Macroprudential policies and monetary policy: an empirical assessment

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Abstract

Based on an original database of 121 Brazilian banks from March 2001 to June 2015, this study contributes to understand how monetary policy affects macroprudential financial institutions-based policies. The findings denote that an increase in the monetary policy interest rate implies an adjustment in the banks' strategy for ensuring the safety and soundness, which, in turn, amplifies the use of macroprudential financial institutions-based policies. On the other hand, when this interest rate falls, the instruments for macroprudential financial institutions-based policies (capital buffer, credit provisions, and leverage) are reduced, which implies a greater risk for the financial stability. This result suggests the need for coordination between macroprudential policy and monetary policy.

Key words: macroprudential regulation, financial stability, monetary policy.

Resumo

A partir de uma base de dados de 121 bancos brasileiros no período de março de 2001 até junho de 2015 foi analisado o efeito das taxas de juros da política monetária sobre o comportamento dos instrumentos macroprudenciais. Os resultados indicam que um aumento da taxa de juros da política monetária leva os bancos a aumentar o *buffer* de capital, as provisões de crédito e a alavancagem bancária (instrumentos macroprudenciais). Por outro lado, quando há queda das taxas de juros os instrumentos macroprudenciais são reduzidos, o que implica em um maior risco para a estabilidade financeira. Este resultado sugere a necessidade da coordenação entre a utilização dos instrumentos macroprudenciais e a política monetária, principalmente durante os períodos de baixas taxa de juros.

Palavras-chave: Política Macroprudencial, Estabilidade Financeira e Política monetária.

JEL classification: E44, E52, E58

1. Introduction

In general, central banks have two objectives: price stability and financial stability. One consequence of the subprime crisis for central bank's management is the need to use macroprudential instruments to safeguard the financial system. Nowadays, an important issue for policymakers is to identify the effects that exist between monetary policy and macroprudential policy (Cecchetti, 2016). A challenge for central banks is to see how the conduct of the monetary policy can affect the macroprudential instruments that are being used to ensure the stability of the financial system (Poloz, 2015; and Smets, 2014).

In order to ensure financial stability, macroprudential policy must be used to avoid or minimize the procyclicality of banks' behavior (Claessens, 2015). The macroprudential instrument that has gained most attention from policymakers is the countercyclical capital buffer – CCyB (BCBS, 2010; Drehmann, Borio, and Tsatsaronis, 2011). The aim of the use of CCyB is to ensure that commercial banks raise the buffer when the economy is expanding in order to be used to absorb bank losses in times of downturn. In addition to CCyB, the countercyclical use of credit provisions (dynamic provisions) and the limits on leverage has been considered by policymakers as a toolkit of financial institutions-based policies (Cerutti, Claessens, Laeven, 2017).

This study is a contribution to the literature that analyzes the effect of monetary policy interest rate on the use of macroprudential financial institutions-based policies. In order to evaluate this phenomenon it is necessary to consider an economic environment that combines a developed financial system and that the central bank has the interest rate as its main instrument of monetary policy. In this context, Brazil has characteristics that fit in this profile and thus allows an investigation that can be useful for other economies. The Central Bank of Brazil (CBB) has two mandates: financial stability and price stability. In order to maintain financial stability, the CBB supervises the operation of all banks (Brazilian banks' assets correspond to 180% of GDP - IMF, 2012). Regarding the search for price stability, the CBB adopts inflation targeting since June 1999 and has the Selic rate (monetary policy interest rate) as its main instrument.

The CBB analyzes economic-financial data provided by commercial banks to supervise the banks. Based on this information, the CBB discloses, every quarter, the "economic-financial analysis" report. Hence, such reports represent an essential source of information for micro and macroprudential analysis. An original database (total 7,000 observations taking into account 121 banks) was built by analyzing the content of the reports for the period from March 2001 to June 2015. This database extracted from banks (micro-level data) allows us to evaluate how changes in the CBB's monetary policy interest rate affect macroprudential financial institutions-based policies. For this purpose, several panel data models are used which consider monetary policy interest rate and specific instruments for macroprudential financial institutions-based policies (capital buffer, credit provisions, and leverage).

The findings denote that an increase in the monetary policy interest rate implies an adjustment in the banks' strategy for ensuring the safety and soundness, which, in turn, amplifies the use macroprudential financial institutions-based policies. In contrast, when the central bank reduces the interest rate, banks reduce the use of this kind of macroprudential tools and thereby decrease the safety of the financial system.

Besides this introduction, this paper is organized as follows. Section 2 presents the data and variables, as well as the models and methods used in this study. Section 3 shows evidence regarding the effect of the monetary policy interest rate on the macroprudential financial institutions-based policies. Section 4 presents the conclusion.

2. Data and methodology

The effect of monetary policy on the financial system is through the banks' risk-taking channel. The risk-taking channel refers to how changes in monetary policy interest rates affect the banks' risk perceptions (Borio and Zhu, 2012). Nowadays, in addition to the risk-taking channel, policymakers are concerned with investigating whether monetary policy can affect financial stability (Poloz, 2015, Smets, 2014). Assuming that macroprudential instruments are useful to maintain the financial stability, this study is a contribution to understand this relashionship.

In order to consider the impact of the conduct of monetary policy on macroprudential instruments, panel data models are used. The sample consists of 7,000 observations extracted from the balance sheets of 121 banks for the period from March 2001 to June 2015 (58 quarters). Such information is made available from the CBB through the IF.data system (Selected Information on Supervised Institutions). In order to carry out this study, three instruments for macroprudential financial institutions-based policies are considered: capital buffer, credit provisions, and bank leverage.

The capital buffer (*BUF*) represents the volume of capital higher than the minimum regulatory requirement held by the banks. The buffer is measured by the difference between the capital of financial institutions and the minimum capital required by the regulators (CAR). Therefore, the larger the buffer, the lower the risk of bankruptcy. On the other hand, in relation to the economic cycle, banks maintain the buffer on a procyclical path, that is, reduce the buffer in times of economic growth and increase in times of depression (Stolz and Wedow, 2011). In other words, they amplify the cycle and thus increase the risk of events of financial instability.

Credit provisions (*PROV*) represent the coverage that banks maintain to support probable credit losses. Provisions are measured by the ratio of the coverage for credit losses provided by the banks to the total credit volume. It is important to highlight that credit provisions held by banks have a forward-looking characteristic because they behave according to banks' expectations in relation to the future business cycle (de Moraes, Montes and Antunes, 2016; Jiménez and Saurina, 2006). Such as observed for the case of the capital buffer, the procyclical behavior regarding credit provisions can represent a threat for the financial stability.

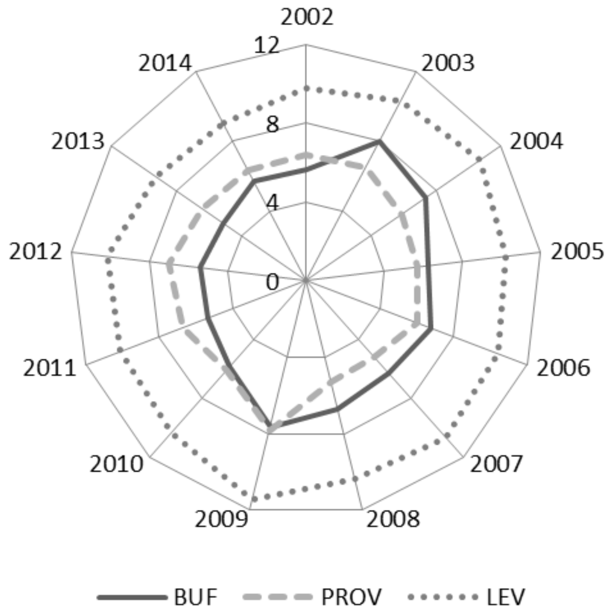
Bank's leverage (*LEV*) represents capital to assets ratio. Therefore, it is calculated by the ratio between the capital and the total assets held by the banks. Therefore, the higher the *LEV* the lower the leverage. The behavior of bank's leverage is procyclical, that is, leverage increases in times of economic boom and reduces in times of economic downturn (Adrian and Shin, 2009). As a result of the subprime crisis, the Basel Committee suggested that central banks should monitor and limit bank's leverage in order to reduce their procyclical component (BCBS, 2014).

Taking into account the annual average of the financial institutions used in this study, figure 1 shows the path of macroprudential instruments between 2002 and 2014.

In relation to the capital buffer, the increase in 2003-2004 represents a period of adaptation due to the regulatory changes from Basel II Accord. In the following years, a retreat in the capital buffer is observed. However, due to the advent of the subprime crisis there was a new increase in the use of this tool and only after 2009 was a reduction observed. Regarding credit provisions, there was relative stability until the subprime crisis, when there was an increase followed by a return to the pattern of the previous years. Similar movement to credit provisions is also observed for bank's leverage. In brief, the paths of macroprudential instruments show that there exists a similar reaction (increase) to the subprime crisis.

Figure 1

Capital Buffer, credit provisions, bank's leverage



The monetary policy interest rate in Brazil is the Selic interest rate (*IR*), the interest rate for overnight interbank loans collateralized by government bonds registered with and traded on the Sistema Especial de Liquidação e Custódia. The monetary policy interest rate target is fixed for the period between meetings of the Committee of Monetary Policy (COPOM) with the objective to achieve the inflation target.

The behavior of macroprudential instruments (*BUF*, *PROV*, and *LEV*) with the monetary policy interest rate can be observed in figures 2 to 4. In general, the capital buffer, the credit provisions, and bank's leverage overreacted in two moments. A first moment was in 2003 due to the confidence crisis caused by the election of President Luiz Inácio Lula da Silva who promised to change the macroeconomic policy in Brazil. A second moment was in 2008 because of the subprime crisis, which in turn affected the behavior of banks around the world. These moments show a clear opposite path between the monetary policy interest rate and the macroprudential instruments. However, most of the time, it is possible to see the monetary policy interest rate and the macroprudential instruments following a similar path.

Figure 2
Capital buffer and monetary policy interest rate

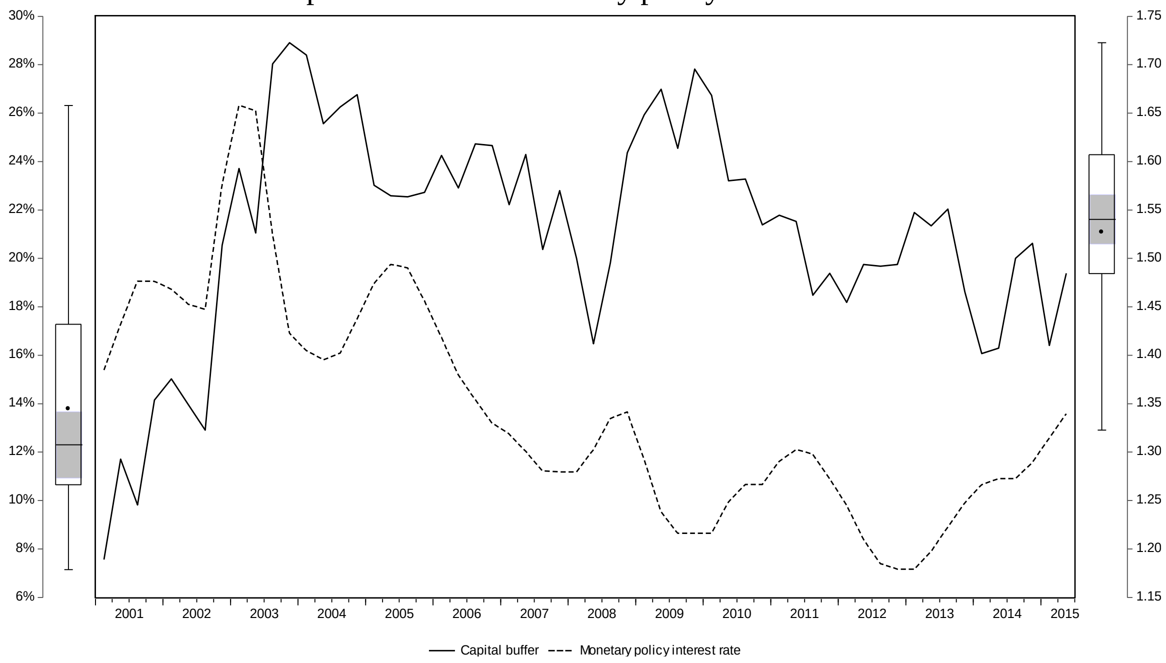


Figure 3
Credit provisions and monetary policy interest rate

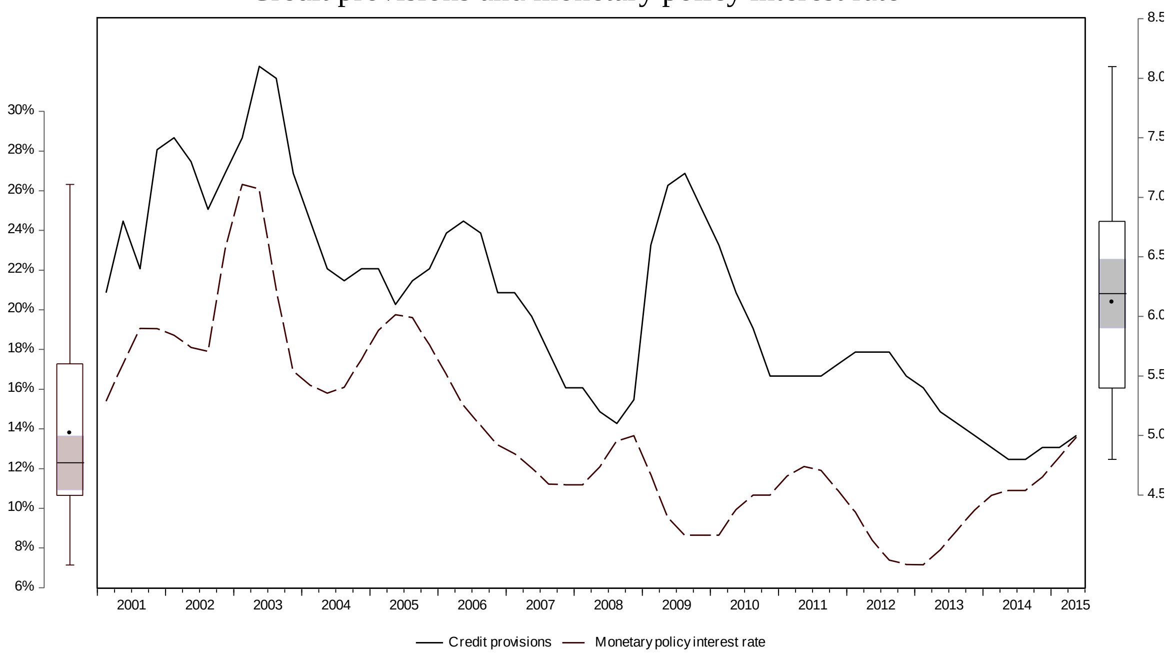
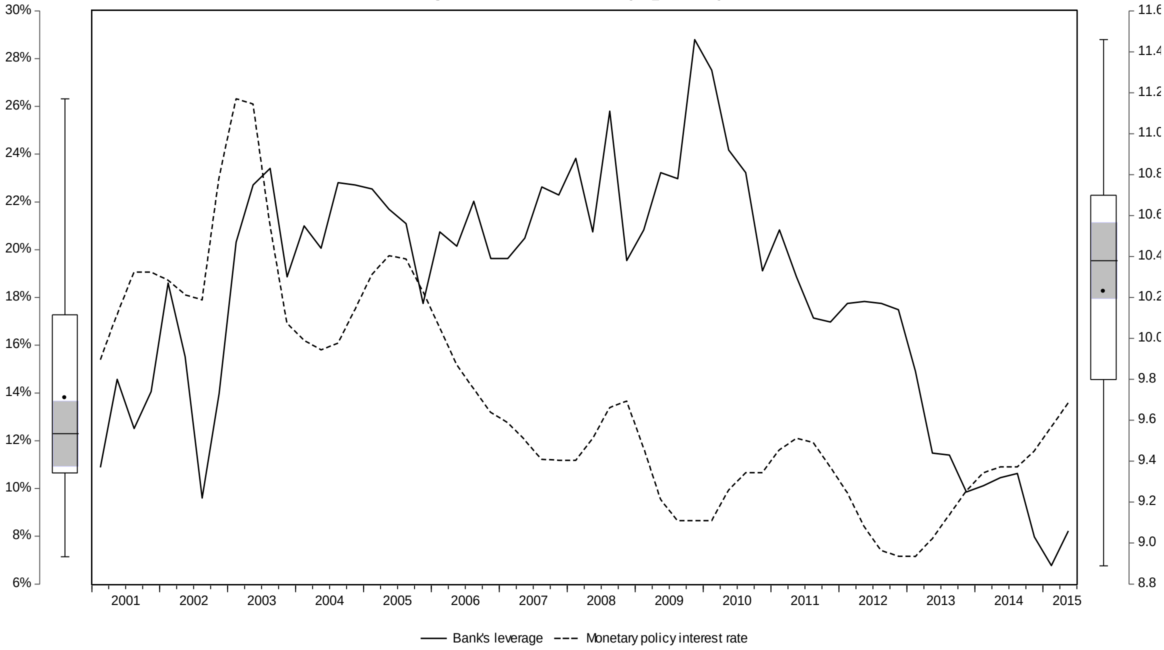


Figure 4
Bank's leverage and monetary policy interest rate



In order to mitigate omitted variable biases we consider well-accepted variables present in the literature on the determination of capital buffer, credit provisions and leverage. As most studies taken into consideration, the effect from liquidity, equity or regulatory capital, and performance in the analysis (see Stolz and Wedow, 2011; Gambacorta and Mistrulli, 2004; Dahl, 2012; and Tabak et al., 2013), we included the following variables in the empirical model: banking liquidity (*LIQ*) - liquid assets/total assets ratio, rate of change in credit (*CRED*), return on equity (*ROE*) – net income returned as a percentage of shareholders equity, non-performing loans (*NPL*) measured by the ratio transactions between credit operations with arrears over 90 days and total credit portfolio. All data is gathered from Central Bank of Brazil with quarterly frequency.

Based on the variables described above and taking into account the aim of investigating the impact of the monetary policy interest rate on the macroprudential instruments, our general specification is as follows:[1]

(1) $$MT_{i,t} = \delta_0 + \delta_1 MT_{i,t-1} + \delta_2 IR_{t-1} + \delta_3 Z_{i,t-1} + \varepsilon_{i,t} ,$$

where the subscript $i=1,2,\ldots,121$ is the bank; $t=1,2,\ldots,58$ is the time period, and ε is the disturbance. *MT* is the macroprudential instruments denoted by the three alternative variables: capital buffer (*BUF*), credit provisions (*PROV*), and bank's leverage (*LEV*). *IR* is the interest rate of monetary policy, and *Z* covers mostly the bank's individual characteristics (*LIQ, CRED, ROE*, and *NPL*).

Apart from the variables mentioned above, other control variables are included

[1] See table A.1 (appendix) for sources of data, description of the variables, and descriptive statistics.

in the model in order to consider the possible effect caused by the business cycle, size of banks, and the subprime crisis on the macroprudential instruments. In this context, the output gap (*GAP*), measured as result of the difference between GDP and the potential output (Hodrick-Prescott filter), is introduced in order to observe the effects from the business cycle. In the same vein, the size of banks (*SIZE*) measured by the log of total banks' assets is also included in the analysis. At last, in order to consider the effect from the subprime crisis, a dummy variable (*CRISIS*) equal to one for the period from the second quarter 2008 to second quarter 2009 (period which CBB reduced the interest rate in response to the crisis) and zero otherwise is introduced in the model.

Such as Guidara et.al (2013), and Stolz and Wedow (2011) this study makes use of dynamic panel data framework through System Generalized Method of Moments (S-GMM). According to Arellano and Bond (1991), the use of dynamic panel data method (GMM) is able to eliminate non-observed effects on the regressions and the estimates are reliable even in the presence of omitted variables. The use of instruments permits the estimation of parameters more consistently, even in the case of endogeneity in explanatory variables and in the presence of measurement errors (Bond, Hoeffler, and Temple, 2001).

The empirical model developed in this study is subject to the above-mentioned problems. In short, not all explanatory variables of the model are known and measurable. In addition, the presence of reverse causality is possible, for example, in the relation between capital buffer and liquidity as well as in the relation between credit provisions and rate of change in credit. Furthermore, regarding the endogeneity/simultaneity problem, it is possible that credit provisions affect non-performing loans.

As a way of mitigating the fact that, for example, first-difference GMM has a bias (for large and small samples), low accuracy, and the use of lags can generate weak instruments, Arellano and Bover (1995) and Blundell and Bond (1998) suggest the introduction of moment conditions. Therefore, S-GMM combines regression equations in differences and in levels into one system and makes use of lagged differences and lagged levels as instruments.

Although S-GMM estimation approach is suitable for a small number of time periods (*t*) and a large number of cross-sections (*i*), in the case of small samples, when the instruments are too many, they tend to over-fit the instrumented variables generating a bias in the outcomes (Roodman, 2009). Hence, with the intention of avoiding the use of an excessive number of instruments in the regressions, and thus lose the power of tests, the number of instruments/number of cross-sections ratio considered in each regression is less than 1 (de Mendonça and Barcelos, 2015). Furthermore, in order to observe the validity of the instruments in the models, the test of over-identifying restrictions (J-test) is performed as suggested by Arellano (2003). Moreover, tests of first-order (AR1) and second-order (AR2) serial correlation are also performed.

Taking into account the baseline model, we extend our analysis providing new empirical evidence regarding the effect of the monetary policy interest rate on the macroprudential instruments through a Panel Structural Vector Autoregressive approach (panel S-VAR).

$$(2) \qquad MT_{i,t} = \beta_0^0 + \sum_{n=1}^{p} \alpha_n^0 MT_{i,t-n} + \sum_{n=1}^{p} \alpha_n^1 IR_{i,t-n} + \beta_0^1 Z_{i,t-1} + \mu_{i,t}^0$$

where: $n=1,2,\ldots, p$ (order); β_0^0 and β_0^1 are constant terms; and μ_0^0 is the innovation term (impulse or shocks).

Although, a VAR model allows one to see how each variable in the model responds to itself and others, the focus of this analysis in on how an impulse transmitted by monetary policy interest rate affects the macroprudential instruments over time. In general, the dynamic analysis of VAR is made through impulse response functions. Thus graphs which show the response of *BUF*, *PROV*, and *LEV* to *IR* with a horizon of five years (twenty quarters) are presented. The errors are orthogonalized by Cholesky decomposition, which in turn implies that the ordination of the variables in the model is important for impulse-response analysis (see Enders, 2015). Following the presentation of the variables in equation 1 and based on Akaike (AIC), Schwarz (SIC), and Hannan-Quinn (HQ) criteria, the VAR order is defined (see table A.2 - appendix).[2] Furthermore, it is noteworthy to highlight that all roots in models have modulus less than one and lie inside the unit circle and thus impulse response and standard errors are valid (see table A.4 – appendix).

3. Estimation results

With the objective of observing the relation between the variables used in the models regarding monetary policy interest rate and macroprudential instruments, the correlation matrix is presented in table A.5 (see appendix). In particular, we can observe that the positive correlation between *IR* and *BUF*, *PROV*, and *LEV* (macroprudential instruments) suggests that a restrictive monetary policy induces banks to increase the security of the financial system. On the other hand, a reduction in the interest rate may lead banks to reduce capital buffer, credit provisions and to increase leverage, thereby reducing the protection of the financial system.

The estimation results for capital buffer, credit provisions, and bank's leverage, all of which take into account the effect from the monetary policy interest rate, are reported in tables 1, 2, and 3, respectively. All regressions accept the null hypothesis in the J-test and thus the over-identifying restrictions are valid. Furthermore, both serial autocorrelation tests (AR(1) and AR(2)) do not indicate the presence of serial autocorrelation.

In general, the results from all models (see tables 1, 2 and 3) reveal statistical significance for the coefficients regarding monetary policy interest rate. Therefore, we cannot rule out the effect the monetary policy interest rate has on macroprudential instruments (*BUF*, *PROV* and *LEV*). The sign of the coefficients denotes that the banks react to an increase in the interest rates with the amplification of the macroprudential instruments. This result can be explained by an increase in bank's risk aversion due to an expected worsening of the economy's consequence of the increase in the interest rate. On the other hand, a reduction in the interest rate increases the bank's risk appetite, which in turn implies a reduction of macroprudential instruments and, therefore, a greater risk for the financial stability.

In particular, the increase in the capital buffer due to an increase in the monetary policy interest rate (see table 1) denotes the concern of the banks to increase their coverage against bank's solvency risk (increase in the buffer). On the other hand, a reduction of the interest rate induces banks to reduce the capital buffer. Hence, this

[2] In order to check presence of unit root, the tests Levin-Lin-Chu, Im-Pesaran-Shin, Fisher-ADF, and Fisher-PP were performed (see table A.3 - appendix). The results do not indicate that the series are non-stationary.

indicates that in a low interest rate environment there is a greater risk to lose financial stability. This result is in line with the results observed by Cecchetti and Kohler (2014).

Regarding the effect of the monetary policy interest rate on credit provision (see table 2), the positive sign and the statistical significance observed reveal another connection between monetary and macroprudential policies. In this sense, in the case of an increase in the interest rate, banks tend to increase the coverage for credit loss. This result is equivalent to those found by Altunbas, Gambacorta, and Marqués-Ibáñez (2014).

Table 1
Capital Buffer

Regressors	Model 1	Model 2	Model 3	Model 4
BUF(-1)	0.5465***	0.5490***	0.5492***	0.5473***
	(0.0033)	(0.0034)	(0.0041)	(0.0044)
IR(-1)	0.0496***	0.0449***	0.2048***	0.1972***
	(0.0097)	(0.0095)	(0.0176)	(0.0194)
LIQ(-1)	0.2558***	0.2508***	0.2998***	0.2980***
	(0.0106)	(0.0011)	(0.0174)	(0.0155)
CRED	-1.7141***	-1.7017***	-1.6396***	-1.7468***
	(0.0650)	(0.0725)	(0.0863)	(0.0902)
ROE(-1)	0.0167***	0.0155***	0.0246***	0.0201***
	(0.0047)	(0.0045)	(0.0056)	(0.0053)
GAP(-1)		-0.0159***	-0.0185***	-0.0168***
		(0.0043)	(0.0058)	(0.0062)
SIZE(-1)			1.4484***	1.3994***
			(0.2123)	(0.2271)
Crisis				0.2342*
				(0.1308)
Obs.	4784	4784	4775	4775
N.Instr/N. cross sec.	0.53	0.53	0.54	0.53
J-statistic	69.53	66.20	67.49	64.06
P-valor	0.12	0.16	0.12	0.16
AR(1)	-0.49	-0.49	-0.49	-0.50
P-valor	0.00	0.00	0.00	0.00
AR(2)	-0.02	-0.02	-0.02	-0.01
P-valor	0.14	0.131	0.10	0.23

Note: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. White's heteroskedasticity consistent covariance matrix was applied in regressions. Standard errors between parentheses. S-GMM – uses two-step of Arellano and Bover (1995) without time period effects. Tests for AR (1) and AR (2) check for the presence of first order and second-order serial correlation in the first-difference residuals. The sample is an unbalanced panel of 121 banks from 2001q1 to 2015q2.

In the same way as observed for the macroprudential instruments mentioned earlier, the result of the estimation of the models presented in table 3 shows that the coefficient on the monetary policy interest rate is positive and significant. In other words, this result indicates that banks reduce leverage under a scenario of increasing interest rates and increase it when decreasing interest rates. As an example of similar results, see Dell'Ariccia, Laeven, and Marquez (2013).

The buffer, credit provision and leverage's reaction to monetary policy can be explained by banks' forward-looking behavior. When there is an increase in the monetary policy interest rate, banks expect a deterioration of the economy and thus they adopt a conservative position (intensify the protection through macroprudential instruments). On the other hand, when monetary policy interest rate decreases, banks reduce the security level of macroprudential instruments. The intuition behind these results corresponding the idea that banks react taking less risk when monetary policy is tightened and more when it is eased, similar to Jimenez et al. (2014) for least capitalized banks.

Table 2

Credit provisions

Regressors	Model 1	Model 2	Model 3	Model 4
PROV(-1)	0.5345***	0.5378***	0.6674***	0.5514***
	(0.0216)	(0.0228)	(0.0198)	(0.0271)
IR(-1)	0.1716***	0.1764***	0.2221***	0.1804***
	(0.0433)	(0.0410)	(0.0405)	(0.0452)
LIQ(-1)	0.37663***	0.3937***	0.3977***	0.4773***
	(0.0783)	(0.0788)	(0.0606)	(0.0790)
CRED	-0.5578***	-0.5450***	-0.5745***	-0.5608***
	(0.0174)	(0.0187)	(0.0170)	(0.0176)
NPL(-1)	0.1411***	0.1145***	0.0630***	0.07828**
	(0.0168)	(0.0164)	(0.0178)	(0.0208)
GAP(-1)		-0.0922***	-0.1079***	-0.0694***
		(0.0163)	(0.0162)	(0.0159)
SIZE(-1)			1.9672***	0.7159**
			(0.2549)	(0.3030)
Crisis				1.1901***
				(0.3191)
Obs.	5043	5043	5023	5026
N.Instr/N. cross sec.	0.48	0.48	0.50	0.48
J-statistic	58.64	59.03	57.11	55.91
P-valor	0.21	0.17	0.25	0.20
AR(1)	-0.41	-0.40	-0.41	-0.39
P-valor	0.00	0.00	0.00	0.00
AR(2)	0.01	0.01	0.01	0.02
P-valor	0.16	0.29	0.31	0.27

Note: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. White's heteroskedasticity consistent covariance matrix was applied in regressions. Standard errors between parentheses. S-GMM – uses two-step of Arellano and Bover (1995) without time period effects. Tests for AR (1) and AR (2) check for the presence of first order and second-order serial correlation in the first-difference residuals. The sample is an unbalanced panel of 121 banks from 2001q1 to 2015q2.

In relation to the variables that represent the individual characteristics of the banks (variable *Z* - equation 1), the results are in agreement with those observed for most of the literature on banks. The coefficients on liquidity (*LIQ*) are positive and significant in all models, which makes it possible to infer that macroprudential instruments (*BUF*, *PROV* and *LEV*) are sensitive to liquidity conditions. The more liquid the banks are, the less risk they assume. In relation to the coefficients related to the credit growth rate (*CRED*), it is observed that they are negative and significant. As observed by Jokivuolle, Pesola, and Viren (2015), this result suggests that, for example, when there is a positive credit variation, capital buffer and leverage are reduced due to higher bank leverage with respect to credit. Moreover, as observed by Foos, Norden, and Weber (2010), this result indicates that the higher the provision for credit risk (PROV), the lower the volume of credit granted to the economy as a whole. In consonance with de Mendonça and Barcelos (2015), the positive sign and the statistical significance observed for return on assets (*ROE*) in the models for capital buffer and for leverage denote the well-known relationship between risk and return. In the model for credit provision the statistical significance and the positive sign of the coefficients related to non-performing loans (*NPL*) reveal that the higher the default, the greater the coverage for credit risk.

Table 3

Bank's leverage

Regressors	Model 1	Model 2	Model 3	Model 4
LEV(-1)	0.7959***	0.7685***	0.8465***	0.8510***
	(0.0148)	(0.0160)	(0.0152)	(0.0147)
IR(-1)	0.0935***	0.0846***	0.0916***	0.0940***
	(0.0139)	(0.0133)	(0.0132)	(0.0135)
LIQ(-1)	0.0214***	0.0344***	0.0198***	0.0203***
	(0.0055)	(0.0046)	(0.0053)	(0.0053)
CRED	-0.1010***	-0.0576*	-0.1141***	-0.1209***
	(0.0286)	(0.0320)	(0.0302)	(0.0297)
ROE(-1)	0.0634***	0.0924*	0.0725***	0.0733***
	(0.0098)	(0.0112)	(0.0110)	(0.0116)
GAP(-1)		-0.03475***	-0.0257***	-0.0161
		(0.0092)	(0.0091)	(0.0120)
SIZE(-1)			0.4238***	0.4382***
			(0.0815)	(0.0835)
Crisis				0.1367*
				(0.0749)
Obs.	5120	5113	5112	5112
N.Instr/N. cross sec.	0.49	0.49	0.50	0.51
J-statistic	53.65	63.51	54.42	53.54
P-valor	0.16	0.15	0.41	0.45
AR(1)	-0.50	-0.48	-0.50	-0.50
P-valor	0.00	0.00	0.00	0.00
AR(2)	0.00	0.00	0.00	0.00
P-valor	0.60	0.62	0.68	0.65

Note: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. White's heteroskedasticity consistent covariance matrix was applied in regressions. Standard errors between parentheses. S-GMM – uses two-step of Arellano and Bover (1995) without time period effects. Tests for AR (1) and AR (2) check for the presence of first order and second-order serial correlation in the first-difference residuals. The sample is an unbalanced panel of 121 banks from 2001q1 to 2015q2.

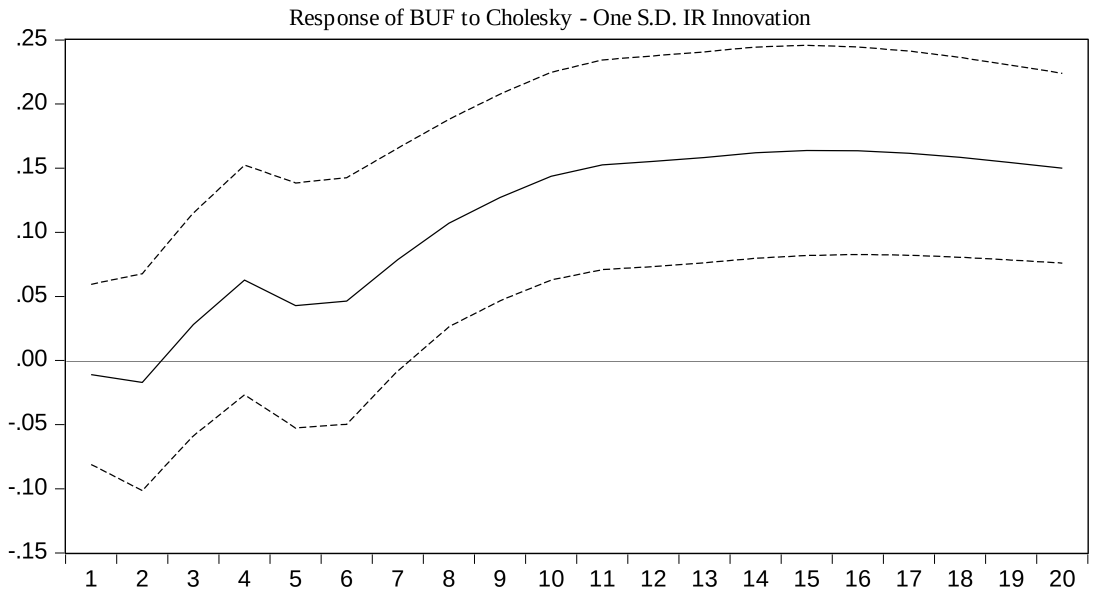
As extensions to the basic model, new estimates are made taking into account economic cycle (*GAP*), bank's size (*SIZE*), and the effect from the subprime crisis (models 2 to 4 - tables 2, 3 and 4). The statistical significance and the negative sign of *GAP* indicate that macroprudential instruments behave procyclically. On the one hand, when there is economic growth, banks reduce the soundness of the financial system through the reduction of macroprudential instruments. On the other hand, when the economic growth is lower than the potential, banks widen macroprudential instruments and therefore increase the soundness of the financial system. In brief, countercyclical regulatory actions are necessary in order to maintain financial stability (BIS 2014, Murcia and Kohlscheen, 2016). Statistical significance and the positive sign of *SIZE* indicate that larger banks tend to maintain larger coverages for risks assumed. One possible explanation for this result is the fact that large banks have greater access to the market (equity and debt markets). Finally, the statistical significance and the positive sign related to the subprime crisis dummy indicate that banks react to financial crises with greater risk aversion (increase protection through macroprudential instruments).

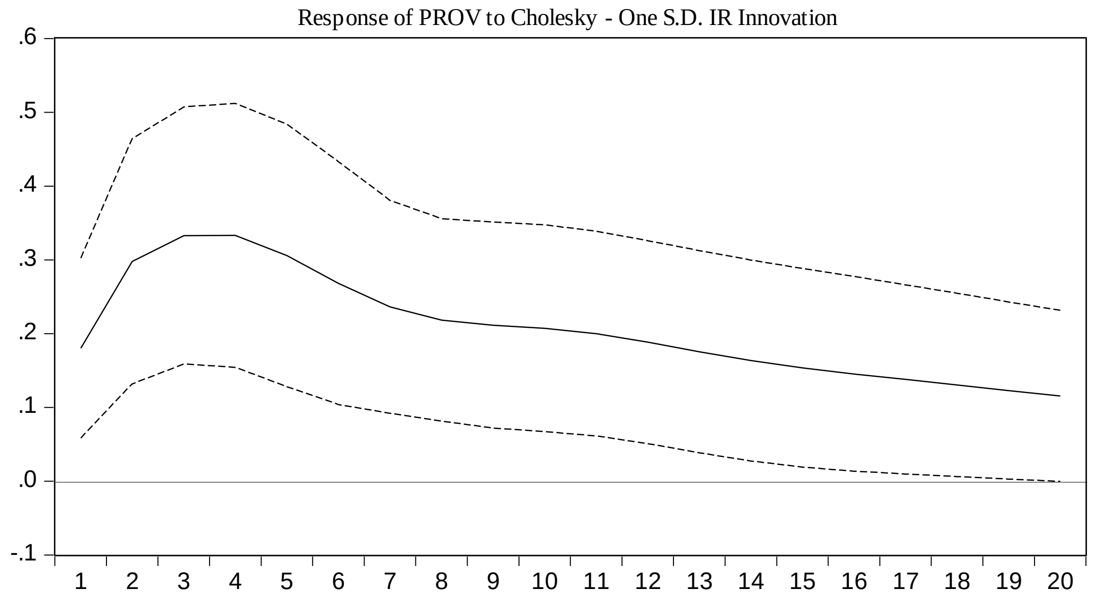
Extending the analysis regarding the impact of the monetary policy interest rate on macroprudential instruments, impulse-response functions plotted out to the 20th quarter from a S-VAR model (see equation 2) are presented. In general, the findings are in consonance with those observed in tables 2, 3 and 4. In other words, figure 5 shows that a positive shock transmitted through interest rate provokes an amplification of the macroprudential instruments which abides over time.

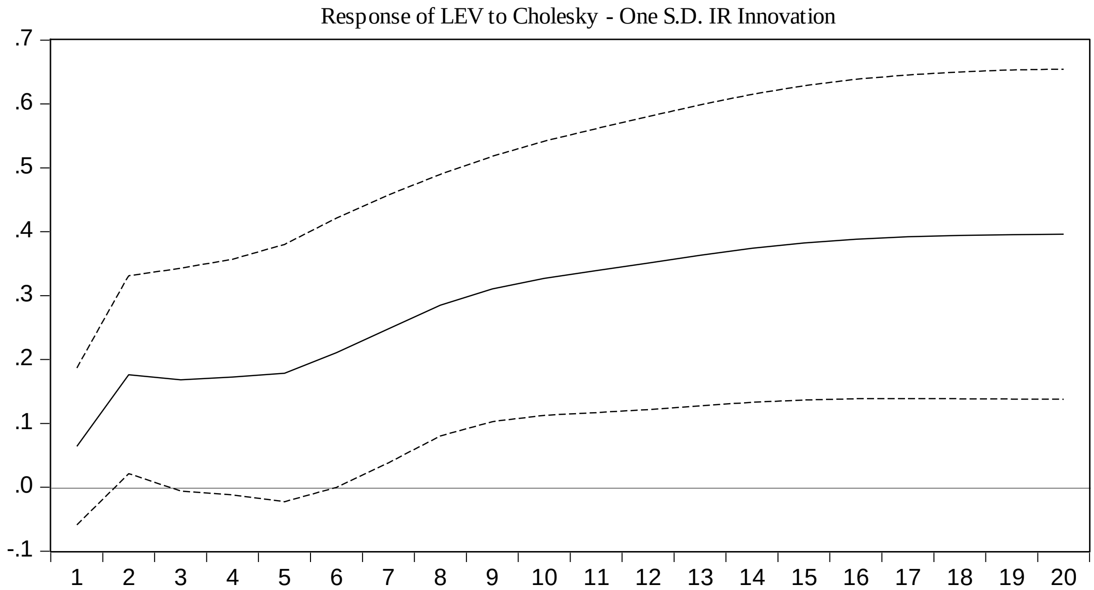
Regarding the capital buffer and leverage, the response to a shock transmitted through monetary policy interest rate (first and third graphs in figure 5) denotes that there is statistical significance for an increase in the capital buffer and leverage from 7th quarter. This is an important observation, because according to the BCBS (2010), the announcement of an increase in the countercyclical capital buffer (*CCyB*) takes four quarters to be effective. The same interpretation is valid for leverage because this variable is similar to the capital buffer and thus it represents a relation between the capital and the bank's assets. The shock transmitted through interest rate to credit provisions (second graph in figure 5) does not show lag for seeing statistical significance. A possible justification for this result is that, in a different manner from the previous instruments, there is no schedule of adjustment for this instrument (time to be effective).

Figure 5

Responses of macroprudential instruments to monetary policy interest rate innovation







4. Conclusion

Based on an original database built from balance sheets provided by Central Bank of Brasil of 121 banks for a whole of 58 quarters (March 2001 to June 2015), this study investigated empirically the relation between macroprudential policy and monetary policy. In particular, the effect of the monetary policy interest rate on the instruments for macroprudential financial institutions-based policies (capital buffer, credit provisions, and leverage) was analyzed.

The empirical evidence in this study allows one to see that the monetary policy affects macroprudential instruments. The findings indicate that an increase in the monetary policy interest rate takes banks to increase capital buffer and credit provisions and to decrease leverage. A possible explanation for this reaction is the banks' forward-looking behavior causing the banks to anticipate a scenario of an increase in the interest rate. Therefore, when there is an increase in the monetary policy interest rate, banks expect a deterioration of the economy and thus adopt a conservative position (amplify the protection through macroprudential instruments). On the other hand, a decrease in the interest rate takes banks to accept more risk, which, in turn, can represent a threat for the financial stability. In brief, under a scenario of an increase in the interest rate the financial system becomes more solid. However, when there is a decrease in the interest rate the system tends to be fragile which, in turn, demands actions from the macroprudential supervisor.

It is important to highlight that the main objective of the monetary policy is not to guarantee the financial stability. However, the effects that the monetary policy interest rate causes on macroprudential instruments cannot be neglected. Therefore, it is mandatory to aggregate to the macroprudential policy the possibility of interconnection with the monetary policy in order to guarantee financial stability.

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Appendix

Table A.1

Sources of data, description of the variables, and descriptive statistics

Variable	description	Data source	Mean	Std. dev.	Min	Max	Obs
BUF	Difference between the capital of financial institutions and the minimum capital required by regulators (CAR).	IEFA/CBB – devised by authors	3.29	5.67	-2.38	90.82	5857
PROV	Coverage for credit losses provided by the banks/ total credit volume ratio.	IEFA/CBB – devised by authors	5.82	9.04	0.00	100.00	5642
LEV	Capital to assets ratio	IEFA/CBB – devised by authors	25.83	21.16	0.11	173.31	6060
IR	Monetary policy interest rate (SELIC).	CBB, SGS – devised by authors	13.79	4.56	7.15	26.32	7018
LIQ	Liquid assets/total assets ratio.	IEFA/CBB – devised by authors	29.95	21.34	0.01	100.00	5882
CRED	Credit growth rate.	IEFA/CBB – devised by authors	0.16	4.11	-1.00	255.91	5524
ROE	Net income/shareholder's equity ratio.	IEFA/CBB – devised by authors	4.87	14.14	-247.99	138.43	5768
NPL	Credit operations with arrears over 90 days/total credit portfolio ratio.	IEFA/CBB – devised by authors	6.29	8.84	0.00	100.00	5647
GAP	Difference between GDP and the potential output (Hodrick-Prescott filter).	TSMS/CBB – devised by authors	-0.04	3.06	-9.88	7.76	7018
SIZE	Log of total banks' assets.	IEFA/CBB– devised by authors	21.04	2.28	14.90	27.70	6052

Note: IEFA/CBB - Information for Economic-Financial Analysis/Central Bank of Brazil, TSMS/CBB – Time Series Management System.

Table A.2

AIC, SIC, and HQ criteria for VAR

	Buffer			Prov			Lev		
Lag	AIC	SC	HQ	AIC	SC	HQ	AIC	SC	HQ
0	11.765	11.781	11.771	12.892	12.908	12.897	14.422	14.438	14.427
1	8.121	8.142	8.128	9.099	9.120	9.106	9.139	9.160	9.147
2	7.690	7.716	7.699	8.657	8.684	8.667	8.689	8.715	8.698
3	7.368	7.400	7.380	8.393	8.425	8.404	8.420	8.452*	8.431
4	7.355	7.392	7.368	8.386*	8.423*	8.399*	8.417	8.454	8.430
5	7.333*	7.376*	7.348*	8.386	8.429	8.401	8.412*	8.455	8.427*
6	7.335	7.382	7.351	8.387	8.435	8.404	8.413	8.461	8.430

Note: (*) denotes lag order selected by the criterion.

Table A.3
Unit root tests
Levin-Lin-Chu, Im-Pesaran-Shin, Fisher-ADF, and Fisher-PP

Series	Levin-Lin-Chu		Im-Pesaran-Shin		ADF-Fisher		PP - Fisher	
	Statistic	Prob	Statistic	Prob	Statistic	Prob	Statistic	Prob
BUF	-2.458	0.007	-15.276	0.000	769.016	0.000	1401.36	0.000
PROV	-4.510	0.000	-8.312	0.000	509.200	0.000	562.276	0.000
LEV	-7.127	0.000	-9.758	0.000	578.413	0.000	733.944	0.000
IR	-15.158	0.000	-13.493	0.000	559.910	0.000	179.755	0.999
LIQ	-5.644	0.000	-10.178	0.000	580.896	0.000	1193.590	0.000
CRED	-181.594	0.000	-50.602	0.000	1595.380	0.000	2663.83	0.000
ROE	-31.550	0.000	-31.445	0.000	1525.48	0.000	966.647	0.000
NPL	-7.432	0.000	-11.185	0.000	565.741	0.000	756.927	0.000
GAP	-110.610	0.000	-106.359	0.000	5845.100	0.000	6216.230	0.000
SIZE	-8.394	0.000	0.745	0.772	302.249	0.003	417.854	0.000

Note: Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality. Automatic lag difference term and bandwidth selection (using the Schwarz criterion for the lag differences, and the Newey-West method and the Bartlett kernel for the bandwidth). Exogenous variables: individual effects.

Table A.4
Roots of Characteristic Polynomial (Modulus)

BUF	*PROV*	*LEV*
0.9355	0.9405	0.9662
0.8704	0.8572	0.9250
0.7315	0.7208	0.7319
0.7315	0.7208	0.7319
0.6755	0.47355	0.5215
0.6755	0.47355	0.5215
0.5954	0.4088	0.5209
0.4202	0.0987	0.5082
0.2771		0.2777
0.2217		0.2284

Note: No root lies outside the unit circle. Var satisfies the stability condition.

Table A.5
Correlation Matrix

	BUF	*PROV*	*LEV*	*IR*	*LIQ*	*CRED*	*ROE*	*NPL*	*GAP*	*SIZE*
BUFFER	1.000									
PROV	0.285	1.000								
LEV	0.633	0.185	1.000							
IR	0.040	0.049	0.054	1.000						
LIQ	0.494	0.227	0.505	-0.020	1.000					
CRED	0.001	-0.024	0.007	-0.007	0.018	1.000				
ROE	-0.056	-0.155	-0.081	0.097	-0.093	-0.006	1.000			
NPL	0.156	0.524	0.125	0.026	0.052	-0.027	-0.132	1.000		
GAP	0.009	-0.017	-0.007	-0.050	-0.007	-0.016	0.014	-0.039	1.000	
SIZE	-0.372	-0.118	-0.640	-0.196	-0.236	-0.010	0.142	-0.128	0.009	1.000