

Modelling central bank behaviour in Nigeria: A Markov-switching approach

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ABSTRACT

The study models the behaviour of the Central Bank of Nigeria. An extended Taylor's framework that accounted for exchange rate dynamics and political risk factors was adopted. In order to capture both ex-ante and ex-post behaviours of the monetary authority in the country, Markov-Switching Dynamic Regression (MSDR) approach was employed. The period of investigation spanned 1981q1 – 2017q4. The study found that money supply in Nigeria was endogenous and showed, consequently, that the Central Bank of Nigeria (CBN) acted discretionarily rather than stick to some monetary policy rules for the period under investigation. The results also suggested that political risk factors significantly moderated the behaviour of the CBN; especially during period of high interest rate regime. With or without the effects of political risks being accounted for, low interest rate regime was found to be more persistent than high interest rate regime. With a relatively high persistence of low interest rate, the study found evidence for the popular Fisher's effect and, then, suggested that inflation targeting should be one of the policy strategies of the monetary authority in Nigeria.

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1. Introduction

The behaviour of central bank is usually understood to mean the strategy adopted in the conduct of monetary policy from time to time. Bernanke and Mishkin (1992) recognized this behaviour as an ex-ante strategy of rules or discretionary monetary policy (Sibert, 2005). Mishkin (2004), on the one hand, identified this as an ex-post strategy of the central bank being either transparent or non-transparent with improved communication to the public. On the other hand, Eijffinger and De Haan (1996) considered the behaviour of central bank in the form of central bank independence while Rogoff (1985) extended it to include conservative central banking.

Kuttner and Posner (1999) captured this behaviour of the central bank as a tripod element of untrusted discretionary, strictly targeting and trusted optimal state contingent rule-following central banker. Although, Kydland and Prescott (1977), alongside Barro and Gordon (1983), emphasized on the cost implication of discretionary monetary policy while Bernanke and Mishkin (1992) posited that only costless behaviour consistent with low and stable inflation rates is the hybrid strategy.

In Nigeria, the monetary authority tends to operationalize its monetary policy strategy at discretion rather than stick to policy rules. This is due to the fact that the growth of actual money supply in Nigeria deviated largely from the growth of targeted money supply for the period 1985–2018 (CBN, 2018). However, both the actual and targeted growths of money supply converged for the periods 1996–1997, 2004, 2009 and 2011. In contrast, growth of the targeted money supply was relatively stable between 1996 and 2005 and hovered around 20 percent while growth rate of the

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actual money supply, which exceeded 60 percent in 2008, was cyclical throughout except for the period 1995–1998 (CBN, 2018). This gives insights into the discretionary behaviour of money supply in Nigeria. Intuitively and in contrast to convention, money supply has been subjected to policy variations in Nigeria. Hence, the exogenous determination of money supply in the Nigerian economy can be viewed as been suspect.

In response to the domestic and global dynamics, central bank behaviour can further be examined on the basis of how the monetary authority employs the use of monetary policy instruments to achieve the overall health of the economy within series of macroeconomic trade-offs (Le Heron, 2009; Mishkin, 1992). In effect, the attainments of macroeconomic objectives are to be examined within the context of monetary policy stability. Specifically, examining the ex-ante behaviour relates to how the central bank uses the monetary policy instruments to achieve macroeconomic objectives while an assessment of the ex-post behaviour indicates how the attainment of macroeconomic objectives affect the stability of monetary policy outcomes such as interest rate and exchange rate (Siri, 2012). According to available statistics, the real interest rate for Nigeria peaked in the years 1991 and 1999 while it has an all-time low in the year 1995. Throughout the periods, however, the real interest rate, which hovered around 10 percent, has been largely unstable except for the period 2011–2015. During this period, deposits would be high and investment projects would increase appreciably. On the other hand, the years 1970–1997 are periods of financial repression in Nigeria as high rate of interest would stiffened resource mobilization efforts and crowd out investment opportunities. Consequently, aggregate demand would reduce drastically. It is important that the government and policy makers should ensure a stable price level in the economy through sustainable macroeconomic policies.

Since 1998, the downswings in the real interest rates occurred at three different years. These were 2005, 2010 and 2016. The year 2005 coincided with the period of stock market crash, the year 2010 coincided with the aftermath effect of the global financial crisis of the 2007–2009 on the Nigerian financial sector and the year 2016 related to the occurrence of the national economic crisis in Nigeria. Nigeria experienced a negative real interest rate of 60 percent between 1992 and 1997 (CBN, 2018). This implies that the price level during this period were very high as the nominal interest rate was stabilized at about 13.5 percent between 1994 and 1998. Regarding the exchange rate, there were four (4) episodes of exchange rate regimes in Nigeria. The first episode occurred before the structural adjustment programme (SAP) of 1986 and the SAP era ushered in financial liberalization policies where exchange rate of *naira* to the international referenced currency of United States (US) *dollar* followed the market forces of demand and supply. This was the second regime. Between 1993 and 1998, however, there was fixed exchange rate regime where the domestic currency was held in constant exchange to the US dollar; using the money supply as a moderating variable. This era returned Nigeria to a fixed exchange rate regime as was previously practiced prior to the 1986 era. Since 1998 when Nigeria birthed the return to democratic rule, however, the domestic currency aligned with the market forces again up until the year 2016. In 2016, there was economic recession that necessitated a free fall of the *naira*. This, again, necessitated the need for exchange rate intervention by the monetary authority in Nigeria (CBN, 2018).

On the attendant consequences of these policy issues tailing central bank behaviour, the independence of the monetary authority has been proposed as the adequate solution to enhance the policy outcomes (Wachtel, 2010; De Sousa, 2001). However, the conceptual issues around independence of the central bank has challenged this solution. Classifications into legal, operational and

instrument independence (see De Sousa, 2001; De Belle and Fischer, 1994); on the one hand, and personnel, financial and policy independence, on the other hand (Eijffinger and De Haan, 1996) suggest that the independence of the central bank, as a concept, is not without controversy. More so, optimal outcome of central bank independence in resolving the inflation bias problem has been questioned and a conservative central banker has been suggested (Freedman, 1993; Rogoff, 1985). This study argues that the central bank cannot be adjudged on the basis (personnel independence and financial independence) upon which it is incapacitated. The central bank, as an institution, can mainly be assessed based on the strategy adopted in its conduct of monetary policy from time to time. Importantly, the studies on central bank independence were ex-post analyses of central bank behaviour, this study models both the ex-ante and ex-post behaviours of the monetary authority in Nigeria. This is the gap in the literature that this study seeks to bridge.

This study aims to achieve three main objectives. The first is to capture comprehensively; the behaviour (both ex-ante and ex-post behaviours) of the Central Bank of Nigeria. The second objective seeks to examine the effects of central bank's behaviour on the policy outcomes as well as macroeconomic fundamentals in Nigeria and the third is to identify the various shock effects to the behaviour of the Central Bank of Nigeria. In addition to this introductory section, this study is further divided into four other sections. In Section 2.0 extant conceptual, theoretical and empirical literature were reviewed while the methodological framework upon which the empirical investigation would be conducted was provided in Section 3.0. In section 4.0, estimations of empirical model was undertaken and findings were discussed while conclusions were reached and policy suggestions were proffered in section 5.0.

2. Literature review

Central bank behaviour, as a concept, simply denotes the strategy adopted for conducting monetary policy; either as a rule or at discretion. A monetary policy rule specifies future monetary actions as a simple function of economic or monetary conditions and rules out the use of contingent approaches when confronted with economic uncertainties (see Blejer, 1998). Kydland and Prescott (1977) succinctly posited that rules increase the ability of the central bank to remain discipline at its committed policies so as to avoid monetary surprises and, in the end, obtain a lower optimal rate of inflation (see Fischer, 1990). On the other hand, discretion is a 'zero-based' strategy that seeks to revise the current monetary policy in tandem with the prevailing economic and/or financial realities. Unlike policy rule that is targeted at price stability only, discretionary monetary policy focuses on economic stability; a combination of price stability and employment generation (Hetzel and Mehra, 1988). However, discretion is dynamically time inconsistent. Hence, considered as a sub-optimal policy outcome (Svensson, 1997; Cukierman, 1986, 1992, 2006; Barro and Gordon, 1983).

Nonetheless, there are many measurement issues attributed to monetary policy rules. Barro (1986) considered it either as quantity or price rules while Van Lear (2000),¹ categorized these measurement approaches into five. These are the quantity theory, the McCallum's (1988) money growth rule, Angell's (1992) commodity price rule, natural rate of unemployment measure and the Taylor's (1993) rule. As a hybrid strategy, however, inflation-targeting has been suggested as a valid approach to counteract the effects of both

¹ See Barro and Gordon (1983); Barro (1986) and Van Lear (2000) for a standard review of measurement issues.

rules and discretionary policy strategies of the monetary authority; especially for developing economies (Walsh, 2009). Since inflation-targeting has been disputed in some empirical studies (Friedman, 2004), Barro and Gordon (1983) suggested good reputation and sound credibility as rules substitute. The theoretical literature on central bank behaviour can be explained either as positive or normative hypothesis (Cukierman and Meltzer, 1986). The former is an exposition about the objectives and constraints that central bankers have to contend with. In this case, inferences are usually drawn from observable variables (such as inflation rate and rate of money growth) while intuition and heuristic implications are obtained from unobservable variables (such as policy credibility). On the other hand, normative hypothesis relates to how the monetary authority would improve the social welfare conditions of all economic agents in a country.

It is along this thread that Kibmer and Wagner (1998) provided three central reasons (such as the employment motive, revenue motive and the balance of payment motive) for the time inconsistency policy; popularly known in the literature as the inflation bias problem. The employment motive is a game-theoretic model which centres on the short-run Phillip curve. This motive predicts that changes in employment is mainly predicated on unexpected inflation and that given perfect forecast as well as rational expectations of private economic agents, output would fluctuate around its natural level on the attendant effects of supply shock. The model presumes that the natural unemployment level can only be lower than the socially desirable output if there exists distortions in taxes or in the presence of distorting wage-setting. The revenue motive presupposes that the government can be motivated to generate unexpected inflation; even in the presence of nominal debt without any effect on the nominal interest rate. In real terms, cost of debt would decline and the real balances for inflation tax would remain unchanged. Regarding the BOP motive, an unexpected devaluation can be undertaken by policymakers in the presence of persistent current account deficits. This is analogous to surprised inflation but explained under the theory of one price. It is indicative to note that one major feature standing out of these motives is the potency of rational expectation of the private agents in shaping the opinion of the policy makers towards a desirable socially optimal welfare function (Blanchard and Fischer, 1989; Schaling, 1995; Kibmer and Wagner, 1998).

The empirical literature on central bank behaviour can be dichotomized into two. The first category has to do with those studies that investigated *ex-ante* behaviour of central bank; through simulations, while the second relates to those studies that examined the *ex-post* behaviour of the monetary authority; in the form of reaction functions. Brzozowski (2005) conducted a study to identify central bank's preferences for the case of Poland. The author tested the hypothesis that the weight on output gap variability in the central bank's loss function was equal to zero in Poland. The framework adopted was to derive monetary policy reaction function from the central banks optimization problem. The study found that the weights assigned to target variables were not constant over the period 1995–2003. More so, the results showed that the weight attached to inflation stabilization objective in the central bank's loss function in Poland was equal to the weight assigned to output gap stabilization in the period 1995–1999 but that the output stabilization goal has been abandoned since the year 2000. Besides, Epstein (2009) argued that to get more information on central bank developmental efforts and economic outcomes, case studies will be more useful than cross-country econometrics. The author submitted that there are series of models and institutional structures to learn from and that the cross-country data in the extant literature support central bank's developmental efforts to promote real investment and economic growth

but that the shortfall of these data is that they failed to indicate other broad conclusions of success or failure.

On the other hand, Agu (2011) specified two simple models of monetary policy reaction function for Nigeria with the first being a tracking model based on the revealed preference of the Central Bank of Nigeria and the second as an alternate model which closely followed the Taylor rule. The study could not find evidence for interest rate smoothing and fiscal dominance in the reaction function. No long-run relationship was established among monetary variables and even less so between monetary and real sector variables. The result was found to be consistent with the pronounced policy of the Central Bank of Nigeria to tackle inflation as a priority and the primacy of credit to the private sector as the growth strategies of the monetary authority. However, these results contradicted the findings in the study of Bello and Sanusi (undated) where they found that the Central Bank of Nigeria was conscious of interest rate smoothing. Bello and Sanusi (undated) estimated monetary policy reaction function for the Central Bank of Nigeria through a Taylor-typed rule with quarterly data that spanned 2006Q4 – 2015Q2. The technique of analysis was the Generalized Method of Moment and the results obtained showed that the central bank followed a forward-looking policy rule and committed to an anti-cyclical monetary policy with a forward-looking behaviour of not more than a single quarter into the future.

Iklaga (2007) examined the effect of monetary policy on macroeconomic variables through a Taylor-typed reaction function. The results showed the significance of inflationary pressures in the decision-making process of the monetary authority and that output played the path dependence of interest rate. Also, Siri (2009) analyzed the reaction function of the Central Banks of Ghana, Nigeria and WAEMU and found that the monetary policies for Ghana and Nigeria were not consistent with the Taylor-typed rule or any of its variants. Evidence obtained showed that interest rate weakly reacted to the variations of inflation and output gap. The main observation from the result obtained was that monetary policy applied was different from those announced a priori and that except for the inflation rate, output appears not to have any influence on the adjustment of the interest rate of the Bank of Ghana (BoG) and the Central Bank of Nigeria (CBN). In addition, the negative sign of the two bank's reaction coefficient did not adjust their interest rate in response to economic over-activity. Recently, the study of Onanuga et al. (2017) relied on the augmented Taylor's rule to evaluate the reaction function of the historical path of nominal monetary policy rate in Nigeria for the quarterly period that spanned 1996Q1 – 2014Q4. The main technique of analysis was the Generalized Method of Moments and the reaction function was augmented with the real exchange rate. The study found that real output and exchange rate were both significant in explaining the path of monetary policy in Nigeria.

3. Methodology

The Taylor's (1993) rule has been the most prominent framework in investigating the reaction function of central banks. It is important to emphasize that the Taylor's (1993) rule is a closed-economy framework and an apolitical simple interest rate rule that the monetary authority is expected to adhere to in order to reduce price and output losses. In this study, however, we obtain an extended Taylor's rule to capture the political economy of interest rate rule and also specify the behaviour of central bank through a regime switching framework. The extensions to the baseline Taylor's (1993) rule are done in two ways. The first is the inclusion of political risks factor as an integral part of central bank reaction function in a developing economy such as Nigeria. This is to address the political economy of central bank's reaction function in Nigeria.

As enunciated, a purely self-serving public office holder will deliberately keep the interest rate low in order to enjoy public fund at little or no cost for political activities and perpetuate itself in office. As previously done in earlier studies, the exchange rate is introduced in order to capture the economic activities with other economies of the world. This is only an open economy component which does not fully reflect the entire open economy dynamics faced by the central bank.

The second aspect of the extensions is methodological. This is to model the reaction function of the central bank; not as a deterministic model but within the regime switching framework. Basically, the baseline Taylor rule is structured in such a way that the monetary authority is expected to stick to rules in its strategic adoption of policies; even with the inclusion of an open economy component – the exchange rate. It does not allow for discretionary policy. The policy strategy to adopt by the monetary authority would have been identified at the wake of every year and issues in global and domestic dynamics are not expected to affect it. However, the behaviour of the central bank may not face a rule-based approach as the monetary authority is sometimes expected to continually review its policies and strategies in order to strategically place the economy and reduce the actual and impending uncertainties facing the economy to the barest minimum.

Specifically, the Central Bank of Nigeria describes its policy actions in terms of discretion owing to several factors accounted for during several meetings of the Monetary Policy Committee (MPC) held at successive intervals. Using an extended Taylor's rule, the idea is to model how the seemingly discretionary policy expected of the central bank can be empirically described by a systematic rule that allows for occasional regime switches. Beginning with a baseline reaction function of the form;

$$\dot{i}_t = r^* + \pi_{t-1} + \alpha(\pi_t - \pi^*) + \beta(y_t - y_t^*) \quad (1)$$

Where; i is the nominal interest rate; r^* is the equilibrium real interest rate; π is the rate of inflation over the previous four quarters; π^* is the target inflation rate while $y_t - y_t^*$ is the percentage deviation of real GDP from its target level (Hodrick and Prescott, 1997). Modifying the basic Taylor rule in equation (1) and incorporating exchange rate as a control variable, the appropriate reaction function for the Central Bank of Nigeria is given as;

$$\dot{i}_t = \theta \dot{i}_{t-1} + \alpha(\pi - \pi^*)_t + \rho \pi_{t-1} + \beta(y_t - y_t^*) + \vartheta z_t + \mu_t \quad (2)$$

Where; r^* as earlier defined is the measure of interest rate smoothing² but would be used in this study as the lagged dependent variable, \dot{i}_{t-1} . The π_{t-1} is to capture the backward-looking as well as ex-ante behaviour of the central bank while the $(\pi - \pi^*)$ addresses the ex-post behaviour of the central bank. z_t is to capture the political risk factors of central bank reaction function in Nigeria. The Holdrick-Prescott filter would be used to obtain the potential output as developing and small open-economy like Nigeria does not have a forward-looking projection.

Considering an unobserved states or regimes which is said to follow a Markov chain process (Quandt, 1972; Goldfeld and Quandt, 1973; Mills and Wang, 2006; Guidolin, 2011a, 2011b), the evolution of interest rate (see Appendix 1 for the methodological framework of the Markov Switching Model) can be modeled as a state-dependent intercept term for k states;

$$\dot{i}_t = \psi_{s_t} + \phi \dot{i}_{t-1} + \xi_{s_t}; \quad (3)$$

$$\dot{i}_t = \psi_{s_t} + \beta \sum_{t=1}^3 X_t + Z_t \lambda_s + \xi_s \quad (4)$$

Equation (3) is a Markov Switching Autoregression Model while equation (4) is a Markov Switching Dynamic Regression Model. The former has a fixed transition probability while the latter has a time-varying transition probability that is amenable to the changing form of the transition probability from one state to another; due to the dynamics of the explanatory variables. Equation (4) has state-invariant coefficients β while other variables that drive interest rate are considered as control variables coupled with independently identically distributed random variable ξ_s that follows a normal distribution with zero mean and $\delta_{s_t}^2$ state-dependent variance (equations (5) and (6)). λ_s is the state-dependent coefficients for the control variables.

$$\xi_t \sim N(0, \delta_{s_t}^2) \quad (5)$$

$$\delta_{s_t}^2 = \sum_{s=1}^k \delta_{s_t}^2, \sum_{s=1}^{k-1} \delta_{s_t}^2 > 0 \quad (6)$$

$$\psi_{s_t} = \sum_{s=1}^k \psi_s, \quad (7)$$

Where; $\psi_{s_t} = \psi_1$ when $s_t = 1$, $\psi_{s_t} = \psi_2$ when $s_t = 2$, ..., and $\psi_{s_t} = \psi_k$ when $s_t = k$. The conditional density of i_t is assumed to be dependent only on the realization of the current state s_t and is given by $f(i_t | s_t = n, i_{t-1}; \vartheta)$ where ϑ is a vector of parameters. There are k conditional densities for k states, and estimation of ϑ is performed by updating the conditional likelihood using a nonlinear filter. s_t is an irreducible, aperiodic Markov chain starting from its ergodic distribution $\pi = (\pi_1, \dots, \pi_k)$; (Hamilton, 1989, 1990). The probability distribution of the Markov Switching model is expected to follow a logistic distribution (Appendix 1; Hamilton, 1999; Chen and Shen, 2007 for modeling frameworks). Considering the regime switching modeling of the central bank reaction function, equation (7) becomes;

$$\dot{i}_t = \psi_{s_t} + \alpha(\pi - \pi^*)_t + \rho \pi_{t-1} + \beta(y_t - y_t^*) + \dot{i}_{t-1} + \vartheta z_t + \xi_s \quad (8)$$

The regime switching parameters are as earlier defined. The period of investigation spanned 1981q1 – 2017q4 and data were sourced from various issues of the Central Bank of Nigeria (CBN) Statistical Bulletin, National Bureau of Statistics (NBS) Annual Statistics and the databank of the International Country Risk Guide (ICRG).

4. Results and findings

4.1. Descriptive statistics and data stability conditions

4.1.1. Statistical properties of variables

In order to obtain the statistical properties for the variables included in our specified models, both the descriptive statistics and correlation among these variables were found appropriate. As detailed in Table 1, the change in the exchange rate (Δe) has mean value of 5.95. This suggests that the exchange rate in Nigeria depreciated more during the period under consideration. More so, the skewness value of 8.57 indicates *naira* positively deviated from

² See Agu (2011).

Table 1
Descriptive statistics of the variables.

Variables	Maximum	Minimum	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera Stat.
<i>∆e</i>	294.41	-9.22	5.95	28.19	8.57	83.91	39.045*
<i>cpi</i>	180.15	0.48	47.84	51.95	1.00	2.83	23.08*
<i>intr</i>	26.00	6.00	13.15	4.02	0.59	3.73	11.09*
<i>rgdp</i>	10.46	-11.57	1.21	3.08	-1.13	9.38	261.85*
<i>politrisk</i>	54.33	38.46	45.76	3.90	0.65	2.69	10.21*

Source: E-Views Output. Note: * denotes significance at the 1 percent level.

its expected market value for the period under review. The implication is that there was over-valuation of the domestic currency during the period. This is supported by the standard deviation value of 28.19 which indicates that the domestic currency largely deviated from its expected value. Although, the kurtosis (being an atheoretical measure of normal distribution) value of 83.91 suggests that the distribution of exchange rate in Nigeria was leptokurtic. That is, it was highly peaked with very thin tail.

Also, the political risk variable (denoted *aspolitrisk*) shows that political risk in Nigeria is averagely very high as the mean value is below the 50 percent threshold. Specifically, it is 45.76. The skewness value of 0.65 is an indication that political risk in Nigeria is positively skewed; implying that it escalated a little bit above its expected value. In complementary analysis with the skewness value, the standard deviation value of 3.90 for political risk factor in Nigeria shows that the political risk in the country does not deviate substantially from the expected value. Both the kurtosis value of 2.69 and Jarque-bera statistics of 10.21 strongly lend credence to the normal distribution of political risk in the country for the period under review.

On the other hand, the growth of real gross domestic product (denoted *asrgdp*) is averagely 1.21 but with -1.31 skewness value. This shows that economic growth in Nigeria has averagely been on a downswing and has skewed negatively from the expected value by 1.31. This is an indication that economic growth in Nigeria has been grossly non-performing for the period under consideration. Interestingly, the domestic interest rate is normally distributed with kurtosis value of 3.73. This is supported by the Jarque-bera statistics of 11.09 values. This is considered significant; even at the 1 percent level. However, the domestic interest rate deviated from its market determined value; as shown by the standard deviation of 4.02. This suggests a marginal skewness of 0.59.

4.1.2. Unit-root and stationarity tests

The test statistics for the unit-root and stationarity tests detailed in Table 2 suggests that some of the variables are unit-root as well as non-stationary at levels while some other variables are non-

Table 2
Conventional unit root and stationarity tests.

VARIABLES	Level			First Difference		
	ADF	PP	KPSS	ADF	PP	KPSS
<i>∆e</i>	-10.932*	-10.928*	0.189*	-	-	-
<i>intr</i>	-3.013**	-2.415	0.256*	-	-9.494	-
<i>rgdp</i>	-2.673	-21.797*	0.724	-21.583*	-	0.328*
<i>infr</i>	-2.916*	-8.390*	0.403**	-	-	-
<i>politrisk</i>	-1.559**	-2.042	0.193*	-4.596*	-4.471*	-

Note: Unit-root and Stationarity tests are with constant but without deterministic trend. Lags are included with automatic and based on Schwarz info criteria. *, **, *** imply that the series is stationary at 1%, 5% and 10% respectively. ADF, PP and KPSS represent Augmented Dickey-Fuller, Phillips-Perron and Kwiatkowski-Phillips-Schmidt-Shin Unit Root and stationarity tests respectively. ADF: 1% = -3.478; 5% = -2.882; 10% = -2.578; PP: 1% = -3.478; 5% = -2.882; 10% = -2.578; KPSS: 1% = 0.739; 5% = 0.463; 10% = 0.347.

unit-root as well as stationary at levels. The use of the Augmented Dickey Fuller (ADF) and the Phillip-Perron (PP) confirm the non-unit-root of the change in the exchange rate while the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) confirm its stationarity. The corresponding ADF and PP test statistics for change in exchange rate (proxied as *∆e*) are -10.923 and -10.928 respectively. These are greater than their values at the 1 percent critical level; given as -3.478 for both. As such, the null hypothesis of unit-root is rejected; even at the 1 percent level of significance. The *infr* have -2.916 and -8.390 as test statistic values for both ADF and PP that are greater than their critical values at the 5 percent levels. Hence, the null hypothesis of unit-root is also rejected. The stationarity test for these variables reinforces the decisions on non-unit-root of these variables as the test statistics values for *∆e* suggests that the null hypothesis of stationarity for the KPSS cannot be rejected at the 1 percent level of significance (Table 2). The implication that the non-unit-root as well as stationarity of these variables portend for the Markov Switching models is that it suggests that the long-run probability of each state actually exists.

This suggests that the estimated probabilities can be used for forecasting and predictions as well as for diagnostic tests. As detailed in Table 3, it is evident that the variables have different break periods and the levels of stationarity also differ. Only the change in the exchange rate, growth rate of the economy and the output gap that are non-unit-root at levels. Other variables such as the political risk factor, interest rate and the inflation rate are unit-root at levels. Combining these variables with different levels of stationarity and varying break periods in the same model suggests that the use of deterministic models would not be appropriate for this study. This further justifies the use of the Markov Switching models that can capture different break-point period within a structural analysis in a modeling framework such as this.

4.2. Model estimations and discussion of findings

The estimates show that only two states can be optimized at convergence level for interest rate regime switching in Nigeria. The estimates show that there is evidence for interest rate smoothing in Nigeria, irrespective of the regimes of interest rate. This conforms to findings in the studies of Agu (2011) and Bello and Sanusi (undated). Without political risks, the average rate of interest for State 1 is 5.102 while that of State 2 is 0.164. The corresponding

Table 3
Zivot-Andrew unit-root (with structural breaks) test.

Variables	Break Point Period	Test Statistics Value
<i>∆e</i>	1999:01	-6.245*
<i>intr</i>	2005:01	-3.675
<i>rgdp</i>	2000:01	-8.243*
<i>infr</i>	1995:04	-4.007
<i>outpgap</i>	2001:02	-6.520*
<i>politrisk</i>	2001:02	-3.166

Source: RATS Output. Note: Critical Values at the 1% = 5.34; 5% = -4.80.

average rate of interest with the existence of political risk factors for States 1 and 2 are 2.857 and –1.763 respectively. The implication of these estimates is that State 1 can be categorized as the high interest rate state while State 2 can be categorized as the low interest rate state. An attempt to optimize for more than two states of interest rate regime switching could not yield convergence. Therefore, it is valid to conclude that there are only two regimes of high and low interest rates dynamics in Nigeria for the periods 1981Q1 – 2017Q4 (Table 4).

The estimates obtained showed that the previous level of interest rate ($intr_L_1$) negatively impacted on its current level; except for the case of high interest rate regime under political risks. The lagged interest rate for the high interest rate regime has –0.537 coefficients with highly statistically significant probability value of 0.000; if political risks are not considered. This implies that a higher interest rate in the previous period; excluding political risk, would attract a lower interest rate in the current period and vice versa. This is also the case when political risks were considered except that it is highly insignificant. Generally, political risk is positively related to both high and low regimes of interest rate but only significantly related in the former. It has a positive coefficient of 0.23 with 0.071 probability values and 0.044 coefficients with 0.132 probability values for the high and low interest rate regimes respectively. This suggests that a higher value of political risk, which translates to lower degree of political risk in the country, would engender higher level of interest rate in the country at the 10 percent level of significance. This, thereby, increases the inflow of capital transactions into the economy and leads to increased degree of financial openness. That the same lower degree of political risk would enhance lower rate of interest is not statistically significant; even at the 10 percent level of significance.

With or without political risk, output gaps for the economy is significantly positively related to the rate of interest under a high interest rate regime but negative under a low rate of interest; albeit insignificantly. This is intuitive in that when the actual output level exceeds its potential level for the economy, then, the interest rate increases further to control for inflationary pressure that could be occasioned by excess production in the domestic economy. By contrast, the exchange rate movement; with or without political risks factor, is negatively related to a higher interest rate regime but positively related to a lower interest rate regime; albeit significantly. The implication is that exchange rate depreciation should provide counter-cyclical impulses on the cost of doing business in the domestic economy; given the dynamics of interest rate in the

country. Except for the case of high interest rate regime without the effect of political risk in the country, the rate of inflation is generally positively related to the rate of interest. This largely confirms the popular Fisher's effect and further suggests that inflation targeting is one of the policy strategies of the monetary authority. Previous studies on this note include Agu (2011) but it contradicts the findings that interest rate weakly reacts to inflation and output gap as obtained in the study of Siri (2009).

The estimates on the transitional probabilities and duration of persistence of interest rate regimes provide more insightful information. The 0.410 estimate is the probability that a high interest rate regime in the current quarter will remain high in the next quarter but a 59 percent chance that it will transit to a low interest rate regime in the next quarter. On the other hand, there is a 3.2 percent chance that a low interest rate in the current quarter will transit to a high interest rate in the next quarter. However, there is a 96.8 percent chance that a low interest rate regime in the current quarter will remain low in the next quarter. The implication is that the duration of persistence for high interest rate regime in Nigeria is approximately two (2) quarters while that of a low interest rate regime is approximately 31 quarters; about eight (8) years equivalently. All these transitions and persistence are without the consideration of political risk factors. With political factors considered, there is persistence of high interest rate regime to 75.8 percent chance and the transition from a high interest rate regime to a low interest rate regime diminishes to 24.2 percent chance (Table 5). This suggests that political factors stimulate the persistence of high interest rate in Nigeria and reduce the tendency for low interest rate persistence. The implication, therefore, is that perhaps, the use of loanable funds for preparing for political activities and electioneering activities in the country has allowed financial institutions to charge higher interest rate on investible funds in the country (Buchanan and Wagner, 1977).

In fact, the duration of persistence has marginally increased for high interest rate regime by a spate of about additional two-and-half ($2\frac{1}{2}$) quarters while the duration of persistence for low interest rate regime reduces half-life; from 31.13 quarters to 29.9 quarters (Table 5). The smoothed regime probabilities is instructive enough to note that both probabilities for State 1 ($S(t) = 1$) and State 2 ($S(t) = 2$) are true mirror images of each other (see Fig. 1 below). This is evident in that State 1 skewed positively by 0.350 value while State 2 skewed negatively by –0.350 value. Also, the mean value suggests that after being smoothed, State 1 (High interest rate regime) has a probability transition to remain at the

Table 4
Estimates of the standard and extended Taylor's rule for Nigeria.

Panel A: Standard Taylor's Rule for Nigeria (Without Political Risks of the Country)				Regime 2 (Regime of Low Interest Rate)			
Regime 1 (Regime of High Interest Rate)				Regime 2 (Regime of Low Interest Rate)			
Variable	Estimation	Std. Error	P z	Variable	Estimation	Std. Error	P z
$intr_L_1$	–0.537	0.120	0.000	$intr_L_1$	0.991	0.021	0.000
ζ_1	5.102	1.640	0.002	ζ_2	0.164	0.293	0.576
$outpgap$	1.077	0.183	0.000	$outpgap$	–0.072	0.029	0.011
λe	–0.005	0.033	0.889	λe	0.008	0.243	0.005
$infr$	–0.305	0.166	0.066	$infr$	0.009	0.014	0.532

Panel B: Extended Taylor's Rule for Nigeria (With Political Risks of the Country)				Regime 2 (Regime of Low Interest Rate)			
Regime 1 (Regime of High Interest Rate)				Regime 2 (Regime of Low Interest Rate)			
Variable	Estimation	Std. Error	P z	Variable	Estimation	Std. Error	P z
$intr_L_1$	–0.017	0.080	0.830	$intr_L_1$	0.981	0.024	0.000
ζ_1	2.857	5.596	0.610	ζ_2	–1.763	1.207	0.144
$outpgap$	0.678	0.094	0.000	$outpgap$	–0.048	0.033	0.142
λe	–0.099	0.09	0.287	λe	0.088	0.03	0.002
$infr$	0.025	0.059	0.676	$infr$	0.016	0.016	0.317
$politrisk$	0.230	0.127	0.071	$politrisk$	0.044	0.029	0.132

Source: STATA Output.

Table 5
Probabilities of transition and durations of persistence for the Taylor’s rule for Nigeria (with and without political risks).

Panel A: Transitional Probabilities of Interest Rate Regime in Nigeria			
Transition Probabilities without Political Risks		Transition Probabilities with Political Risks	
Expected Probabilities	Estimates	Expected Probabilities	Estimates
P_{11}	0.410	P_{11}	0.758
P_{12}	0.590	P_{12}	0.242
P_{21}	0.032	P_{21}	0.033
P_{22}	0.968	P_{22}	0.967

Panel B: Duration of Persistence of Interest Rate Regimes in Nigeria			
Duration of Persistence without Political Risks		Duration of Persistence with Political Risks	
Expected Duration	Estimates	Expected Duration	Estimates
S_1	1.70	S_1	4.13
S_2	31.13	S_2	29.90

Source: STATA Output.

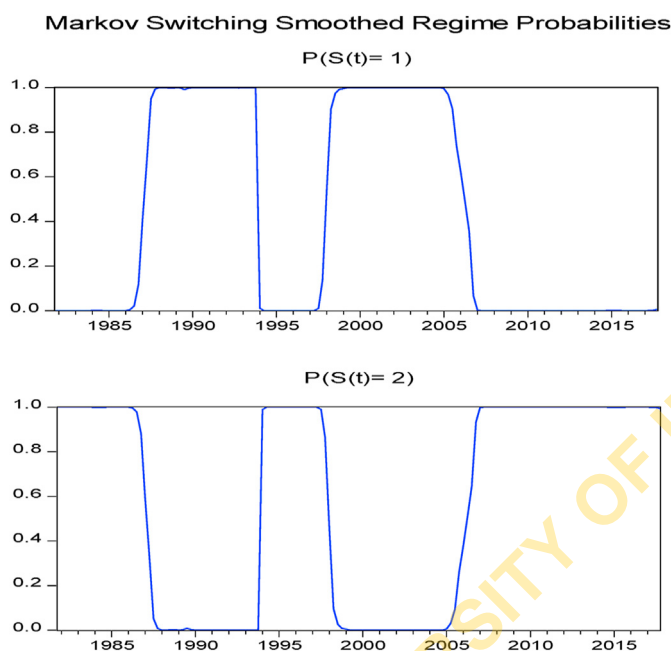


Fig. 1. Markov switching smoothed regime probabilities.

same State at 41.3 percent while State 2 (Low interest rate regime) has probability transition to remain in the same State at 58.7 percent (see Table 6).

5. Conclusion and recommendation

As shown by the disparities between the actual and targeted broad money supply, the reaction function of the Central Bank of Nigeria (CBN) has been carried out at discretion rather than stuck to

Table 6
Summary statistics of smoothed regime probabilities.

	P(S(t) = 1)	P(S(t) = 2)
Mean	0.413	0.587
Median	0.002	0.998
Standard Deviation	0.478	0.478
Skewness	0.350	-0.350
Kurtosis	1.174	1.174
Jarque-Bera Stat.	23.091	23.091
Prob. (Jarque-Bera Stat.)	0.000	0.000

Source: E-Views Output.

rules. Since it was found that the monetary target, which was found to be endogenous of the direction of the exchange rate, does not affect the rate of interest, it could be said that the monetary authority acts independently in Nigeria. The Zivot-Andrew unit-root test, with structural breaks, indicates that there were different break periods for the variables included in the model; lending credence to the Markov-Switching modelling approach employed for this study. The empirical evidence obtained from the extended Taylor’s rule suggests that political risk matters for the behaviour of Central Bank of Nigeria (CBN). The result obtained showed that political risk distorts the significance level of interest rate and that the historical level of the interest rate does not matter. In fact, it was found that high political risk significantly triggers high interest rate in the country. This evidence supports the political economy thesis of financial liberalization.

In fact, the Fisher’s effect was supported for the Nigerian economy only when the effects of political risks were considered. Consequently, the study suggests that inflation targeting should be one of the policy strategies of the monetary authority. There are many benefits attributed to the inflation-targeting policy. Also, inflating-targeting is not without some criticisms too. The inability to address the uncertainties of the financial system and its ineffectiveness to check fiscal dominance problem have been the prominent criticisms facing the inflation-targeting policy. However, the ability to counter-balance the inadequacies of policy rule and discretionary strategy remains its strongest benefit. In Nigeria, the practicability of the inflation-targeting policy, as recommended, cannot be out of place because it will curtail the flagrant abuse that the Central Bank of Nigeria faces from political forces. The reckless abandon of the policy target to cater for discretionary forces; both within the domestic and global economies, would be drastically reduced with inflation-targeting policy in place. Again, monetary policy would, as a result of the inflation-targeting policy, becomes the dominant strategy and undue influences from the fiscal side would be largely under control. For the uncertainties in the financial system, no known strategy has been full-proof; especially when it comes to uncertainties due to global dynamics. However, an inflation-targeting policy will address a large aspect of financial sector uncertainties occasioned by dynamics in the domestic financial system and further moderates the global dynamics.

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Appendix 1. Framework for Markov Switching Dynamic Regression

Considering an unobserved states or regimes which is said to follow a Markov chain process (Quandt, 1972; Goldfeld and Quandt, 1973; Mills and Wang, 2006; Guidolin, 2011a, 2011b), the evolution of exchange rate can be modeled as a state-dependent intercept term for k states;

$$y_t = \psi_{s_t} + \phi y_{t-1} + \xi_s; s_t \in \{0, 1\} \tag{1}$$

$$y_t = \psi_{s_t} + \beta \sum_{t=1}^3 X_t + Z_t \lambda_s + \xi_s \tag{2}$$

Equation (1) is a Markov Switching Autoregression Model while equation (2) is a Markov Switching Dynamic Regression Model. The former has a fixed transition probability while the latter has a time-varying transition probability that is amenable to the changing form of the transition probability from one state to another; due to the dynamics of the explanatory variables. The explanatory variables include the triad-policy of exchange rate stability, financial integration and monetary independence; this gives the summation of the financial trilemma components. It has state-invariant coefficients β while other variables that drive exchange rate are considered as control variables coupled with independently identically distributed random variable ξ_s that follows a normal distribution with zero mean and $\delta_{s_t}^2$ state-dependent variance (equations (3) and (4)). λ_s is the state-dependent coefficients for the control variables.

$$\xi_t \sim N(0, \delta_{s_t}^2) \tag{3}$$

$$\delta_{s_t}^2 = \sum_{s=1}^k \delta_s^2, \sum_{s=1}^{k-1} \delta_s^2 > 0 \tag{4}$$

$$\psi_{s_t} = \sum_{s=1}^k \psi_s, \tag{5}$$

Where; $\psi_{s_t} = \psi_1$ when $s_t = 1$, $\psi_{s_t} = \psi_2$ when $s_t = 2$, ..., and $\psi_{s_t} = \psi_k$ when $s_t = k$. The conditional density of i_t is assumed to be dependent only on the realization of the current state s_t and is given by $f(i_t | s_t = n, i_{t-1}; \vartheta)$ where ϑ is a vector of parameters. There are k conditional densities for k states, and estimation of ϑ is performed by updating the conditional likelihood using a nonlinear filter. s_t is an irreducible, aperiodic Markov chain starting from its ergodic distribution $\pi = (\pi_1, \dots, \pi_k)$; (Hamilton, 1989, 1990). The probability distribution of the Markov Switching model is expected to follow a logistic distribution (Appendix 1; Hamilton, 1999; Chen and Shen, 2007 for modeling frameworks).

The probability that s_t is equal to $j \in (1, \dots, k)$ depends on the most recent realization, s_{t-1} , and is given by:

$$\Pr(s_t = j | s_{t-1} = i) = p_{ij} \tag{6}$$

All possible transitions from one state to the other can be collected in a $k \times k$ transition matrix given as;

$$P = \begin{bmatrix} p_{11} & p_{21} & \dots & p_{k1} \\ p_{12} & p_{22} & \dots & p_{k2} \\ \dots & \dots & \dots & \dots \\ p_{1k} & p_{2k} & \dots & p_{kk} \end{bmatrix}, \sum_{j=1}^k p_{ij} = 1 \tag{7}$$

which governs the evolution of the Markov chain. All elements of P are non-negative and column sums to 1. In order to avoid some numerical complications caused by $\sum_{j=1}^k p_{ij} = 1$, the probability distribution follows a logistic form with the estimations of p_{ij} being normalized by p_{ik} . This gives;

$$p_{ij} = \frac{\exp(-q_{ij})}{1 + \exp(-q_{i1}) + \exp(-q_{i2}) + \dots + \exp(-q_{i,k-1})} \tag{8}$$

for $j \in \{1, 2, \dots, k-1\}$.

Normalizing p_{ik} by imposing;

$$p_{ik} = \frac{1}{1 + \exp(-q_{i1}) + \exp(-q_{i2}) + \dots + \exp(-q_{i,k-1})} \tag{9}$$

Equation (1) describes the behaviour of the state-dependent parameter ψ .

Equation (3) is the fixed probability Markov regime changing distribution. In order to obtain a time-varying distribution where the probabilities of regime changes are endogenized by introducing the economic variables as their determinants, the transition matrix in equation (3) is altered thus;

$$P = \begin{bmatrix} p_{11}\eta_{t-1} & p_{21}\eta_{t-1} & \dots & p_{k1}\eta_{t-1} \\ p_{12}\eta_{t-1} & p_{22}\eta_{t-1} & \dots & p_{k2}\eta_{t-1} \\ \dots & \dots & \dots & \dots \\ p_{1k}\eta_{t-1} & p_{2k}\eta_{t-1} & \dots & p_{kk}\eta_{t-1} \end{bmatrix} \tag{10}$$

Where; η_{t-1} is a set of information variables that includes the composite variable of financial trilemma (FI) and vector of control variables (Z) that determine interest rate. Therefore, the argument of the transition probabilities now includes information set. As a result, the normalization to a logistic distribution in equation (3), then, becomes;

$$p_{ik} = \frac{1}{1 + \exp(-\eta_{t-1}\Omega_0) + \exp(-\eta_{t-1}\Omega_0) + \dots + \exp(-\eta_{t-1}\Omega_0)} \tag{11}$$

Where; Ω_0 denotes the vector coefficients of information variables.

In order to estimate the regime switching model, a complete data likelihood function is imperative. This is well documented in the methodological literature (Balcilar et al., 2014). Also, the form of iterative procedure employed and the algorithm undertaken to generate unique and optimal solution of the regime switching models would have to be spelt out. Prominent in these regards are the Hamilton's recursive filter method, the Hill climbing procedure, the Expectation Maximization (EM) algorithm and the Bayesian MCMC parameter estimation procedure based on Gibbs sampling (Balcilar et al., 2014 for extensive review).

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