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Bank Credit Channel of Monetary Policy in the UEMOA Zone: A TVP-VAR Approach

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Abstract

The main objective of this article is to analyze the transmission of monetary policy in the WAEMU zone via the bank credit channel, using monthly data from January 1999 to December 2021. Methodologically, we apply a TVP-VAR model that allows coefficients to vary over time to reflect potential changes in time series dynamics. First, we find that the bank credit channel remains relatively weak in the union. Secondly, monetary policy shocks have evolved over time. Thirdly, the tertiary sector is relatively more responsive to monetary policy shocks than the primary and secondary sectors.

Keywords: WAEMU zone, monetary policy, bank credit channel, TVP-VAR

1. Introduction

Monetary policy is generally defined as the set of instruments or means used by the central bank to regulate the supply of money in an economy. Its main objective is to support economic activity through financing while ensuring price stability. Thus, the study of monetary policy involves the analysis of its main transmission channels, which enable us to understand how the central bank's actions influence economic variables (Abdul et al., 2010).

Theoretically, the literature highlights several transmission channels, namely the interest rate channel, the asset price channel, the exchange rate channel, and finally the bank credit channel (Bangura et al., 2021). The effectiveness of monetary policy depends heavily on the choice of transmission channel used, as well as on the specific characteristics of banks and the economic environment in which they operate. In developing economies such as those of the WAEMU zone, the asset price and exchange rate channels are inoperative due to the embryonic state of the financial market and the pegging of the local currency (CFA Franc) to the euro, through the fixed parity. Concerning the interest rate channel, Gbénou (2021) considers that it has strengthened in recent years within the union, but remains less significant than the credit channel. Kanga (2021) also seems to support this conclusion by examining the impact of monetary policy on banks' credit supply. The existing literature suggests that the only channel that remains operational in WAEMU zone is the bank credit channel.

The credit channel, initially developed by Bernanke and Blinder (1988) and subsequently taken up by Bernanke and Gertler (1995) and Kashyap and Stein (1995), focuses on how the supply of bank credit reacts to monetary policy impulses. From this perspective, this channel identifies two sub-channels through which the transmission of credit-based monetary policy operates. On the one hand, the balance sheet channel, which influences borrowers' net worth and therefore their ability to take out loans, and on the other, the bank credit channel, which acts through the reaction of the supply of loans to the economy to changes in the monetary policy stance (Bangura et al., 2021).

In the WAEMU zone, the Central Bank of West African States (BCEAO) is responsible for monetary policy. In recent years, the BCEAO has implemented major reforms such as the liberalization of the financial sector, the introduction of the minimum reserve system in 1993, the establishment of market mechanisms to inject liquidity into the banking sector, and adherence to the Basel Accords in 2018 to reinforce the stability of the banking system (Joseph, 2002).

The main aim of these reforms was to encourage bank lending, but there were several shortcomings. Firstly, it emerged that the union's banking sector continued to face excess liquidity. According to the March 2020

Monetary Policy Report, for the period from November 16 to December 15, 2019, reserve requirements stood at CFAF 701.9 billion, while banks maintained an average of CFAF 1,636.6 billion in reserves. This represents an excess of CFAF 937.7 billion. Similarly, the September 2022 report indicates that for the period May 16 to June 15, 2022, required reserves were CFA 1035.8 billion, while banks held CFA 3140.5 billion in reserves, generating a surplus of CFA 2104.7 billion in excess reserves.

However, despite the persistence of excess reserves, the countries of the union are subject to severe financing constraints. According to World Bank data (WDI, 2023), credit provided to the private sector represented an average of 22% of GDP in 2023. These credits are essentially dominated by short-term credits, estimated at 72.92% of total credit, and medium- and long-term credits at 25.7% and 7.34% respectively. Large companies receive 55.64% of credit granted, while micro, small, and medium-sized companies receive 28.27%, 11.51%, and 8.58% respectively. Given this contrast, the question this study seeks to answer is: to what extent does monetary policy influence bank credit supply conditions in the WAEMU zone?

In the WAEMU zone, the bank credit channel was found to be more effective than the interest rate channel, even though the former is strongly influenced by the heterogeneous characteristics (liquidity, solvency, risk-taking, and market power) of the zone's credit institutions (Gbénou, 2021). For his part, Kanga (2021) finds two important results. The first is that bank lending would be sensitive to monetary policy impulses. The second is that weakly capitalized banks reduce their lending more than strongly capitalized banks, following a restrictive monetary policy.

The present study differs from previous ones in several respects (Tadenyo, 2015; Koop & Korobilis, 2010). Firstly, the analysis of the reaction of credit to changes in monetary policy is based on monthly data, unlike previous studies, which were based on annual data. Thus, the monthly frequency of the data offers a clear improvement in the quality of the information, as opposed to annual data, which are merely aggregations, not allowing the variability of trends over time to be captured. Secondly, we disaggregate credit to the economy into credit to the various sectors of the economy (primary, secondary, and tertiary) to assess how sectoral lending reacts to monetary policy shocks. Previous research seems to have neglected the effects of changes in monetary transmission mechanisms on lending to different sectors of the economy. Indeed, in recent years, deregulation in the banking sector, the opening up to competition, the adoption of the single license system, and prudential standards, could modify the transmission channels of monetary policy. To ignore these developments would be to assume that the effects of monetary policy remain constant over time, which seems unlikely (Endut et al., 2018). This explains the use of the stochastic volatility VAR (TVP-VAR) model to examine the effects of monetary policy impulses. This approach has the advantage of allowing coefficients to be adjusted over time to reflect possible changes in the impact of monetary policy.

The remainder of this article is organized as follows. Section 2 reviews the literature on the subject. Section 3 is devoted to the methodological framework of the study. Section 4 is devoted to the results and section 5 to the conclusion.

2. Review of Theoretical and Empirical Literature on the Bank Credit Channel of Monetary Policy

This section is dedicated to the analysis of the theoretical review and empirical work.

2.1 Theoretical Review

In theoretical terms, the importance of the bank credit channel was demonstrated in the study by Bernanke and Blinder (1988). Three conditions must be met for this channel to function effectively. Firstly, the central bank must be able to regulate the volume of bank lending by adjusting reserves. Secondly, borrowers must not completely dissociate their actual spending from fluctuations in the availability of bank credit. Thirdly, there must be imperfect substitution between bank credit and other financial instruments (Oliner & Rudebusch, 1995).

According to Creel and Levasseur (2006), the credit channel operates by acting on two aspects: the supply of bank loans (bank lending channel) and the financial situation of potential borrowers (balance sheet channel). The bank-lending channel confers central importance on banking institutions because of their ability to resolve information imbalances in the credit market. The balance sheet channel, on the other hand, is concerned with the demand for credit and is based on the idea that adjustments in monetary policy can alter the net worth of borrowers. Thus, when the net worth of borrowers decreases, this leads to an increase in the risk premium due to asymmetric information between banks and borrowers (Hermando & Martínez-Pagés, 2001).

2.2 Empirical Review

In terms of empirical literature, studies have explored the existence of the bank credit channel in both developed and developing countries.

In Spain, using data from 1991 to 1998, Hermando and Martínez-Pagés (2001) validate the presence of the credit channel during this period. On a sample of 480 banks from Italy, Japan, Germany, and England, Salachas et al (2017) analyzed the influence of monetary policy on the bank credit channel before and after the 2007 financial crisis. The results indicate that the bank credit channel operated effectively in response to changes in central bank policy rates before the crisis, but that after it, this traditional mechanism was altered. Nevertheless, unconventional measures had a statistically significant impact on banks' credit supply behavior.

The work of Heryán and Tzeremes (2017) indicates that the effect of central bank policy rates on the bank credit channel is more pronounced in pre-crisis Europe than in post-crisis Europe.

In developing countries, a few studies exist on the credit channel of monetary policy.

In Nigeria, Matousek and Solomon (2018) examined the bank credit channel of monetary policy between 2002 and 2008. Using the system GMM estimator on a panel of 23 banks, they found that the monetary policy reforms undertaken had improved the functioning of the credit channel. The results also show that the volume of credit granted is a function of bank size and capitalization.

In Sierra Leone, on a panel of 11 banks, Bangura et al. (2021) showed that monetary policy had a significant and negative impact on the supply of bank loans. Specifically, the results indicate that a 100 basis point increase in the central bank's policy rate translates into a 0.43% reduction in the supply of credit to the economy. This finding supports the existence of a monetary policy transmission channel through bank lending in Sierra Leone.

In the case of SADC countries, over the period 1990 to 2006, Lungu (2007) examines the transmission mechanism of monetary policy, using a vector autoregression (VAR) model. The results generally indicate the existence of a bank-lending channel in all SADC countries, with a few variations. For UEMOA countries, studies by Kanga (2021) and Gbenou (2021) conclude that bank lending responds significantly to monetary policy. However, the bank credit channel is strongly influenced by bank-specific features such as capitalization and liquidity.

One limitation persists in all these studies. All these studies assume that transmission mechanisms remain constant over time. However, the UEMOA banking sector has undergone major changes in terms of interest rates, bank capitalization, and operational monetary policy instruments. To better understand the effect of variations in the transmission of monetary policy, VAR models with time-varying parameters are used. For example, Primiceri (2005) examines the role of monetary policy in U.S. dynamics and unemployment using a TVP-VAR with stochastic volatility for the period 1953 to 2001. His results show evidence of temporal variations in monetary policy over the period studied. In particular, he observes that unsystematic monetary policy has evolved considerably over the years, becoming less preponderant in the latter part of the sample. On the other hand, systematic monetary policy has become more aggressive in managing inflation and unemployment.

Concerning Japan, Ijiri (2017) studies the exchange rate and bank credit channel in Japan between 2001 and 2006, applying a TVP-VAR model. His results reveal that the exchange rate channel was most effective around 2005, while the bank credit channel remained relatively inactive.

3. Study Methodology

This section describes the model, the estimation procedure, the variables, and the data source.

3.1 Model Description

The present study builds on the work of Primiceri (2005) and Nakajima (2011), who analyzed monetary transmission mechanisms taking into account the variation of shocks as well as structural changes using a TVP-VAR model. The state-space model is represented as follows:

$$y_t = c_t + B_{1,t}y_{t-1} + \cdots + B_{k,t}y_{t-k} + u_t \qquad \text{With } t = 1, \dots, T \tag{1}$$

In equation (1), y_t is a vector $(n \times 1)$ of observed endogenous variables. c_t is a vector $(n \times 1)$ of time-varying coefficients that multiply the constant terms. $B_{i,t}, i = 1, \dots, k$ are the $(n \times n)$ matrices of time-varying coefficients. The u_t term represents unobservable heteroskedastic shocks with variance-covariance matrix Ω_t. Using triangular reduction, the variance-covariance matrix can be rewritten as follows:

$$\Omega_t = A_t^{-1} \sum_t \sum_t (A_t^{-1})' \tag{2}$$

where A_t is a lower triangular matrix reflecting the simultaneous relationships between the variables, with the elements of the main diagonal all equal to one. In addition, the matrix A_t is allowed to vary over time. $\sum_t$ is a diagonal matrix for idiosyncratic shocks:

$$A_t=\begin{pmatrix} 1 & 0 & \dots & 0 \\ a_{21,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{n1,t} & \cdots a_{n,n-1,t} & & 1 \end{pmatrix} \qquad \sum_t=\begin{pmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \cdots & \vdots \\ \vdots & 0 & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{n,t} \end{pmatrix}$$

Thus, equation (1) becomes:

$$y_t = c_t + B_{1,t}y_{t-1} + \cdots + B_{k,t}y_{t-k} + A_t^{-1}\sum_t \varepsilon_t \qquad \text{With } \varepsilon_t \sim N(0, I_n) \tag{3}$$

The reduced form of equation (3) is as follows:

$$Y_t = X_t B_t + A_t^{-1}\sum_t \varepsilon_t \tag{4}$$

With $X_t = I_n \otimes [1,\ y_{t-1}, \dots\dots,\ y_{t-k}]$, where the symbol $\otimes$ represents the Kronecker product

The modeling strategy is to model the coefficient process in equation (4) rather than equation (1). Indeed, the bijective correspondence between the two equations fully justifies this approach. Let α_t be the vector of non-zero and non-equal-to-one elements of matrix A_t (stacked by rows) and σ_t the vector of diagonal elements of matrix $\sum_t$. The time-varying parameter dynamics of the model are specified as follows:

$$B_t = B_{t-1} + v_t \tag{5}$$

$$\alpha_t = \alpha_{t-1} + \xi_t \tag{6}$$

$$log\sigma_t = log\sigma_{t-1} + \eta_t \tag{7}$$

The distribution assumptions concerning $(\varepsilon_t, v_t, \xi_t, \eta_t)$ are stated below. The elements of the vector B_t are modeled as random walks, as are the free elements of the matrix A_t. The standard deviations σ_t are assumed to evolve according to geometric random walks, belonging to the category of model known as stochastic volatility. All innovations in the model are assumed to be jointly distributed according to a normal distribution, with the following assumption concerning the variance-covariance matrix:

$$V = var\begin{bmatrix} \varepsilon_t \\ v_t \\ \xi_t \\ \eta_t \end{bmatrix} \sim \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix} \tag{8}$$

Where I_n is an n-dimensional identity matrix. Q, S, and W are positive definite matrices. Note that none of the restrictions on the structure of V is essential. All null blocks could be replaced by non-null blocks, with slight modifications to the estimation procedure to be described in the next section.

3.2 Description of Variables and Data Sources

The data used in this study come from monthly time series extracted from the BCEAO database for the year 2022 (BCEAO, 2022). The time interval examined covers the period from January 1999 to December 2021. This study period is relevant because it coincides with the year of implementation of the inflation-targeting rule, allowing the period to be divided into two equal sub-samples. We use the WAEMU money market rate (MMR) as a monetary policy instrument, i.e. the rate at which the BCEAO lends liquidity to commercial banks. An increase in the MMR indicates a restrictive monetary policy, while a decrease corresponds to an expansionary monetary policy. This variable was used by Nubukpo (2002) as a monetary policy instrument in an earlier study.

To assess the impact of monetary policy shocks on the credit channel, we use credit to the economy (Cred_eco) like Gbenou (2021). Credit to the economy measures the quantity of credit offered to economic actors by banks. Theoretically, a positive monetary policy shock leads to a reduction in the supply of credit. In terms of measuring the output gap, we use the Industrial Production Index (IPI), which was also employed by Oloufade (2015). According to theory, a restrictive monetary policy leads to a decrease in output. Therefore, the theoretical prediction suggests that an increase in the IMT is accompanied by a reduction in credit and output.

To assess the sensitivity of the various sectors of activity to monetary policy shocks, we take into account the credit allocation specific to each sector, i.e. loans granted to the primary (Cred_prim), secondary (Cred_sec), and tertiary (Cred_ter) sectors. Within the union, these sectors rely heavily on credit flows from the banking sector to support the development of their activities. Consequently, a tightening of monetary policy could potentially restrict lending conditions, thereby hampering growth in these sectors. It is therefore foreseeable that a significant increase in money market rates would lead to a reduction in the volume of credit allocated to these sectors.

Several indicators are available for measuring inflation. For example, Tandeyo (2015) used the consumer price index and its components, while Fall and Sy (2019) opted for the harmonized price index. In our study, we use the Consumer Price Index (CPI) as an indicator of the level of inflation. An increase in the CPI reflects a

deterioration in the purchasing power of economic agents. In line with economic theory, a positive monetary policy shock leads to a fall in the level of inflation. Consequently, we anticipate that a positive shock to the Tmm will result in a negative response from the Ipc. Table 1 summarizes the variables and predicts the expected signs.

Table 1. Summary of variables and prediction of expected signs

Variables	Variable definitions	Sources	Predictions
Tmm	Monthly money market rate	BCEAO	
Ipc	Consumer price index	BCEAO	-
Ipi	Industrial production index	BCEAO	-
Cred_eco	Credit to the economy	BCEAO	-
Cred_prim	Primary sector credit	BCEAO	-
Cred_sec	Credit to the secondary sector	BCEAO	-
Cred_ter	Credit to the tertiary sector	BCEAO	-

Source: Author based on literature.

3.3 Estimation du TVP-VAR

According to Nakajima (2011), there are several estimation methods for TVP-VAR models. When the coefficients are time-varying and volatility is constant, the parameters can be estimated using the standard Kalman filter. In the case of stochastic volatility, however, this method is not easy to implement, as the model forms a non-linear state-space model. The difficulty therefore lies in choosing a model that can represent the key parameters while avoiding over-parametrization (Koop et al., 2009; Koop & Korobilis, 2010; Korobilis, 2013). Under these conditions, Bayesian methods are highly recommended for estimating this class of model, as they enable us to solve the problem of over-parametrization. Bayesian methods are used to evaluate the joint posterior distributions of the parameters of interest, i.e. the unobservable states and the hyper-parameters of the covariance-variance matrix V, based on established prior probability densities (Primiceri, 2005). With Bayesian inference, the Monte Carlos Markov Chain (MCMC) sampling method is used, the aim of which is to evaluate the joint a posteriori distribution of the parameters of interest under a certain a priori probability density that the researchers have set in advance. MCMC effectively handles problems of high dimensionality in the parameter space and preserves parsimony in the estimation of time-varying parameters. This approach also deals with model non-linearity by dividing the original estimation problem into smaller, simpler ones, resulting in smoothed estimates (Primiceri, 2005).

4. Results and Discussion

This section is structured around two main points. The first deals with data analysis, while the second is devoted to analysis and commentary on the results.

4.1 Data Analysis and Preliminary Tests

The results of the descriptive statistics of the variables are summarized in the following table.

Table 2. Descriptive statistics of variables

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Tmm	276	3.745	1.048	2	4.95
Ipi	276	98.673	17.946	62.65	147.1
Ipc	276	90.806	12.218	68.7	111.8
Cred_sec	276	907409,3	432029,9	129162	1751212
Cred_ter	276	3319404	1927602	477088	8250986
Cred_prim	276	177806,3	100426,1	39199	468174,3
Cred_eco	276	4405630	2434505	645449	1,00E+07

Source: Author based on BCEAO data (2022).

According to Table 2, the monthly money market rate averaged 3.745% over the study period. The standard deviation, at 1.048, remains below the average, suggesting moderate volatility in the money market rate, with minimum and maximum values of 2% and 4.95% respectively. About loans granted to the economy within the union, the average stands at 4,405,630 million. However, an analysis of sectoral credits reveals distinct averages of 3,319,404 million for the tertiary sector; 907,409.3 million for the secondary sector, and 177,806.3 million for the primary sector. The tertiary and secondary sectors are the biggest beneficiaries of bank loans. The average

consumer price index stands at 90.806, with a standard deviation of 12.218.

The industrial production index averaged 98.673%, and its low volatility (17.946) suggests a high degree of similarity between the countries of the union in terms of industrial production. The correlation matrix between the variables is shown in Table 3.

Table 3. Corr dation matrix of variables

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
[1] Ipi	1						
[2] Ipc	0.580*	1					
[3] Cred_prim	0.697*	0.800*	1				
[4] Cred_sec	0.605*	0.927*	0.872*	1			
[5] Cred_ter	0.703*	0.955*	0.884*	0.951*	1		
[6] Cred_eco	0.692*	0.955*	0.896*	0.969*	0.997*	1	
[7] Tmm	-0.484*	-0.871*	-0.605*	-0.750*	-0.819*	-0.807*	1

Source: Authors based on BCEAO data (2022).

Note. * represents the significance level at 5%.

Table 3 shows a negative correlation between the monthly money market rate and the volume of credit extended to the economy, illustrated by a coefficient of around -0.807. If we assess the relationship between the money market rate and the set of sector lending variables, we also find a negative correlation. The coefficients are -0.605, -0.750, and -0.819 respectively, for credit to the primary, secondary, and tertiary sectors. These figures indicate that monetary policy shocks have a more marked influence on credit to the tertiary and secondary sectors.

For the industrial production index and the consumer price index, there is a negative correlation with the money market rate, with coefficients of -0.871 and -0.484 respectively.

It follows from this analysis that the money market rate has a stronger influence on the consumer price index than on the industrial production index within the union.

4.2 Presentation of Bayesian Inference Results

For this analysis, four models have been estimated. The first model analyzes the sensitivity of credit to monetary policy shocks. The other three models respectively assess the sensitivity of sectoral credit (primary, secondary and tertiary sectors) to monetary policy shocks. But first, we take care to find the optimal number of lags in the model. Based on the Akaike (AIC) and Schwartz (SC) information criteria, 4 lags are retained in models 1; 2, and 4, while model 3 is estimated with an optimal number of lags of 2. Tables 4; 5; 6 and 7 present the results of the TVP-VAR model. These results are obtained by implementing the MCMC algorithm, which gives the posterior means and standard deviation, confidence interval, Geweke convergence diagnosis, and inefficiency for the four models.

Table 4. Result of Model 1 with credit to the economy

Parameter	Mean	Standard deviation	[95%U	95%L]	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.225	15.87
sb2	0.0023	0.0003	0.0018	0.0028	0.781	15.3
sa1	0.005	0.0029	0.0031	0.0118	0.023	37.67
sh1	0.2255	0.0318	0.1724	0.2978	0.534	47.68
sh2	0.7251	0.0943	0.5722	0.9301	0.46	117.9

Source: Authors based on BCEAO data (2022).

Table 5. Model 2 results with credit to the primary sector

Parameter	Mean	Standard deviation	[95%U	95%L]	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.521	12.86
sb2	0.0023	0.0003	0.0019	0.0029	0.929	16.81
sa1	0.0043	0.0008	0.0031	0.0064	0.515	36.83
sh1	0.2199	0.0305	0.1681	0.289	0.627	42.59
sh2	0.693	0.071	0.5629	0.8396	0.503	41.12

Source: Authors based on BCEAO data (2022).

Table 6. Model 3 results with credit to the secondary sector

Parameter	Mean	Standard deviation	[95%U	95%L]	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.221	14.44
sb2	0.0023	0.0003	0.0018	0.0029	0.479	10.9
sa1	0.0043	0.0009	0.003	0.0064	0.348	41.9
sh1	0.0074	0.0031	0.0039	0.0153	0.008	191.48
sh2	0.423	0.0468	0.3383	0.5209	0.654	58.6

Source: Authors based on BCEAO data (2022).

Table 7. Model 4 results with credit to the tertiary sector

Parameter	Mean	Standard deviation	[95%U	95%L]	Geweke	Inefficiency
sb1	0.0023	0.0003	0.0018	0.0029	0.343	12.42
sb2	0.0023	0.0003	0.0018	0.0029	0.218	20.18
sa1	0.0233	0.0622	0.0034	0.1659	0.01	27.81
sh1	0.3022	0.0347	0.2448	0.38	0.595	88.63
sh2	1.0624	0.1764	0.728	1.4193	0.004	220.44

Source: Authors based on BCEAO data (2022).

Examination of the various tables 4; 5; 6 and 7 shows that the null hypothesis of convergence to the a posteriori distribution cannot be rejected, as all Geweke values are below 1, i.e. the results converge to the a posteriori distribution. What's more, all the inefficiency factors are below 100, except for a single case in models 1, 3, and 4. This suggests that the sum of iterations is appropriate for convergence of the TVP-VAR model parameters and that our sampling of a posteriori draws is efficient. Furthermore, the estimated posterior averages for each parameter lie within their respective 95% confidence intervals, indicating that it is reasonable to assume that the estimated posterior averages are close to the true value. Here, the MCMC algorithm generates efficient posterior draws (Nakajima, 2011).

Figures 1; 2; 3 and 4 show the sample autocorrelation, sampling paths, and parameter densities for each model.

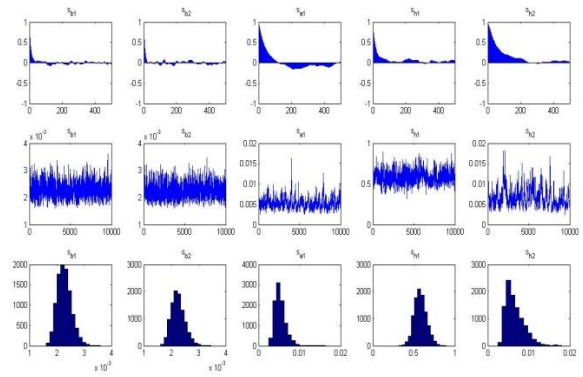

Figure 1: Model 1

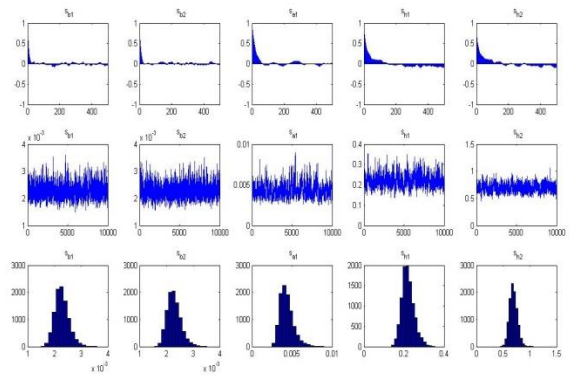

Figure 2: Model 2

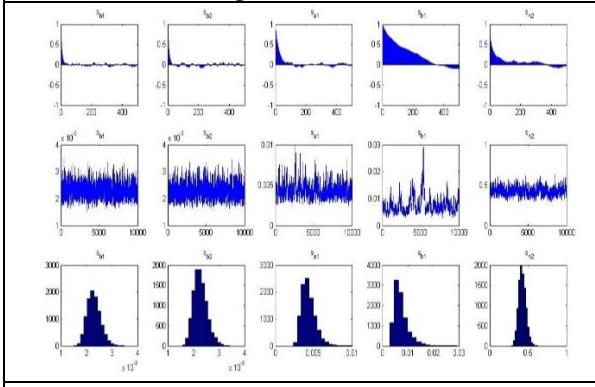

Figure 3. Model 3

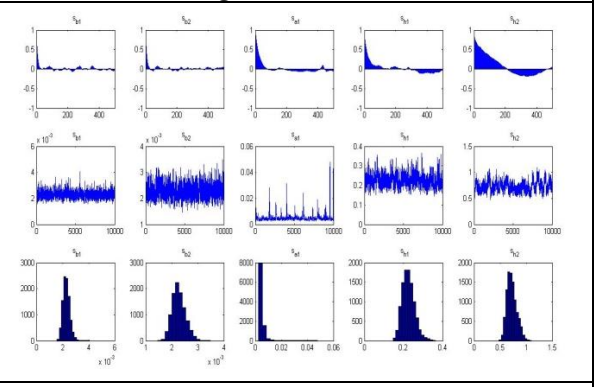

Figure 4. Model 4

Source: Author based on BCEAO data (2022).

Analysis of Figures 1; 2; 3 and 4 reveals, for each of the four models, a steady decrease in autocorrelations, which eventually stabilize around zero. This suggests that the sampling method effectively produces samples with low autocorrelation, as argued by Primiceri (2005). Furthermore, the trajectories of the samples all remain relatively stable, indicating that the samples generated by the MCMC method are efficient (Nakajima, 2011). Finally, the a posteriori densities indicate that the estimates obtained via the MCMC method generate stable samples. Figure 5 shows the stochastic volatility of the different variables.

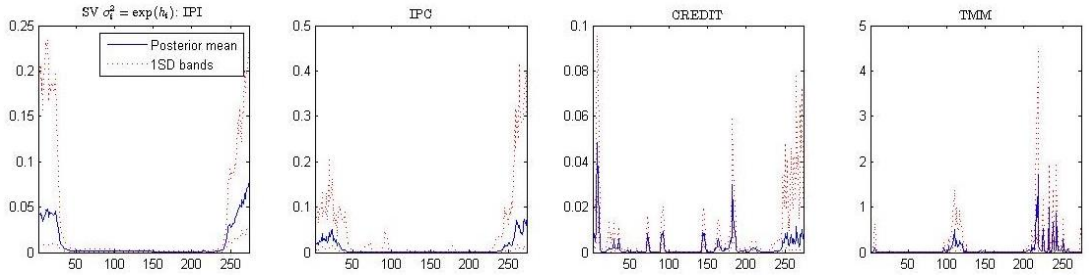

Figure 5. Stochastic volatility of variables

Source: Author based on BCEAO data (2022).

Note. the x-axes are graduated in several periods. 50 = February 2003; 100 = April 2007; 150 = June 2011; 200 = August 2015 and 250 = November 2020.

Figure 5 shows that the volatility of the industrial production index and the consumer price index was slightly high between 1999 and 2000. However, this is canceled out and remains constant until 2019. From 2019 onwards, both indices again show increasing volatility. Credit volatility seems persistent over the whole period, and that of the monthly money market rate reached its first peak in April 2007, before easing around 2011. From August 2015 to November 2020, the money market rate again showed high volatility. As a result, credit and the monthly money market rate appear highly volatile about the industrial production index and the consumer price index. The next step is to analyze the impulse response functions of the various variables to the monetary policy shock.

4.3 Analysis of TVP-VAR Impulse Response Functions

The impulse response functions (IRF) of the TVP-VAR will be analyzed by considering, firstly, total credit to the economy and, secondly, sectoral credit.

For the analysis of IRFs for credit to the economy in response to a monetary policy shock, responses are constructed for a four-month horizon (dotted line), an eight-month horizon (dashed line), and a one-year horizon (solid line). Figure 6 shows the impulse response functions.

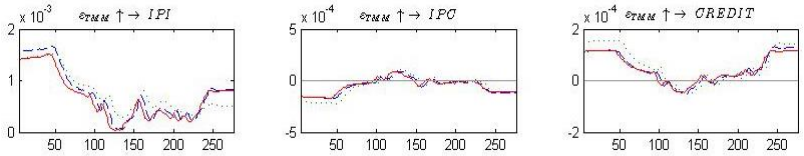

Figure 6. Impulse response function for Model 1

Source: Authors based on BCEAO data (2022).

Note. abscissa axes are graduated in several periods. 50 = February 2003; 100 = April 2007; 150 = June 2011; 200 = August 2015 and 250 = November 2020.

In Figure 6, we see that over the period 1999 to 2021, credit to the economy initially reacted positively to monetary policy tightening, but this impact tends to diminish from February 2003 onwards, even turning negative in April 2007. From then on, credit to the economy increases over the rest of the period. This result indicates that a tightening of monetary policy induces a fall in credit in the short term, but in the medium term, bank credit increases in the WAEMU zone. Monetary tightening was not automatically passed on to banks, which probably means that the supply of bank credit is less sensitive to changes in money market rates. This counter-intuitive result could be justified by the excess liquidity enjoyed by the sub-regional banking system (Doumbia, 2011). Indeed, in an environment characterized by high excess reserves and strong bank capitalization, banks enjoy a certain degree of autonomy vis-à-vis the central bank, enabling them to adjust the

volume of credit they extend at will, despite variations in key rates. In the long run, this situation may amplify the inefficiency of monetary policy in the union.

Figure 6 also shows that the industrial production index reacts positively to a positive monetary policy shock. However, the growth rate of the industrial production index, which appears to be higher between 1999 and 2003, gradually declines, albeit positively, to stabilize from 2008 onwards. A tightening of monetary policy leads to an increase in industrial production in the Union. Although contrary to our expectations, this result is in line with that obtained by Oloufadé (2015) for the UEMOA zone.

As for the consumer price index, in response to a positive monetary policy shock, it reacted negatively, although its impact was slight at the start of the period. It then began to rise slightly, stabilizing at its equilibrium level from April 2007. The negative reaction of the consumer price index to the monetary policy shock is in line with the literature. However, the positive reaction of the price index shows that the general price level reacts weakly to the monetary policy shock in the WAEMU zone. Monetary policy has a weak influence on the price level, as emphasized by Tadenyo (2015), a sign of poor transmission to prices of the signals issued by the monetary authorities.

Still concerning model 1, Figure 7 presents the impulse response functions at different dates arbitrarily chosen over a period n of 12 months to assess the change in the transmission of monetary policy. In order to assess the change in the transmission of monetary policy, we arbitrarily selected the dates of February 2003 and June 2011, representing the periods before and after the implementation of the inflation-targeting policy. We chose the November 2020 date to observe current monetary policy transmission.

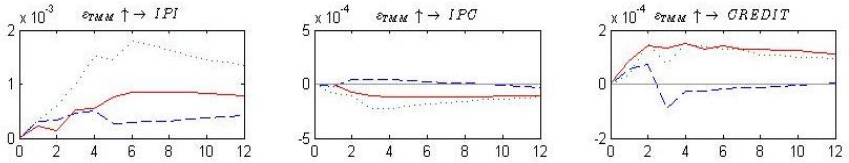

Figure 7. Model 1 impulse response function for the change in transmission of the monetary mechanism

Source: Author based on BCEAO data (2022).

Note. 50 = February 2003; 150 = June 2011 and 200 = November 2020.

Figure 7 shows whether the impact of monetary policy on credit, industrial production, and the price index has varied over time. Concerning credit, we find that a positive monetary policy shock leads to a positive and growing credit response over a two-month horizon for the years 2003 and 2020. This period of growth is immediately followed by a sharp fall in credit, which becomes negative before returning to its equilibrium level after six months. Figure 7 shows that the industrial production index reacts positively to the monetary policy shock, from the very first month for all three dates. However, the impact was greater in 2003, with a response of around 2% in the sixth month, while in 2011 and 2020 it was 0.2% and 0.5% respectively. From the sixth month onwards, the effect begins to dissipate. As for the consumer price index, it reacts negatively but weakly to the monetary policy shock for the post-inflation-targeting dates. After the first month, the effect begins to fade, becoming zero by the sixth month.

Overall, prior to 2010, monetary policy did not react to shocks to the consumer price index. However, from 2010 onwards, the Monetary Policy Committee considered shocks to the consumer price index. Monetary policy tightening reduces the consumer price index at the start of the period but increases it after that. Moreover, there is a positive relationship between the consumer price index and positive credit shocks, indicating that increased credit leads to an increase in the quantity of money in circulation, which in turn raises the general price level. If the tightening of monetary policy fails to reduce inflation, then this is certainly due to the excess liquidity of WAEMU banks, which encourages them to lend. Such a scenario is plausible, given that the relationship between MMR and credit shocks, which was zero between 1999 and 2010, became positive from 2010 onwards. Indeed, between 1999 and 2010, monetary policy did not react to credit shocks. However, with the implementation of the inflation-targeting policy in 2010, credit shocks are perceived as sources of inflation. Thus, following a positive credit shock, MMR increases to counteract the inflationary effects.

Indeed, the implementation of the inflation-targeting policy and the definition of financial stability as the primary objective of monetary policy have enabled the Monetary Policy Committee to fight inflation more effectively.

Shocks to the industrial production index have no effect on monetary policy, indicating that the industrial

production index is not taken into account in the central bank's reaction function. Moreover, monetary policy tightening does not have a negative effect on industrial production, as it acts positively on the industrial production index over the entire study period.

The results indicate that during the period 1999-2010, the consumer price index was somewhat sensitive to shocks to the industrial production index. However, from 2010 to 2021, the industrial production index and the consumer price index are unrelated. Indeed, from 2010 onwards, when inflation targeting began, industrial production shocks have no effect on the consumer price index.

At the end of these various simulations, it appears that there has been a change in the transmission of monetary policy in the WAEMU zone. In addition, monetary policy shocks are not always conctracyclical and have little impact on real variables. These results show that the BCEAO money market rate has little impact on the economy's real variables.

Following these various analyses, we introduce sectoral credit variables into the model in order to assess the sensitivity of different sectoral credits to monetary policy shocks. The Figure gives an overview of the sectoral impulse response functions.

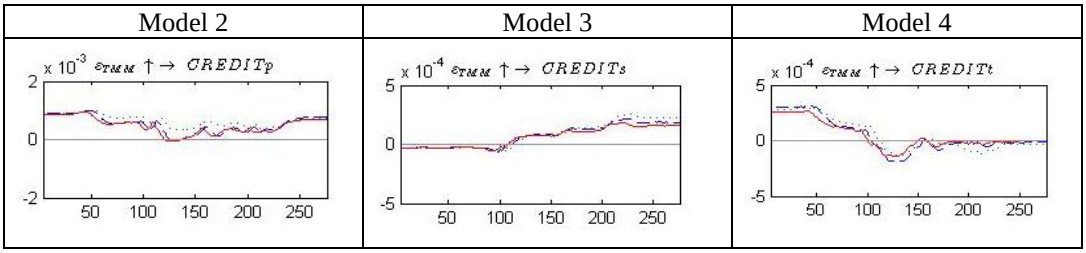

Figure 8. Impulse response function of sectoral credits

Source: Author based on BCEAO data (2022).

Note. abscissa axes are graduated in several periods. 50 = February 2003; 100 = April 2007; 150 = June 2011; 200 = August 2015 and 250 = November 2020.

In Figure 8, models 2, 3, and 4 show the impulse response functions for credit to the primary, secondary, and tertiary sectors respectively. Looking at the impulse response functions, we see that credit to the primary sector reacts positively to a monetary policy shock, although this impact remains relatively stable over the whole period, stability is no doubt linked to the fact that the volume of credit granted to the primary sector is limited. Credit to the primary sector seems to react little to monetary policy shocks within the union. For the secondary sector, credit initially reacted negatively, but very slightly, to monetary policy shocks between January 1999 and April 2007. Thereafter, this reaction becomes positive, and credit to this sector increases for the rest of the period. As a result, the impact of monetary policy on credit to the secondary sector is negligible overall prior to 2010, as the producer price index is virtually independent of monetary policy shocks. However, from 2011 onwards, credit granted to this sector increases, certainly with the recovery of the zone's economy following the Ivorian crisis.

Credit to the tertiary sector initially reacts positively to monetary policy shocks, but this reaction diminishes considerably, becoming negative in April 2007. From then on, it begins to increase slightly, finally stabilizing at its equilibrium level by June 2011. This suggests that credit to the service sector is more sensitive to monetary policy shocks than credit to the other two sectors. One possible explanation for these results lies in the fact that, within the countries of the union, the tertiary sector is the most dynamic, encompassing sub-sectors such as trade, services, public works and construction. The tertiary sector accounts for around 56% of GDP in Côte d'Ivoire and 61% of GDP in Senegal, the two largest countries in the Union.

As of 2011, a tightening of monetary policy has had no depressive effect on the primary and secondary sectors. Lending to these two sectors does not depend on the BCEAO monetary rate. On the other hand, a tightening of monetary policy would have a more significant impact on the tertiary sector, as the volume of credit granted to this sector is highly dependent on the BCEAO monetary rate.

5. Conclusion

This article aimed to examine the transmission of monetary policy in the WAEMU zone through the bank credit channel. To this end, we applied a TVP-VAR model to data from January 1999 to December 2021. After estimation, the results indicate that BCEAO's monetary policy has a weak influence on real economic variables. A positive monetary policy shock positively affects credit to the economy, but its impact gradually diminishes

over time. This result indicates that a restrictive monetary policy leads to an increase in credit to the economy. Such a result could be explained by the high capitalization of banks and the excess bank liquidity that makes them autonomous from the central bank. The study also concludes that the tightening of monetary policy has a negative but weak influence on the consumer price index, while its impact on the industrial production index is positive.

Furthermore, our simulations based on impulse response functions indicate that there has been a change in the transmission of monetary policy in the WAEMU zone. Analysis of the sensitivity of sectoral credits (primary, secondary, and tertiary) to monetary policy shocks reveals that the primary and secondary sectors are less sensitive to monetary policy shocks than the tertiary sector.

However, the results did highlight the credit channel of monetary policy in the UEMOA zone, given that the results indicated a relationship between MMR and credit shocks that was zero between 1999 and 2010 and became positive from 2010 onwards. This result is contrary to those of Heryán and Tzeremes (2017), who indicate that the effect of central bank policy rates on the bank credit channel is more pronounced before the crisis than after the crisis in Europe.

Overall, the findings indicate that the effects of monetary policy changes within the WAEMU zone are not very effective in terms of price levels, industrial production, and credit to the economy. In terms of economic policy implications, it is up to the monetary authorities to implement mechanisms aimed at reducing excess liquidity in the banking sector. This could considerably improve the effectiveness of monetary policy and facilitate better financing of local economic activities. Furthermore, given that the transmission of monetary policy evolves, monetary authorities must improve their assessment methods to constantly adjust their decisions to make them consistent with the economic context. The monetary authorities must ensure that monetary policy, as an economic policy instrument, is geared to channeling financing towards high value-added sectors.

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