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Financial stability and monetary policy of the Central Bank of West African Countries: a Markov-Switching model

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Abstract

Purpose – This paper aims to examine the response of monetary policy to financial instability in the West African Economic and Monetary Union.

Design/methodology/approach – Through annual aggregated data from 1970 to 2019, the empirical strategy is based on the Markov regime-switching model with fixed probabilities.

Findings – The results revealed that the monetary policy of the central bank of the West African Economic and Monetary Union is characterized by two regimes (calm and distress) with respect to the trend of financial stability. The authors also found that the occurrence of the calm regime was likely greater than that of the distress regime. In addition, the calm regime is longer than the distress regime. The authors finally revealed that the central bank reacts to financial instability risk by increasing its short-term interest rate when financial instability reaches a threshold.

Research limitations/implications – The limitation of this study is the unavailability of monthly or quarterly data that are more suitable for the methodological approach adopted.

Originality/value – This study is the one to estimate the response of the Central Bank of West African Countries to financial stress using a novel approach based on the Markov-Switching regression.

Keywords Financial stability, Monetary policy, Markov regime switching model

Paper type Research paper

1. Introduction

1.1 Background

The international economic and financial crisis of 2007 and the recent coronavirus disease 2019 (COVID-19) health crisis revived the debate on the relationship between financial stability (FS) and monetary policy. In the literature, the effect of monetary policy on FS is controversial. For some, monetary policy can reduce the occurrence of financial crises through so-called unconventional interventions. Unconventional monetary policy dated back to the works of Krugman *et al.* (1998) in which they argued that deflation impedes the real interest rate from falling enough to reach the full employment goal. Consequently, these authors suggested that monetary policy should react by raising the market's expectations about future inflation to sufficiently lower the real interest rate to stimulate aggregate demand. Unconventional monetary policy used three instruments: (1) increasing the Central Bank's balance sheet through the purchase of large-scale assets or securities (quantitative easing) to support credits to the economy, (2) modifying the structure of the Central Bank's balance sheet (Credit Easing), and (3) influencing investors' expectations in the medium- and long-term through a communication strategy on keeping the short-term interest rates low in the medium term (forwards guidance). The main channels through which monetary policy affects the probability of financial crisis occurrence transit through the aggregate demand in

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the short run and, saving and capital accumulation in the medium run. For example, when facing the financial crisis in 2007, the European Central Bank is committed to restoring confidence in financial markets, supporting the banking system and avoiding households and businesses being rationed to credits by implementing unconventional monetary policy. As revealed by Ait Hmadouch (2019), this policy adopted by the European Central Bank absorbed financial markets and banking system turbulences. Recently, with the COVID-19 crisis, several central banks in emerging countries have adopted unconventional measures for the first time through the use of quantitative easing (Arslan *et al.*, 2020). In developed countries, central banks have reduced their short-term interest and have facilitated the implementation of fiscal stimulus plans (Rebucci *et al.*, 2022). In the United States, the Federal Reserve (FED) has reacted to the COVID-19 crisis by facilitating credits. In particular, the FED implemented the zero bound short interest rate and bought back a significant number of securities (Feldkircher *et al.*, 2021). In Africa, the Central Bank of West African States (BCEAO), on the one hand, increased the resources available to banks and, on the other hand, set up an interest rate subsidy fund and a due date reporting mechanism for companies that encounter difficulties in performing their loads (BCEAO, 2020). These interventions have certainly prevented the occurrence of stress in the banking system and financial markets.

However, because such interventions, namely, unconventional monetary policy, fall outside the traditional mandate of the central bank, another stand of the literature disagrees with their effectiveness. Thus, Maddaloni and Peydró (2011) and Jimenez *et al.* (2014) argued that sustainable lower short-term interest rates can encourage the financial sector to seek rent and lead to macro-financial imbalances. In addition, authors such as Taylor (2011) argued that the zero-bound interest rate policy implemented by the FED in the USA since 2003 was the main cause of the financial crisis of 2007. Given these contradictions, the relationship between FS and monetary policy goes beyond theoretical considerations. Such a problem should be addressed through empirical evidence, and the present paper contributes to that goal by focusing on the monetary policy of the West African Economic and Monetary central bank (BCEAO).

1.2 Problem of statement

There are many definitions of FS in the literature. However, despite their diversity, all these definitions agree with the fact that FS refers to the absence of system-wide episodes in which the financial system fails to function. Consequently, FS allows an efficient allocation of resources, assessment and management of financial risks, promotion of full employment and elimination of relative price movements of real or financial assets that will affect monetary stability or employment levels. When an economy fails to promote FS, which leads to financial instability, the causes can be distinguished into three categories: banking crises, currency crises and twin crises. The former occurs when doubts on the solvency of the banking system lead to a large-scale withdrawal of deposits or when there is large-scale liquidity support from monetary authorities. A currency crisis refers to a situation in which a sharp decline in the demand for the currency leads to one or more of the following events: substantial reserve losses, a sharp increase in short-term interest rates and depreciation of the currency exchange rate (Goldstein *et al.*, 2000). A twin crisis is defined as a simultaneous collapse of the banking system and the currency system.

Financial instability is an important issue of economic development since it affects the real economy through many channels. First, financial instability adversely affects productivity by inducing an instability of the investment rate and increasing the real exchange rate volatility, which in turn scrambles the price signals and leads to a misallocation of resources (Guillaumont and Kpodar, 2007). Second, financial instability prevents the transmission of monetary policy to the economy. In addition, financial instability neutralizes the growth effects of financial development (Ndiaye, 2020).

Despite the importance of FS to promote sustainable economic growth, there is no consensus that FS should be taken as an objective of the central bank along with its traditional mandate of price stability. Thus, for the separate approach, integrating FS into the reaction function of the central bank would be counterproductive insofar as this strategy will further reinforce the divergences between economies (Couppey-Soubeyran and Dehmej, 2016; Laseen and Pescator, 2020). On the other hand, for the integrated approach, the central bank must take FS into account in conducting monetary policy (IMF, 2015; Ugo *et al.*, 2020). This idea was widely argued during the financial crisis in 2007, and many authors argued that there is a very close link between price stability and FS (Schularick and Taylor, 2012). Taylor (2011) and Basu *et al.* (2020) stated that one of the main causes of 2007's financial crisis was the expansionist monetary policy implemented in many developed countries and then supported the necessity to affect FS to central bank objectives.

Empirically, the literature also leads to divergent conclusions. For the first group of studies, monetary policy does not affect FS (Blot, 2015; Laseen and Pescator, 2020). On the other hand, using a linear specification of the Taylor rule, several works have provided evidence that the central bank is concerned with FS in the conduct of monetary policy in developed and emerging countries (Diamond and Rajan, 2012; Nair and Anand, 2020). In addition, based on a nonlinear monetary policy reaction function, recent literature confirms that central banks adopted restrictive monetary policies in high risks of financial instability (Alba and Wang, 2016; Floro and Van, 2017; Dibooglu *et al.*, 2020). The findings of this last stand of works suggest that macro-prudential tools should be used to complement interest rate policy in achieving price stability. Within the West African Economic and Monetary Union (WAEMU) countries, BCEAO (2013) and Tenou (2002) used Taylor's rule to evaluate the monetary policy of the BCEAO. These studies failed to take into consideration FS in the central bank reaction function and their results relied on a linear specification of the central bank reaction function. Moreover, a recent strand of the literature supports the view that the relationship between FS and monetary policy is nonlinear (Floro and van Roye, 2017; Dibooglu *et al.*, 2020).

Overall, it is worth noting that studies evaluating the relationship between monetary policy and FS are extensive in developed and emerging countries. Nonetheless, few studies exist on the effectiveness of monetary policy to tackle financial instability in sub-Saharan countries, especially in the WAEMU region. The present paper attempts to fill this gap in the literature by examining the effect of FS on BCEAO monetary policy. The contribution of this paper is twofold. First, to the best of our knowledge, this paper is the first to investigate the reaction of Central Bank in WAENU region (BCEAO) to FS using different indicators of FS. Second, in contrast to most of the previous studies, the study use endogenous Markov regime-switching modeling with specificity to estimate the transition probabilities and the duration of regimes. Moreover, we estimate the financial instability threshold from which the central bank becomes sensitive.

The rest of the paper is organized as follows. Section 2 presents an explicit literature review on the research topic. The methodology and the data used are described respectively in sections 3 and 4. Section 5 presents and discusses the results obtained from the estimations. The robustness tests are presented in section 6, and conclusion is provided in section 7.

2. Literature review

The 2007's financial crisis has raised the debate on the relationship between monetary policy and FS. For the authors of the "separate approach", the monetary policy mandated for price stability should be separated from macro-prudential policy aimed at FS (Svensson, 2012; Gali, 2014). Thus, integrating FS into the reaction function of central banks would be counterproductive as this strategy will further reinforce the divergences between economies (Couppey-Soubeyran and Dehmej, 2016). Based on a strict reading of the principle of separation, the rule of Tinbergen (1952) and the principle of Mundell (1962), the separate approach advocates allocating the entire monetary policy to monetary stability and macro-prudential policy, to FS (Woodford, 2010; Svensson, 2017). Two arguments may justify the thesis of the separate approach. First, monetary policy through the short-term interest rate has only a limited effect on credit and the risk-taking behavior of economic agents. In addition, the short-term interest rate has a limited effect on financial instability.

In contrast to the separate approach, other authors support the view that monetary stability does not lead systematically to FS (Mishkin, 2011; Woodford, 2012). For instance, low short-term interest rates spur credit risk-taking by banks, which increases the probability of default (Jimenez *et al.*, 2014). This effect is referred to as the "risk-taking channel" of monetary policy transmission. Thus, central banks should take into account FS in the conduct of monetary policy, by combining the regulatory aspect of monetary stability through the prices of assets in Taylor's rule (Allegret, 2017). Consequently, FS becomes the second objective of monetary policy and the latter can adopt a systematic monetary policy of type "leaning against the wind". The leaning against the wind policy consists in a smooth transition of the central bank short-term interest rate by adopting a restrictive monetary policy in expansion periods in order to avoid excessive indebtedness and bubbles in asset prices, both of which lead to a financial crisis and to a recession. This new framework is based on four assumptions that can be mitigated through interest rate policy and balance sheet policy (Borio, 2014): (1) monetary policy influences the risk-taking behavior by financial intermediaries, (2) macro-prudential policy cannot influence the entire financial cycle because banks arbitrate between regulations and the high profitability, (3) financial fragility affects the transmission of monetary policy to economic activity and (4) the efficiency of the interest rate to deal with a financial crisis is limited. Although this analytical framework is relevant, in practice, the policy of "leaning against the Wind" has often been rejected by central banks (Rostagno *et al.*, 2021). This rejection is justified by the fact that the monetary authorities believe that it would take high-interest rates to constrain the increase in asset prices or debt and that this would weaken the economy.

Empirically, the pioneering literature on the integration of Taylor's rule augmented by FS dates back to the work of Borio and Lowe (2004) and McCulley and Toloui (2008). These works respectively consider the credit gap, the change in the exchange rate to capture the FS in the reaction function of the central bank. Thus, the literature on the relationship between monetary policy and FS led to two main results.

The first group of works argued that monetary policy prevents financial instability. For example, Altunbas *et al.* (2014) showed that monetary policy affects the ability of financial markets and banks to bear financial risks in the eurozone and the USA with a delayed effect. Aikman *et al.* (2017) also indicated that the increase in the ratio of credit to GDP is correlated with banking crises. Based on this result, the authors recommend responding to excessive credit growth with a macro-prudential policy aimed at increasing the cost of holding risky portfolios. This result had already been highlighted by Ahrend (2010) by revealing the existence of a correlation between asset prices via FS and short-term interest rates. Moreover, Leeper and Nason (2015) supported the integration of FS into the reaction function of the central bank through adjustments of monetary policy according to the economic cycle. Based on the augmented Taylor's rule integrating asset prices, Nair and Anand (2020) showed that the Indian central bank prevents financial instability effectively when it targets asset prices in the conduct of monetary policy. Although asset prices are an important source of financial instability, the difficulty of targeting prices (gold, currencies, land and housing) limits their integration into the reaction function of central banks (Gertler and Bernanke, 1999).

A second group of studies argued that monetary policy has no effect on FS (Blot, 2015). Laseen and Pescator (2020) concluded that it is not appropriate for the Canadian central bank to use monetary policy to ensure FS via a balance of growth in household indebtedness and house prices. Their simulations revealed that a monetary policy shock affects the probability of a crisis (financial instability) with a long lag. Similarly, the relationship between credit to the economy and the likelihood of a financial crisis occurring is uncertain. Contrary to previous studies, the empirical elements against the integration of FS (via financial asset prices) in the objective of monetary stability have been provided by certain works. These works postulate that monetary policy has a detrimental effect on FS. First, Allen *et al.* (2009) and Brunnermeier *et al.* (2019) provided a negative answers due to the unpredictable nature of the underlying variables. Jorda *et al.* (2015) concluded that asset price bubbles are dangerous when they are associated with strong credit growth. Moreover, Blot (2015) rejected the hypothesis that price stability serves FS. From this literature, we note that empirical studies led to mixed results on the effectiveness of monetary policy to prevent FS. Besides, the majority of these studies focused on developed and emerging countries, devoting less importance to developing and sub-Saharan countries in particular. This paper attempts to fill this gap in the literature by examining the effect of FS on BCEAO monetary policy.

3. Methodology

3.1 Nonlinear specification of the augmented Taylor's rule

Recent literature on the conduct of monetary policy refers to Taylor (1993). The latter defined a monetary policy rule that allows the central bank to adjust its short-term interest rate according to economic cycles. Taylor's rule determines an optimal short-term interest rate that takes into account the inflation gap and the output gap (measured by the growth rate of gross domestic product) while assigning a certain weight to each of these two goals. The inflation and output gap refer to the difference between current inflation (at a given period t) and output at their respective target level (potential value), respectively. The basic Taylor's rule is specified as:

$$i_t^* = \bar{r} + \pi^* + \alpha_1(\pi_t - \pi^*) + \alpha_2(y_t - y_t^*) \quad (1)$$

where i_t^* is the nominal value of the central bank's short-term interest rate, $\bar{r}$ is the real equilibrium interest rate, and $\pi_t - \pi^*$ and $y_t - y_t^*$ are the inflation and output gaps, respectively. The differences between their current and potential (target) value. The parameters α_1 and α_2 measure the sensitivity of the central bank to inflation and production deviations from their target values, respectively, and t is the time operator that takes values between 1 and T.

Based on the objectives of this paper, we make some modifications to Taylor's rule specified in equation (1). First, we adopt the forwards-looking rule specification in contrast to the backwards-looking rule. Indeed, Taylor's rule assumes that the central bank takes into account the past or current level of inflation and the output gap in the conduct of monetary policy, especially the last four-quarters. However, Clarida *et al.* (1998) found that central banks do not take into account the past or current level of inflation and the output gap in the conduct of monetary policy but rather their expected values. Equation (1) becomes:

$$i_t^* = \bar{r} + \pi^* + \alpha_1[E(\pi_{t+k}|\Omega_t) - \pi^*] + \alpha_2\left[E\left(y_{t+p} - y_{t+p}^*\right)\middle|\Omega_t\right] \quad (2)$$

where $E(\pi_{t+k}|\Omega_t) - \pi^*$ and $E(y_{t+p} - y_{t+p}^*)|\Omega_t$ are the expected inflation and output gap based on k and p ahead periods, respectively. The parameter E is the expectation operator, and Ω_t is a vector that contains all information available to the central bank when setting its interest rate.

Second, Taylor assumes that the central bank systematically adjusts its current short-term interest rate to its target value. However, several empirical works overturned this thesis in favor of a smooth adjustment, indicating that the central bank gradually adjusts its current short-term interest rate from its target value with a certain degree of speed rho. The latter measures the proportion of the gap between the current interest rate and its target value that the central bank manages to eliminate. In the theoretical view, the smooth adjustment assumption can be justified by the existence of transaction costs, fear in financial markets, loss of credibility of monetary policy and uncertainties about the effects of economic shocks (Castro, 2011). Empirically, taking into account interest rate smoothing corrects the autocorrelation problem observed at the interest rate. The smooth process of the interest rate is specified as follows:

$$i_t = \left(1 - \sum_{j=1}^{n} \rho_j\right) i_t^* + \sum_{j=1}^{n} \rho_j i_{t-j}, \ \forall \ \sum_{j=1}^{n} \rho_j \in]0;1[\tag{3}$$

where j is the optimal lag of the interest rate and ranges from 1 to n. The smoothing dynamic reflects that the central bank is eliminating a fraction of the gap between the current interest rate and its n past values. Following BCEAO (2013), we set $n = 1$.

Third, following Mishkin (2008, 2009) and recently Dibooglu *et al.* (2020) in the USA, Heimonen *et al.* (2017) in OECD countries and Floro and Van Roye (2017) from a sample of developed and emerging countries, we add FS to the BCEAO's reaction function. In addition, we assume that monetary policy behavior is asymmetric, implying that the central bank behaves differently depending on whether the economy is in a situation of financial instability. We further include the net foreign assets in the BCEAO reaction function since it is recognized that in a fixed exchange rate regime, the central bank is concerned about and given that the BCEAO opted for a fixed exchange rate regime.

After some rearrangements, equation (2) leads to:

$$\alpha_0 = \overline{r} - \beta_1 \pi^* + \pi^* = \overline{r} - (\beta_1 - 1)\pi^* \tag{4}$$

Then, by substituting equation (4) into equation (2) and in turn substituting the obtained equation (2) into equation (3), with $n = 1$, the BCEAO reaction function can be specified after some arrangements as follows:

$$i_t = \beta_0 + \beta_1 \pi_{t+k} + \beta_2 g_{t+p} + \beta_3 f_{t+q} + \beta_4 a_{t+r} + \rho_1 i_{t-1} + \varepsilon_t$$

where f_{t+q} and a_{t+r} are the FS index and the net foreign assets gap, respectively, and q and r are their respective ahead lags. g_{t+p} is the output gap and is equal to $g_{t+p} = \tilde{y}_{t+p} = y_{t+p} - y^*_{t+p}$ from equation (2).

To address the nonlinearity assumption of the BCEAO reaction function, we use the Markov regime-switching model. Indeed, nonlinear time series analysis can be categorized into two groups, namely, threshold models and Markov regime-switching models. The main difference between these two groups of nonlinear models is that the threshold effect models assume that the generating process of nonlinearity comes from observable characteristics, but the number of thresholds and the value associated with each threshold are unknown. Conversely, Markov regime-switching models assume that the nonlinearity process is generated by latent variables. The Markov regime-switching model assumes that the probability of realization of a regime is conditioned on past realizations of the interest variables (Engel and Hamilton, 1990). The advantage of Markov regime-switching models with respect to the threshold effects models is that the latter requires less information on the mechanism governing the transition process (Deschamps, 2008).

In sum, the general form of the Markov regime-switching model is written as:

$$Y_t = \mu(s) + \beta(s) X_t + \varepsilon_t \tag{5}$$

Where,

$$\begin{cases} \varepsilon_t \sim i.i.d\ \mathrm{N}(0, \sigma_\varepsilon^2) \\ \mu_{s_t} = \mu_1^{s_{1t}} + \mu_2^{s_{2t}} + \ldots.. + \mu_K^{s_{Kt}} \\ \beta(s) = \beta_1(s_1) + \beta_2(s_2) + \ldots.. + \beta_K(s_K) \end{cases}$$

In equation (5), Y is the dependent variable, X is the vector of explanatory variables including the lagged value of Y, and $\mu(s)$ and $\beta(s)$ are parameters to be estimated. We assume that σ_ε do not vary with the regimes. Under the null hypothesis that the probability of shifting from regime j at t to regime i follows a Markov process of order 1, we have:

$$P(S_t = j | S_{t-1} = i) = p_{ij} \forall i, j = 1, 2, \ldots., K \text{ et } \sum_{j=1}^{K} p_{ij} = 1 \quad (6)$$

where $\forall\ i \neq j$ and p_{ij} are the transition probabilities of shifting from regime i to regime j at t, while p_{ij} is the probability of remaining in regime i at date $t\ \forall\ i = j$.

In equation (6), S is a random variable that follows a first-order Markov chain process, i.e. the values of S at date t depend on the values of S at period $t-1$. In other words, S_t is an autocorrelated random variable of order 1. The variability of S makes it such that it is impossible to know the state k of S at a given date t. However, it is possible to estimate the probability of being in a state k as follows:

$$P = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} \quad (7)$$

The duration D_i of state i follows a geometric distribution, and the mean duration is given as:

$$E(D_i) = \frac{1}{1 - p_{ij}} \forall\ i \neq j \quad (8)$$

3.2 Estimation strategy

From equations (4) and (5), the nonlinear form of the reaction function of BCEAO is specified as follows:

$$i_t = \beta_0(s_t) + \beta_1 \pi_{t+k}(s_t) + \beta_2 \tilde{y}_{t+p}(s_t) + \beta_3 f_{t+q}(s_t) + \beta_4 a_{t+r}(s_t) + \rho_1 i_{t-1}(s_t) + \varepsilon_t \quad (9)$$

It appears that the inflation gap and the economic cycle are endogenous in the central bank short-term interest rate equation (Kim, 2004). Consequently, to take into account this endogeneity problem, we use the two-stage maximum likelihood estimation (MLE) technique as used by Kim (2009) by instrumenting the inflation gap equation and that of the output gap as in equations (10) and (11) through the MLE:

$$i_{t+k} = \alpha_{1t}(s)\omega_{1t} + u_{1t}, \forall u_{1t} \sim i.i.d\ \mathrm{N}\left(0, \sigma_{u_{1t}}^2\right) \quad (10)$$

$$y_{t+k} = \alpha_{2t}(s)\omega_{2t} + u_{2t},\ \forall\ u_{2t} \sim i.i.d\ \mathrm{N}\left(0, \sigma_{u_{2t}}^2\right) \quad (11)$$

Where:

$$\alpha_{.t} = \alpha_{.t-1} + v_{.t} \text{où} v_{.t} \sim i.i.d\ \mathrm{N}(0, \sigma_v^2) \quad (12)$$

$$\sigma_{u_{.t}}^2 = b_{0.} + b_{1.} u_{.t-1}^2 + b_{2.} \sigma_{u_{.t-1}}^2 \quad (13)$$

In equations (10) and (11), $\omega_{.t}$ is a vector of instruments associated with each endogenous variable. We use in the estimations the lags of endogenous variables as instruments. The terms α_{1t} and α_{2t} follow an autocorrelated process of order 1. Given that the equation of instrumental endogenous variables and the instruments are all dependent on time, following Harvey *et al.* (1992), these two equations are estimated through the Kalman filter in the first stage. In a second stage, we predicted the residuals from the estimation of equations (10) and (11) $(\widehat{u_{1t}} et\ \widehat{u_{2t}})$ and then introduced them into equation (9) before applying the maximum likelihood method.

3.3 Financial instability threshold

In this section, we are interested in the estimation of the threshold of financial instability from which monetary policy of the BCEAO transits from a calm regime to a distress regime. Thus, after estimating the probability of transitioning from a calm regime to a distress regime, the threshold of financial instability is estimated as:

$$\Pr = \alpha_0 + \alpha_1 FS + \alpha_2 FS^2 \tag{14}$$

Where Pr is the predicted probability obtained for the estimation of equation (9), and FS refers to the FS index measured by the indicators SCE and SMM.

By setting the first derivatives of equation (14) with respect to FS equal to zero, we have:

$$\text{Threshold of FS} = -\frac{\partial \Pr / \partial FS}{\partial \Pr / \partial FS^2} \tag{15}$$

The estimated threshold in equation (15) is then substituted into equation (14) to obtain the probability associated with the estimated threshold of financial instability.

4. Data

We use annual aggregate data of seven (07) countries of WAEMU, namely, Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo and cover the period 1970–2019. The choice of this study period is constrained by the availability of data. Even though monthly or quarterly data are more appropriate when estimating Taylor's rule, it is worth noting that the unavailability of these data in the WAEMU zone justifies the use of aggregated annual data.

The BCEAO short-term interest rate is measured by the marginal lending rate. This indicator is unique for all the WAEMU countries. The economic cycle measures the ratio of the deviation of real gross domestic product (GDP) to potential GDP obtained via the Hodrick–Prescott filter on the potential level of real GDP as $\frac{GDP - GDP_{hp}}{GDP_{hp}} * 100$. We used the reel GDP constant 2015 in local currency unit.

The inflation rate is measured by the consumer price index base (2014 = 100).The target inflation rate is defined as the value of inflation set by the central bank. In this study, the target inflation is measured by its mean over the 1970–1990, 1991–2010 and 2011–2019 subperiods. Each of these periods marks the starting point of a major reform implemented by the BCEAO. The target of net foreign assets is measured by its average for the 1970–1990, 1991–2010 and 2011–2019 subperiods. All values used are obtained from the direction of statistics of the BCEAO's website [1].

The measure of FS has been subject to numerous critics justifying the multiplicity of indicators used for its measurement (*z* score, ratio of nonperforming loans and quality of financial regulation). Thus, following Ndiaye (2020), we used two (02) indicators of the financial sector to capture financial development from which the indicators of FS are computed. We used:

(1) The ratio of broad money to GDP in percentage (M2)/GDP: it measures the financial depth or the global size of the financial system.

(2) The ratio of credits to the economy (internal or domestic)/GDP measures the degree of intermediation in the economy. This indicator highlights the proportion of resources supplied to the private sector by the banking system.

We measure FS by the variance of the cyclical component of the indicators of financial development considered. The cyclical component is equal to the difference between the indicator of financial development considered and its long-run trend. Let Foreign Direct Investisments (FDI) denotes the indicator of financial development, cyclical component (CC) denotes its cyclical component, and trend component (TC) denotes its trend component.

$$CC_t = FDI_t - TC_t \tag{16}$$

The TC is measured in different ways depending on whether it assumes linear, determinist, stochastic, mixed or moving averages. This trend component is extracted through the filter whose algorithm is based on weighted moving averages. In particular, we use the Hodrick and Prescott (1980) filter to compute the trend component.

Then, the FS indicator is determined by the variance of the CC, where the smaller this variance is, the better the FS. The FS at time t noted FS_t is measured by the difference between the value of the cyclical component CC_t and its median value $Me(CC)$ over the period of interest.

$$FS_t = [CC_t - Me(CC)] \tag{17}$$

The calculated FS indices FS_t are then normalized to range between 0 and 100 to facilitate the interpretations. A FS index equal to 0 denotes high FS, while a FS index equal to 100 indicates a high risk of financial instability. Let SMM and SCE are just notations for financial stability (FS) computed from the ratio of broad money and the ratio of credits to the economy, respectively. We obtained from our calculations an average FS index of 41.3 for the SMM and 45.3 for the SCE.

5. The results and discussion

5.1 Descriptive analysis

Figure 1 describes the relationship between the central bank short-term interest rate and the FS index. First, we note that over the period 1970 to 1980, which refers to the petroleum and oil crisis, the short-term interest rate has the same trend as the different measures of FS. Thus, the BCEAO seems to have adopted restrictive monetary policies to prevent potential risks of financial instability. Second, over the period of the banking crisis coupled with changes in parity in January 1994 (1981–1994) in the WAEMU region, we observe an opposite relation between the short-term interest rate and the FS indices. Finally, from 2003 to 2019, the BCEAO seems to have maintained its short-term interest rate at a constant level, with a slight decrease observed in recent years.

In sum, the graphical analysis of the relationship between the short interest rate and the indicators of FS leads to mixed conclusions, a positive relation at one instance, negative at another or the absence of a relationship. Consequently, we cannot conclude about the nature of the relationship between FS and monetary policy from the descriptive analysis. These results highlight the use of econometric tools to obtain more understanding.

5.2 Validation of Markov regime-switching model

Before estimating the model in equation (9), it is common in the time series analysis to verify the presence of a unit root. Thus, we performed the augmented Dickey-Fuller (ADF) unit root

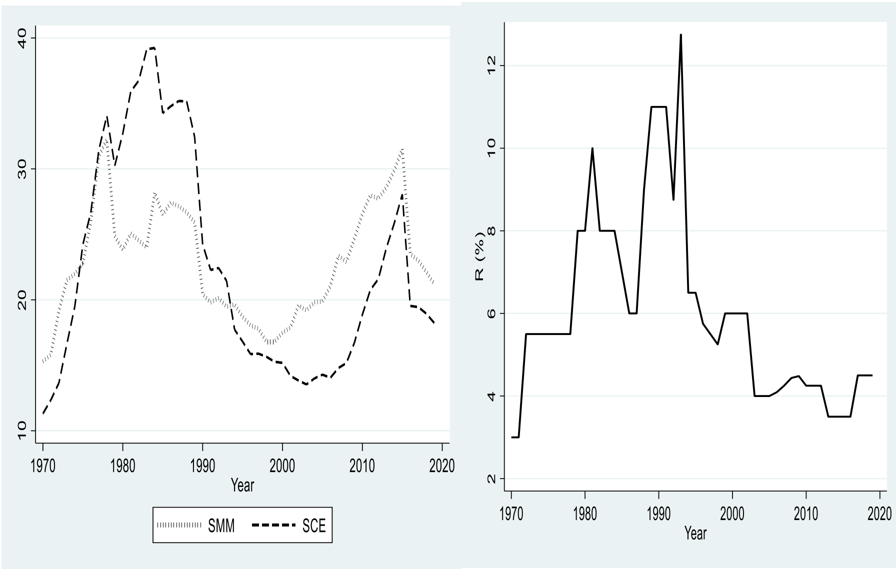

Figure 1.
Financial stability and short-term interest rate of the BCEAO

test and the Andrews and Zivot (1992) unit root test. The results of the ADF unit root test presented in Table A1 in the appendix show that all the series are stationary at level, except the short-term interest rate and the gross domestic product. Following these results, the Andrews and Zivot (1992) unit root test was carried out. This test has the advantage of taking into account the existence of potential structural breaks in the dynamics of the series, which is ignored by the conventional ADF unit root test Phillips–Perron unit root test. The results of the Andrews and Zivot (1992) unit root test reveal the presence of a structural break at the short-term interest rate in 1994 and at the gross domestic product in 1980 (Table A2 in the appendix). In addition, the results of this test confirm that both the short-term interest rate and the gross domestic product are stationary at the same level (Table A1 in the appendix).

The Akaike information criterion (AIC), Bayesian information criterion (BIC) and Hannan–Quinn information criterion (HQIC) reported in Table 1 confirm the superiority of the regime-switching model to the linear model. These results confirm the thesis of a nonlinear relation between the short-term interest rate and FS. Our results corroborate those of Floro and van Roye (2017) and Dibooglu *et al.* (2020).

5.3 Identification and characterization of regimes

The identification of regimes in the Markov regime-switching model was done through the comparison of the constants resulting from the two regimes. We estimated the short-term interest rate by including only the constant as the explanatory variable. The regimes are generally identified according to the estimated constant terms, the standard deviations or transition probabilities (Bojanic, 2021).

Table 1.
Choice of the best model

Information criteria	SCE model	SMM model	Linear model
AIC	−6.11	−6.06	180.13
BIC	−5.38	−5.78	195.26
HQC	−5.84	−5.32	–

Results of our estimations presented in Table 2 revealed that the constant term of regime 1 (0.041) is inferior to that of regime 2 (0.070). We thus identified regime 1 as a calm regime (without financial stress) and regime 2 as a distress regime (with high financial stress). This result is also confirmed when the standard deviations are used to identify the regimes. Indeed, the standard deviation of regime 1 (0.004) is lower than that of regime 2 (0.022).

To characterize the two regimes identified, we carried out a correlation test between the predicted transition probabilities of the distress regime (regime 2) and the FS indices. Recall that a positive correlation coefficient indicates a risk of financial instability. The results of the correlation test presented in Table 3 show that the predicted transition probabilities of regime 2 are positively correlated with the FS indices. Thus, the distressed regime is characterized by periods of high risks of financial instability and economic recession, as the conditions of credits to the economy are tight. In contrast, the calm regime is characterized by periods of FS and expansion, indicating the existence of better conditions of credits for investors.

5.4 Results of Markov regime-switching model

The results of the Markov regime-switching model with fixed transition probability as specified in equation (9) are presented in Table 4. First, these results show that the coefficients η_1 and η_2 are all significant in at least one of the two regimes, supporting the consideration of endogeneity in the estimations. These results are confirmed in both models by Wald's test when we simultaneously test the null hypothesis of the coefficients in the two regimes, that is, $\eta_{.}(s) = 0$.

The statistics of the test are all greater than the theoretical values, implying the rejection of the null hypothesis: SMM ($\chi^2 = 14.56$ and probability of the test is 0.000) and SCE ($\chi^2 = 12.40$ and the test probability is 0.002).

5.4.1 Financial stability and monetary policy. Estimation results presented in Table 4 indicate that the FS index has a positive and significant coefficient in the distress regime [R2 (SCE) = 0.041; R2 (SMM) = 0.040)] irrespective of the measure of the indicator used. This result implies that the BCEAO seems to have had a restrictive monetary policy faced with the risk of financial instability. In addition, the reaction of the BCEAO is more aggressive in the periods of the "distress regime" given that the coefficient of the index of FS in this regime

Variable	Regime 1 (calm)	*Coefficient.* (Std. Deviation)	Regime 2 (distress)
Constant	0.041*** (0.001)		0.070*** (0.004)
Sigma	0.004 (0.001)		0.022 (0.002)
Log. likelihood	168.93		161.92
N.obs		50	
AIC		−5.539	
SBIC		−5.309	
HQIC		−5.452	

Note(s): Markov switching estimated with intercept only
*, **, *** are significance at 10%, 5%, and 1% respectively

Table 2. Identification of regimes

Name	SMM	SCE
Probability distress regime	0.165	
Probability distress regime		0.149

Table 3. Probability of distress regime and FS index

Table 4.
Result of Markov regime-switching model

Variable	Regime 1 (calm) Coef. (standard deviation) SCE	SMM	Regime 2 (distress) Coef. (standard deviation) SCE	SMM
β_0	0.046*** (0.061)	0.475*** (0.071)	0.728*** (0.089)	0.798*** (0.201)
β_1	0.070** (0.003)	0.092** (0.003)	0.140 (0.011)	0.248*** (0.013)
β_2	0.011 (0.038)	0.046 (0.026)	−0.005* (0.038)	−0.029 (0.073)
β_3	0.012 (0.004)	0.011 (0.000)	0.041*** (0.001)	0.040** (0.017)
β_4	0.002 (0.000)	0.001 (0.000)	−0.008*** (0.001)	−0.005*** (0.001)
η_1	−0.009*** (0.003)	−0.008*** (0.003)	−0.012* (0.01)	−0.012 (0.012)
η_2	−0.196*** (0.064)	0.165*** (0.046)	0.145 (0.001)	−0.367 (0.231)
μ	0.028 (0.004)	0.027** (0.004)	−0.001 (0.007)	−0.032 (0.017)
Sigma	0.006 (0.001)	0.005 (0.001)		
Log.likelihood	168.93	167.53		
N.obs	49	49		
AIC	−6.11	−6.06		
SBIC	−5.38	−5.78		
HQIC	−5.84	−5.32		

Note(s): *, **, *** significance at 10, 5, 1%

(0.04) is greater than that obtained in the "calm regime" (0.011) for all the different measures of FS. Specifically, this difference is confirmed for the SCE indicator by the Chi-square statistic, which is $\chi^2(1) = 39.3$ with a significance probability equal to 0.000. These results are in line with the recommendations of Mishkin (2008), according to which, monetary policy can be aggressive in very agitated economic conditions, implying that the central bank adopts a restrictive monetary policy by increasing its short-term interest rate when facing high risks of financial instability. Our results also confirm those of Dibooglu *et al.* (2020) based on the monetary policy of the FED in the USA between 1971 and 2017; those of Floro and van Roye (2017) from a sample of 11 emerging countries between 1996 and 2013; and those of Alba and Wang (2016) in the USA.

Moreover, our findings confirm stylized facts when observing the conduct of monetary policy in some African countries. For instance, when facing the problem of liquidity shortages in the Nigerian banking system in the wake of the global financial crisis in 2008, the central bank of Nigeria adopted an expansionist monetary policy by lowering its monetary policy rate from 10.25 to 6.0% during the period 2008–2010. Thus, it is worth noting that since that period, apart from its mandate of ensuring price stability and economic growth, the Nigerian central bank monetary policy has been designed to FS, to the stable and competitive exchange rate of the Nigeria currency (naira), and to the achievement of positive real interest rates (CBN, 2021). Consequently, after the recovery (the post-2008 period) and when facing a high risk of financial stress, especially an excessive expansion of credits and excessive volatility of asset prices, the central bank of Nigeria adopted a restrictive policy. Its monetary policy rate doubled by increasing from 6.0% to 12.0% during September 2010–December 2011. The central bank also adopted other tightened policies, such as foreign exchange net open position limits, discount window operations, cash reserve ratios and open market operations (CBN, 2021).

Our findings are meaningful since a restrictive monetary policy can be effective in promoting FS. An increase in the central bank short-term interest rate tends to slow down the accumulation of capital by means of bank credit allocation in the medium run, thereby limiting the occurrence of the so-called twin crisis. Indeed, a twin crisis is a situation in which both a currency crisis and banking crisis occur at the same time, self-sustained with consequences on the real economy (recession) (Goldstein *et al.*, 2000). Many authors supported the view that the long zero lower bound interest rate policy of the FED in the USA between 2003 and 2007 that led to excessive credit growth and then to the unsustainable growth of asset prices (especially property prices) was the main cause of the global financial crisis in 2007 (Jordà *et al.*, 2017; Schularick and Taylor, 2012; Taylor, 2011; Jimenez *et al.*, 2014).

In addition, we estimated a threshold of 49.0 of the FS index (SCE) from which monetary policy of the BCEAO transits from a calm regime to a distress regime with an associated probability of 0.30. In contrast, the probability of transitioning from a calm regime to a distress regime is high (0.75) for a relatively low threshold of 31.0 of the FS index measured by the SMM.

5.4.2 Price stability, economic growth and monetary policy. The results of our estimation presented in Table 4 show that the coefficients of the difference in the inflation rate are positive and significant in the two regimes of the SMM model on the one hand and in the first regime of the estimated SCE model. These results align with theoretical predictions of Taylor's rule according to which the estimated coefficient of the inflation gap has to be positive. On the other hand, Taylor's rule is verified for the output gap (negative coefficient) only in the distress regime, indicating that monetary authorities effectively ensure the balance of monetary policy objectives, especially in distress conditions.

The estimated coefficients of the inflation gap are higher in the "distress regime" than in the "calm regime" irrespective of the model considered. Indeed, when testing the difference between the means of coefficients, the Chi-square statistic gives a value of 3.9 with an associated probability of 0.046 for the SMM model and a Chi-square statistic of 3.9 and an associated probability of 0.018 for the SCE model. These results imply that the BCEAO is more concerned with price stability in conducting monetary policy in distress regimes. Likewise, our results show that the estimated coefficients of the inflation gap are greater in absolute value than those of the output gap. This result confirms that the BCEAO effectively accomplishes its mandate, which ensures price stability in the monetary zone.

However, the BCEAO is also concerned with full employment by supporting economic activity even though the weight assigned to the production objective is less than that of price stability. Our results are in line with those of Floro and van Roye (2017). Using a dynamic panel threshold regression with common error components, these authors found that monetary policy assigned more importance to price stability than economic growth in a sample of 21 advanced and emerging countries during the period 1994–2013. Dibooglu *et al.* (2020) also confirmed that the FED in the USA is more concerned about inflation in distress periods than of calm regimes using a Markov regime-switching model.

In addition, the coefficient of the lagged value of the central bank short-term interest rate is significant at 1% level in all regimes irrespective of the FS indicator. This shows a strong degree of *inertia* in the monetary policy of the BCEAO or a high persistence of shock financial stress periods (regime 2). This *inertia* revealed in the reaction function is likely to make the transmission channels of the BCEAO short-term interest rate ineffective in the real economy.

Finally, our results denoted that the coefficient of net foreign assets is positive and significant at 1% level only in the distress regime (regime 2). This result implies that the BCEAO seems to raise its short interest rate in the period of the "distress regime" followed by an increase in the level of net foreign assets. Our results align with those found by a previous study on the estimation of a reaction function for BCEAO (BCEAO, 2013). On the other hand, in the calm regime, the level of net foreign assets does not have a significant effect on the monetary policy of the BCEAO.

5.4.3 Transition probabilities and duration of regimes. The results of the estimation of transition probabilities presented in Table 5 show that the "calm regime" is persistent in the two models. For example, the results indicate that it is three times more likely (3.45 times) to remain in the "calm regime" than in the "distress regime" in the SMM model. Otherwise, the probability of remaining in the "calm regime" is 0.87, while that of remaining in the "distress regime" is only 0.13. In addition, irrespective of the model considered, the calm regime is longer than the distress regime. In the SMM model, the average duration of the "calm regime" is 7.62 years, while that of the "distress regime" is approximately 2.21 years (Table 5). Thus, the calm regime is more persistent than the distress regime. These results confirm those of Dibooglu *et al.* (2020), who estimated an average duration of 47 months for the "calm regime" versus 12 months for the "distress regime" in the USA using monthly data from January 1971 to December 2017. Our findings are consistent with the evolution of the BCEAO short-term interest rate. Indeed, from Figure 1, we note that the BCEAO short-term interest rate rose from 5.25% in 1998 to 6.0% in 2002, before adopting a low rate of 4.0% in 2003, indicative of a restrictive monetary policy duration of three years. Similarly, we can observe that the BCEAO maintained a high short-term interest rate during 1989–1991 by raising it from 9.0% in 1988 to 11.0% in 1989, implying a restrictive monetary policy duration of approximately two years. In addition, a sharp restrictive monetary policy was observed in 1993, while five years of monetary policy was noted during 1979–1984.

6. Robustness test

To test the robustness of our estimations, we specified the BCEAO reaction function according to the backwards-looking rule. In other words, we estimate a model of the interest rate of the BCEAO, in which the exogenous variables are taken as variables lagged by one period. The results of this specification presented in Table 6 show that the coefficients of FS indices are positive and significant in at least one regime, notably the distress regime. Overall, change in model specification does not change the general trend of previous conclusions even though the values of some control parameters are different.

7. Conclusion

This paper explores the adequate specification of the reaction function of the BCEAO when facing financial risks. To that end, we based our empirical strategy on the specification of an augmented Taylor reaction function on FS and net foreign assets. Through aggregated annual data covering the period of 1970–2019, a Markov regime-switching model with fixed transition probability is used to test the hypothesis of asymmetric behavior of monetary policy.

Our results showed that the BCEAO seems to have been more aggressive in the distress regime than in the calm regime in reaction to the risk of financial instability and inflation, indicating the adoption of restrictive monetary policy. In addition, our results revealed that the calm regime is more persistent than the distressed regime, as indicated by a high average duration (7 years) and a relatively high probability of occurrence (0.8).

Overall, our results are robust to alternative specifications, particularly the Markov model and the backwards-looking rule. These findings suggest taking into account FS in conducting monetary policy in the WAEMU region to reduce the vulnerability of the union to

	Regime (calm)		Regime (distress)	
	SCE	*SMM*	*SCE*	*SMM*
Duration	6.25	7.62	2.40	2.21
P1	0.84	0.87	0.16	0.13
P2	0.42	0.45	0.58	0.55

Note(s): P_{ij} = probability from regime i to regime j, $\forall i \neq j$
P_{ii} = probability from regime i to regime i

Table 5. Transition probabilities and duration of regimes

Variable	SCE Coef	SCE Std. dev	SCE Prob	SMM Coef	SMM Std. dev	SMM Prob
			Regime 1 (calm)			
β_0	0.367	0.075	0.000	0.461	0.071	0.000
β_1	0.052	0.003	0.056	0.011	0.004	0.007
β_2	0.034	0.031	0.267	0.046	0.030	0.134
β_3	0.001	0.000	0.047	0.002	0.001	0.003
β_4	−0.002	0.001	0.000	−0.003	0.001	0.000
η_1	−0.008	0.002	0.000	−0.015	0.004	0.000
η_2	−0.139	0.042	0.001	−0.221	0.063	0.000
μ	0.041	0.006	0.000	0.035	0.005	0.000
			Regime 2 (distress)			
β_0	0.984	0.061	0.000	1.042	0.061	0.000
β_1	−0.004	0.004	0.286	−0.001	0.003	0.750
β_2	0.059	0.040	0.136	0.032	0.043	0.464
β_3	0.002	0.000	0.065	0.002	0.000	0.349
β_4	0.006	0.001	0.000	0.006	0.001	0.000
η_1	0.009	0.004	0.020	0.004	0.002	0.041
η_2	−0.010	0.125	0.935	0.172	0.113	0.126
μ	−0.000	0.003	0.949	−0.003	0.003	0.384
Log.likelihood		168.51203			170.4633	
N.obs		49			49	
AIC		−6.1025			−6.1822	
SBIC		−5.3690			−5.4486	
HQIC		−5.8242			−5.9039	

Table 6. Robustness test

financial instability risks. In this regard, we recommend the promotion of interventions that aim at strengthening the prerogatives of the FS committee that is in charge of monitoring financial risks within the BCEAO, since FS can contribute to consolidating the resilience of the financial sector to internal and external shocks.

Note

1. The BCEAO's website is accessed at https://www.bceao.int/fr/content/la-base-des-donnees-economiques-et-financieres.

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Appendix

Variables	Statistics	Critical value (5%)	Decision
Augmented Dickey–Fuller test (ADF)			
R	−2.404	−3.516	Unit root
SMM	−2.641	−1.678	Stationary
SCE	−2.081	−1.678	Stationary
SDB	−3.588	−1.678	Stationary
INF	−4.615	−3.504	Stationary
GDP	−3.324	−3.516	Unit root
NEA	−7.816	−3.504	Stationary
Zivot–Andrews unit root test			
R	−6.394	−5.080	Stationary
SMM	−7.008	−5.080	Stationary
SCE	−6.678	−5.080	Stationary
SDB	−5.362	−5.080	Stationary
INF	−7.192	−5.080	Stationary
GDP	−6.848	−5.080	Stationary
NEA	−8.747	−5.080	Stationary

Table A1. Unit root tests

Variables	Statistics	Prob	Date of break
R	23.384	0.000	1994
GDP	10.164	0.088	1980
NEA	94.296	0.000	1979

Table A2. Structural break test

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