Threshold Effect in the Bank Lending Channel of Monetary Policy Transmission and the Role of Bank Portfolio Deterioration: A PSTR Specification in the WAEMU Zone

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Abstract

The objective of this paper is to analyse the influence of monetary policy on credit supply in the WAEMU zone over the period 1996-2017. The study focuses on the WAEMU countries, except for Guinea-Bissau, due to the unavailability of sufficient data. We apply the Panel Smooth Transition Regression (PSTR) model of Gonzalez et al. (2005). The results reveal the non-linearity of the link between monetary policy and credit supply. There is a threshold of credit risk exposure of 8.726% above which monetary policy loses its effectiveness. Indeed, monetary policy has a positive effect on the supply of credit when the value of the gross bank portfolio deterioration rate is less than or equal to the threshold of 8.726% and an insignificant effect above this threshold. Above this threshold, the link between monetary policy and bank credit supply is distended. In this case, it is the level of economic activity that stimulates the supply of bank credit in this area. These results indicate that the effectiveness of the monetary policy conducted by the Central Bank of West African States (BCEAO), through the bank credit channel, should take into account the level of credit risk attained by banks. Thus, the study recommends that the authorities further strengthen prudential supervision within the WAEMU.

1. Introduction

The question of the transmission of monetary policy has remained largely obscure. Although most economists agree, at least in the short run, that monetary policy can significantly influence developments in the real economy, the exact process of this transmission mechanism still remains a "black box" (Bernanke and Gertler, 1995). Recent research has shown that a precise definition of the role of banks in the transmission of monetary policy is essential to explain the effects of this policy on the real economy.

Traditionally, the literature on the transmission channels of monetary policy and the role of banks has been examined mainly in the context of "bank lending". This bank lending channel of monetary transmission assumes that a monetary contraction policy conducted by the central bank will force banks to adjust their lending conditions, i.e., an increase in lending rates on new loans and/or a decrease in the amount of loans offered. As a result, as Dolignon and Roger (2010) note, firms that experience such an increase in the cost of credit are forced to reduce their investment spending, and by extension, their level of production. On the other hand, an easing of monetary policy, through a reduction in the key interest rate, for a period of time, would cause the cost of credit to fall, which would lead firms to request more credit in order to invest and increase production. Banks, for their part, will seek to satisfy this growing demand for credit expressed by companies and improve their profitability.

The literature also presents the macroeconomic environment as a factor influencing the credit supply behavior of banks, following a change in monetary policy. Indeed, when the credit risk of financial institutions is high, an accommodative monetary policy could have a reduced impact on the real sector as financial institutions will seek to tighten credit conditions to protect their balance sheet position (Gameiro et al., 2011). When the deterioration of

the banks' portfolio reaches a certain threshold, the transmission of monetary signals through the bank credit channel could be inefficient (Bashir et al., 2020).Indeed, when high delinquencies are provisioned, banks' profitability is reduced and their ability to finance productive activities is negatively affected. For this reason, Altunbas et al (2009) consider that credit risk, capitalization, bank size and liquidity should be carefully considered when analyzing the functioning of the bank lending channel of monetary policy.

In terms of empirical studies, in the United States, Lamont-Black et al (2010) seek to identify the role of banks in the transmission of monetary policy by examining banks' business strategies through financing and mortgage lending, using quarterly data from 1995 to 2005. The major result of this study is that there is a bank lending channel in the transmission of U.S. monetary policy, a transmission that is stronger for large banks with adequate regulatory capital. In Europe, Heryan and Tzeremes (2017) examine the existence of the bank lending channel of monetary policy, applying the generalized method of moments (GMM) over a period from 1999 to 2012. They show that over the pre-crisis period, the effect of changes in short-term market interest rates on the bank lending channel of monetary policy is more pronounced in the "old" EU countries than in the "new" union countries. Recently, using a sample of 328 banks, Hamid and Yunus (2020) examine the existence of a bank lending channel within Southeast Asian countries over the period 2009-2015. The results confirm that a bank lending channel is effective in these countries. Indeed, they find that consumer and commercial loans are sensitive to changes in monetary policy, but mortgages and business loans are not. They also find that commercial banks are vulnerable to changes in monetary policy, unlike investment banks and Islamic banks. Indeed, specialized banks have a high capacity to overcome the effect of monetary policy tightening.

In the CEMAC zone, Takoulac et al. (2020) study the effect of banking concentration on the transmission mechanism of monetary policy in Cameroon, using data from 6 commercial banks observed over the period 2006-2016. They find that the banking concentration negatively and significantly affects the credit supply in Cameroon. Therefore, they recommend that the Central Bank authorities reduce the amount of regulatory capital to a reasonable level in order to facilitate the entry of new banks into the sector in order to make it competitive.

In the ECOWAS zone, a few authors have conducted studies on the link between monetary policy and bank credit supply. Using a sample of 23 banks, Matousek and Solomon (2018) analyze the role of the bank lending channel in the monetary policy transmission mechanism in Nigeria over the period 2002 to 2008. The results indicate that large and well-capitalized banks are less sensitive to monetary policy changes. The authors conclude that bank restructuring measures initiated by the central bank have improved the impact of the bank lending channel. In Sierra Leone, using quarterly bank data over the period 2014-2018, Bangura et al. (2021), indicate that there is a monetary policy transmission channel through bank lending. They conclude that banks play an important role in the monetary transmission mechanism but that large banks are less sensitive to monetary shocks than small banks. However, the authors indicate that liquidity and regulatory capital have no influence on the supply of bank credit, only the size of banks matters.

In the WAEMU zone, Kanga (2015) examines the role of banks in the transmission of monetary policy. Using a simple partial equilibrium model based on adjustment and intermediation costs, the results indicate that over the period from 1998 to 2012, bank credit is affected by many characteristics such as institutional quality, minimum capital stock, bank size and liquidity. But weakly capitalized banks are less responsive to monetary policy impulses. Very recently, Koné(2021) analyzes the effect of the main transmission channels of monetary policy on economic growth and inflation in the WAEMU zone. Using a staggered lag autoregressive model (ARDL), and quarterly data from 2001 to 2016, for seven countries in the WAEMU zone, the study shows that monetary policy transmission channels have a positive influence on inflation and growth. However, this influence is weaker in the long run than in the short run. In addition, the author finds that the interest rate channel is the most active in terms of price stabilization, while the credit channel is the most effective in terms of boosting output in the WAEMU zone. In this zone, the adoption of an inflation targeting framework by the BCEAO in 2010 has revived the issue of monetary policy transmission. The success of such a monetary policy option presupposes the existence of functional channels that allow for the effective transmission of interest rate impulses to activity and then to prices (Tadenyo, 2015). Moreover, there is evidence that the transmission of monetary policy through the bank lending channel may react differently in different countries, depending on the structure and efficiency of the economic and financial system (Rashid et al., 2020).

In this context, it becomes legitimate to know to what extent the different monetary policy options implemented have been able to influence key macroeconomic variables, notably bank credit. Based on data from WDI (2019) and the BCEAO, the average repo rate of the BCEAO fell from 6.30% to 4.10% between 1996 and 2004, a drop of more than 2 points. Over the same period, the average bank credit supply in the UEMOA zone rose from 11.20% to 11.80%, an increase of 0.6 points. This weak reaction of bank credit to the cut in the central bank's key rate is said

to be due to the level of credit risk in the banking sector. Indeed, the gross deterioration rate of the banking portfolio between 1996 and 2004 was on average 13.43%. However, looking at the same variables between 2009 and 2015, we notice that credit risk has declined slightly, with the gross run-off rate of the banking book falling from 7.54% to 6.40%. During this period, the repo rate hardly changed as it averaged around 4%. However, there was a sharp increase in bank lending during this period, from 12.80% to 23.14%. On the basis of these contradictory developments, it appears that the role of bank risk in the bank credit channel of monetary policy is ambiguous. And this is where we place the problematic of this study which revolves around the following questions: What is the effect of the repo rate on the supply of credit? What role does portfolio quality play in the transmission of monetary policy in WAEMU countries? From these two questions, a central question emerges: to what extent does bank risk affect the relationship between bank credit and monetary policy impulses?

Consequently, the general objective of our study is to examine the role of credit risk in the effectiveness of the reaction of bank credit to monetary policy impulses in the WAEMU zone. Specifically, it is to:

- examine the effect of the repo rate on the supply of credit in the WAEMU zone
- to determine the role of portfolio quality in the transmission of monetary policy in WAEMU countries.

In relation to our objectives, we put forward two hypotheses mentioned below:

- an accommodating monetary policy (lowering the repo rate) leads to an increase in credit;;
- the positive effect of the decrease in the repo rate depends on the risk level of the banks.

Our study is not lacking in interest and stakes. Indeed, very few studies have focused on the link between monetary policy, bank risk and credit supply in the WAEMU. In particular, the literature on the role of bank portfolio deterioration in the bank lending channel of monetary policy has not emphasized the non-linearity of the relationship. Moreover, the determination of thresholds is missing in many studies.This study provides an empirical contribution on this subject, for the benefit of the monetary authorities of the WAEMU zone. At the methodological level, this study was carried out using panel smooth threshold regression (PSTR) estimators to analyse the non-linearity of the variation of the repo rate on credit supply.

This article is organised as follows: Section 2 is devoted to the literature review. Section 3 presents the methodology of the study. Section 4 presents the data source and the description of the variables. Section 5 is reserved for the empirical results. Section 6 is reserved for the conclusion of the study.

2. Strategy of Empirical Reseach

We adopt panel specifications based on data from WAEMU countries, taking into account the existence of probable endogenous thresholds. This section presents first, the model on which our study is based, secondly, the empirical model of the study and thirdly, the estimation approach.

2.1 The Model Specification

To examine the role of bank risk in the bank lending channel of monetary policy transmission in the WAEMU area, we use a threshold-effect Panel modeling. Threshold effect models are an instrument for the analysis of non-linear economic phenomena. They allow economic series to have different dynamics depending on the regimes in which they evolve. The transition mechanism for the transition from one regime to another is carried out using an observable transition variable, a threshold and a transition function. There are two main types of panel threshold modeling: the modeling proposed by Hansen (1999) and that of Gonzalez et al. (2005). In that of Hansen [1999], nonlinearity is reflected in the fact that the dependent variable is generated by two distinct processes. We are located in one process or another according to the value taken by a variable called transition variable. The modeling assumes that the transition between the two regimes is abrupt. Indeed, we are located in the dynamics of one process or the other. However, it could very well be that, instead of being abrupt, this transition is rather smooth.The PSTR modeling proposed by Gonzales et al. (2005) thus makes it possible to model situations where the transition from one regime to another takes place gradually. Thus, the transition function will be, not an indicator, but rather a continuous function. The PSTR can also be seen as models in which, there are two extreme regimes between which, there would be a continium of regimes. In the context of this study, the gradual transition models (PSTR) are more appropriate to describe the change in economic behaviors induced by quantitative regime variables. To illustrate the relationship between monetary policy, bank risk and the bank credit channel, we assume the simple case of the PSTR with two extreme regimes and a single transition function. In the case of two extreme regimes and a single transition function, the PSTR model can be written as follows :

$$y_{it} = \mu_i + \lambda_t + \beta'_0 x_{it} + \beta'_1 x_{it} G(TBDPB_{it}; y, c) + \varepsilon_{it} \tag{1}$$

Where i = 1, 2, …, N is the number of countries and t = 1, 2, …, T is the number of periods. These are the individual dimensions and the temporary dimensions of the panel, respectively. The dependent variable y_{it} is a scalar and represents the supply of credit to the private sectors (CRED), x_{it} is a K-dimensional vector of the explanatory variables generally considered in the literature on the supply of bank credit. μ_i et λ_t represent fixed individual effects and time effects, respectively, and ε_{it} is the error term, and β the regression coefficients. Transition function $G(TBDPB_{it}; \gamma, c)$ is a continuous function and depends on threshold variable ($TBDPB_{it}$) and normalized to be bounded between 0 and 1, and these extreme values are associated with regression coefficients β_0 and ($\beta_0 + \beta_1$), and on $c = \{c_1, …., c_m\}$ which is a vector of threshold parameters and the parameter γ determines the slope of the transition function and indicates the transition speed from one regime to another (transition parameter). Like Granger and Teräsvirta (1993), Gonzàlez et al. (2005), we consider the following logistic transition function :

$$G(TBDPB_{it}; \gamma, c) = \left[1 + \exp\left(- \gamma \prod_{j=1}^{m} (TBDPB_{it}; -c) \right) \right]^{-1} \tag{2}$$

With $\gamma > 0$ and $C_1 \le C_2 \le \cdots \le C_m$.

Note that m is the number of location parameters and $C_1 \le C_2 \le \cdots \le C_m$. For m = 1, the model has the two extreme regimes separating low and high values of $TBDPB_{it}$ with a single monotonic transition of the coefficients from β_0 and ($\beta_0 + \beta_1$), as $TBDPB_{it}$ increases. For a higher value, the transition becomes rougher and transition function G ($TBDPB_{it}$, γ, c) becomes the indicator function G ($TBDPB_{it}$, c). When tends towards infinite, indicator function G ($TBDPB_{it}$, c) = 1 if event $TBDPB_{it}$, > c occurs, and indicator function G ($TBDPB_{it}$, c) = 0 otherwise. When is close to 0, the transition function G ($TBDPB_{it}$, γ, c) is constant. In that case, the PSTR converges towards the tworegime panel threshold regression (PTR) of Hansen (1999). In general, for any value of m, the transition function G ($TBDPB_{it}$, γ, c) is constant when is close to 0. In which case, the model in equation (1) becomes a linear panel regression model with fixed effects. The empirical model to be estimated is presented as follow :

$$CRED_{it} = \mu_i + \alpha CRED_{it-1} + \theta_1 TPENS_{it} + \theta_2 TBDPB_{it} + \theta_3 TXCHR_{it} + \theta_4 PIBH_{it} + (\theta'_1 TPENS_{it} +$$
$$\theta'_2 TBDPB_{it} + \theta'_3 TXCHR_{it} + \theta'_4 PIBH_{it}) * G(TBDPB_{it}; y, c) + \varepsilon_{it} \tag{3}$$

Where θ_i represents the regression coefficients. $CRED_{it}$ is the bank credit granted to the private sector for each country at time t, $TPENS_{it}$ the variable Repo rate at time t for each country, $TBDPB_{it}$ the variable Gross Portfolio Degradation Rate for each country at time t, $TXCHR_{it}$ the real exchange rate for each country at time t, and $PIBH_{it}$ the gross domestic product per capita for each country at time t. This model allows to examine the influence of banks' exposure to credit risk on the conduct of monetary policy in the WAEMU area over the period 1995-2012. We retain only these variables to avoid losing degrees of freedom because when the sample size is not large enough, introducing too many explanatory variables leads to multicollinearity problems.

The econometric approach is based on three steps. In the first one, the stationarity of each variable is examined by performing two unit roots tests, namely, Breitung and Das (2005) and Pesaran (2007). In the second one, we test both the linearity against the PSTR model and the number of transition function. Finlay, in the third one, we apply the non-linear least squares methods to estimate our PSTR model. We can now present the estimation procedure for obtaining the coefficients.

2.2 The Estimation Procedure

We first present the stationarity test of Pesaran (2007) and then the linearity test of Breitung and Das (2005).

- The stationarity tests of Breitung and Das (2005) and Pesaran (2007).

Taking into account the presence of inter-individual dependence, the order of integration of our series is

determined, using the second generation unit root tests of Pesaran, (2007) and Breitung and Das (2005).

- The Pesaran test (2007)

The Pesaran (2007) test accounts for cross-sectional dependence and also assumes parameter heterogeneity. For this test, the null hypothesis H_0 is that each individual time series contains a unit root. The alternative hypothesis is that some of the series are stationary.

Hypothesis test:

H_0: All series have a unit root (non-stationarity).

H_1: Part of the series has a unit root (stationarity)

- The Breitung and Das test (2005)

The Breitung and Das test is based on a common unit root process based on the null hypothesis of unit root.

We formulate the following hypotheses:

H_0: Presence of unit root (non-stationarity)

H_1: Absence of unit root (stationarity)

- **Linearity test**

The estimation of the PSTR model begins with the elimination of the fixed individual effects μ_i by removing the mean of the specific individual effects and thus applying the nonlinear least squares on the transformed model. Gonzàlez et al. (2005) proposes a test procedure according to the following order :

i)   The linearity test against the PSTR model,

ii)   Determination of the number r of the transition functions

The linearity test in the PSTR model (equation 1) can be done by testing:

$$H_0: \gamma = 0 \ \ or \ \ H_0: \beta_1 = \beta_0$$

However, under the null hypothesis, the test will not be the same in both cases, and the PSTR model contains unidentified nuisance parameters. One possible solution is to replace the transition function $G(z_{it}; y, c)$ with the Taylor expression at order 1 around $\gamma = 0$ and test an equivalent hypothesis in an auxiliary regression. We then get the following:

$$CRED_{it} = \mu_i + \alpha CRED_{it-1} + \theta_1^* TPENS_{it} + \theta_2^* TBDPB_{it} + \theta_3^* TXCHR_{it} + \theta_4^* PIBH_{it} + (\theta^{*'}{}_1 TPENS_{it} + \theta^{*'}{}_2 TBDPB_{it} + \theta^{*'}{}_3 TXCHR_{it} + \theta^{*'}{}_4 PIBH_{it}) * G(TBDPB_{it}; \gamma, c) + \varepsilon_{it}^* \ (4)$$

Since the parameters $\theta^{*1} ... ... \theta^{*m}$ are proportional to the slope parameters of the transition function, and ε_{it}^* is ε_{it} plus the residue of Taylors development. The null hypothesis of the linearity test becomes H0 : $\theta^{*1} = \cdots = \theta^{*m} = 0$ and the linearity is tested with standard tests.

We use Wald test expressed as follows:

$$LM_w = \frac{NT(SCR_0 - SCR_1)}{SCR_0}$$

where SCR_0 is the sum of the squares of the panel residuals under the hypothesis H_0 and SCR_1 is the sum of the squares of the panel residuals in the PSTR model with m regimes. Then the corresponding statistic F is then defined as follows:

$$LM_F = \frac{(SCR_0 - SCR_1)/mK}{SCR_0/(TN-N-mK)} \sim F(mK, TN - N - mK) \tag{5}$$

Where T, N and K are the number of years, the number of countries and the number of exogenous variables respectively. After applying the linearity test, the problem is to identify the number of transition functions. LMF follows a Fisher distribution with mK and $(TN - N - mK)$ degrees of freedom (F(mK,$TN - N - mK$)). All these linearity tests are distributed $\chi^2(k)$ under the null hypothesis.

3. Variables and Data Sources

In this section, we proceed to describe the variables of the study and to present the data sources.

3.1 Description of the Variables

To carry out this presentation, we distinguish the endogenous variable and the exogenous variables.

- The endogenous variable

The endogenous variable represents the variable that indicates the phenomenon that we are trying to explain. In this study, the dependent variable is the supply of credit to the private sector (CRED). The supply of credit is measured by the ratio of bank credit granted to the private sector as a percentage of GDP. This credit offer excludes any other form of credit, such as those granted to the government, the public sector and state-owned companies. It also excludes loans issued by the central bank. This ratio underlines the importance of the role played by the banking sector in financing the private sector.

- The exogenous variable

We distinguish two types of exogenous variables: the variable of interest and the control variable.

  o The variable of interest

The variable of interest refers to the variable that is the main object of the research. In this study, we use the repo rate of monetary policy (TPENS). This rate is the interest rate applied by a central bank to commercial banks that borrow cash from it against the delivery of securities. The repo rate is one of the key rates of a central bank. A decrease in this rate should allow commercial banks to provide more bank credit.

  o Control variables

The control variables designate all the other variables added in a regression in order to avoid a bias in the estimation of the parameter of interest. In this study, we have the transition variable and the other control variables.

- The transition variable

The transition variable is the gross rate of deterioration of the bank portfolio (TBDPB). This is the indicator chosen to measure the quality of credits. It is defined as the ratio of overdue appropriations to total appropriations. This measure of credit risk is the variable on which the endogenous thresholds are determined. It has also been used by Trinnou and Igue (2015).

- The other control variables

The other control variables that are used in the framework of our study are the real exchange rate (TXCHR) and the gross domestic product per capita (PIBH). The real exchange rate (TXCHR) is the rate at which an individual can exchange domestic goods and services with those of another country (relative price of goods). The real exchange rate is a crucial factor in determining a country's exports and imports. It is calculated as the product of the nominal exchange rate by the price ratios. As for the gross domestic product per capita (GDP per capita), it reflects the wealth of the population, and is equal to the GDP of a country divided by the number of inhabitants. Highly appreciated by economists, it gives a complementary indicator of the level of development of a country. After the presentation of the variables, it is appropriate to give the sources of the data used in this study.

3.2 Data Sources

In this study, the data used for the estimates mainly come from two major sources: the Central Bank of West African States (BCEAO, 2020) and the Word Development Indicator (WDI, 2020). The summary of the variables and the different data sources are presented in Table 1.

Table 1. Summary of variables and sources

Variable	Description	Sources
CRED	Credit provided to the private sector by banks as a percentage of GDP	BCEAO
TPENS	Repurchase rate	BCEAO
PIBH	Gross domestic product per capita	WDI
TXCHR	Real exchange rate	WDI
TBDPB	Rate of deterioration of the bank portfolio	BCEAO

Source: Authors from the economic literature

After the description and presentation of the sources of the variables of the study, we can proceed to a step, that of providing the main results.

4. Results of Empirical Research

In the following lines, we will present, on the one hand, the econometric results of the study and, on the other hand, the economic interpretations.

4.1 Descriptive Statistics and Preliminary Test Results

We successively present the results of the descriptive analysis and the various preliminary tests.

4.1.1 Descriptive Statistics

The descriptive statistics of the model variables are recorded in Table 2. We note that credit, which is our dependent variable, has an average of 15.428% with a maximum of 41.065% against a minimum of 2.651%, this low average is explained by a low rate of banking in the area and the low monetary dimension of development. Regarding the repo rate, the average is 4.656%, a maximum of 6.31% and a standard deviation of 0.915. The low value of the standard deviation is explained by the maintenance of an expansionary monetary policy over the study period.

Table 2. Descriptive statistics of the variables

Variable	Observation	Mean	Standard deviation	Min	Max
CRED	154	15.428	7.342	2.651	41.065
TPENS	154	4.656	0.915	3.5	6.31
TBDP	154	7.424	4/121	0	21.526
TXCHR	154	2.806	7.612	-27.912	60.399
PIBH	154	723.133	310.599	322.149	1632.677

Source: Author's calculations from the data of BCEAO (2020) and WDI (2020)

In terms of per capita income, the average value, over the period from 1996 to 2017, is around USD 723.618, with a maximum amount of USD 1632.667 and an estimated standard deviation of 310.599. The high value of the standard deviation of income reflects the high inequality and heterogeneity in the area. As for the exchange rate, we note that the average is 2.806 and a maximum of 60.399. Such a gap could be explained by an appreciation of the currency and a loss of competitiveness. Regarding the gross degradation rate of the portfolio, it has a maximum of 21.526 and a minimum of 0, thus testifying to the good quality of the loans offered in the area. The correlation between the model variables is presented in Table 3.

Table 3. Correlation matrix

	CRED	TPENS	TBDP	TXCHR	PIBH
CRED	1.000				
TPENS	-0.507*	1.000			
TBDP	-0.062	0.048	1.000		
TXCHR	-0.161*	-0.015	-0.053	1.000	
PIBH	0.155*	-0.043*	-0.283*	0.115	1.000

Note: * means that the correlation is significant at the 5% threshold.

Source: Author's calculations from the data of BCEAO (2020) and WDI (2020)

The work of Kennedy (1985) shows that the multi-collinearity problem occurs when the correlation coefficient between two explanatory variables is greater than 0.8. Thus, from Table 3, it is possible to say that the variables are weakly explained among themselves. The strongest correlation at the level of explanatory variables is observed between the repurchase rate and the credit supply with a coefficient equal to -0.507. As a result, we can use all the variables of the empirical model.

4.1.2 Results of Preliminary Tests

As mentioned above, we present the results of the stationarity and linearity tests.

- Results of the stationarity tests of Breitung and Das (2005) and Pesaran (2007).

It is a question of checking whether a series is stationary or not, which makes it possible to see whether the structure of the process evolves or not over time. Indeed, when series are characterized by an average, a variance and a covariance that do not depend on time, we say that they are stationary. Generally, if one of these three characteristics is not respected, we are in the presence of non-stationary series. The results presented in Table 4 show that at the threshold of 10% and 1%, the variables TPENS, TXCHR, PIBH are all stationary while the variables CRED and TBDPB are integrated of order 1, that is to say stationary in first difference.

Table 4. Result of the stationarity test

	At Level		**First difference**		**Decision**
Variable	Pesaran	Breitung&Das	Pesaran	Breitung&Das	
CRED	0.897 (0.815)	0.244 (0.596)	-3.979*** (0.000)	-2.400*** (0.008)	I (1)
TPENS	-1.397* (0.081)	-1.618* (0.052)	-	-	I (0)
TBDPB	-0.255 (0.399)	-1.722** (0.042)	-7.540*** (0.000)	-6.035*** (0.000)	I (1)
TXCHR	-4.191*** (0.000)	-2.939*** (0.001)	-	-	I (0)
PIBH	-4.404*** (0.000)	-2.511*** (0.006)	-	-	I (0)

Note: (***, **, *) indicate statistical significance at the 1%, 5%, and 10% respectively.

Source: Author's calculations from the data of BCEAO (2020), GFDD and WDI (2020)

As a result, the variables CRED and TBDPB are introduced into the model as a first difference.

- Linearity test

The linearity test is applied in order to find out if the threshold effect is statistically significant and to demonstrate that the link between the explanatory variable and the explained variable can be represented using a regime change model. If the linearity hypothesis is rejected, then two tests of bad specifications must be successively set up. These are the constancy test of the parameters and the residual nonlinearity test or the

number of regimes. The hypotheses of the test are as follows:

H_0: Linear model

H_1: Non-linear model

Table 5. Result of the linearity test

	Test	Statistics	P-value
linearity test	Tests de Wald (LM)	9.094	0.059
	Tests de Fisher (LMF)	2.244	0.067
	Tests de LRT (LRT)	9.374	0.052

Source: Author's calculations from the data of BCEAO (2020) and WDI (2020)

The results of the linearity tests (Table 5), based on the statistics of: Wald (LM), Fisher (LMF) and LRT, unanimously reject, at the significance thresholds of 5% and 10% (p-value < 10%), the null hypothesis (H0) of a linear relationship between the credit supply and the monetary policy instrument, the repo rate. The linearity hypothesis being rejected, we proceed to the second step which consists in determining the optimal number of transition functions necessary to capture all the non-linearity. These tests for specifying the absence of residual non-linearity make it possible to identify the number of regimes. It will therefore be a question of seeing whether the null hypothesis of a PSTR model with a threshold (two regimes) is accepted or not.

The hypotheses of the test are as follows

$$\begin{cases} H_0: PSTR \ with \ r = 1 \\ H_1: PSTR \ with \ r \geq 2 \end{cases}$$

The results of these tests are recorded in Table 6. The results indicate that at a significance level of 10%, we cannot reject the null hypothesis of a PSTR model with a threshold (two regimes). It follows from this that the optimal number of transition functions, based on the same statistics (LM, LMF and LRT) is less than two. There is thus a single threshold that allows the transition from a regime of low gross portfolio degradation rate (regime 1) to a regime of high gross portfolio degradation rate (regime 2).

Table 6. Testing the number of regimes

Test	Statistics	P-value
Tests de Wald (LM)	1.988	0.738
Tests de Fisher (LMF)	0.441	0.779
Tests de LRT (LRT)	2.001	0.736

Source: Author's calculations from the data of BCEAO (2020) and WDI (2020)

This threshold separates the low (regime 1) and high (regime 2) gross portfolio degradation rate regimes. It is expected that banks, in their lending activity, will react differently to monetary policy in these two regimes.

4.2 Results of Estimates and Interpretations

This section includes the results obtained, the economic interpretations and the implications of economic policies.

4.2.1 Estimation Results

The results of Table 7 show that only the variables of the repo rate (TPENS) and the real exchange rate (TCHXR) are significant at the threshold of 10% and 5% respectively in the 1st regime. On the other hand, in the 2nd regime, only the variables of the gross rate of deterioration of the bank portfolio (TBDPB), and of the gross domestic product per capita (GIPP) are significant at the 5% threshold.

Table 7. Results of the PSTR model

Variable explained: CREDIT		
	Regime 1: TBDP ≤ 8.726	**Regime 2: TBDP > 8.726**
	Coefficients	**Coefficients**
TPENS	-4.141***	0.464
	(-12.277)	(0.849)
TBDPB	0.126	-0.543**
	(0.590)	(-2.041)
TXCHR	0.108**	-0.086
	(2.403)	(-0.928)
PIBH	-0.068	0.559**
	(-0.680)	(2.477)

Note: (***, **, *) indicate statistical significance at the 1%, 5%, and 10% respectively.

Source: Author's calculations from the data of BCEAO (2020) and WDI (2020)

When the credit risk is below the threshold of 8.726%, banks are sensitive only to changes in the repo rate (TPENS) and the real exchange rate (TXCHR). On the other hand, for any level of credit risk strictly higher than 8.726%, banks react only to the gross portfolio degradation rate (GDRR) and the gross domestic product per capita (GDIP).

4.2.2 Interpretation of Results and Discussions

We note in Table 9 that the effectiveness of monetary policy through the credit channel, in the WAEMU zone, banking depends on the level of credit risk reached by the banks. For the values of the gross rate of deterioration of the bank portfolio (TBDPB) less than or equal to the threshold of 8.726% (1st regime), we notice a decreasing relationship between the repurchase rate and the credit offer. The coefficient associated with the repo rate is negative and significant at the 10% threshold. Indeed, these results mean that, for a value of the gross rate of deterioration of the bank portfolio (TBDPB) less than or equal to 8.726%, a decrease in the repurchase rate translates into an increase in the supply of bank credit. Commercial banks were therefore reacting to an accommodative monetary policy when the risk involved is low. On the other hand, for values with a gross portfolio degradation rate (GDRR) strictly greater than 8.726% (2nd regime), the coefficient associated with repo rates is not significant, not even at the 10% threshold. For these values, the credit supply remains insensitive to a decrease in the repurchase rate. This result means that when the degree of credit risk reached by banks is below 8.726%, monetary policy through the bank credit channel is effective. On the other hand, when the credit risk reached by banks is above the threshold of 8.726%, monetary policy through the credit channel loses its effectiveness.

According to Abdou (2002), when the deterioration of the banks' portfolio reaches a certain threshold, the transmission of monetary signals through the bank credit channel could prove to be inefficient. These results imply that in order to be effective, any monetary policy measure aimed at increasing the supply of credit in the WAEMU area must take into account the level of credit risk reached by banks. Our result is in line with that of Trinnou and Igue (2015) who find that the monetary policy of the BCEAO loses its effectiveness when the rate of deterioration of the banks' portfolio reaches 18.82%. The difference in threshold with the study of Trinnou and Igue can be attributed to the methodology used and the period of the study. Starting from 8.726%, as a level of risk, banks begin a gradual reduction in the supply of credit. In the work of Trinnou and Igue, the reduction is abrupt from 18.82% risk level. In addition, the coefficient of the real exchange rate variable (TXCHR) is significant and positive at the 5% threshold in the first regime, but is not significant in the second regime. The positive relationship between the real exchange rate and the credit supply obtained in the first regime means that an increase in the real exchange rate leads to an increase in the credit supply. According to the Bella-Balassa effect, an appreciation of the currency means that there is dynamism in the economy. Indeed, an appreciation of the currency under a fixed exchange rate regime makes tradable goods less competitive and leads to an increase in imports, with the result that resources shift from the production of tradable goods to the production of non-tradable goods. This incentive of production demand will lead banks to increase the supply of credit. In

addition, the appreciation of the currency leads to a loss of competitiveness, which will lead the monetary authorities to intervene. This intervention takes the form of a relaxation of monetary policy favorable to the supply of credit. The coefficient of gross domestic product per capita (GIPP) is not significant in the first regime, on the other hand, it is significant and positive in the second regime at the 5% threshold. Indeed, when the credit risk reached by banks is above the threshold of 8.726%, banks lend only to agents with a high income. We also note that the gross portfolio degradation rate is not significant in the 1st regime, while it is significant at the 5% threshold in the 2nd regime. Thus, for any level of exposure to credit risk above 8.726%, banks reduce their credit offers. The only factor that can push banks to increase their credit offers is the renewed activity. In times of strong economic growth, banks increase their credit offers even if the risk involved is high. Here we find the idea of Minsky's "paradox of tranquility" (1986), according to which the more confident investors are, the riskier they will adopt a financing behavior.

5. Concluding Remarks

The objective of this study was to analyze the influence of monetary policy on the supply of credit in the WAEMU area during the period 1996-2017. Specifically, the aim was, on the one hand, to show how the repo rate affects the credit supply and, on the other hand, to show the role of the quality of the bank portfolio in the relationship between the repo rate and the credit supply in the WAEMU countries. Guinea-Bissau is excluded from the sample due to the absence of data on our study period. At the methodological level, we apply the panel smooth threshold regression (PSTR) model of Gonzalez et al. (2005. The results reveal the non-linearity of the link between monetary policy and the supply of credit. Indeed, there is a credit risk exposure threshold of 8.726%, beyond which monetary policy loses its effectiveness. The study indicates that monetary policy has a positive effect on the supply of credit when the value of the gross bank portfolio downgrade rate is less than or equal to the threshold of 8.726% and a non-significant effect beyond this threshold. Not being "short-sighted to disaster", banks refuse to grant loans once they cross this risk threshold in their loan portfolio. Similarly, the study indicates that in a risky environment, only the level of economic activity could encourage banks to increase the volume of loans distributed.

This result shows that in order to be effective, any monetary policy aimed at increasing the supply of credit in the WAEMU area will have to take into account the level of credit risk reached by banks. As major lessons, the reduction of banking risk in the WAEMU zone is a favorable factor for the supply of loans. In addition, economic performance remains an essential element of the distribution of bank credit in the area. Thus, the study recommends that monetary authorities further strengthen prudential supervision within the WAEMU. They must work to reduce banking risks in order to stimulate the supply of bank loans. As for the political authorities, they must continue their efforts to promote economic growth because it strengthens the confidence of the players in the banking sector. Despite the robustness of our results, this study used macroeconomic data that can mask individual and microeconomic realities. This is why a subsequent study, this time based on microeconomic or disaggregated data, will be able to deepen this research.

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