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

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ABSTRACT

The study theoretical in nature, 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 linearized 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. The study concluded that smoothing parameter (i_{t-1}) is the transition variable in both Botswana and Morocco. In the cases of Egypt and South-Africa, inflation is the major 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, monetary policy response is tightening in order 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. The results, however, showed that Egyptian pounds are not depreciating significantly when compared to the other currencies.

Keywords: Regime Switching, Monetary Policy, Nonlinear, Taylor Rule and African Open Economies.

INTRODUCTION

Following the advent of the Nixon shock of the 1970s, monetary policy's mandate of achieving intermediate targets has increasingly become more important. Concerns about exchange rate management now rest more on the monetary authorities [1,2,3]. In recent times, complexity in the management of the exchange rate appears to be increasing [4,5]. Two important factors might be attributed to the increasing challenges in managing exchange rates, especially in developing, open economies [6,7]. Firstly, over the years, it appears structural adjustments across most developing countries, accompanied by an opening up and deregulation of capital account, have forged a major watershed in monetary policy in many countries [8,9]. Informed by the need to mitigate instability in domestic currency monetary authorities in these countries seem to have been conducting monetary policy in order to either improve capital inflows or curtail excessive capital outflows [10,11]. This is in line with [6]. Secondly, amplified by increased market integration and sophistication of financial instrument, which allows for easy capital mobility, capital movements across markets are ever becoming volatile[1]. This evidence has recently been documented in a number of studies by [12,13,14,15]. Evidence of these capital flow volatilities and its spillover effect on the exchange rate of domestic currency are likely to pose greater macroeconomic policy challenges. Consequently, compelled by these factors, many African countries appear to have adopted diverse strategies of managing 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 [16,17]. The ability to meet the intermediate target becomes increasingly challenging. For instance, in sub-Saharan Africa, Botswana has abandoned the Rand Monetary Area (RMA) to establish an independent domestic currency using a fixed exchange regime [18,19]. However, the central bank discarded the fixed regime and adopts the crawling exchange rate regime. This was necessary because of the pressure imposed by the exchange rate basket [20]. Similarly, the South African reserve bank abandoned its initial fixed exchange rate regime and pursues an independent managed floating exchange rate regime. In the same vein, open economies in the northern part of Africa appeared not to be shielded from the vagaries of exchange rate fluctuation that is associated with capital volatility spillover [21]. Thus, they are equally compelled to changes in exchange rate regimes in order to maintain stability in domestic currency. For example, both the Moroccan and Egyptian central banks appeared to have gone through significant departures from their initial exchange rate regimes [22]. In the case of the Moroccan dirham, it was first pegged using the fixed exchange regime but was 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 was used to replace the initial fixed regime [23]. These departures in exchange rate regimes experienced in open African economies is an attestation of the challenges confronting the monetary authorities in managing the exchange rate value of the domestic currencies [24]. 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 target, present additional challenges by increasing exchange rate volatility [25]. Given the high pass-through effects of exchange rate to 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 [26]. 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.

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 [27,28] and the result reveals that monetary policy success achieved by the central banks in Germany, Japan and the US was down to the application of forward-looking, inflation targeting framework by 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 [29,30]. 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, especially because of the interconnectivity of financial markets across Europe and responsiveness of capital flow to the changes in the monetary policy [31]. Therefore, this strongly indicates the relevance of the external sector in stabilizing the domestic economy. A study by [32], however, points out, that in addition to exchange rate consideration in monetary policy reaction, the European Central Bank (ECB) and Bank of England also consider financial conditions in the conduct of monetary policy. Financial condition includes, but is not necessarily restricted to, asset prices. The study applies the Smooth Transition Autoregression (STAR) model in the estimation of the nonlinear monetary policy reaction function[2]. An interesting finding that emanates is the distinctiveness in the behaviour between the two central banks in terms of how they react [33]. The ECB was found to react to asset prices whereas the Bank of England do not. The non-responsiveness of the bank to asset prices means it is shy capital flow movement in and out of the economy. Hence, this might make such an economy vulnerable to financial crises spillover from other markets. [34] apply the Taylor rule in analyzing the monetary policy in Latin American counties. The result of the study shows 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 as a major target and less importance is placed on stabilizing 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 backward-looking monetary policy rule over the forward-looking rule [35].

Recently, empirical evidence [36] has shown the great relevance of monetary policy under capital account control. The study emphasizes the radical effect capital control has on monetary policy. [37] argues that monetary policy will be near optimal under a liberalized capital account regime only when the monetary authority is committed to keeping inflation low. The study maintains that economies under controlled capital account are better shielded to financial crises, even when inflationary pressures are relatively higher. As such, 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 [38], as well as [39], shed some light on the effect of capital account liberalization which many countries in the 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 is an indication that economic stability in countries with liberalized capital account is at great risk and monetary policy may struggle in stabilizing exchange rate whenever financial crises hit the economy. Similarly, [40] provides support to [41]. who argues that exchange rate management under optimal capital control tends to provide better welfare than monetary policy that targets inflation. These studies provide evidence that optimal exchange rate policy can eliminate inefficiencies that arise from nominal rigidities. Furthermore, [40] 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 [7]. [25] argues that capital controls are only complimentary tools which can be applied to either discretionary or monetary policy rules. However, [8] maintains that capital control is essentially used in order to cushion the effect of sudden stop in capital inflows which is associated with inefficiency of capital market dynamics. This argument is also at variance with the position of [15], who is of the view that capital control is primarily used for the stabilization of external accounts and to mitigate against excessive exposure to risk.

Methodology

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

1 Baseline Model

The building blocks of the baseline model is made up of households and firms that behave optimally; households maximize the expected present value of utility, and firms maximize profits. There is also a central bank that controls the nominal rate of interest. The central bank, in contrast to households and firms, is not assumed to behave optimally. The non-optimizing behaviour of the central bank is necessitated by the affinity for credibility which rest on its commitment to shun optimizing 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, on the basis of the non-optimizing 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 [7], which is 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, share of wage income, that is kept as real money balances, M_t/P_t, that is kept in a 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 maximize the expected present discounted value of utility by aggregating using the CES aggregator on the various bundle identified ($C_t;M_t/P_t$ and $1\text{-}l_t$):

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

Where χ is the coefficient that explains elasticity of household leisure.The bundle of consumption goods in the consumer basket consists of heterogeneous finite products supplied by monopolistically competitive firms [9]. 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 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.

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

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 [6].

In attempting to maximize the household utility function, the definite integral of the composite consumption function is taken, with respect to the differentiated bundles of 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 maximize profits, subject to three constraints. The first is the production function summarizing the available technology. For simplicity, capital is ignored, so 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 in each period some firms are not able to adjust their price. The specific model of price stickiness used is from [11]. 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 a zero-average inflation, steady-state equilibrium to obtain an expression for aggregate inflation of the form:

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

There are now all the components of a simple general equilibrium model that is consistent with optimizing behaviour on the part of households and firms. Because consumption is equal to output in this model (there is no government or investment since capital has been ignored), equation 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 5 with equation 6 gives a simple two-equation, forward-looking, rational-expectations model for inflation and the output gap measure $\mathbf{Y}_t$. This two-equation model represents the equilibrium conditions for a well-specified general equilibrium model. Equations 5 and 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 through control of the nominal interest rate. Alternatively, if the central bank implements monetary policy by setting a path for the nominal supply of money, equation 5 and equation 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 with care to ensure that the policy rule does not render the system unstable or introduce multiple equilibria. Assuming, suppose monetary policy is represented by the following rule for $\hat{\imath}_t$:

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

This specification makes the nominal interest rate an exogenous AR (1) process with innovation V_t combining equation 7 with equation 5 and equation 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 (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 [8,9]. 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 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 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 which 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, ι ^_t can be eliminated and the resulting system written as:

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

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

[9] show that a unique stationary equilibrium exists as long as $\delta > 1$. Setting $\delta > 1$ is referred to as the [17] stressed the importance of interest-rate rules that called for responding more than one for one to changes in inflation.

Suppose that, instead of reacting solely to inflation, as in equation 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 [7], and variants of it 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 and δ_y.

Data

Quarterly data for this study were drawn from international financial statistics of the IMF, ranging from 1990Q1 to 2016Q1. The sample period eclipsed the period of global financial meltdown. Hence this period may roughly depict some evidence of regime changes in the monetary policy of the central banks. The data on an output gap are generated using the Hodrick-Prescott (HP) filters. The data on output are proxied by the nominal GDP for the period under review. The Consumer Price Index (CPI) is used as a proxy for 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 US dollar is used as the exchange rate in each of the countries.

Empirical Specification

Following from the linearized objective function of the central bank, which is consistent with theoretical Taylor rule, as found in equation 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 [7]. These deviations that are target by the central bank can be express in equation 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 12 is referred to as the rational expectation model, which assumes a central bank that incorporates the information on both current inflation and future expected inflation when taking decisions on current monetary policy rate. The econometric form of the model is express as:

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

Equation 13 captures baseline linearized monetary rule which ignores two important commitments of the central banks in Africa, one of which is the weight the central banks could be giving to exchange rate due to the openness of the economies[3] and the evidence of asymmetries and non-linearity that might exist in the nominal anchor setting behaviour of central banks [18,19].

Therefore, a modified version of the baseline policy rule of a central bank that internalizes the monetary policy effort in managing the exchange rate of domestic economies and nonlinear attributes of the central banks' behaviour, that arises due to differences in how the central banks react in 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:

$$i_t = \begin{cases} (\beta_{1,0} + \beta_{1,\pi}\pi_{1,t} + \beta_{1,gap}y_{1,t} + \beta_{1,e}e_{1,t} + \beta_{1,i}i_{1,t-1})(1 - G(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c})) + u_t, & G(.) = 0 \\ (\beta_{2,0} + \beta_{2,\pi}\pi_{1,t} + \beta_{2,gap}y_{1,t} + \beta_{2,e}e_{2,t} + \beta_{2,i}i_{2,,t-1})G(\boldsymbol{s_{t-i}}, \gamma, c) + u_t, & G(.) = 1 \end{cases} \quad 6.14$$

Where $\boldsymbol{G}$ is the transition function, which captures the transition from one (inflation or exchange rate) regime to the next; $\boldsymbol{s_{t-i}}$ is the transition variable, which is akin to the policy variable that triggers changes in monetary policy regime; $\boldsymbol{\gamma}$ measures the speed of transition from one regime to the next. The $\boldsymbol{c}$ is the location parameter which is the threshold value that triggers the regime switch from a low inflation environment, that is associated with relatively appreciable domestic currency, to a high inflation environment, that is characterized by depreciable domestic currency. This specification is consistent with [20]. 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 (LSTAR) function is:

$$\boldsymbol{G}\,(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) = [(1 + \boldsymbol{exp}\{-\,\boldsymbol{\gamma}(\boldsymbol{s_{t-i}}, -\,\boldsymbol{c})\})^{-1}] \quad 15$$

The transition procedure stated above is referred to as the Logistics Smooth Transition (LSTAR). An alternative specification to the transition function is the Exponential Smooth Transition (ESTAR).

$$\boldsymbol{G}\,(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) = [(1 + \boldsymbol{exp}\{-\,\boldsymbol{\gamma}(\boldsymbol{s_{t-i}}, -\,\boldsymbol{c})\}) - 2] \quad 16$$

Therefore, the estimated model will be a semi-parametric model. If the $\boldsymbol{\gamma}$ is very high, then the $\boldsymbol{G}$ (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 $\boldsymbol{G}(.) = 0$ to $\boldsymbol{G}(.) = 1$ or Smooth Transition Autoregressive model (STAR)[4].

Equation 34 can be referred to as the semi parametric nonlinear model because it bears an AR (1) component which is both parametric and linear. In addition, it has a nonparametric and nonlinear component, which also determines the regime switch [9].

Test for Nonlinearity

Following [13], 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 LSTR, 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 [11] the transition variable $\boldsymbol{s_{t-i}}$ is determined using the auxiliary equation:

$$y_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' \tilde{z}_t s_t^j + u_t^* \quad 17$$

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

.

RESULTS AND DISCUSSION

This section presents the estimated results obtained from the test of nonlinearity in the model and 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. This is because the null hypothesis of linearity against STR using the F-version[5] of the LM-test was rejected for all countries.

Table 1: Result of regime switching nonlinearity STR test6

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

Source: Author's computation.

The transition variables across the countries indicate some level of consistency. Firstly, there is consistency in 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 [20], who provide similar evidence using a semiparametric, nonlinear, logistic model for the South African Reserved Bank.The smooth transition nonlinear test suggests the presence of nonlinearity in the reaction of monetary policy in all the countries. The test indicates 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 [23]. Therefore, the presence of the logistics nonlinear smooth transition model indicates evidence of regime switching behaviour in the monetary policy of the countries. This implies 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 entirely 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 lesser amount of domestic currency with the foreign currency (in this case currency of respective countries to the US 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 as a threat and therefore the central bank does not react to domestic inflation when the pula is appreciating against the US dollar.

5 Note that the F-version of the LM test was applied because in small sample sizes it has a better size and power properties (Granger and Terasvirta, 1993; Van Dijk, Terasvirta & Franses, 2002).

6 The transition variable for each country is chosen following Terasvirta (1994). The result presented in table 6.1 are computed statistics for several transition candidates. The variable with the smallest p-value is selected as the true transition variable.

However, the bank reacts to stabilize 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 at 10% and 1% level of significance respectively. This means that the country's central bank reaction to the deviation of actual out from potential is significant. In any deviation of the domestic output from potential that is up to 1%, the central bank reacts by changing the short-run interest rate by about 28%. This means that the central bank derives some benefit of short-run output stabilization without trading off with higher inflation and this benefit comes from the positive spill over 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 characterized 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 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. 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 exchange rate appreciation regime. As such, the result in table 2 shows, the coefficient of inflation is statistically significant at 10% level of significance. This indicates that, on average, the bank raises its short-run interest rate by more than 170 basis points in order to reverse a 1% increase in inflation. This change in interest rate that targets inflation spills to exchange rate, though the spillover effect is not significant. 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 US dollar. Hence, the bank's reaction to small changes in general prices also is not significant. More so, because domestic inflation is relatively stable under an exchange rate appreciation regime, the output gap increases and therefore it is unstable. Unlike the Egyptian central bank, the Moroccan bank is less aggressive under exchange rate appreciation regime. Perhaps this less aggressiveness explains why the appreciation in the Moroccan dirham (MAD) is not volatile. Despite 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

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

Country	Linear Variables	Coefficient	p-values
Botswana	$\beta_{1,0}$	1.2095	0.0000
	$\pi_{1,t}$	-	-
	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.

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. As shown in table 2, the coefficient of both the output gap and the exchange rate are statistically significant at 1% and 10% level of significance 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 the country's economy, despite its tendency to exert inflationary pressures and bigger current account deficit as consumers buy more imports due to domestic supply constraints. The good outcomes of comes 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 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. In view of the empirical evidence in this section, it is compelling to assert that the exchange rate regime associated with domestic currency appreciation is characterized 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 aggressiveness 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 [4]. 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 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 presents an analysis of the monetary policy reaction of the countries focusing on two key aspects. The first strand of analysis seeks to answer two important questions. Starting with analysing, what causes the switch? Then how does the monetary policy switch from 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. In a subtle way, the response to this question provides an answer to how the central banks react to their monetary policy targets after switching. The high exchange regime referred to as the exchange rate depreciation regime. Each of the countries under regime exhibits different behaviour when switching from 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 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 effort by central bank 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 a regime switch in the reaction function of the central banks. Meanwhile, each of the central banks has its unique location parameter that triggers the regime switch. This parameter is otherwise called the 'threshold', beyond which the change in regime is initiated. 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 3 indicates that the reaction function of the 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 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 value of 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 characterized by exchange rate appreciation than any of the other central banks. Therefore, the Moroccan dirham has greater stability when its exchange rate value is appreciating, compared to the pula, Egyptian pound and rand.

Table 3: Result of monetary policy reaction to exchange rate depreciating regime

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

Country	Linear Variables	Coefficient	p-values	$[(1 + \boldsymbol{exp}\{-\boldsymbol{\gamma}(s_{t-1} - \boldsymbol{c})\})^{-1}]$
Botswana	$\beta_{2,0}$	-	-	$[(1 + \boldsymbol{exp}\{-4.88(i_{t-1} - 2.06)\})^{-1}]$
	$\pi_{2,t}$	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	$\beta_{2,0}$	-	-	$[(1 + \boldsymbol{exp}\{-38.2(\pi_t - 3.42)\})^{-1}]$
	$\pi_{2,t}$	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	$[(1 + \boldsymbol{exp}\{-429(i_{t-1} - 4.49)\})^{-1}]$
	$\pi_{2,t}$	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	$[(1 + \boldsymbol{exp}\{-24.22(\pi_t - 3.50)\})^{-1}]$
	$\pi_{2,t}$	-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 found to be statistically significant at a 10% level of significance respectively. This indicates that with any change of domestic output and exchange rate from their potential of up to 1%, the Botswanan monetary authorities are expected to react by reducing its policy rate by 27% in the case of any of the aforementioned events. 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 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 situations. Moreover, the coefficient of exchange rate in Morocco and South Africa is both statistically significant at 1% and 10% level of significance respectively. Furthermore, considering the above and other factors, the study discovers another key behaviour of the monetary policy regime switch, which is the speed of transition from one regime to another. This attribute reveals a very important 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 [5,7]. This means that the smoothness of the transition is determined by the speed of regime switch. 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 [5,20], 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 low exchange rate to a high exchange rate. Hence, the logistics transition is relatively slow and this means that a regime switch can occur without disequilibria to 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. 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 stabilize the value of 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, monetary policy response is tightening 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 exchange rate depreciating regime. This suggests instability in output which is accompanied by a significant fall in the exchange rate values of all the currencies under investigation. The result, however, shows that Egyptian pounds are not depreciating significantly when 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 LSTR model with two regimes. Thus, there is evidence for the validity of nonlinearity in the models. This attempted to analyze 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 US dollar. However, the bank reacts to stabilize 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 [7]. This signifies that the monetary authorities have a greater tendency to remain in a lower regime that is characterized 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 [11]. 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 [10]. 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 [14]. 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 [15]. This means that the continuous function in the specified model is approximated to an indicator function [16]. 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.

CONCLUSION

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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