus, it suggests regime changes in the exchange rate in emerging economies.

III. METHODOLOGY

This section focused on the framework used for the study, the methods to be applied and the data.

1. Baseline Model

The baseline model's building blocks are comprised of households and firms that behave optimally; households maximise the expected present value of utility, and firms maximise profits. There is also a central bank that controls the nominal rate of interest. In contrast to households and firms, the central bank is not assumed to behave optimally.

The affinity necessitates the non-optimising behaviour of the central bank for credibility. This also rests on its commitment to shun optimising goals that could arise from deviation from rule after private agents have made commitments by demanding wages and setting prices [given the monopolistic nature of the markets, labour union on one side and employers (government) on the other side] based on the expectation that the rule set out by the central bank will not change.

Therefore, based on the non-optimising behaviour of a central bank, it is assumed that a central bank's monetary policy is represented by a rule for setting the nominal interest rate. This policy rule is derived from a specification of the central bank's objective function (Walsh, 2003), consistent with the theoretical Taylor rule.

Households: The representative household that enters the model assumes a revealed preference that is defined by a basket of consumption good C_t, the share of wage income, that is kept as accurate money balances, M_t/P_t, that is kept in demand deposits for precautionary, transitionary speculative purposes. Leisure $1\text{-}l_t$ represents a share of labour time not sold, where l_t is the share of labour time supplied to the labour market, which is rewarded at the prevailing wage rate. Households maximise the expected present discounted value of utility by aggregating using the C.E.S. aggregator on the various bundle identified ($C_t;M_t/P_t$ and $1\text{-}l_t$):

$$E_t \sum_{i=0}^{\infty} \alpha^{i} \left(\frac{C_{t+i}^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-b} \left[\frac{M_{t+1}}{P_{t+i}} \right]^{1-b} - \chi \frac{l_{t+i}^{1+\eta}}{1+\eta} \right) \quad 1$$

Whereχ, stands a coefficient that explains the elasticity of household leisure.

The bundle of consumption goods in the consumer basket consists of heterogeneous finite products supplied by monopolistically competitive firms (Fuhrer, 2000). The industry is composed of a finite series of undifferentiated firms assumed to be in a Euclidean space. Hence, the composite consumption basket that enters the household’s utility function is defined as consumption, leisure, labour supply, money and financial assets. Note that the negative summation of the leisure component in the consumption basket equation 6.1 is attributed to the opportunity costs of the wages income forgone due to increasing leisure time consumed by the household or the disutility from working at the prevailing wage rate.

$$C_t^{-\sigma} = \beta(1 + \iota_t) E_t \left(\frac{P_t}{P_{t+1}} \right) C_{t+1}^{-\sigma} \quad 2$$

These conditions represent the Euler condition for the optimal inter-temporal allocation of consumption, the inter-temporal optimality condition setting the marginal rate of substitution between money and consumption equal to the opportunity cost of holding money, and the inter-temporal optimality condition setting the marginal rate of substitution between leisure and consumption equal to the real wage (Walsh, 2003, 333; Roma, 2012, 315-316).

In attempting to maximise the household utility function, the definite integral of the composite consumption function is taken, concerning the differentiated bundles of the commodity produced by the firm denoted as ***j.***, the limits of the definite integral [0,1] represents the measure of firms in the industry. Therefore:

$$\{\int_0^1 c_{jt}^{(\emptyset-1)/\emptyset}\,dj\}^{\emptyset/\emptyset-1} \qquad 3$$

Firms: Firms maximise profits, subject to three constraints. The first is the production function summarising the available technology. For simplicity, capital is ignored, so the output is a function solely of labour input $l_{jt,}$ and an aggregate productivity disturbance Z_t, where constant returns to scale has been assumed. The second constraint on the firm is the demand curve each firm faces. The third constraint is that some firms are not able to adjust their price in each period. The specific model of price stickiness used is from Calvo (1983). In each period, the firms that adjust their price are randomly selected, and a fraction 1-Ω of all firms adjust, while the remaining Ω fraction do not adjust and the price can be approximated around zero-average inflation, steady-state equilibrium to obtain an expression for aggregate inflation of the form:

$$\pi_t = \beta E_t \pi_{t+1} + K y_t \qquad 4$$

Conclusion: there are now all the components of a simple general equilibrium model that is consistent with optimising behaviour on households and firms. Because consumption is equal to output in this model (there is no government or investment since capital has been ignored), equation 5.2 can be approximated around the zero-inflation steady state as:

$$y_t = E_t \hat{y}_{t+1} - \left(\frac{1}{\sigma}\right)(\hat{\imath}_t - E_t \pi_{t+1}) \qquad 5$$

Expressing this in terms of the output gap,

$$X_t = \hat{y}_t - \hat{y}_t^f$$

$$y_t = E_t y_{t+1} - \left(\frac{1}{\sigma}\right)(\hat{\imath}_t - E_t \pi_{t+1}) + u_t \qquad 6$$

$Where\ u_t \equiv E_t \hat{y}_{t+1}^f - \hat{y}_t^f$ Depends only on the exogenous productivity disturbance.

Combining equation 6.5 with equation 6.6 gives a simple two-equation, forward-looking, rational-expectations model for inflation and the output gap measure **Yₜ**. This two-equation model represents the equilibrium conditions for a well-specified general equilibrium model. Equations 6.5 and 6.6 contain three variables: the output gap, inflation, and the nominal interest rate. The model can be closed by assuming that the central bank implements monetary policy by controlling the nominal interest rate. Alternatively, if the central bank implements monetary policy by setting a path for the nominal supply of money, equation 6.5 and equation 6.6 determine y_t, π_t, and $\hat{\imath}_t$.

If a policy rule for the nominal interest rate is added to the model, this must be done to ensure that the policy rule does not render the system unstable or introduce multiple equilibria. Assuming, suppose the following rule for $\hat{\imath}_t$ represents monetary policy:

$$\hat{\imath}_t = P_r \hat{\imath}_{t-1} + V_t \qquad 7$$

This specification makes the nominal interest rate an exogenous AR (1) process with innovation V_t combining equation 6.7 with equation 6.5 and equation 6.6. The resulting system of equations can be written as:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & \sigma^{-1} \\ 0 & 0 & \beta \end{bmatrix} \begin{bmatrix} \hat{\imath}_t & 0 \\ E_t & y_{t+1} \\ E_t & \pi_{t+1} \end{bmatrix} = \begin{bmatrix} P_r & 0 & 0 \\ \sigma^{-1} & 1 & 0 \\ 0 & -K & 1 \end{bmatrix} \begin{bmatrix} \hat{\imath}_{t-1} \\ y_t \\ \pi_t \end{bmatrix} + \begin{bmatrix} V_t \\ -y_t \\ 0 \end{bmatrix}$$

Premultiplying both sides by the inverse of the matrix on the left produces:

$$\begin{bmatrix} \hat{\imath}_t \\ E_t y_{t+1} \\ E_t \pi_{t+1} \end{bmatrix} = M \begin{bmatrix} \hat{\imath}_{t-1} \\ y_t \\ \pi_t \end{bmatrix} + \begin{bmatrix} V_t \\ -y_t \\ 0 \end{bmatrix} \qquad 8$$

Equation (6.8) has a unique, stationary solution for the output gap, inflation, and the nominal interest rate, if, and only if, the number of eigen-values of M outside the unit circle is equal to the number of forward-looking variables, which, in this case, is 2 (Blanchard & Kahn, 1980, as cited in Walsh, 2003).

This illustrates an exogenous policy rule — one that does not respond to the endogenous variables x and π introduces the possibility of multiple equilibria. To see why, consider what would happen if expected inflation were to rise. Because equation 6.7 does not allow for any endogenous feedback from this rise in expected inflation to the nominal interest rate, the real interest rate must fall. This decline in the real interest rate is expansionary, and the output gap increases. The rise in output increases actual inflation, according to equation 6.4. Thus, a change in expected inflation, even if due to factors unrelated to the fundamentals of inflation, can set off a self-fulfilling change in actual inflation.

This discussion suggests that a policy that raises the nominal interest rate when inflation rises and raises $\hat{\imath}_t$ enough to increase the real interest rate so that the output gap falls is sufficient to ensure a unique equilibrium. Assuming the nominal interest rate responds to inflation according to the rule:

$$\hat{\imath}_t = \delta\pi_t + V_t \qquad 9$$

Combining equation 1.5 with equation 1.4, ıˆ_t can be eliminated and the resulting system written as:

$$\begin{bmatrix} E_t & y_{t+1} \\ E_t & \pi_{t+1} \end{bmatrix} = N \begin{bmatrix} y_t \\ \pi_t \end{bmatrix} + \begin{bmatrix} \delta^{-1} & V_t & - & u_t \\ & 0 & & \end{bmatrix}$$

$$Where N = \begin{bmatrix} 1 + \frac{K}{\sigma\beta} & (\beta\delta - 1) \\ -\frac{K}{\beta} & \frac{1}{\beta} \end{bmatrix}$$

Bullard and Mitra (2002), as cited by Walsh (2003), show that a unique stationary equilibrium exists as long as δ> 1. Setting δ> 1 is referred to as the Taylor principle because John Taylor (1993) stressed the importance of interest-rate rules that called for responding more than one to changes in inflation.

Suppose instead of reacting solely to inflation, as in equation 6.9, the central bank responds to both inflation and the output gap according to:

$$\hat{\imath}_t = \delta_\pi\pi_t + \delta_x y_t + V_t \qquad 10$$

This type of policy rule is called the Taylor rule (Taylor, 1993a), and variants have been shown to provide a reasonable empirical description of the policy behaviour of many central banks (Clarida, Galı' & Gertler, 2000). With this policy rule, the condition necessary to ensure that the economy has a unique stationary equilibrium becomes:

$$K(\delta_\pi - 1) + (1 - \beta) \qquad 11$$

Stability now depends on both the policy parameters δ_π andδ_y.

2. Data

Quarterly data for this study were drawn from international financial statistics of the I.M.F., ranging from 1990Q1 to 2016Q1. The sample period eclipsed the period of the global financial meltdown. Hence, this period may roughly depict some evidence of regime changes in the central banks' monetary policy. The data on an output gap is generated using the Hodrick-Prescott (H.P.) filters. The data on output are proxied by the nominal G.D.P. for the period under review. The Consumer Price Index (C.P.I.) is used to proxy inflation in the respective countries. The nominal anchor is denoted by the official monetary policy rate of the respective central banks of the countries. The nominal market exchange rate of the domestic currency to the U.S. dollar is used as the exchange rate in each of the countries.

3. Empirical Specification

Following from the linearised objective function of the central bank, which is consistent with the theoretical Taylor rule, as found in equation 6.10 in explicit form, is a relation of a central bank that targets deviation of the actual output from its potential level and the deviation of the actual inflation from the expected inflation. Fundamentally, it incorporates the output gap and a forward-looking central bank as found in the literature (Gali & Gertla, 1999). These deviations that are a target by the central bank can be expressed in equation 6.12 as:

$$i_t = \beta_0 + \beta_\pi \pi_t + \beta_{gap} y_t + \beta_i i_{t-1} \qquad 12$$

Where i_t, π_t, y_{st} are the nominal anchor, deviation of current inflation from expected and deviation of the actual inflation.

Equation 6.12 is the rational expectation model, which assumes a central bank that incorporates the information on current and future expected inflation when making decisions on the current monetary policy rate. The econometric form of the model is expressed as:

$$i_t = \beta_0 + \beta_\pi \pi_t + \beta_{gap} y_t + \beta_i i_{t-1} + u_t \qquad 13$$

Equation 6.13 captures the baseline linearised monetary rule, which ignores two essential commitments of the central banks in Africa, one of which is the weight the central banks could be giving to exchange rates due to the openness of the economies[6] Moreover, there is evidence of asymmetries and nonlinearity that might exist in the nominal anchor setting behaviour of central banks (Naraidoo & Raputsoane, 2013; Naraidoo & Paya, 2012; Bello & Sanusi, 2018).

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Therefore, a modified version of the baseline policy rule of a central bank to include:

The internalisation of the monetary policy effort in managing the exchange rate of domestic economies; and nonlinear attributes of the central banks' behaviour arises due to differences in how the central banks react in the period of high inflation or depreciation in the value of the domestic currency and period of low inflation of period of appreciation of the currency, is expressed as:

$$i_t = \begin{cases} (\beta_{1,0} + \beta_{1,\pi}\pi_{1,t} + \beta_{1,gap}y_{1,t} + \beta_{1,e}e_{1,t} + \beta_{1,i}i_{1,t-1})(1 - G(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c})) + u_t & G(.) = 0 \\ (\beta_{2,0} + \beta_{2,\pi}\pi_{1,t} + \beta_{2,gap}y_{1,t} + \beta_{2,e}e_{2,t} + \beta_{2,i}i_{2,,t-1})G(\boldsymbol{s_{t-i}}, \gamma, c) + u_t & G(.) = 1 \end{cases} \qquad 14$$

Where G is the transition function, which captures the transition from one (inflation or exchange rate) regime to the next; s_{t-i} is the transition variable, which is akin to the policy variable that triggers changes in monetary policy regime; γ measures the speed of transition from one regime to the next. The c is the location parameter, which is the threshold value that triggers the regime switch from a low inflation environment associated with relatively appreciable domestic currency to a high inflation environment, characterised by depreciable domestic currency. This specification is consistent with Van Dijk, Terasvirta and Franses (2002).

The transition function can take a logistic form where the regime change occurs monotonically, or it may be in exponential form, in which the regime switch is said to be symmetrical. The explicit specification of the logistics smooth transition (L.S.T.A.R.) function is:

$$\boldsymbol{G}\,(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) = [(1 + \boldsymbol{exp}\{-\,\boldsymbol{\gamma}(\boldsymbol{s_{t-i}}, -\,\boldsymbol{c})\})^{-1}] \quad 6.15$$

The transition procedure stated above is referred to as the Logistics Smooth Transition (L.S.T.A.R.). An alternative specification to the transition function is the Exponential Smooth Transition (E.S.T.A.R.).

$$\boldsymbol{G}\,(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) = [(1 + \boldsymbol{exp}\{-\,\boldsymbol{\gamma}(\boldsymbol{s_{t-i}}, -\,\boldsymbol{c})\}) - 2] \quad 6.16$$

Therefore, the estimated model will be semi-parametric.

If the γ is very high, then the G (transition function) will be approximated with an indicator function $I[\pi_{t-1}$ >and, in this case, the approximated model will be a Self-Exciting Threshold Autoregressive model (SETAR); otherwise, it is a continuous function which changes smoothly from $G(.) = 0$ to $G(.) = 1$ or Smooth Transition Autoregressive model (STAR)[7].

Equation 34 can be called the semi-parametric nonlinear model because it bears an AR (1) parametric and linear component. In addition, it has a nonparametric and nonlinear component, which also determines the regime switch (Bello & Sanusi, 2016).

4. Test for Nonlinearity

5. Following Franses and van Dijik (2000 and 2003), the determination of the transition variable is examined, which is responsible for the nonlinear switch in monetary policy and to establish if the nonlinear model is SETAR or STAR by testing the presence of linearity and against nonlinearity. Also, it is imperative to undertake a nonlinearity test to

establish the specific variant (either first or second order L.S.T.R., i.e., LSTR1 or LSTR2) of the model to be estimated if the transition variable confirms STAR.

The choice of the model will be based on the following hypotheses:

$H_{04}: \beta_3 = 0$

$H_{03}: \beta_2 = 0 | \beta_3 = 0$

$H_{02}: \beta_1 = 0 | \beta_2 = \beta_3 = 0$

Thus, following Kratzig (2005) the transition variable s_{t-i} is determined using the auxiliary equation:

$$y_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' \tilde{z}_t s_t^j + u_t^* \qquad 6.17$$

All variables will be given an equal chance of selection as a transition variable; as such, no restriction is imposed on the exogenous and endogenous variables.

RESULTS AND DISCUSSION

This section presents the estimated results obtained from the nonlinearity test in the model and the determination of the transition variable in the regime-switching. The results presented in table .1 indicate the presence of nonlinearity in the monetary policy reaction of all the central banks under review.

Country	Transition variable	F	F4	F3	F2	Suggested model
Botswana	i_{t-1}	3.248e-07	1.6845e-07	5.9910e-01	1.5164e-02	LSTR1
Egypt	π_t	1.3857e-05	6.5672e-04	4.8662e-03	4.8460e-02	LSTR1
Morocco	i_{t-1}	5.1513e-17	3.0799e-10	9.8139e-08	3.6356e-03	LSTR1
South Africa	π_t	4.1760e-14	8.4932e-12	2.6374e-05	3.8292e-01	LSTR1

Table 1: Result of regime-switching nonlinearity STR test[9]
Source: Author's computation.

This is because of the null hypothesis of linearity against STR using the F-version.[8] The LM-test was rejected for all countries.

The transition variables across the countries indicate some level of consistency. Firstly, there is consistency in the smoothing parameter (i_{t-1}) as it was found as the transition variable in both Botswana and Morocco. The smoothing parameter reveals the degree of aggressiveness of monetary policy in central banks. In the case of Egypt and South Africa, inflation was found to be the variable that causes regime switch; hence it represents the transition variable in both countries. This finding corroborates the research of Naraidoo and Paya (2010), who provide similar evidence using a semiparametric, nonlinear, logistic model for the South African Reserve Bank.

The smooth transition nonlinear test suggests the presence of nonlinearity in the reaction of monetary policy in all the countries. The test indicates that monetary policy follows a logistics type of nonlinear monetary policy in these countries. This means that the central banks' reaction to their policy targets changes monotonically as the transition variable of each bank increases (Franses and van Dijk, 2003). Therefore, the logistics nonlinear smooth transition model indicates evidence of regime-switching behaviour in the countries' monetary policy. This implies that the central banks exhibit different behaviour when reacting to inflation and output when the exchange rate is appreciating. Also, the banks' reaction to both inflation and output is unique in periods of currency depreciation.

An analysis of the monetary policy in these two different regimes and the conditions under which the regime switch could occur will be discussed.

- Monetary Policy Reaction to Exchange Rate Appreciation Regime: Low Exchange Rate Regime

The low exchange rate regime connotes periods of exchanging a lesser amount of domestic currency with the foreign currency (in this case, currency of respective countries to the U.S. dollars), i.e., appreciation. The result of the low exchange rate regime is presented in table 2.

The evidence from Botswana suggests that in a period of currency appreciation, the central bank does not consider inflation a threat, and therefore the central bank does not react to domestic inflation when the pula is appreciating against the U.S. dollar. However, the bank reacts to stabilise domestic output and exchange rate of the pula in this regime. Thus, the coefficient of both the output gap and exchange rate were statistically significant at 10% and 1% levels of significance, respectively. This means that the country's central bank reaction to the deviation of actual out from potential is significant. With a deviation of domestic output from the potential up to 1%, central banks react by changing the short-run interest rate by about 28%. This means that the central bank derives some benefit from short-run output stabilisation without trading off with higher inflation, and this benefit comes from the positive spillover effect of appreciation in domestic currency. Furthermore, the result suggests that exchange rate pass-through plays a critical role in explaining inflation dynamics in Botswana. This explains why appreciation is characterised by non-reaction to inflation, and also, the central bank is not aggressive in changing its monetary policy rate.

Unlike Botswana, the Egyptian central bank reacts to both inflation and output targets even when the Egyptian pound appreciates. Hence, the Egyptian central bank exerts some aggressiveness in keeping inflation at a moderate level. There are minor changes in domestic inflation during currency appreciation, but domestic output from potential deviation is much smaller than the change in inflation in this regime. This provides an acceptable explanation for the aggressiveness in the monetary policy behaviour of the central bank.

The exchange rate appreciation regime in Egypt appears to be dominated by episodes of gradual appreciation, and even so, much of the appreciation in the currency is not significant. This is evidenced in the coefficient of the exchange rate. This explains the instability in prices even when the economy is experiencing exchange rate appreciation. Compared to other central banks under review, the Egyptian central bank exhibits more aggressive behaviour in taming inflation under the exchange rate appreciation regime. As such, the result in table 2 shows that the coefficient of inflation is statistically significant at a 10% level of significance. This indicates that, on average, the bank raises its short-run interest rate by more than 170 basis points to reverse a 1% increase in inflation. This change in an interest rate targets inflation spills to the exchange rate, though the spillover effect is insignificant. Due to the aggressiveness of the Egyptian central bank under the exchange rate appreciation regime, the output is traded for price stability. Therefore, the output gap increases in response to the tightening of the monetary policy.

In the case of the Moroccan central bank, changes in inflation are not significant considering an issue whereby the domestic currency is appreciating against the U.S. dollar. Hence, the bank's reaction to small changes in general prices is not significant. More so, because domestic inflation is relatively stable under an exchange rate appreciation regime, the output gap increases, making it unstable. Unlike the Egyptian central bank, the Moroccan is less aggressive under the exchange rate appreciation regime. Perhaps this less aggressiveness explains why the Moroccan dirham (MAD) appreciation is not volatile. However, the result indicates that the coefficient of nominal interest is significant at 1% level of significance. Thus, a percentage change in nominal interest would cause a 0.73% change in the real interest rate in an exchange rate appreciation regime. Hence, both inflation and exchange rate stability are achieved under this regime.

Table 2: Result of monetary policy reaction to exchange rate appreciation regime

$$(\beta_{1,0} + \beta_{1,\pi}\pi_{1,t} + \beta_{1,gap}y_{1,t} + \beta_{1,e}e_{1,t} + \beta_{1,i}i_{1,t-1})(1 - G(s_{t-i}, \gamma, c)) + u_t,\ \&\ G(.) = 0$$

Country	Linear Variables	Coefficient	p-values
	$\beta_{1,0}$	1.2095	0.0000
	$\pi_{1,t}$	-	-
Botswana	y_{gap}	0.2790	0.0705*

	$e_{1,3}$	0.2707	0.0000***
	$i_{1,t-1}$	-	-
Egypt	$\beta_{1,0}$	0.0388	0.5179
	$\pi_{1,t}$	-0.1705	0.0611*
	y_{gap}	-0.1663	-0.5332
	$e_{1,3}$	-0.0619	0.2065
	$i_{1,t-1}$	1.2756	0.5332
Morocco	$\beta_{1,0}$	-0.3785	0.7711
	$\pi_{1,t}$	0.1955	0.4873
	y_{gap}	-0.2605	0.4943
	$e_{1,3}$	0.0190	0.9700
	$i_{1,t-1}$	0.7396	0.0000***
South Africa	$\beta_{1,0}$	-1.2578	0.7416
	$\pi_{1,t}$	0.3316	0.7736
	y_{gap}	5.5238	0.0000***
	$e_{1,3}$	0.8956	0.0771*
	$i_{1,t-1}$	0.4813	0.1183

Note: *, ** and ****, denote the 10%, 5% and 1% significance levels respectively.
Source: Author’s computation.

Unlike the Moroccan central bank, the South African reserve bank maintains output stability in an exchange rate appreciation regime. By extension, the output gap decreases in an exchange rate appreciation regime. As shown in table 2, the coefficient of both the output gap and the exchange rate is statistically significant at 1% and 10% significance levels, respectively. This means that any change in the short-run nominal anchor is to maintain the relative stability in output and keep the *rand* appreciating, which depicts a positive output gap for the country. Thus, the positive output gap indicates a high demand for goods and services in the country, which is beneficial to its economy, despite its tendency to exert inflationary pressures and a more enormous current account deficit as consumers buy more imports due to domestic supply constraints. The excellent outcome of the country's result under the exchange rate regime in question is that inflation responds moderately to small changes in the central banks' reaction to prices. Thus, the bank is less aggressive under the exchange rate appreciation, especially since inflation is not a threat. Therefore, the bank achieves and maintains output stability.

Given the empirical evidence in this section, it is compelling to assert that the exchange rate regime associated with domestic currency appreciation is characterised by relatively low inflation and stable output, especially for Botswana, Morocco and South Africa. Thus, the dominant behaviour of the monetary policy in these countries is less aggressive towards inflation. To a large extent, low exchange rate pass-through to domestic prices in some African economies under this regime could be attributed to this (see Sanusi, 2011). However, the aggressiveness shown by Egyptian monetary authorities suggests the economy is operating close to its potential, and perhaps unemployment is at a natural level and therefore, any attempt to loosen the monetary policy will harm the domestic inflation. Thus, the bank must maintain aggressive behaviour under the exchange rate appreciation regime. Next is to analyse the reaction of the monetary policy in a high exchange rate regime.

- Monetary Policy Reaction to Exchange Rate Depreciation Regime: High Exchange Rate Regime

This section analyses the countries' monetary policy reactions, focusing on two key aspects. The first strand of analysis seeks to answer two critical questions. Starting with analysing, what causes the switch? Then how does the monetary policy switch from a low exchange rate regime to a high exchange rate regime?

The second strand of analysis provides an answer to the question of what is the behaviour of the reaction function monetary after switching. Subtly, the response to this question answers how the central banks react to their monetary policy targets after switching.

The high exchange regime is referred to as the exchange rate depreciation regime. Each country under the regime exhibits different behaviour when switching from a low exchange rate regime to a high exchange rate regime. However, commonalities exist in the cause of regime switch within the countries under review. The cause of the regime switch in the monetary policy reaction function is the transition variable. In the case of Botswana and Morocco, the smoothing parameter is the cause of the regime switch. However, for Egypt and South Africa, inflation is the transition variable; hence the regime switch is caused by inflation. This means that the effort by the central bank in Botswana and Morocco to smooth the effect of current interest rate change relative to the past change causes a change from a low to a high exchange rate regime. Conversely, the resolve by the Egyptian and South African central banks to tame changes in inflation leads to a regime switch in the reaction function of the central banks.

Meanwhile, each central bank has its unique location parameter that triggers the regime switch. This parameter is otherwise called the 'threshold', which initiates the regime change. Once the transition variable leads the short-run interest rate close to the premises of the threshold, the reacting parameter will approach the threshold value. The central banks will remain within the horizon of the existing regime. The trajectory to a new regime is set if, and only if, the reacting parameter takes the value of the threshold parameter.

The result presented in Table 6.2 indicates that the reaction function of Botswana's central bank has the lowest threshold value of 2.06. This means that at any given time horizon, the reacting parameter takes the value of 2.06, the reaction function of the bank switches from a low to high exchange rate regime. In the case of the Egyptian and South African central banks, both have almost equal threshold values. This means that monetary authorities in Egypt and South Africa are faced with threshold values of almost equal magnitude at 3.4 and 3.5, respectively. This suggests changes in inflation that compel the reacting parameter to take the 3.4 and 3.5 will trigger a switch from low to high exchange rate regime.

The Moroccan central bank bears the highest threshold. This signifies that the monetary authorities have a greater tendency to remain in a lower regime that is characterised by exchange rate appreciation than any of the other central banks. Therefore, the Moroccan dirham has more excellent stability when its exchange rate value appreciates than the pula, Egyptian pound and rand.

Table 3: Result of monetary policy reaction to exchange rate depreciating regime $(\beta_{2,0} + \beta_{2,\pi}\pi_{1,t} + \beta_{2,gap}y_{1,t} + \beta_{2,e}e_{2,t} + \beta_{2,i}i_{2,,t-1})\boldsymbol{G}(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) + u_t,\ \&\ \boldsymbol{G}(.) = 1$

Country	Linear Variables	Coefficient	p-values	$[(1 + exp\{-\gamma(s_{t-1} - c)\})^{-1}]$
Botswana	$\beta_{2,0}$	-	-	$[(1 + exp\{-4.88(i_{t-1} - 2.06)\})^{-1}]$
	$\pi_{2,t}$	1.6011	0.5873	
	$y_{2,gap}$	-0.2790	0.0707*	
	$e_{2,3}$	-0.2707	0.0000***	
	$i_{2,t-1}$	-0.8572	0.6482	

Egypt	$\beta_{2,0}$	-	-	$[(1 + exp\{-38.2(\pi_t - 3.42)\})^{-1}]$
	$\pi_{2,t}$	0.1620	0.0755*	
	$y_{2,gap}$	0.1663	0.5332	
	$e_{2,3}$	0.8230	0.1390	
	$i_{2,t-1}$	-0.3015	0.0232**	
Morocco	$\beta_{2,0}$	1.2768	0.5279	$[(1 + exp\{-429(i_{t-1} - 4.49)\})^{-1}]$
	$\pi_{2,t}$	0.6465	0.0873*	
	$y_{2,gap}$	0.1259	0.8281	
	$e_{2,3}$	-1.5376	0.0354**	
	$i_{2,t-1}$	-0.5438	0.0000***	
South Africa	$\beta_{2,0}$	1.379	0.7175	$[(1 + exp\{-24.22(\pi_t - 3.50)\})^{-1}]$
	$\pi_{2,t}$	-0.3646	0.7517	
	$y_{2,gap}$	-5.3470	0.0000***	
	$e_{2,3}$	-0.8581	0.0922*	
	$i_{2,t-1}$	0.4967	0.1085	

Note: *, ** and ****, denote the 10%, 5% and 1% significance levels respectively.

Source: Author’s computation.

As the results show in table .3, under the exchange rate depreciating regime, the Botswanan output gap and exchange rate results are statistically significant at a 10% level of significance, respectively. This indicates that changes in domestic output and exchange rate from their potential of 1%, Botswanan's monetary authorities will react by reducing its policy rate by 27% in the case of any of the events mentioned above. Moreover, the economy exhibits stable inflation under this regime. Unlike Botswana, Egypt and Moroccan results depict that, in both countries, the coefficient of inflation is significant at a 10% level of significance 0.0755 and 0.0873, respectively. Thus, a percentage change or deviation of current inflation from expected would lead the monetary authority in Egypt and Morocco to change their policy rate by 162 and 646 basis points, respectively, for the authorities to upset the situation. Moreover, the exchange rate coefficient in Morocco and South Africa is statistically significant at a 1% and 10% significance level, respectively.

Furthermore, considering the above and other factors, the study discovers another critical monetary policy regime switch behaviour: the transition speed from one regime to another. This attribute reveals a critical feature of the nonlinear reaction function of the central banks in question that the higher the speed of transition, the less smooth is the reaction function (Franses & van Dijk, 2000; 2003).

This means that the speed of the regime switch determines the smoothness of the transition. Therefore, given the estimated result of the transition speed presented in table .1, the study opposes that the Egyptian and Moroccan central banks’ reaction function has speed that exceeds Franses and van Dijk classification of a normal smooth transition. Therefore, in line with Chan and Tong (1986), and Granger and Terasvistra (1993), these two central banks follow a Self-Excited Threshold Autoregressive (SETAR) model. This means that the continuous function in the specified model is approximated to an indicator function. Thus, the central bank in Botswana bears the smoothest transition from a low exchange rate to a high exchange rate. Hence, the logistics transition is relatively slow, which means that a regime switch can occur without disequilibria to the exchange rate market.

In the case of South Africa, the transition remains smooth, but the switch path is steeper than that of Botswana. Therefore, it is suspected that both Botswana and South Africa's monetary authorities carry out some form of intervention in the exchange rate market to stabilise the value of the domestic currency.

In accounting for the behaviour of the monetary policy in the high exchange rate regime, Botswana and South Africa are faced with much higher inflation than Egypt and Morocco. Therefore, the monetary policy response is tightening to reduce the effects of the higher inflation experienced in an exchange rate depreciating regime. The output gap increases across all the countries under the exchange rate depreciating regime. This suggests instability in output, accompanied by a significant fall in the exchange rate values of all the currencies under investigation. However, the result shows that Egyptian pounds are not depreciating significantly compared to the other currencies.

Table 4: Result of diagnostics test

Country Model	Serial Correlation test *F-stats (p-value)*	Remaining Nonlinearity test *F-stats (p-value)*	Parameter constancy test *F-stats (p-value)*	Arch-LM test (Heteroskedasticity) *chi-square (p-value)*
Botswana	0.2291 (0.8758)	6.4967e-02	4.8201 (0.8948)	6.5618 (0.1350)
Egypt	0.3625 (0.6973)	1.9715e-13	3.3420 (0.7230)	9.4304 (0.09576)
Morocco	0.0067 (0.9349)	2.6603e-01	1.3505 (0.2381)	0.1652 (1.0000)
South Africa	0.1804 (0.9477)	9.6976e-10	5.8942 (0.0895)	5.2338 (0.6356)

Source: Author’s computation.

The diagnostics test presented in table .3 reveals that there is no serial correlation in all the models for all the countries. Therefore, the null hypothesis states that the absence of serial correlation is accepted for all the countries. In a similar manner, the result indicates an absence of parameter constancy for three of the models, i.e. Botswana, Egypt and Morocco. As such the null hypothesis that states the absence of parameter constancy for the aforementioned countries is accepted.

In the case of South Africa, the result suggests that there is a presence of parameter constancy. The p-value of 0.0895 is significant at a 10% level of significance. Thus, the null hypothesis is rejected, and the alternate hypothesis that states the presence of parameter constancy in the model is accepted.

The ARCH-LM test conducted indicates that there is no heteroskedasticity for the model, except for Egypt, in which the null hypothesis (that profess absence of heteroskedasticity) is rejected, and the alternative hypothesis at a 10% level of significance is accepted.

Similarly, the result indicates the absence of nonlinearity in all the models. Furthermore, the remaining nonlinearity test approximates that some nonlinearity was engrossed by the L.S.T.R. model with two regimes. Thus, there is evidence for the validity of nonlinearity in the models.

CONCLUSION

This chapter attempted to analyse the monetary policy reaction of the central banks in the countries under the two different exchange regimes. The empirical evidence reveals that the smoothing parameter (i_{t-1}) is found to be the transition variable in both Botswana and Morocco. In the case of Egypt and South Africa, inflation is found to be the variable that causes a regime switch; hence, it represents the transition variable in both countries.

The smooth transition nonlinear test suggests the presence of nonlinearity in the reaction of monetary policy in all the countries. The test indicates that monetary policy follows a logistic type of nonlinear monetary policy in the countries under review.

The evidence from Botswana suggests that in the period of currency appreciation, the central bank does not consider inflation as a threat and therefore the central bank does not react to domestic inflation when the pula is appreciating against the U.S. dollar. However, the bank reacts to stabilise domestic output and exchange rate of the pula in this regime. Thus, the coefficient of both the output gap and exchange rate were found to be statistically significant.

Unlike Botswana, the Egyptian central bank reacts to both inflation and output targets even when the Egyptian pound is appreciating. Hence, the Egyptian central bank exerts some degree of aggressiveness in keeping inflation at a moderate level. There are small changes in domestic inflation during currency appreciation but the deviation of domestic output from potential is much smaller than the change in inflation in this regime. This provides an acceptable explanation for the aggressiveness in the monetary policy behaviour of the central bank.

In the case of the Moroccan central bank, the bank's reaction to small changes in general prices is not significant, more so, because domestic inflation is relatively stable under exchange rate appreciation regime output gap increases and therefore unstable. Unlike the Egyptian central bank, the Moroccan bank is less aggressive under exchange rate appreciation regime.

The Moroccan central bank bears the highest threshold. This signifies that the monetary authorities have a greater tendency to remain in a lower regime that is characterised by exchange rate appreciation than any of the other central banks.

Contrary to the Moroccan central bank, the South African reserve bank maintains output stability in an exchange rate appreciation regime. By extension, the output gap decreases in an exchange rate appreciation regime. Any change in the short-run nominal anchor is to maintain the relative stability in output and keep the rand appreciating.

Inflation responds moderately to small changes in the central banks' reaction to prices under this regime. Thus, the bank is seen to be less aggressive under the exchange rate appreciation, especially since inflation is not a threat. Therefore, the bank achieves and maintains stability in output.

Botswana's and Morocco's smoothing parameter is the causes of the regime switch. However, for Egypt and South Africa, inflation is the transition variable, and hence the regime switch is caused by inflation. This means that effort by the central banks in Botswana and Morocco to smoothing the effect of current interest rate change relative to the past change causes a change from low to high exchange rate regime. Conversely, the resolve by the Egyptian and South African central banks to tame changes in inflation leads to regime switch in the reaction function of the central banks.

Each of the central banks has its unique location parameter that triggers the regime switch. The reaction function of Botswana's central bank has the lowest threshold value of 2.06. This means that at any given time frame, the reacting parameter takes the value of 2.06, and the reaction function of the bank switches from low to high exchange rate regime. In the case of Egypt and South Africa, both central banks have almost equal threshold values.

The Egyptian and Moroccan central banks' reaction function follows a Self-Excited Threshold Autoregressive (SETAR) model. This means that the continuous function in the specified model is approximated to an indicator function.

The central bank in Botswana bears the smoothest transition from a low exchange rate to a high exchange rate. Hence, the logistics transition is relatively slow and this means a regime switch can occur without disequilibria in the exchange rate market. In the case of South Africa, the transition still remains smooth but the switch path is steeper than that of Botswana.

The monetary policy in the high exchange rate regime of Botswana and South Africa is faced with much higher inflation than Egypt and Morocco. Therefore, monetary policy response tightens in order to reduce the effects of the higher inflation experienced in an exchange rate depreciating regime. The output gap increases across all the countries under an exchange rate depreciating regime. This suggests instability in output which is accompanied by a significant fall in the exchange values of all the currencies. The result, however, shows that Egyptian pounds do not depreciate significantly when compared to the other currencies.

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