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Article

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The role of Structural Breaks and Time-Varying Conditions in the Evolution of the Reaction Function of the Central bank of Nigeria

(Evolution of CB reaction function in Nigeria)

Abidemi C. Adegboye[1] and Queeneth I. Emoedume[2]

Abstract

In this study, we examine the evolution of the Central Bank of Nigeria's (CBN) reaction function since the adoption of the structural Adjustment Programme (SAP). We consider the role of structural breaks in the reaction function, the leading composition, as well as the driving factors behind changing weights assigned to target variables are identified. Using a Taylor-rule with forward looking conditions and interest rate smoothing, we show that multiple structural breaks exist in the reaction function for the 1994Q1 and 2002Q3 period. The study employs the GMM estimator and finds an efficiency trade-off in the inflation and output stabilisation mandates of the CBN. The study also finds that inclusion of more instruments in the CBN's reaction function tends to weaken its overall efficiency, although exchange rate management enhances the output stabilisation mandate of the function. We also find evidence that the 1994 structural break is fully explained by a shift in CBN's exchange rate management dynamics, while the 2002 break is linked with a shift in the Bank's focus on money growth. The study therefore emphasises the difficulty of the CBN to effectively manage inflation and output stabilisation simultaneously, which makes the adoption of a single predominant mandate the most efficient means of conducting interest rate-based monetary policy.

Keywords: Central Bank of Nigeria, inflation, monetary policy rate, output stabilisation Taylor rule

JEL Classification: E52, E58, E61

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1. Introduction

The principal role of a Central Bank (CB) is managing economic fluctuations and achieving price stability in an economy using monetary policy. Modern CBs have internalized this central role within the framework of the reaction function which endogenously describes the goals and instruments of monetary policy. Specifically, the reaction function is a model setup that takes into consideration the consequences of any economic disturbance with prompts that facilitate automatic responses within the model. The reaction function therefore describes the patterns of the CB's responses to economic conditions, while outlining the channels of such effects and facilitating comprehensive interactions between the CB and other agents (Watson, 2011; Carvalho et al., 2021). This implies that the reaction function is useful for easing the transmission mechanism of monetary policy, providing insights into the direction of focus of the CB (in relation to inflation versus output), and as information provider for both the CBs and economic agents (Sutherland, (2011; Owusu, 2020; Adrian et al., 2023).

The effectiveness of a central bank's reaction function essentially lies in its capability to successfully set manageable targets towards which the bank can efficiently guide the economy for its attainment. The macroeconomic environment which necessitates the implementation of a Central Bank's (CB's) reaction function is however constantly changing and increasingly becoming more complex. Central Banks have therefore had to grapple with several other functions in addition to their core mandate of monetary policy in the past few decades. This has consistently placed the Banks in situations where they are forced to strike a balance among competing objectives with apparent trade-offs (Blinder, 1999; da Silva & Aragón, 2021; Chang, 2022) leading to significant evolution of the Banks into a complex structure of financial functions and powers (De Leo et al., 2022; Adrian et al., 2023). In particular, the effectiveness of the CB is heavily influenced by the composition and features of the financial system, the political environment, and the level of a country's economic development (Epstein, 2005, Walsh, 2014; Bernanke, 2020). Thus, the efficiency of the CB relies on the capacity to constantly adapt or adjust to real or anticipated changes in macroeconomic variables by formulating efficient reactionary tendencies over time. This, in turn, has implications for the tools, techniques, targets and performance measures that the CBs have considered over the years.

For developing countries, the CB's reaction function is often more difficult to frame due to three basic factors that have shaped the conduct of monetary policy over the last few decades. These include the drive for sustainable and inclusive growth, development of institutional capacity, and weak long-term mechanisms that provide buffers against macroeconomic shocks. These factors provide additional force for the unstable nature of the CBs' reaction function in developing economies. Such dynamism of the reaction function is further intensified by internal mechanisms of CBs including time bounds for policy responses, composition of intervention variables and the overall outlook (or philosophy) of the CB (Adegboye, 2015; Olaitan, 2015; Turkay, 2017; CBN, 2020; Fabris & Lazić, 2022; Carvalho et al., 2021). These influences are considered as basic structural diversions to which the CB's reaction function often adjusts. They therefore form the structural breaks and time variation of instrument weighting that have become standard composition of CB's reaction function. In Nigeria, for instance, it is argued that certain developments in the macroeconomic space over the years might have altered the framework of the CBN in performing its core mandate of reacting to inflationary pressure or the output gap. In particular, cognizance of the inherent time inconsistency in the implementation of monetary policy influenced the Central Bank of Nigeria (CBN)'s adoption of a medium term-framework in its reaction function in 2002 (CBN, 2020) which was a major shift in the time bounds of its reaction function. Also, the monetary policy framework of indirect controls was stepped up with the use of Open Market Operations (OMO) in 1993, while the ratio of money supply to GDP also increased sharply in 1994.

CBs in developing countries also face the dilemma of the choice of instruments within a transparent and time consistent framework, especially given the level of development of the financial system. While it is generally agreed that the short-term nominal interest rate should be the main instrument of monetary policy, the choice and efficacy of financial stability instruments is still very much work in progress. In particular, there are arguments that expansion of instruments is often inevitable and tends to improve the efficiency of the reaction function in developing countries (Xie et al, 2017; Fabris & Lazić, 2022; Istrefi et al., 2023). For instance, the desire to conform to the WAMZ's Exchange Rate Mechanism (ERM) arrangement has guided the CBN's exchange rate interventions since the early 2000s (Akpan et al., 2018), while oil prices in the international market have strategically influenced the CBN's monetary policy in recent years (CBN, 2020). Thus, the evolution of a reaction function would also consider not only the broad

instrument choice, but also the inter-temporal instrument variation. The question then is whether the inclusion of more instruments makes the reaction function more efficient and what determines how policy makers vary the instruments over time.

In this study, the inherent evolution of the reaction function of the CBN is examined. This is performed by taking cognizance of the evolution of the composition of instruments as well as the variations in the weights allotted to the instruments over time. We take a historical review of the CBN's reaction function from the perspective of monetary policy dimensions, highlighting the essential characteristics of the function. The study also evaluates structural breaks (endogenous and exogenous) in the reaction function of the CBN and identifies the leading composition of the breaks as well as the driving factors behind changing weights assigned to instruments of the reaction function over time. The study is divided into five sections, including this introductory section. A review of pertinent theoretical and empirical literature is performed in section two, while the framework and methodology of the study is demonstrated in section three. In section four the results of the empirical analysis are presented and discussed while conclusions are made in section five.

2. Literature Review

Within the reaction function framework, the CB adopts a set of monetary policy rules in terms of instruments and targets in response to deviations in macroeconomic variables with the aim of achieving its set goals (Nhapulo & Nicolau, 2017; Carvalho et al., 2021). In line with the policy rule formulated by Taylor (1993), most of the definitions of the CB's Reaction Function (CBRF) in the literature relays with the interest rate because it provides a rule for forecasting changes in the central bank's policy instruments (usually short-term interest rate). Further extensions to the Taylor rule modeling takes into account the expected inflation and output targeting, the linearity of parameter responses, time varying conditions of the parameters, structural breaks, additional variables, and central bank independence and voting patterns. For instance, Clarida et al. (2000) noted that expected targets, rather than current ones mattered for policy setting by CBs, while also adapting a smoothing process for interest rate setting.

Another aspect of the theoretical consideration of the CB's reaction function relates to non-linearity of the model. Tillman (2011) demonstrates that nonlinear rules efficiently measure

optimality of policy rules with parameter uncertainty by the monetary authority. Given rapid switches in macroeconomic performances in emerging economies, the non-linear reaction function may be more relevant in capturing the central bank's policy stance (Jawadi et al., 2014; da Silva & Aragón, 2021). Time-varying conditions of the reaction function have also become a veritable aspect of research into the CB's reaction function. The argument is that the parameters of the reaction function are bound to vary over time, especially when significant macroeconomic activities or regime changes occur within the period (Klose, 2014; Debortoli & Nunes, 2014; de Medeiros et al., 2016; Aragon, 2021). The focus in this study is on the non-constancy of parameters and possible changes in preferred instruments within the CBN's reaction function. This provides more insightful information on the evolution of the CB's reaction function in terms of composition and weighting as well as the main factors that drive shifts in the function.

Empirically, Tillmann (2011) found nonlinearity of the Reserve Bank's reaction function using data for post-1982 U.S. period. Similarly, Jawadi et al. (2011) showed that pursuit of several targets drives non-linearity in the central bank reaction function for the BRICS countries. Brüggemann and Riedel (2011) examined a Taylor-type reaction function in the United Kingdom using quarterly data from 1970Q1 to 2006Q2 and showed that analysis of historical monetary policy rules performs efficiently when non-linear estimation procedures are adopted. Also, de Medeiros et al. (2016) examined the existence of nonlinearities in the reaction function of the Central Bank of Brazil due to policymaker's uncertainties about the relationship between the output gap and inflation. They found strong non-linearities in the reaction function which they attributed to uncertainties about the slope in the Phillips curve and increasing rate of inclusion of exchange rate in the reaction function.

Models with structural breaks appear to have performed well in reaction functions for all sets of economies. For instance, Assenmacher-Wesche (2005) found that over time, the central banks of US, UK and Germany assigned changing weights to inflation and the output gap by following the categorization of low- and a high-inflation regime. In the same vein, de Medeiros et al. (2016) employed structural break analysis to assess possible changes in the conduct of monetary policy in Brazil during the inflation-targeting regime and found the structural break in the monetary rule parameters in the third quarter of 2003 linked to regime preferences. Aragon (2021) tested for structural break in the conduct of monetary policy by the Central Bank of Brazil. They found

evidence of structural breaks that confirmed regime preferences with different reactions of the policy rate to inflation and output gaps. In the same vein, Aragón (2021) also found that the reaction of the Selic rate to inflation and output gaps varied in line with the Chair of Brazil's Central Bank. This suggests that the uniqueness of preference for inflation stabilization by the Bank's Chair also determines structural breaks in the reaction function.

Structural breaks are however not limited to the influences of policy makers' preferences. For instance, Assenmacher-Wesche (2005) found that parameter shifts 'embody preference parameters as well as parameters characterizing the structure of the economy' while Lee and Son (2013) demonstrated that structural breaks in the reaction function may not necessarily entail inclusion of more variables. Debortoli and Nunes (2014) found that changes in the parameters of reaction functions do not necessarily correspond to changes in policymakers' preferences. Addo (2018) showed that for South Africa, though policy parameters exhibit significant changes, the changes may not be related to the different governors at the central bank over the period of the analysis. Trecroci and Vassalli (2010) estimated a reaction function that allowed for time variation in the response parameters and in the variance of the policy rate for the monetary policy for a set of five OECD economies. They found that the responses of the anchor rate in the economies actually allows for time variation in their parameters as well as strong variances in the policy rates. In the same vein, Zhu et al. (2021) found that implicit short term inflation target of the Bank of England was time-varying in response to shocks that are exogenous or cost push and technology-driven.

For Nigeria, Akpan et al. (2018) employed VAR model to estimate a backward and forward-looking Taylor rule for the CBN. The estimated VAR model was augmented with exchange rate and crude oil price for the period 2000Q1 to 2018Q2. They found that the reaction function was limited to the Taylor rule. This outcome shows that important information on the CBN reaction function may be obtained by expanding the model using a time-varying structure. Our study therefore significantly enhances the literature on the CBN's reaction function over time. Uyaebo et al. (2016) applied structural breaks for CBN monetary policy mandate using annual data for 1970 – 2014 period and found a significant break in October 2005. The study however focused on the monetary base as the anchor for monetary policy rather than the monetary policy rate (MPR) which has become CBN's anchor rate since December 2006.

Moreover, inclusion of further targets in a central bank's reaction function appears to be more efficient irrespective of the type of economy or whether the central bank adopts an inflation targeting approach. In an elaborate study by Gerdesmeier and Rofia (2005), the traditional Taylor rule was extended in estimating the reaction function for the Euro Area by including other explanatory variables and also employing different measurement of the inflation term and output gap. The study found that other variables like exchange rate, oil price and asset prices performed well as information contents for policy makers in certain countries. Jawadi et al. (2014) estimated forward-looking and linear reaction function for Brazil and China by including changes in financial markets, monetary conditions, the foreign exchange market and the commodity price as target variables. They showed that while Brazil's central bank significantly responded to the real effective exchange rate along with inflation and output gaps, China responded significantly to interest rate and the commodity prices.

For the European Central Bank and Swedish Central Bank, Owusu (2020) found that foreign interest rates and real exchange rates were important additional mandates to which the Banks significantly responded. Xie et al. (2017) also included wage inflation as an intermediate target for the central bank in South Korea. Their results indicate that wage inflation targeting complemented price inflation targeting in improving the optimality of the reaction. For the US economy, Filardo et al. (2022) showed that actions of Federal Reserve's policy makers significantly influenced patterns of imbalances in the equity, housing, and credit markets. Also, Chang (2022) found that extending the Federal Reserve Bank's mandate to include income and wealth redistribution tends to enhance policy credibility.

The basic limitation in the reviewed literature relates to the absence of an extended Taylor-type reaction function for Nigeria. Although studies on other countries have considered the roles of other economic and institutional inputs in explaining reaction functions of CBs, the studies in Nigeria have been limited to drivers of inflation and output stabilisation by the CBN. For instance, Uyaebo et al. (2016) and Akpan et al. (2018) only considered the traditional Taylor function with no attempt to extend the instruments in the rule. Also, although Uyaebo et al. (2016) and Addo (2018) considered regime changes in the CBN's reaction function, there was no mention of the drivers of such shifts in regime. This is a major contribution of this study where the main input factors that cause shifts in CBN reaction function are also examined. We argue that better

information on the CBN's reaction function may be obtained by expanding the model and using a time-varying structure.

3. Methodology

3.1 Specifying CBN's reaction function

The goal of the study is to estimate the reaction function for the CBN and investigate structural breaks and time-varying characteristics of the function. In specifying the reaction function, we take into cognizance the various factors that the CBN has fully considered in setting policy rates over the years. Essentially the model follows a forward-looking formulation by Clarida et al. (2000) and adapted by Gerdesmeier and Rofia (2005) and Trecroci and Vassalli (2010) where the inflation component is considered as deviations from expected rates and other variables are brought into the model. Given the existence of lags in the transmission of monetary policy to the economy, the central bank is expected to be forward-looking, thereby implying that current development in prices does not provide an effective measure for guiding the monetary policy decisions. Thus, a Taylor rule that incorporates forward-looking information provides more suitable abstraction of actual conditions. The baseline forward-looking rule is specified as:

$$r_t^* = r^* + \alpha[E(\pi_{t+k}) - \pi^*] + \beta E(y_{t+q}) \qquad (1)$$

Where r_t^* is the target rate for the nominal interest rate (the MPR), r^* is the desired nominal rate of the policy instrument when both inflation and output are at their target levels, π_{t+k} is the k-step ahead inflation, π^* is the target inflation rate, and y_{t+q} is the q-step ahead output gap. It should be noted that decisions on both inflation expectation and output gap are taken based on "information set available at time t when the interest rate is set" (Lee & Son, 2013).

The additional variables included in the model are the nominal exchange rate variation, monetary development, oil price variations, and the stock price index. It should be noted that the exchange rate and monetary base have formed consistent consideration for the CBN policy reactions over the years. Moreover, oil price trends to play significant roles in CBN policy framework during periods of downturn in the international markets, while the influences of the stock market have been observed in recent MPC communications.

Inclusion of these additional variables permits an evaluation of the focus of CBN's policy additional instruments in terms of either intermediate or final objectives, outside of those included in the baseline specification.

$$r_t^* = r^* + \alpha[E(\pi_{t+k}) - \pi^*] + \beta E(y_{t+q}) + \gamma e_t + \delta m_t + \mu s_t + \varphi l_t \qquad (2)$$

where e_t is exchange rate deviations at time *t*, *m* is the monetary development (deviations in growth of the monetary base), *s* is the indicator of the stock market performance, and *l* is the deviations in oil price in the international market. For the additional variables, it is assumed that, unlike the cases with inflation and the output gap, the CBN responds to the current deviations in each of the variable. The nature of CBN's policy reaction often demonstrates full knowledge of observed movements in exchange rate and oil price conditions, as demonstrated by CBN (2020) and for the Brazilian Central Bank (Jawadi et al., 2014). For instance, the MPC has moved swiftly in recent quarters to address exchange rate depreciations and liquidity trends in the economy. As Lee and Son (2013) have noted, the specification in (2) suggests that monetary policy affects output and inflation with a certain extent of lag, but it affects the additional variables simultaneously.

In order to account for policy fine tuning by the monetary authority, the speed of adjustment component of the policy rate to changes in economic conditions is included by specifying the following interest rate smoothening function:

$$r_t = \rho r_{t-1} + (1 - \rho) r_t^* \qquad (3)$$

Where r_t is the actual policy interest rate (i.e. the monetary policy rate), and ρ is the degree of interest rate smoothening. Equation (3) shows the adjustment of policy interest rates to the target rate *r**. The Equation demonstrates that for each period, the CBN adjusts its interest rate by a fraction (*1-ρ*) of its current target rate. By substituting Eq (2) into Eq (3) and solving through a Fisher equation process, the following specification of the CBN reaction function is presented:

$$r_t = \rho r_{t-1} + (1 - \rho)\theta + (1 - \rho)[\alpha\pi_{t+k} + \beta y_{t+q} + \gamma e_t + \delta m_t + \mu s_t + \varphi l_t] + \epsilon_t \qquad (4)$$

where $\theta = r^* - (1 - \alpha)\pi^*$represents the long-term equilibrium real policy interest rate and ϵ is the stochastic error term. Note that the introduction of the smoothening mechanism ensures that a lagged interest rate term is included in the specification, which is expected to provide more robust results (Castelnuovo, 2003). In the model, it is expected that α should take the values $\alpha > 1$ (for rules that are characterised by active or aggressive responses to expected inflation) or $\alpha \leq 1$ (for

accommodative rules). Moreover, given that the CBN's nominal anchor is predominantly monetary targeting, the parameter, δ, is also important for consideration. The apriori excitation follows the same format as α. Also, the coefficient of output gap, exchange rate, and oil price gaps can be either positive (active CBN responses) or negative (policy stance that is accommodative).

The typical framework of the reaction function arising from the Taylor-rule with interest rate smoothing considers the long-run coefficients (Altavilla & Landolfo, 2007; Cœuré, 2017; Istrefi et al., 2023). The long run coefficients are computed from Eqn (4) as follows:

$$\alpha_l = \frac{\alpha}{1-\rho}, \beta_l = \frac{\beta}{1-\rho}, \gamma_l = \frac{\gamma}{1-\rho}, \delta_l = \frac{\delta}{1-\rho}, \mu_l = \frac{\mu}{1-\rho}, \varphi_l = \frac{\varphi}{1-\rho}$$

These long run coefficients of the monetary policy rules identify the expected full impacts of the changes in policy rules (Nhapulo & Nicolau, 2017).

3.2 Method of Analysis

In estimating the forward-looking Taylor-type reaction function, there is the challenge with an overlapping observation structure by combining current and lagged variables since they may be correlated with the error term, leading to biased estimates of the coefficients of interest (Lee & Son, 2013; Güney, 2018). The basic means of addressing this problem is by using instrumental variables whereby instruments are chosen such that they are correlated with the variables of interest but uncorrelated with the error term. In this study, the Generalised Method of Moments (GMM) estimator, which corrects for endogeneity biases as well as non-spherical errors, is employed for the estimation. The GMM estimator possesses excellent asymptotic properties for a large time series. Given the large time series used in the study, a heteroscedasticity and serial correlation consistent (HAC) estimator is also required. We use the Bartlett kernel with Newey–West's fixed bandwidth selection in this regard. The instruments set used in the GMM estimation includes lagged values of inflation and the output gap for up to four periods.

3.3 Structural Breaks and Time-varying conditions in the CBN Reaction Function

Equation (4) represents the modified Taylor rule model that is tested in this study for the CBN. However, two issues are crucial when modeling evolution of a central bank's reaction function; the time bounds (or variations) in the parameters, and structural breaks in the function (Cukierman & Muscatelli, 2008; Trecroci & Vassalli, 2010; Tillman, 2011; Lee & Son, 2013; Klose, 2014; Jawadi et al., 2014; de Medeiros et al., 2016; Aragon, 2021). A major objective in this study is

therefore to observe the pattern of changes in CBN reaction functions through target conditions or strength of instrument assignment through determination of structural breaks and time-varying conditions of structural parameters. In investigating structural breaks in the reaction function, it is argued that certain developments in the macroeconomic space over the years might have altered the framework of the CBN in performing its core mandate of reacting to inflationary pressure or the output gap. For instance, periods of strong concern for exchange rate management could have altered the interest rate-based parameters of the reaction function of the CBN. Hence, structural break analysis is adopted to verify the proposition of stable interest rate rule parameters over the years. A special procedure is required for testing structural breaks because the reaction function in Eq (4) assumes constant regression parameters over time.

We adopt the procedure presented by de Medeiros et al. (2016) where endogenous regressors with correlated errors were adapted for tests of structural breaks applying the Perron and Yamamoto (2015) structure. This involves estimating the reduced forms of endogenous regressors by ordinary least squares (OLS) and a sequential determination of the break dates with the sup$F(l + 1|l)$ test used to verify the stability of parameters of the model. If the reduced forms are unstable, the predicted values of endogenous regressors are obtained for each subsample in line with the estimated break dates. If the reduced form is stable, the values predicted for endogenous regressors are estimated by taking into account the whole sample, the reaction function is estimated with endogenous regressors replaced with the generated regressors and the sup$F(l + 1|l)$ statistic is also used to verify the existence of structural breaks in these equations. Aragon (2021) provided clear justification for this method of testing structural breaks. The test of structural breaks is therefore expected to provide conditions for observing time-variations in the parameters by using the different sample periods provided by the tests to estimate different parameters.

3.4 Data and Variables for the Study

Data used is quarterly data from 1987Q1 to 2019Q4[3]. All the data except oil prices are obtained from CBN Statistical Bulletins of different editions. The output gap is measured as the percentage difference between the seasonally adjusted series and the potential output. Potential output and

[3] The CBN's market-based policy framework came into effect from 1986 in Nigeria. Thus, the reaction function for the CBN is formulated for the period after 1986.

expected inflation are obtained by fitting a trend to the original series using the HP filter[4]. The inflation rate is measured as the year-on-year changes in quarterly consumer price index (on which the MPC rates are based by the CBN). Exchange rate deviations from equilibrium level are also measured using the HP filter. The money growth gap indicator is measured by the deviation of quarterly M2 growth from the CBN's target value for monetary growth, while oil price and stock market deviations are measured as the quarterly variations in their series. The M2 is used an anchor in this study because it has been shown to have the most stable relationship with price level and output among other monetary bases (Mishkin, 2001; Tule et al., 2018; Boucekkine et al., 2021). Hence, M2 sufficiently serves as an efficient target to provide both short term and long run warning signals about when to change monetary policy stance. Oil price deviations are also measured as difference between quarterly prices and annual budgetary benchmarks (since 2003). Each of the target variables are computed in terms of deviations because it is assumed that the Central Bank always has a given target level for the given instrument variable, and that the Bank sets its reaction function to minimise the differences between the target and the actual level. For instance, the CBN will adjust MPR appropriately when oil prices fall or rise beyond given target levels. This implies that the Bank seeks to reduce the deviations of each variable in its reaction function. This is considered the optimal structure of a reaction function.

4. Empirical Analysis

4.1 Description of Data

We briefly describe the variables used in the study in Table 1 by reporting the summaries for the full sample and sub-samples following the estimated structural breaks (to be presented later). Average inflation gap is negative, suggesting that actual inflation have been generally greater than expected rates. On the other hand, average output gap is low at 0.01 percent, although the standard deviation and skewness suggest that the gap was not stable over the period. Growth in exchange rate, money supply and stock market prices are high over the period and exchange rate has also had strong variations. For the sub-sample periods, it is seen that much macroeconomic activities rapidly developed during the 1987-1994 period, given that most of the variables – including the

[4] Note that the HP filter has been known to surfer from end-point bias as a result of asymmetry inherent in the filter at the extreme points of a time series. This problem was minimized in our estimation by extending the sample period quarterly series to 2020Q3, using CBN projections. According to Konuki (2008), extending the sample endpoint with forecast values essentially turns the filtering problem into a joint forecasting which ensures that the optimality properties of the filter are preserved.

policy rate – had the highest average values in the period. Note that the economy was just transiting into a more liberalized and open system, with attendant significant shift in CBN regulatory activities. The CBN therefore appeared to be quite active in reacting to the swiftly changing leading indicators in the economy during the 1987 to 1994 period. Average exchange rate deviations were lowest during the 1994-2002 period, partly due to the fixed official rate operated by the Abacha regime till 1998.

Table 1: Descriptive statistics

	r	***π***	***y***	***e***	***m***	***l***	***s***
Full sample							
Mean	14.13	-0.58	0.01	21.90	21.76	9.84	24.32
Median	13.50	-0.40	0.02	3.13	22.41	5.76	22.40
Std. Dev.	3.97	12.55	0.32	60.13	27.30	34.66	36.89
Skewness	0.40	-0.42	-1.04	4.43	-2.66	0.69	0.34
1987 – 1994							
Mean	18.21	-1.47	-0.06	35.86	35.15	1.97	38.56
Median	18.50	-9.62	-0.01	19.51	40.10	-2.14	38.59
Std. Dev.	3.65	21.85	0.18	30.66	16.52	26.03	16.13
Skewness	0.45	0.25	-1.28	0.82	-0.84	0.97	-0.06
1994 – 2002							
Mean	14.65	-0.08	0.02	51.07	27.93	15.40	34.16
Median	13.50	4.08	-0.01	0.50	24.35	8.32	37.31
Std. Dev.	1.66	16.50	0.08	118.51	11.37	42.80	47.40
Skewness	0.88	-1.21	0.25	1.98	1.13	1.29	0.67
2002 – 2018							
Mean	11.80	-0.16	0.01	6.79	12.87	13.27	13.24
Median	12.00	-0.04	0.06	0.76	15.43	8.53	11.89
Std. Dev.	2.83	3.82	0.42	14.10	33.04	34.48	36.01
Skewness	-0.60	-0.73	-0.82	2.08	-2.22	-0.18	0.30
2007 – 2018							
Mean	11.08	-0.17	0.03	9.14	6.67	7.82	3.73
Median	12.00	-0.64	0.14	1.72	12.50	4.91	-5.18
Std. Dev.	2.65	2.56	0.46	16.18	37.07	38.04	32.84
Skewness	-0.73	-0.13	-1.01	1.61	-1.88	0.11	0.22

Note: r is the policy rate, π is inflation, y is the output gap, e is exchange rate, m is money supply, s is stock market performance, l is oil prices

Four tests are used to check the level of stationarity among the variables in the model. These are the Augmented Dickey-Fuller, ERS (developed by Elliot et al., 1996), and the MZ_{α}^{GLS} and MZ_{t}^{GLS} by Ng and Perron (2001). Each of these tests reported in Table 2 indicates important elements of the characteristics of the variables. In each of the cases, the Akaike information criterium was used to determine the number of lags in the regressions for the tests and a constant term was included

as deterministic components. All the tests confirm that the null of unit roots in each of the series can be rejected at the 5 percent level, which is to be expected since all the series are derived (computed as deviation). It also demonstrates the mean-reverting characteristic of the MPR framework by the CBN.

Table 2: Unit root tests

Variable	Exogenous regressor	ADF	ERS	MZ_{α}^{GLS}	MZ_{t}^{GLS}
r	*Constant*	2.97*	-2.25*	-9.43*	-2.17*
π	*Constant*	-4.97**	-3.85**	-28.23**	-3.75**
y	*Constant*	-5.08**	-4.54**	-30.68**	-3.91**
e	*Constant*	-3.39**	-3.38**	-23.80**	-3.45**
m	*Constant*	-3.83**	-2.15*	-9.62*	-2.17*
s	*Constant*	-6.02**	-3.14*	-20.77*	-3.22**
l	*Constant*	-2.84*	-2.26*	-11.43*	-2.34*

Note: * and ** indicate significance at 5% and 1% respectively. *r* is the policy rate, π is inflation, *y* is the output gap, *e* is exchange rate, *m* is money supply, *s* is stock market performance, *l* is oil prices

4.2 Estimating the CBN's Reaction Function

4.2.1 Reaction Functions with Constant Parameters

The reaction functions estimated in this section are those that assume stable parameter estimates over the entire period of the study, and those that assume breaks in the parameters thereby implying shifts in weights and response direction on targets in the function. First, the CBN reaction function that assumes constant equation parameters is estimated and presented. Given that a series of lags of the inflation and output gap variables are used as instruments in the GMM estimation, there is overidentification of the estimated equations. Hence, tests for overidentifying restrictions and weakness of instruments are conducted using the Hansen (1982) *J-test* and the Cragg–Donald *F* statistic, proposed by Stock and Yogo (2005) respectively. The test results are reported in Table 3 along with the results of the estimated coefficients. From the result, it is seen that the null hypothesis that the overidentifying restrictions are met cannot be rejected, while the hypotheses that the instruments used in the reaction function are weak can be rejected at the 5 percent level. Moreover, the coefficients of π and *y* show the short-term responses of MPR to inflation and output gaps respectively, while the coefficient of the lagged MPR variable shows the tendency of CBN to adjust interest rate.

The long run (stable) estimates are however more relevant in examining the response function of the CBN (Aragon, 2021). In terms of inflation, only the baseline estimate conforms with the Taylor principle of a counter-cyclical stance (coefficient greater than 1). For the other equations with additional instruments, the coefficient of inflation is less than 1 and mostly insignificant. As Krušković (2022) has noted, this result reveals that the CBN loses efficiency in inflation management when it includes more variables as response instruments. A leaner basket of targets will improve efficiency.

Table 3: CBN reaction function with constant parameters

Variable		*mandate included*				
	baseline	***e***	***m***	***s***	***l***	***Full***
c	3.684 (2.217)	-0.941 (1.060)	0.164 (0.222)	0.489 (0.731)	7.699 (6.184)	0.276 (0.219)
r_{t-1}	0.912*** (0.159)	0.897*** (0.148)	0.933*** (0.157)	0.932*** (0.157)	0.923*** (0.157)	0.900*** (0.156)
π	0.197 (0.113)	0.015* (0.168)	0.008 (0.133)	0.006 (0.097)	0.036 (0.109)	0.005 (0.102)
y	-0.237 (0.188)	0.164 (0.137)	0.053 (0.085)	0.029 (0.061)	-0.572 (0.500)	0.070 (0.092)
e		0.008*** (0.000)				0.007** (0.003)
m			-0.001 (0.010)			0.001 (0.001)
s				-0.004 (0.006)		-0.004 (0.008)
l					-0.024* (0.013)	0.002 (0.005)
Long run						
π	2.240 (1.671)	0.146* (0.076)	0.115 (0.203)	0.090	0.472 (0.312)	0.052 (0.031)
y	-2.693 (1.899)	1.597 (0.980)	0.787 (0.525)	0.423	-7.454 (5.769)	0.703 (0.800)
e		0.076*** (0.012)				0.070** (0.034)
m			-0.020 (0.021)			0.015 (0.045)
s				-0.063 (0.047)		-0.038 (0.071)
l					-0.314* (0.161)	0.022 (0.037)
Adj. R-sq.	0.840	0.852	0.842	0.839	0.844	0.841
J-stat. (prob.)	0.484	0.617	0.708	0.614	0.711	0.535
Cragg–Donald F-stat	29.46***	19.2[a]	18.91[a]	20.03[a]	18.27[a]	19.69[a]

Note: *, **, and *** indicate significance at 10%, 5% and 1% respectively; [a] indicates that the relative bias of the IV estimator compared to the OLS estimator does not exceed 5%. *r* is the policy rate, π is inflation, *y* is the output gap, *e* is exchange rate, *m* is money supply, *s* is stock market performance, *l* is oil prices. Standard errors below each coefficient.

For the target of minimizing the output gap, only the long run coefficient of the equation which includes exchange rate is significant. This shows evidence of a significant response of the output gap to policy interest rates when the exchange rate instrument is included. The coefficient is also positive and indicates that the mandate of output stabilisation of the CBN is only achieved when the Bank includes exchange rate management as an instrument. This result therefore emphasises the fundamental role that exchange rate management plays in the CBN's reaction function, as also showed in Obadan (2007) and Vincent (2021). For the other equations, output stabilisation mandate appears to fail with the inclusion of more instruments.

There is also indication that the output mandate of the CBN becomes less efficient when combined with the inflation mandate. A trade-off mechanism between output gap and inflation mandates is highlighted by this outcome. The coefficient of oil price volatility is also significant but negative, suggesting that the CBN's anchor rates respond significantly to oil price movements in an accommodating manner – the rates tend to fall with rising oil prices and vice versa. Although no previous study in Nigeria has considered the oil price instrument in the central bank's reaction function, Natal (2012) demonstrated that policy makers are more reluctant to aggressively react to oil price movements. Moreover, Obadan and Adegboye (2013), found the destabilizing role of oil price shocks to policy mechanism in Nigeria.

There is strong evidence of interest rate smoothing over the period irrespective of the additional target variable included in the function. Strong smoothing tendency are found in many of the previous studies (Apanisile & Ajilore, 2013; Akpan et al., 2018), indicating that the CBN is concerned about maintaining a stable interest rate. This is evident in relative constancy of the MPR over "several spread of the MPC meetings" (Bello & Sanusi, 2016).

4.2.2 Reaction Functions with Time-varying Parameters

The important assumption about the baseline reaction function described in the previous section is that the parameters are stable over the estimation period. However, there is clear evidence that the CBN's policy rules may have altered over the period. Thus, the assumption of stable parameters is relaxed in the next set of analyses and presence of structural breaks (identifying time-varying conditions) in the coefficients of CBN's reaction function is investigated. Stability tests are conducted using the Bai and Perron (2003) multiple breakpoint test. The test result of parameter stability for the CBN reaction function is reported in Table 4. The Chi-Square values for the

Andrews-Fair test based on the IV estimation method are also reported. Tests are performed for different versions of the function, including the basic function and those with additional variables. Based on the $F_T(l+1/l)$ result, there are multiple breaks for each of the equations, with the test values of $supF_T(1)$, $F_T(2/1)$, and $F_T(3/2)$ indicating that two break dates exists irrespective of the variables included in the function. The results overwhelmingly support the beak dates of the first or second quarter of 1994 and the third quarter of 2002. The Andrews-Fair Wald statistic are also significant for each of the equations, suggesting that even the IV estimates support the identified break dates.

A major explanation for structural break occurring in 1994 has been attributed to excess money supply that was engendered by a fledgling financial sector following the series of deregulation in the early 1990s (Gil-Alana et al., 2012; Kumar et al., 2013). Moreover, there is clear historical evidence about possible structural breaks that could have occurred during the two periods in the study. For instance, the monetary policy framework of indirect controls was stepped up with the use of Open Market Operations (OMO) in 1993, while the ratio of money supply to GDP also increased sharply in 1994. The year 2002 marked the period with a new direction for CBN's monetary policy rules with the commencement of a medium-term monetary policy framework by taking into account the temporary nature of shocks such that the problem of time inconsistency of interest rate setting can be minimized and over-reaction due avoided.

Table 4: Structural break tests in the CBN's reaction function

Specification	$supF_T(1)$	$F_T(2/1)$	$F_T(3/2)$	Break dates	Andrews-Fair Wald Stat. (IV-based method)
$rt\text{-}_1, \pi, y$	22.17**	30.51**	8.88	1994Q1; 2002Q3	62.7**
$rt\text{-}_1, \pi, y,e$	19.45**	77.01**	13.76	1994Q2; 2002Q3	60.0**
$rt\text{-}_1, \pi, y,m$	23.25**	29.62**	9.91	1994Q1; 2002Q3	56.4**
$rt\text{-}_1, \pi, y,s$	27.65**	79.84**	11.15	1994Q2; 2002Q3	55.5**
$rt\text{-}_1, \pi, y,l$	22.02**	29.90**	8.35	1994Q1; 2002Q3	53.7**

Note: ** indicates significance at 5%

The estimated breakpoint periods of 1994 and 2002 do not coincide with major macroeconomic shocks like the gulf war crude price shock of 1990 or global financial crisis of 2007-2008. According to Klose (2014), reaction functions do not necessarily change at the beginning of a crisis; rather structural breaks follow the pattern of influences on CBN's policy actions and the pattern of setting policy framework. The structural break in 1994 however coincides with the

change in CBN leadership from Abdulkadir Ahmed (1982-1993) to Paul Ogwuma (1993-1999). The historical support for the structural break is therefore related to the policy shift by Paul Ogwuma's leadership in the CBN, especially in relation to new waves of indirect controls. Although no previous estimates of break points for a full Taylor-type CBN reaction function exists for Nigeria, there are previous related estimates that are similar to those of our study. For instance, the semi-reaction function estimated by Uyaebo et al. (2016) found a break date of 2005 for the relationship between inflation and the policy interest rate. Using older data, Gil-Alana et al. (2012) found break dates that included 1994Q4 in an inflation equation while Omotor (2008) found a break date of 1994 for a money demand equation within a monetary policy framework for the period 1960 to 2008.

Based on the parameter stability tests, the reaction function of the CBN is re-estimated using the different sub-periods determined by the break points, which are 1987-1994, 1995-2001, and 2002-2019. The result for the estimated reaction functions for the different sub-periods in Table 5 shows estimates for both the baseline Taylor-type function and an extended function with additional instrument variables. Again, the long run estimates are the focus of the analysis. In the baseline function for the period 1987-1994, estimates for the response of MPR to the inflationary gap is 1.97, while that of response to output gap is -12.04. Both coefficients are significant at the 1 percent level, clearly highlighting that both inflation and output stabilisation mandates were effective during the sub-period as against the full sample estimates in Table 3. However, only the coefficient of inflation conforms with the Taylor rule, suggesting that the CBN pursued an efficient inflation mandate during the early periods of the reaction function.

On the other hand, the coefficient of output gap is negative and indicates a less efficient stabilisation mandate of the CBN during the period. The result however indicates that the CBN was less efficient in its inflation mandate after 1994 (the coefficients of inflation is less than 1). Bello and Sanusi (2016) and Akpan et al. (2018) have noted that the largely accommodative stance of CBN policy rule in recent years is linked to continuous structural changes and deregulation processes in the economy which has forced the CBN to accommodate inflationary shocks in attempts to minimize output shocks arising from the changes. This can be seen from the coefficients of the output gap in the other sub-periods (after 1994) which are positive and indicates aggressive policy responses to output fluctuations. Our result therefore shows the time-varying

complications of the CBN response function to the inflation mandate in Nigeria. Moreover, the results also emphasise the trade-off in efficiency between the inflation and output stabilisation mandates of the CBN.

Table 5: CBN reaction function for sub-periods

Variable	*1987-1994*		*1995-2002*		*2003-2018*	
	baseline	*Full*	*Baseline*	*full*	*baseline*	*Full*
C	169.5 (121.1)	80.26 (76.9)	-172.4 (180.3)	-399.56 (261.3)	-12.174 (10.08)	-10.525 (9.631)
r_{t-1}	0.860*** (0.055)	0.538*** (0.038)	0.751*** (0.020)	0.693*** (0.043)	0.896*** (0.051)	0.995*** (0.065)
π	0.276*** (0.017)	0.409 (0.391)	0.035*** (0.001)	0.112*** (0.006)	-0.017 (0.039)	-0.362** (0.166)
y	-1.685** (0.822)	-1.732 (2.00)	1.280*** (00.836)	2.106*** (0.175)	1.094** (0.552)	1.136* (0.597)
e		0.024 (0.032)		0.006*** (0.000)		0.012 (0.063)
m		-0.078*** (0.001)		-0.057** (0.022)		0.002 (0.020)
s		0.042** (0.001)		-0.004 (0.007)		0.021*** (0.001)
l		0.082*** (0.001)		0.001 (0.003)		-0.004 (0.005)
Long run						
π	1.971*** (0.017)	0.885 (0.723)	0.141*** (0.008)	0.365*** (0.031)	-0.163 (0.201)	-3.771** (1.251)
y	-12.04** (1.082)	-3.749 (2.729)	5.141*** (0.119)	6.860*** (0.174)	10.519** (4.922)	11.833* (5.733)
e		0.052 (0.061)		0.020*** (0.000)		2.400 (1.901)
m		-0.169*** (002)		-0.186** (0.087)		0.400 (0.416)
s		0.091** (0.038)		-0.013 (0.077)		4.200*** (0.022)
l		0.177*** (0.017)		0.003 (0.009)		-0.800 (1.058)
Adj. R-sq.	0.686	0.633	0.759	0.576	0.898	0.878
J-stat. (prob.)	0.812	0.551	0.716	0.833	0.764	0.459
Cragg–Donald F-stat	31.3**	20.44[a]	33.92**	19.97[a]	29.31**	19.79[a]

Note: *, **, and *** indicate significance at 10%, 5% and 1% respectively; [a] indicates that the relative bias of the IV estimator compared to the OLS estimator does not exceed 5%. *r* is the policy rate, π is inflation, *y* is the output gap, *e* is exchange rate, *m* is money supply, *s* is stock market performance, *l* is oil prices. Baseline estimate are the Taylor-type equations; full estimates are those including all instruments. Standard errors below each coefficient.

When other instruments are included in the function, the responses to inflation no longer align with the Taylor rule, indicating that more instruments weaken the efficiency of the inflation mandate of the CBN, irrespective of the period under consideration. On the other hand, the sign of

the output gap coefficient does not change when more instruments are included. Rather, the result shows that stabilisation mandate remained efficient (conformed to the Taylor rule) over the periods after 1994. This outcome suggests that the CBN might have put less weight on inflation when employing additional instruments, especially after the large deregulations that occurred in the economy since 1994. Among the instruments included, only the exchange rate exhibited aggressive or counter-cyclical policy stance over the entire period, although it was only significant in the 1994-2002 period. This again confirms the argument that the exchange rate is a critical forward-looking policy option of the CBN. The CBN engaged an accommodative rule in terms of money growth for the period before 2002-2019, which signals the drive of the Bank to adapt to instability in money velocity arising from financial sector reforms. The coefficient of the interest rate smoothing variable remains significant at the 1 percent level irrespective of the target variable considered. This shows that this feature of the CBN remained regular across the different structural periods. The negative sign of the constant term in the results also suggests that the CBN expressed some sense of caution in adjusting the nominal anchor rate during the period (Bello & Sanusi, 2016; Carvalho et al., 2021; Adrian, 2023).

Also note that the reported adjusted R-squared values for the baseline estimates are larger than those of the full estimates in for each of the periods. This shows that increases in the variation in MPR that are directly related to responses to variations in inflation and output gaps, rather than to variations in the other policy targets. Thus, the adjusted R-squared values smaller in the full equations even though the significance of the parameter estimates for the other variables is high.

The structural breaks analysis helps to check whether there are shifts in the CBN reaction function over time (time-varying conditions). Based on the outcome of the structural break tests, we employ a dummy variable analysis to check the direction of shift of the function arising from the structural break periods. The result in Table 6 shows the estimates with a 1994 slope dummy in relation to the parameters of each of the target variables. The coefficient of the interest rate smoothing variable remained high and significant at the 1 percent level in the estimates. None of the indicators of monetary policy responses to inflation and output gap is however significant. We focus on the coefficients of the dummy variables in order to observe the main factors that drove the structural break in 1994. Only the coefficient of exchange rate dummy is significant and shows that there was a significant shift away from the focus on the exchange rate management during the 1994

period. Thus, the result suggests that the major factor that led to the structural break in the 1994 period was the declining role of the CBN in exchange rate management which had significant impact on the monetary policy rate (Omotor, 2008; Adebiyi & Mordi, 2012).

Table 6: CBN reaction function with 1994 dummy

Variable		*Mandate included*			
	baseline	***e***	***m***	***l***	***s***
Constant	4.395 (4.116)	-1.651 (1.213)	3.225 (2.903)	0.919 (1.037)	2.957 (2.114)
r_{t-1}	0.860*** (0.032)	0.867*** (0.032)	0.898*** (0.033)	0.924*** (0.034)	0.940*** (0.039)
π	0.019 (0.026)	0.009 (0.016)	-0.002 (0.018)	0.010 (0.010)	0.014 (0.012)
y	-0.226 (0.201)	0.247 (0.170)	-0.152 (0.212)	-0.006 (0.500)	-0.186 (0.161)
π_d94	-0.024 (0.051)				
y_d94	0.013 (0.218)				
e		0.036*** (0.000)			
e_d94		-0.027*** (0.000)			
m			0.011 (0.027)		
m_94			-0.013 (0.028)		
l				0.001 (0.003)	
l_d94				-0.007 (0.017)	
s					-0.008 (0.008)
s_d94					-0.002 (0.002)
Adjusted (long run)					
π	-0.005 (0.012)				
y	-0.19 (0.210)				
e		0.064*** (0.002)			
m			-0.016 (0.047)		
s				-0.074 (0.076)	
l					-0.172 (0.291)
Adj. R-sq.	0.838	0.853	0.839	0.833	0.832
J-stat (prob)	0.249	0.579	0.367	0.534	0.510

Note: *, **, and *** indicate significance at 10%, 5% and 1% respectively. Adjusted coefficients are computed by adding the coefficient of the variables to the coefficient of the corresponding slope dummy. *r* is the policy rate, π is inflation, *y* is the output gap, *e* is exchange rate, *m* is money supply, *s* is stock market performance, *l* is oil prices. Standard errors below each coefficient.

The result for the estimates with a dummy between 1995 and 2002 is presented in Table 7. The coefficients of the dummies for inflation, output gap, exchange rate and oil prices are all significant. This shows that shifts in the policy action weights on inflation, output gap, exchange rate, and oil prices were responsible for the structural break for the period between 1995 and 2005. Thus, there were more tools responsible for the shift in the response function of the CBN over the period. Essentially, there was relative decline in the responses of MPR to inflation, but a strong shift towards more focus on output stabilisation after the 1995 period. In the same vein, exchange rate dynamics received less policy considerations, while more attention was given to oil price dynamics by the monetary authority.

In Table 8, it is seen that the major policy shift in the CBN response function after 2002 was stimulated by less attention to money development (by 0.042 percentage points) in the setting of MPR. This shows that monetary development was the major parameter shift factor that drove CBN monetary policy rates after the period of 2002. In general, the shift analysis indicates that many factors, apart from the traditional inflation and output stabilisation mandates of the CBN have created time varying characteristics of the Bank's reaction function since 1987. This is in line with the major arguments in the study that the structural changes in the economy have forced the CBN to either include more instruments in the response function or vary the weight on the mandate variables of the Bank.

Table 7: CBN reaction function with 1995-2002 dummy

Variable		*mandate included*			
	baseline	***e***	***m***	***l***	***s***
Constant	-0.822 (0.691)	2.708 (2.002)	-1.216 (0.979)	4.179 (3.470)	3.139 (2.982)
r_{t-1}	0.823*** (0.031)	0.848*** (0.028)	0.928*** (0.036)	0.913*** (0.035)	0.946*** (0.039)
π	0.051** (0.024)	0.005 (0.009)	0.010 (0.009)	0.001 (0.004)	0.020 (0.013)
y	0.186 (0.097)	-0.099 (0.217)	0.158 (0.089)	-0.248 (0.225)	-0.210 (0.216)
π_d95_02	-0.110*** (0.000)				
y_d95_02	0.235*** (0.000)				
e		0.038*** (0.000)			
e_d95_02		-0.029*** (0.000)			
m			0.005 (0.010)		
m_d95_02			0.008 (0.008)		
l				-0.015* (0.008)	
l_d95_02				0.024* (0.012)	
s					-0.014* (0.008)
s_d95_02					0.012 (0.020)
Adjusted Coeff. (long run)					
π	-0.333** (0.138)				
y	2.375 (1.652)				
e		0.057*** (0.001)			
m			0.177 (0.310)		
s				0.113 (0.128)	
l					-0.039* (0.020)
Adj. R-sq.	0.833	0.844	0.837	0.816	0.831
J-stat (prob)	0.336	0.626	0.546	0.675	0.531

Note: *, **, and *** indicate significance at 10%, 5% and 1% respectively. Adjusted coefficients are computed by adding the coefficient of the variables to the coefficient of the corresponding slope dummy. Standard errors below each coefficient.

Table 8: CBN reaction function with 2002 dummy

Variable		*mandate included*			
	Baseline	***E***	***m***	***s***	***l***
Constant	-1.856 (0.993)	0.561 (0.311)	-1.653 (1.004)	8.008 (7.170)	6.801 (4.982)
r_{t-1}	0.951*** (0.042)	0.889*** (0.034)	0.880*** (0.034)	0.866*** (0.033)	0.918*** (0.038)
π	-0.014 (0.021)	0.025* (0.013)	-0.013 (0.026)	-0.006 (0.011)	-0.033 (0.039)
y	0.272 (0.179)	0.016 (0.022)	0.269 (0.177)	-0.498 (0.439)	-0.424 (0.301)
π*_d02*	-0.232 (0.217)				
y_d02	0.157 (0.205)				
e		0.009 (0.018)			
e_d02		0.023 (0.024)			
m			0.031** (0.015)		
m_d02			-0.042* (0.023)		
l				0.011 (0.030)	
l_d02				-0.033 (0.028)	
s					0.008 (0.013)
s_d02					-0.029 (0.029)
adjusted coeff. (long run)					
π	-5.020* (5.558)				
y	8.755 (7.373)				
e		0.288 (0.311)			
m			-0.092 (0.174)		
s				-0.164 (0.135)	
l					-0.256 (0.261)
Adj. R-sq.	0.838	0.819	0.841	0.812	0.816
J-stat (prob)	0.745	0.755	0.746	0.781	0.830

Note: *, **, and *** indicate significance at 10%, 5% and 1% respectively. Adjusted coefficients are computed by adding the coefficient of the variables to the coefficient of the corresponding slope dummy. Standard errors below each coefficient.

5. Conclusion

In this study, we sought to investigate the evolution of the CBN's reaction function based on the monetary policy rate over the period since the structural Adjustment Programme (SAP). The Taylor-type reaction function with forward-looking conditions and interest rate smoothing was used as the policy rule. Given the observed tendencies of the CBN in its policy framework over the years, additional instruments were included in the policy rule in order to observe both the magnitude and direction of changes in the CBN mandate options. Thus, we examined the evolution of the CBN reaction function with regard to the composition of the instruments and the weighting of the mandates over the years. Moreover, existence of structural breaks in the reaction function was tested by applying the Perron and Yamamoto (2015) structure with the goal of determining periodic shifts in weights to parameters and number of targets pursued. The result shows a standard trade-off between inflation and output stabilisation which are the major mandates of the CBN. In particular, there is evidence that the output mandate of the CBN becomes less efficient when combined with the inflation mandate. For the sub-periods in the study, it was found that the reaction function was more efficient in its inflation mandate in the earlier period (i.e., between 1987 and 1994), but the weight on output stabilisation became more prominent and efficient after 1994. Moreover, exchange rate targeting was shown to be a critical mandate of the CBN over the entire period of the study, although inclusion of more instruments in the CBN's reaction function weaken the efficiency of the function in addressing either inflation or the output gap.

Results from the study also showed that there were multiple structural breaks in the CBN reaction function which were observed for 1994Q1 and 2002Q3 and robust reaction function estimates occurred for the sub-periods determined by the structural breaks. The 1994 structural break was shown to be explained by CBN's engagement with exchange rate dynamics, while the 2002 break was linked with parameter shifts in money growth as well as incorporation of time inconsistency of policy within the monetary policy framework. Between the two periods, it was shown that the structural break in the CBN's reaction function was primarily driven by the tendency of the Bank to introduce more targets into the function, including the exchange rate, monetary development, and oil prices. The weights of the reaction function in terms of responses to each instrument were also found to change within the different structural periods. In all the analysis, there was evidence of a high level of interest rate smoothing by the CBN in its MPR setting. This effectively ensured higher weights on the responses of monetary policy to long run trends in inflation and output gap.

Given that the study finds a trade-off in the efficiency of the CBN reaction between the inflation and output stabilisation mandates, the difficulty that the Bank faced to effectively manage inflation and growth prospects simultaneously is demonstrated. Interestingly, this outcome is not unique to the CBN. Thus, the efficiency of the CBN's policy activities will be significantly improved by choosing a primary mandate over time on which policy responses would take preeminence over all other mandates. Given the current and prospective direction of Nigeria's economy, it may be more efficient for the CBN to choose inflation targeting as the super mandate on which more attention would be given at any given time. Besides, the study has found that inclusion of more targets in the reaction function weakens the efficiency of both inflation and output stabilisation mandates of the Bank. Another area of consideration is the prominent role of exchange rate in enhancing the efficiency of the reaction function and also playing a pivotal role in the structural shifts in the reaction function. Exchange rate management should therefore be elevated in relevance as a policy target beyond other variables like oil prices and the monetary base.

Finally, although the results of the study are insightful, the application of endogenously determined structural breaks may render the determination of the break-points as relatively ad-hoc. The selected structural break periods (of 1994 and 2002) in the study however coincide with important landmarks of the CBN as stated in the study. There are however other important periods for the Bank that are more efficiently explained by exogenously determined breaks. For instance, the replacement of the minimum rediscount rate with the monetary policy rate in 2006 was a significant landmark in the CBN's policy making history. The application of exogenously determined break-points therefore serves as a crucial area where future research may focus.

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