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Monetary Policy, Commodity Prices and Credit in Brazil: A SVAR Approach

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Abstract

This study aims to analyze, leaning on a structural autoregressive vector (SVAR), whether external variables, such as the commodity price index and the US GDP, are relevant to consistently capture the dynamic interaction between credit and important domestic variables in Brazil, namely, GDP, inflation, interest rate and exchange rate. Shocks to the interest rate happen to be important for credit dynamics. At short horizons, shocks to credit itself play a greater role in explaining this variable. At long horizons, shocks to commodity prices are taken to be a respectable player in credit growth. The results also indicate that a positive shock to the interest rate implies a reduction in Brazilian GDP, remaining below its baseline. In turn, a positive shock to credit gives rise a small growth in Brazil's GDP during a quarter, returning, thereafter, to its baseline. Finally, in the long run, the variance decomposition shows that shocks to commodity prices explain about 67%, 47%, 43% and 15% of the forecast error related to Brazilian GDP, credit, exchange rate and interest rate, respectively. This fact can be taken as an important determinant toward the dynamics of domestic variables in Brazil.

Keywords

Credit Cycle in Brazil, Commodities, SVAR

1. Introduction

There is a remarkable consensus on one point amongst recent scholars, e.g. Bernanke & Gertler (1990), Holmström & Tirole (1997), Kiyotaki & Moore (1997) and Diamond & Rajan (2005): private credit is said to be procyclical. Granted recessions, no new credit is offered. Further, they all seem to embrace the thesis according to which credit supply fits with business cycle and, in particular, its evolution. Moreover, it remains hard to prove it empirically. For the sake of illustration, the question about private vs public credit providers—e.g, why neither banks are prompt to lend (supply side), nor firms are willing to borrow (demand side), or both cases—, hinges partly on how one understands that thesis.

The importance given even today to the bank loan supply for the overall economy makes it clear that the issue is far from settled. It has even been claimed that it requires a particular empirical treatment. Several studies have focused on exogenous shocks to bring forth the causal evidence between availability of bank credit and economic activity. In line with this, Peek & Rosengren (2000) analyze the American contraction in loan supply yielded by Japanese banks within the context of the Japanese banking crisis in the early 1990s. By contrast, Leary (2009) draws the expansion of the US bank loans in the first half of the 1960s (i.e., after the financial innovation due to certificates of deposit in 1961 and during the 1966 Credit Crunch).

More recently, Chava & Purnanandam (2011) examine the effects associated with exogenous disruptions on the loan supply during the Russian crisis of Fall 1998. In most studies, it has been indicated undeniable advantages of bank loan supply concerning firms' finances. But this good deal of evidence proves little. Each of these results, taken in isolation from other sources of variation, may seem implausible to capture variation in loan supply related to business cycle in all its extension.

From another viewpoint, Garcia-Cicco et al. (2017) compare (in the reaction to shocks) the effect of monetary and macroprudential policies on financial and real sectors in four Latin America countries, namely, Chile, Peru, Mexico and Colombia (to be clear, commodity-exporting countries). Within this compass, the authors estimated a small open economy model (DSGE) with frictions in the credit market and a commodity sector for each country. Consequently, for most countries, the effect of external shocks on commodity prices has led to an increase in the supply of credit.

In the same vein, but in a different setup—using wavelet analysis—Ftiti, Kablan, & Guesmi (2016) analyze the relationship between commodity prices and credit to the private sector in commodity-exporting developing countries in three Sub-Saharan Africa: Burkina Faso, Niger and Ivory Coast. They find that the credit market strongly reacts to commodity shocks in the long term, which ensures the lead-lag relationship between the two variables. So, it seems that the question of the influence of commodity prices on the magnitude of credit in the economy has started to be addressed. The present work also contributes to this literature.

Berkelmans (2005), in turn, estimates a small structural vector autoregression (SVAR) model for Australia to evaluate the intertwined relationships of credit with other representative macroeconomic variables. Eventually, shocks to the interest rate, as well as the exchange rate, and past shocks to credit are, in the short run, found to be important for credit growth, whereas, by contrast, in the long run, shocks to output, inflation and commodity prices are said to play a greater role.

In a different scope to the one pursued in this work, Boateng et al. (2020) analyze the impacts of the monetary policy shock on the prices of some commodities in Ghana, using the Vector Error Correction (VEC) model. The study revealed that in the long run, monetary policy rates are negatively correlated to crude oil prices and positively correlated to both cocoa prices and gold prices but to a little extent.

Within this economic spectrum, the present paper aims to evaluate whether, in the case of Brazil, shocks from external variables, e.g. the index of commodity price and the US GDP, are relevant to determine the extent to which the dynamic interplay between credit and a cluster of variables is realized.

In fact, according to a survey carried out in 2014 by the United Nations Conference on Trade and Development (UNCTAD), commodities are so important determinants for Brazilian economy dynamics that they represent 65% of Brazilian exports. By that time, the Ministry of Development, Industry and Foreign Trade (MDIC) announced to the public that commodities rank among the top ten most exported products.

An analysis provided in 2017 by this fact enables Brazilian Central Bank (BCB) targets the ratio of total credit (credit operations to financial market) to GDP in 50%, which is relatively low when compared to the one obtained in advanced economies such as the U.S, whose credit/GDP ratio is about 150%. While comparing it to emerging (or of mean income) countries, e.g. Chile, whose credit/GDP ratio is above 70%, Brazilian credit needs many improvements. However, during this thirteen-years period (2003-2016), Brazil happens to register a credit cycle. In 2003, such ratio was 23% but 49% in 2016. By the way, this credit cycle is made up of four stages as follows: firstly, a credit boom (2003-2008); secondly, the financial contagion effect caused by the subprime crisis (2009-2011); thirdly, a stationary period (2012-2014); finally, a massive retracement period, leading to a reduction in the demand for credit.

Regarding the aforementioned cycle, **Figure 1** plots the ratio between credit balance granted by National Financial System and the corresponding annual values to GDP and the Economic Activity Index (measured by BCB)[1]: the first panel denotes the procyclicality between the credit level as a proportion of GDP and the real economy measured by the IBC-BR, while the second presents the deflated credit balance and its percentage change month over month. **Figure 2**, in turn, is composed of four panels. The first presents the interesting procyclicality between the credit-to-GDP ratio and commodity prices. The second exposes the co-movements between the credit-to-GDP ratio, inflation and interest rates. The third, on the other hand, denotes a possible countercyclicity between

[1]The latter is an indicator crafted with a goal in foreseeing the Brazilian GDP. It can be taken as a primary result toward the evolution regarding Brazilian economic activity, helping the policymakers to define the target to the basic interest rate of the economy.

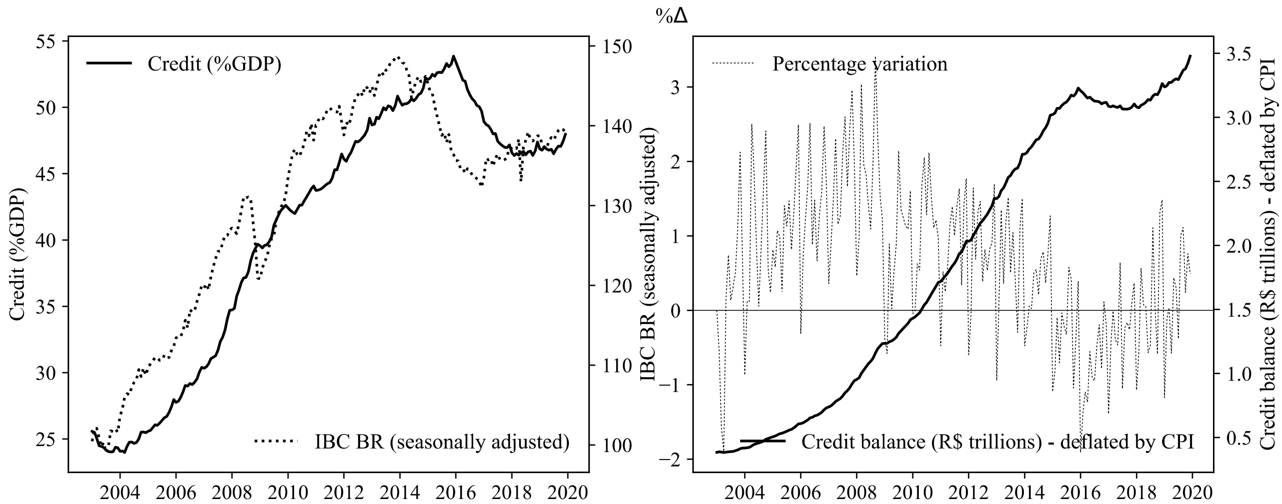

Figure 1. Evolution of credit (%GDP) economic activity index (IBC BR) (Source: Brazilian Central Bank (BCB)).

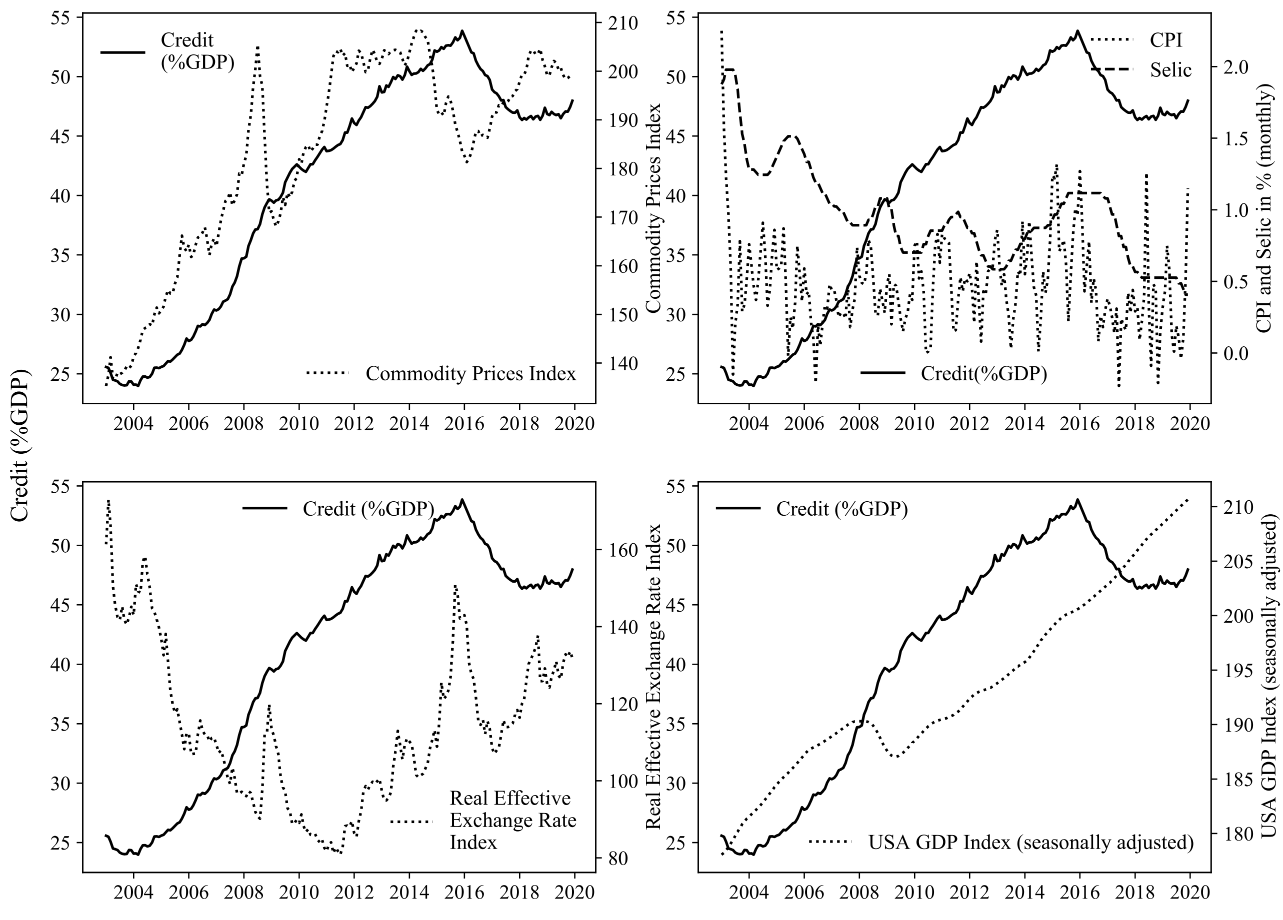

Figure 2. Evolution of credit (%GDP) × other variables. (Source: Brazilian Central Bank (BCB) and Federal Reserve Bank of St. Louis).

the credit level and the exchange rate. Finally, the last panel presents the co-movement between the credit level and the US GDP. At the time of disturbances, there was a considerable expansion vis-à-vis contraction toward credit's scope.

Ultimately, this fact interestingly explains why real or monetary shocks can be both amplified or accommodated. For example, there was an expansion in Brazilian public credit, as a way of accommodating negative shock resulting from the US 2008 subprime crisis (Cunha et al., 2019). During the two-years period (2015-2016), such expansion has stopped soon in virtue of the economic recession faced by the country at that time. Eventually, this fact has entailed a negative variation on the credit balance.

Thus, the dynamic interplay of credit with further endogenous and domestic macroeconomic variables (GDP, inflation, exchange rates and short-term rates) is the central topic in the present paper. It will be used a structural autoregressive vector model (SVAR), which in turn is based on impulse response functions alongside a variance decomposition associated with forecast errors.

Brazil is considered to have a small economy—which corresponds to approximately 3% of GWP—that takes part in world trade, despite being low its trade openness degree, around 19% (exports plus imports/GDP). Thus, shocks in the behavior of external variables, such as the index of commodity price and the US GDP, are relevant to fully capture the change in dynamics of each variable, being two exogenous and five domestics (Brischetto & Voss, 1999). The elective affinity between credit and short-term interest rate (SELIC) will be scrutinized. What is really at issue here is the following: restrictive monetary policies increase SELIC in order to somehow restrain inflationary pressures, which ultimately compel credit conditions (by constraining both credit providers and entrepreneurs' decisions). Likewise, we will investigate the relationship between commodity price shocks and the possible implications for macroeconomic variables, with focus on GDP and credit.

Hence, a crucial result offered here is that (alongside variance decomposition) shocks to the interest rate (in the short and long term) explain partly the forecast errors for Brazilian GDP, inflation and exchange rate. On the other hand, shocks to the interest rate reveal, on average, 40% of the forecast errors for credit. Also, shocks to credit, at short and long horizons, are of little significance in explaining the forecast errors concerning other domestic variables. Finally, in the long run, shocks to commodity prices explain about 67%, 47%, 43% and 15% of the forecast errors for Brazilian GDP, credit, exchange rate and interest rate, respectively, playing a great role in the dynamics of domestic variables.

In addition to this introduction, the following section discusses the existing literature, providing a detailed outlook of the methodology to be used, while in the third section a brief analysis is presented. The fourth section illustrates the setup of the approach, followed by the concluding remarks.

2. Procedures for Estimating and Dataset

With respect the methodology, this paper follows Sims & Uhlig (1991), Sims, Stock, & Watson (1990) and Berkelmans (2005). A distinguishing characteristic of these studies is that SVAR is estimated in levels even when variables are I(1).

The upshot of the present choice is that no restrictions (or presumably incorrect ones) are imposed on the model. Even with I(1) variables, the residuals continue to be stationary given the inclusion of lagged levels of the variables in the model, although some variables in it are non-stationary (Hamilton, 2020).

As far as the results are concerned, the Impulse Response Function (FIR) and Variance Decomposition (reporting the error of forecasts) altogether confirm the dynamic interactions between the variables used in the model in agreement with economic grounds, i.e., there is no spurious relationship between the I(1) variables.

The model was estimated using monthly data, from January 2003 to June 2017. The variables are the following: index of commodity price seasonally adjusted (source: Federal Reserve, Saint Louis); index of US GDP, 2017 = 100 (source: Federal Reserve, Saint Louis); economic activity index—IBC-BR (source: BCB); broad consumer price index—IPCA (source: IBGE); real credit operations to financial system seasonally adjusted, 2017 = 100 (source: IPEADATA); interest rate (source: BCB); and real effective exchange rate index—IPA-DI (source: BCB). The data were used in log, except for SELIC and Inflation that are used in percentage. In general, when the interest rate and inflation variables are in percentage, they are used in the estimated model without any transformation (see, for instance, Berkelmans, 2005, Evangelista & Araújo, 2018, and Walsh, 2014).

Setting up the SVAR

Consider the following autoregressive vector (VAR) in its reduced form:

$$Y_t = C(L)Y_t + \varepsilon_t \tag{1}$$

$$E(\varepsilon_t \varepsilon_t') = \Omega$$

$$E(\varepsilon_t \varepsilon_{t+s}') = 0, \quad \forall s \neq 0.$$

Y_t is to represent the vector of macroeconomic, domestic and external variables; C is a polynomial function of order p; and L is the lag operator.

Consider a matrix A such that it is the contemporaneous relationships between the variables and $A\varepsilon_t = u_t$. Multiplying Equation (1) by A such that:

$$AY_t = AC(L)Y_t + u_t \tag{2}$$

Equation (2) is the structural VAR representation (SVAR) (Hamilton, 2020). Structural shocks in this kind of model can be identified by restricting, via matrix A, contemporaneous relationships between the variables. Previous studies, economic theory and typical facts should be used to determine these restrictions[2].

The model comprises of seven variables: two exogenous (commodity price index (COMP_t) and the US GDP (GDPUSA_t)); five domestic variables (economic activity index-IBC-BR (GDPBR_t), broad consumer price index (INF_t),

[2]With respect the contemporaneous relationships, the present paper closely embraces the identification routine provided by Berkelmans (2005).

total real credit operations to financial system (CRED_t), SELIC interest rate (INTRATE_t) and the real effective exchange rate index (EXRATE_t)).

$$AY_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & 0 & 0 \\ a_{41} & 0 & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & 0 \\ a_{61} & 0 & 0 & 0 & a_{65} & 1 & a_{67} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} \text{COMP}_t \\ \text{GDPUSA}_t \\ \text{GDPBR}_t \\ \text{INF}_t \\ \text{CRED}_t \\ \text{INTRATE}_t \\ \text{EXRATE}_t \end{bmatrix} \tag{3}$$

The previous expression enables to identify structural shocks in a SVAR model, which are in turn nothing other than some restrictions on contemporaneous relationships. To lean on the discussion of contemporaneous relationships, which are illustrated by Equation (3), one might observe that commodity prices are affected by their own shocks, although shocks to commodity prices affect all other variables; the US GDP is affected only by the shocks to commodity prices, whereas its own shock affects the other variables, a notable exception is SELIC (here taking up an asymmetry of information access along with BCB), as well as the effect concerning US economic activity on Brazilian inflation is indirect. In a nutshell, American GDP affects Brazilian GDP, which in turn affects its own inflation. It is also assumed that shocks to domestic variables do not affect the exogenous ones, taking into account Brazil has a low world economy share.

Brazilian GDP behavior, in addition to the contemporaneous interactions with the aforementioned external variables, is the following: it is affected by inflation. An increase in inflation, given the signal extraction problem faced by producers, leads in turn to an increase in their production, thereby a growth of GDP[3]; followed by a shock to credit via aggregate demand. Regarding the cost to borrow money, credits will be promptly allocated to demand. Notice credit has a procyclical behavior, when the productive activity is in expansion, the volume of credit increases, reinforcing further the growth dynamics of the economy. The reverse holds in case of recessions.

Inflation is affected by shocks to commodity prices, i.e. an increase in oil price generates a pressure on domestic inflation. It's also said to be affected by shock to Brazilian GDP via output gap such that set up in Phillips Curve (Bernanke & Blinder, 1992).

Contemporaneously, credit happens to respond to all variables, being shock to exchange rate an exception. Given credit is essentially procyclical, it turns out that individual agents' expectations on expected GDP give rise to a shock to Bra-

[3]This assumption can be found in Lucas-Phelps's imperfect information model (Phelps, 1970; Lucas, 1972, 1973). It has to do with the following abstruse underpinning: individual producers are insecure whether an increase in their price reflects inflationary pressures or otherwise an increase in demand. They increase their production and, as consequence, the GDP.

zilian GDP on credit. The contemporaneous interaction of credit with the interest rate and inflation is due to the perception according to which borrowers will react[4] to the real cost of credit, which is the difference between the interest rate and inflation rate.

The short-term interest rate (SELIC) is affected by shocks to credit, exchange rate and commodity prices—being at issue the expectations about these prices, which are set up by monetary policy decisions—but the shock to US GDP does not affect it. Shocks to Brazilian GDP and inflation also do not affect the interest rate, assuming a lag information hypothesis concerning policymakers from BCB. Contemporaneously, it is taken up those shocks to all variables affect the exchange rate.

3. Estimation and Results

As far as the model estimation is concerned, it follows the conventional routine: unit root (hence, most variables that comprise the model are I(1)), ADF, PP, KPSS and cointegration tests were used. The I(1) variables are the following: commodity price index, US GDP and Brazilian economic activity index (IBC-BR). In the model cointegration can be found. As explained in the second section, the model was estimated placing the variables at level. Committed to information criteria proposed by Schwartz (SC) and Hannan-Quinn (HQ), in the present paper a lag length of two was chosen.

Equation (3) identifies the model. The lags corresponding to domestic variables were not included in the equations for external variables. In light of that setting up, SVAR was estimated. **Table 1** reports that the model is well-specified, i.e., it does not suffer from autocorrelation with respect residuals. By means of a robustification procedure, a careful analysis of residuals will be done later.

3.1. Impulse Response Functions

Figure 3 reports the impulse response functions. They show how domestic variables react to credit and to the interest rate shocks, respectively[5]. To better visualize their dynamic behavior, these variables were placed side by side to GDP, inflation and exchange rate. A positive shock to credit gives rise an increase in inflation, thereby BCB reacts to this by increasing the interest rate, thus, reducing inflation and keeping it on target.

Regarding all model variables, **Figure 3** highlights the positive shocks to the interest rate: credit is reduced and remains below its baseline a bit over one year, as consequence, GDP is reduced, which remains below its baseline over one year. That is, as expected, GDP closely follows the credit dynamics; inflation rises slightly in the first month, falling in the second one and returning to its baseline

[4]Quickly, to put mildly.

[5]The positive shock indicates an innovation of one standard deviation in the Credit and in the interest rate (SELIC).

Table 1. Likelihood ratio test—residuals.

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	55.96440	49	0.2298	1.148593	(49, 735.5)	0.2304
2	62.77366	49	0.0893	1.294212	(49, 735.5)	0.0897
3	123.9498	49	0.0000	2.662780	(49, 735.5)	0.0000
4	58.37805	49	0.1687	1.200061	(49, 735.5)	0.1692
5	49.05218	49	0.4710	1.002103	(49, 735.5)	0.4717
6	43.54465	49	0.6932	0.886333	(49, 735.5)	0.6937
7	63.12994	49	0.0845	1.301867	(49, 735.5)	0.0848
8	52.83818	49	0.3282	1.082174	(49, 735.5)	0.3288

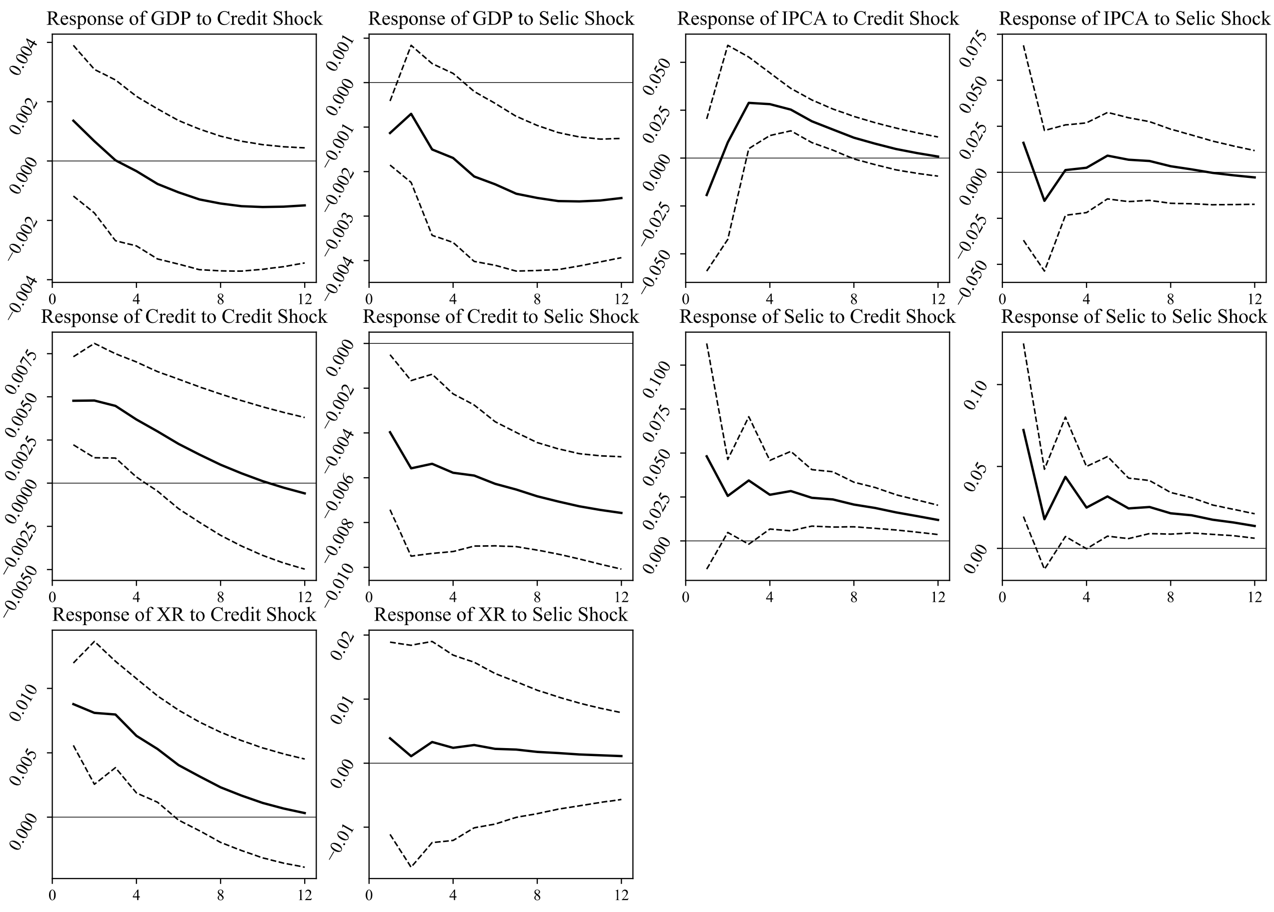

Figure 3. SVAR's responses to innovations ± 2 standard errors[6].

in the third month (remaining around its baseline over time). Shocks to the interest rate give rise a reduction in both credit and GDP. This fact enables Brazilian Central Bank (BCB) to keep inflation low and under control; the interest rate rises and remains above its baseline for the entire analyzed period, over twelve

[6]From now on, we will call the exchange rate by its abbreviation, XR, in all figures.

months; the exchange rate is not significantly affected, it is around its baseline during the whole period taken into consideration.

Figure 3 also reports responses as for positive shock to credit: GDP has a small growth during a trimester, but it quickly returns to its baseline, remaining below this spectrum from the fourth month on. The root-cause from this fact is the shock to credit on inflation, as consequence, on the interest rate. Credit increases, inflation increases, interest increases to contain inflation and, eventually, GDP is reduced; inflation declines rapidly in the first two months, increasing between the third and the tenth month, converging on its baseline; credit sketches a positive and significant effect, remaining during 10 months well above its baseline. But in the eleventh month it converges on its baseline; the interest rate rises and remains above its baseline a bit over one year, this fact pulls down the GDP dynamics; the exchange rate has a slightly depreciation and remains above its baseline for approximately one year.

Figure 4, in turn, denotes the effects on the macroeconomic variables of positive shocks in the price of commodities: it is clear the positive and significant effects on both credit and GDP, which remain above their baseline for more than a year. This result for the credit is in line with Ftiti, Kablan, & Guesmi (2016), who identified that shocks in commodity prices strongly reverberate in the supply of credit in the long term for exporting countries. GDP closely follows this dynamic. As expected, there is an exchange rate appreciation due to the greater

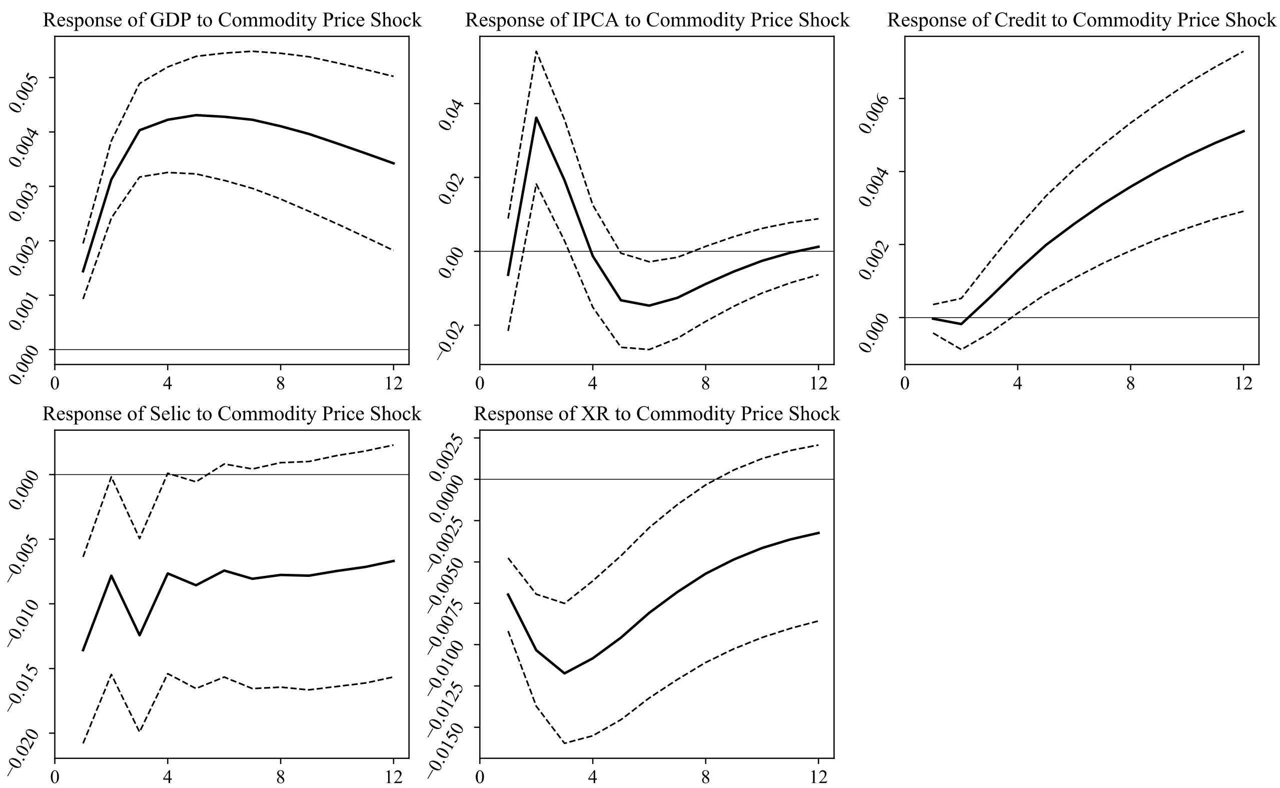

Figure 4. SVAR's responses to innovations ± 2 standard errors.

inflow of foreign capital given the more valued exports. The effect on the exchange rate disappears only between the eighth and tenth month.

Following the positive commodity price shock, we see a sudden increase in inflation in the second and third months. A possible explanation for this fact lies in Gelos & Ustyugova (2017), who point out that countries with a high weight of food in the CPI basket (which is the case of Brazil that has more than 20% of food participation in the CPI basket) and a high intensity of oil in the economy (also the case of Brazil) tend to experience a greater inflationary bias for positive shocks in commodity prices. However, inflation falls from the fifth to the tenth month, returning to its reference level thereafter, probably due to the appreciation of the exchange rate, which made imports cheaper, thus reducing inflationary pressure, even with the increase in the supply of credit. Therefore, it is possible for the Central Bank to keep the interest rate below its reference value for more than one year.

3.2. Variance Decomposition

Table 2 shows the variance decomposition related to forecast error (DV), taking into account four different forecast horizons: one, four, twelve and twenty-four months. Running in parallel with the five domestic variables, each column shows the proportion of forecast error, which is viewed as structural shocks to each of the seven variables that comprises the model, listed duly on the left-hand side of the table. Thus, for each forecast horizon, the entries in a given column sum to one, except when there is a small rounding problem.

Shocks to the interest rate, in the short and long term, explain partly forecast errors related to Brazilian GDP, inflation and exchange rate. However, shocks to the interest rate explain, on average, 40% of the forecast errors to credit. It happens that shocks to credit, at short and long horizons, are of little significance in explaining the forecast errors concerning the other domestic variables. With the exception of the interest rate which, in the short term, has its forecast error affected by credit in 30 % and, in the long term, 25%, on average. In the short and medium term, the forecast errors of the interest rate are explained by their own shocks, by the shocks of credit and the exchange rate, around 80%. In the long run, shocks to commodity prices are taken to be important determinants, around 15%, concerning the forecast error connected to the interest rate. In the short term, credit has its forecast errors explained, around 50%, by its own shocks. In the long run, shocks to commodity prices happens to explain 47% of the forecast error concerning credit.

In the short term, Brazilian GDP has its forecast errors explained by its own shocks and shocks to inflation, 80% on average. However, in the long term, shocks to commodity prices explain about 70% of forecast errors to Brazilian GDP.

The forecast errors for inflation, in the short and long term, are explained by its own shocks, 70% on average, and by the shocks of Brazilian GDP, around

Table 2. Decomposition variance—proportion of forecast error variance for variable %.

Structural shocks (innovation)	Forecast (months)	BR GDP	Inflation	Credit	Interest rate	Exchange rate
Commodity prices	1	4.6	0	0.11	2.5	6.39
	4	30.98	5.41	0.63	5.35	18.06
	12	53.99	4.97	16.07	8.95	31.83
	24	67.43	5.09	46.91	14.7	43.03
US GDP	1	0.24	0.05	0.88	0.01	2.29
	4	9.94	1.27	0.28	0.33	1.04
	12	13.77	1.4	3.06	3.92	0.85
	24	8.26	1.47	2.66	7.76	1.72
BR GDP	1	64.2	14.79	3.4	0.43	4.16
	4	36.6	13.12	2.98	0.27	1.49
	12	14.17	12.44	5.29	2.37	0.79
	24	7.74	12.27	1.79	3.09	0.65
Inflation	1	23.76	83.48	6.97	3.82	1.08
	4	13.73	71.38	16	3.06	3.03
	12	4.66	61.06	10.68	5.48	2.43
	24	3.21	59.91	5.49	5.42	1.92
Credit	1	4.08	0.94	49.85	26.39	8.72
	4	1.17	3.01	33.23	30.21	5.96
	12	2.6	4.37	10.38	29.37	3.94
	24	2.31	4.41	3.53	24.85	3.1
Interest rate	1	2.82	0.65	34.49	59.46	1.7
	4	3.35	0.73	45.78	50.34	0.79
	12	8.7	0.87	51.69	42.76	0.77
	24	8.68	1.14	33.59	36.56	0.76
Exchange rate	1	0.35	0.08	4.28	7.38	75.65
	4	4.22	5.06	2.1	10.43	69.62
	12	2.11	14.88	2.83	7.13	59.39
	24	2.36	15.7	6	7.63	48.82

15%. The exchange rate has its forecast errors explained, in the short term, by its own shocks, around 60%. However, in the long run, shocks to commodity prices explain 43% of forecast errors to exchange rate.

The results shown in **Table 2** are particularly in line with the ones obtained in previous studies (Berkelmans, 2005; Brischetto & Voss 1999; Dungey & Pagan, 2000 and Kim & Roubini, 2000). This highlights the allegiance of the model used here for putting forward the proposed empirical analysis concerning credit cycle in Brazil. Furthermore, it outlines the importance given to the external variables (in particular, commodity prices), in explaining the long-term dynamics of domestic variables, such as Brazilian GDP, credit, interest rate and exchange rate.

3.3. Robustness

To lean on the robustness of the estimation, changes to the sample length are taken into account. By the way, the current estimation comprises of two sub-samples: the first sub-sample leaves out the last two years while the second leaves out the first two years. The business here is to determine the extent to which possible significant changes (if any) are specified by the impulse response functions on the sub-samples vis-à-vis the full sample. Figure 5 and Figure 6 plot the impulse response functions associated with the two sub-samples in the model, respectively. The first sub-sample covers the period from January 2003 to June 2015, while the second corresponds to a time interval from January 2005 to June 2017.

Notice that the SVAR model used to analyze empirically the credit cycle and its dynamic interaction with the interest rate and other domestic macroeconomic

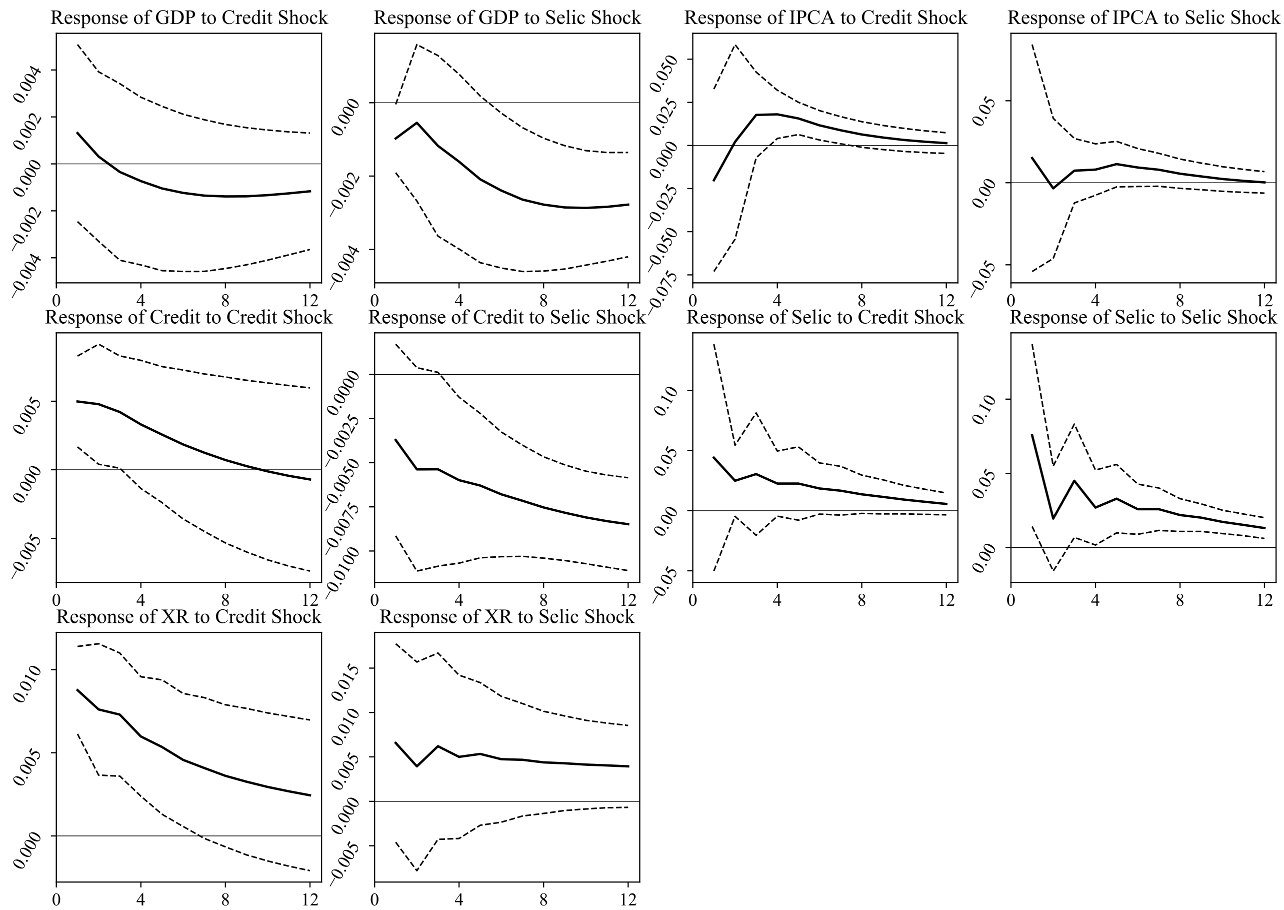

Figure 5. SVAR's responses to innovations ± 2 standard errors.

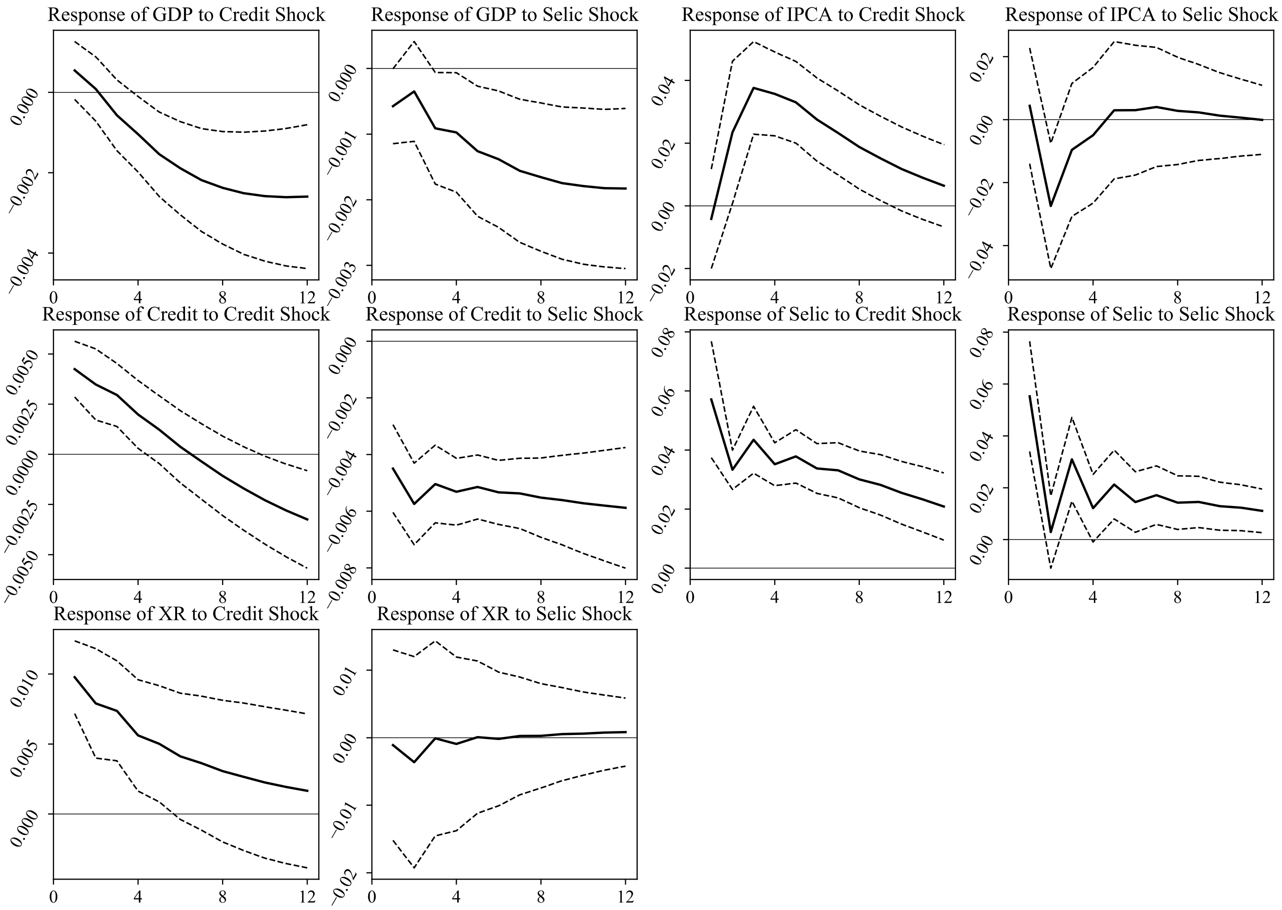

Figure 6. SVAR's responses to innovations ± 2 standard errors.

variables (GDP, inflation and exchange) is said to be quite robust regarding changes to the sample length. The reason is that impulse response functions generated for all variables (and for both sub-samples and full sample) exhibit almost the same shape.

It is important to note that we also again estimate the impulse response functions for the commodity price shock for the two sub-samples. We observed practically the same results obtained previously, which attests to the robustness of the model.

4. Concluding Remarks

The aim of this paper was to seek the dynamic interaction between credit and a cluster of macroeconomic variables in Brazil regarding the 2003-2017 years, a period in which the Brazilian economy had a reasonable but not sustained growth. The present paper leans on a structural autoregressive vector model (SVAR), which in turn is set up by impulse response functions alongside a variance decomposition associated with forecast errors. Findings: positive shock to the interest rate gave rise a reduction in Brazilian GDP, remaining below its baseline (superior to twelve months); a small and sudden rise in inflation, though have being reduced in a couple of days, remaining below its baseline over time; a reduction in credit, remaining below its baseline (superior to twelve months); an increase in the interest rate, but after twelve months it returned to its baseline; finally, a reduction in the exchange rate, remaining below its baseline in few months. This is a rather unconventional result, because the exchange rate tends usually to return to its baseline immediately after one year.

The consequences of a positive shock to credit were: three months of growth of Brazilian GDP, after this period it returned quickly to its baseline; rapid reduction of inflation in the first two months, but it increased from the third to the tenth month and then converging to its baseline; credit presented a positive and significant effect, remaining well above its baseline (superior to twelve months); the interest rate increased in the first three months, converging to its baseline from the fourth month on; and the exchange rate exhibited a slight appreciation, not statistically significant, and remained above its baseline for approximately one year[7].

With respect the variance decomposition, shocks to the interest rate, in the short and long term, explain partly forecast errors related to Brazilian GDP, inflation and credit. However, shocks to the interest rate explain around 20% of forecast errors to exchange rate. In the short and long term, shocks to credit are of little significance in explaining the forecast errors concerning the other domestic variables. With the exception of the interest rate, which in the short term has its forecast error affected 20% by credit and, in the long term, 10%, on average. In the short and medium term, the forecast errors associated with the interest rates are explained by their own shocks and by the shocks of credit and exchange rate, around 80%. In the long run, shocks to commodities also appear to be an important determinant, around 17%, of forecast error to the interest rates. In the short term, credit has its forecast errors explained by its own shocks in 75%. In the long run, shocks to commodities happen to explain 48% of forecast error of credit.

It is noteworthy singling out that the SVAR model used to analyze empirically the credit cycle and its dynamic interaction with the interest rate and other domestic macroeconomic variables (GDP, inflation and exchange) is said to be quite robust regarding changes to the sample length. The reason is that impulse response functions generated for all variables for both sub-samples and full sample exhibit almost the same shape.

By means of these results, it follows that these are closely in line with the ones obtained in previous studies. In turn, this highlights the allegiance of the model used here for putting forward the proposed empirical analysis concerning credit cycle in Brazil. Furthermore, it outlines the importance given to the external variables (in particular, commodity prices), in explaining the long-term dynamics of domestic variables, such as Brazilian GDP, credit, interest and exchange rates.

The main limitation of the work, perhaps, is the use of structural VAR (SVAR)

[7]There is not in the model exchange rate puzzle.

to analyze the comovements of the variables that make up the study, since it is known that the Bayesian VAR (BVAR) presents more robust estimators, which improves the prediction of the model and the results of the impulse response functions and the variance decomposition. Therefore, one of the points on the future research agenda is to study this problem, possibly reestimating the model object of this paper, using BVAR, in order to compare the forecast errors of other models, such as SVAR and unrestricted VAR.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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