Bank regulatory capital, risk-taking channel and monetary policy
Evidence from an inflation targeting emerging economy

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Abstract

This article presents a contribution to the literature on monetary policy and bank regulation since it assesses the link involving monetary policy, capital regulation and risk-taking. This link is explored in an important inflation targeting emerging economy (Brazil) that for several decades has experienced extremely high interest rates and simultaneously a high degree of banking solvency – as measured by the Capital Adequacy Ratio (CAR). The study provides the following evidences through different econometric methods: (i) monetary policy affects bank solvency (financial stability) through loan provisions; and (ii) there is no trade-off between loan provisioning and bank capital. Taken together, these evidences suggest that: (i) a banking supervision strategy must take into account the outcomes of monetary policy on financial stability; and (ii) the demand for additional provision, which is an important instrument used by banking supervisors, does not have the desired effect in a high interest rate economy.

Keywords: financial regulation, monetary policy, risk-taking channel.

Resumo

Este artigo apresenta uma contribuição para a literatura sobre política monetária e regulação bancária, uma vez que avalia a relação envolvendo política monetária, regulação de capital e tomada de riscos. Esta relação é explorada em uma importante economia emergente com metas para inflação (Brasil) que há várias décadas tem experimentado taxas elevadas de juros e, simultaneamente, um elevado grau de solvência bancária - medida pela razão de adequação de capital (CAR). O estudo oferece as seguintes evidências por meio de diferentes métodos econométricos: (i) a política monetária afeta a solvência bancária (estabilidade financeira), através de provisões para o crédito; e (ii) não há trade-off entre a provisão de empréstimos e o capital dos bancos. Tomadas em conjunto, essas evidências sugerem que: (i) uma estratégia de supervisão bancária deve levar em conta os resultados da política monetária sobre a estabilidade financeira; e (ii) a exigência de provisão adicional, que é um importante instrumento usado por autoridades de supervisão bancária, não tem o efeito desejado em uma economia com elevada taxa de juros.

Palavras-chave: regulação financeira; política monetária; canal de tomada de risco

JEL Classification: E44, E52, E58

Área 4 - Macroeconomia, Economia Monetária e Finanças

1. Introduction

The inflation targeting framework (IT) has been adopted by several central banks as a strategy to implement monetary policy. IT's main feature is the official announcement of ranges for inflation fluctuations and the explicit recognition that the main goal of monetary policy is to assure low and stable inflation rates. As pointed out by de Mendonça and de Guimarães e Souza (2012), inflation is like a disease without cure and IT is a good remedy to control but not to eliminate inflation. On the other hand, like any remedy, IT has side effects, and these effects can exceed the targets of monetary policy. When policymakers alter the interest rate they only aim at inflation, but as a side effect they change banks' behavior. Since banks' behavior is an issue for financial stability policy, there is a logical relationship between the IT framework and the financial stability policy.

The idea that monetary policy alters banks' behavior is not new. Bernanke (1983) states that the great depression was aggravated by banks' reactions to monetary policy. But the connection between monetary policy and financial stability is still rare in the literature about emerging economies. Before the 2008-2009 financial crisis, there was a consensus that the relationship between financial stability and banking behavior was a regulatory issue. The financial crisis put the accepted assumptions of financial stability to the test and created an environment of uncertainty with potential impacts on the conduction of monetary policy. The aftermath of the crisis gave birth to a new view where financial stability has to be a part of economic policy, like monetary and fiscal policy. So, it is necessary to understand how monetary policy influences financial stability, which is a relevant part of the ongoing debate over appropriate central bank tools for achieving financial stability.

In consonance with this point of view, many financial stability committees were created around the world after the crisis (for instance, the Financial Stability Oversight Council was created in the United States in July 2010; in England, the Financial Service Act created the Financial Policy Committee in December 2012; in July 2011, Chile created the "Consejo de Estabilidad Financiera" and Mexico created the "Consejo de Estabilidad del Sistema Financiero" in July 2010).

Despite the fact that the Brazilian economy did not suffer huge effects from the crisis, in May 2011 the Central Bank of Brazil (CBB) created the Financial Stability Committee (COMEF). The aim is to achieve an institutional upgrade in the accomplishment of the CBB's mission, namely price and financial stability. Hence, there is a clear opportunity for coordinated action of monetary policy and financial stability management.

The Brazilian economy has some features that make it an important case study for the relationship between monetary policy and financial stability. IT was adopted in Brazil in June 1999. The main task of the CBB is to guide public expectations towards the inflation target defined by the National Monetary Council. The main feature of monetary policy during the entire period under IT in Brazil was high interest rates. The average rate in these years was higher than 14% a year. On the other hand, in the same period there was no noticeable problem with Brazilian banks, even during the subprime crisis. Brazil was considered a successful case of high resilience of the financial sector and Brazil's financial supervision was praised. Under IT, the Brazilian economy was characterized by the coexistence of high interest rates and financial stability, which suggests that monetary policy can contribute to financial stability in terms of banking solvency. That leads to the following question: What kind of relationship does exist between monetary policy and banking behavior in terms of solvency in a high interest rate economy?

This study is a contribution to understand this relationship. In particular, it is a contribution on how banking solvency reacts to monetary policy, shedding light on a little explored transmission channel, namely the risk-taking channel (Borio and Zhu, 2012). The

novelty of the paper regards the analysis of the link, which involves capital regulation, risk-taking and monetary policy. This link is explored in an important IT emerging economy that for several decades has experienced extremely high interest rates and simultaneously a high degree of banking solvency – as measured by the Capital Adequacy Ratio (CAR).

This paper is organized as follows. The next section presents the importance of financial stability and how financial regulation works. Section three presents the transmission mechanism of monetary policy through the bank lending channel and the bank risk-taking channel. Section four provides empirical evidence through ordinary least squares (OLS), generalized method of moments (GMM), system-GMM and dynamic analysis through vector autoregression. Section five concludes.

2. Financial Stability

Banking is one of the most regulated sectors in the economy. Llewellyn (1999) presents a whole set of economic reasons justifying the existence of banking regulation, among them the fact that banks play a central role in the financial system and their impact on the real economy is immediate, since many companies depend on banks as their sole source of funding, not to mention the effect of consumer credit on aggregate demand.

Aligned with these arguments, Stiglitz and Greenwald (2003) affirm that when a bank faces bankruptcy or is sold, a significant amount of information concerning its debtors is lost. As a consequence, the time needed for the competition to acquire information and resume lending at the same level and diversity previously observed may lead to a discontinuity in business.

Other economic reasons used by Llewellyn (1999) to advocate regulation are: the contagion risk, which can lead to a run on deposits; the liquidity mismatch between assets and liabilities, which is inherent to banks' balance sheets and makes them vulnerable to rumors; and finally the interconnection between banks conjugated with the perception depositors have that requests to withdraw money will be satisfied on a first in first out basis. These are economic reasons that reveal the level of fragility faced by banks and support the need for regulation.

Blinder (2010) argues that systemic risk is one that is either large enough in size or broad enough in scope that, if things go wrong, can damage a significant portion of the financial system. Therefore, financial stability depends on keeping systemic risk at bay. Disruption of financial stability can be triggered in many ways: be it the collapse of a huge financial institution, the coordinated movement of smaller firms or the failure of intertwined firms that can drag others through their connections and provoke damage out of proportion to their size.

Banking regulation critics argue that investors are capable of choosing and separating between sound and unhealthy banks. Hence, this ability is the guardian of the system and not regulation. However, as Goodhart et al. (1998) point out, investors are not in a good position to judge a bank's soundness due to asymmetric information between banks and clients. In turn, asymmetric information is intrinsic to the banking business.

According to Mishkin (2000), prudential supervision, broadly construed, involves government regulation and monitoring of the banking system to ensure its safety and soundness. Considering the asymmetry in the banking business and aiming to create incentives that minimize banks' exposure to bankruptcy risks, prudential supervision chooses capital requirements as its main regulatory tool.

Essentially structured as a leverage ratio, capital requirements have converged to the so-called Basel Accords. Supported by the seal of the Bank for International Settlements (BIS), the third Basel Accord, although not fully deployed, defines that the amount of capital divided by the risk-weighted assets must be at least 10.5%. Capital and risk-weighted assets are

constructs developed by the Basel Committee on Banking Supervision (BCBS), and both are broad enough to capture subordinated liabilities such as capital and credit, market and operational risks as risk-weighted assets.

As Mishkin (2000) pointed out, the goal of prudential supervision ranges from the assessment of the quality of banks' assets, especially loans, to the point of determining additional allowances. Provisioning is the mechanism that banks use to adjust the outstanding value of loans to reflect losses arising from credit risk (quality of the loan portfolio). The reduction in the value of loans corresponds to a reduction in the bank's profits, which can also be understood as a reduction in the net asset value of the bank. Individually considered, provisioning reduces the CAR, since it affects capital much more heavily than risk-weighted assets, respectively the numerator and denominator of the CAR (Borio and Lowe, 2001). As Borio and Lowe (2001) detected, provisioning enhances the transparency of banks' balance sheets as well as increases the volatility and cyclicality of banks' profits. In principle, provisioning should lead to a more accurate picture of both a bank's earnings and its assets than would be the case if all loans were measured at their outstanding value.

From a banking supervisor's standpoint, provisions are regarded as important prudential tools because they ensure that banks keep adequate protection against future loan losses. This point of view is supported by the BCBS, which recommends that banking supervisors determine the adequacy of banks' policies and processes for grading and classifying their assets and establishing appropriate and robust provisioning levels for loans.[1] Besides this, it also recommends that banking supervisors should assess whether the classification of assets and their provisioning is adequate for prudential purposes. If assets' classifications are inaccurate or provisions are deemed to be insufficient for prudential purposes, the supervisor has the power to require the bank to adjust its classifications of individual assets, increase its level of provisioning, reserves or capital and, if necessary, impose other measures.

Since capital and provisioning levels are proxies of the soundness of a bank as well as the financial system, they can also be understood as flags to detect problems, allowing banking supervisors to act prudentially to avoid financial instability.

The financial system is not a closed system. It feels the influence of the macroeconomic environment, mainly through the transmission channels of monetary policy. In this way, the Committee on International Economic Policy Reforms (CIEPR) recognizes that financial stability should be an explicit objective of central banks and monetary policy should be regarded as a legitimate part of the macroprudencial toolkit (CIEPR, 2011).

Hence, understanding the relationship between financial stability and monetary policy has a crucial role in the definition of new regulatory strategies, as well as in the action of banking supervision. This understanding must begin with the basic elements of financial stability and monetary policy. From financial stability, the elements are the average level of loan provisions and the CAR of the financial system. From monetary policy, the elements are the basic interest rate and the transmission mechanisms of monetary policy. The issue is how monetary policy impacts banks' level of provision and CAR, and through which channels this impact can be observed.

3. Bank Lending Channel to Risk-Taking Channel

The initial approaches concerning the impact of monetary policy on banks were the works about asymmetric information (Akerlof, 1969; Stiglitz and Weiss, 1981), which revealed that the credit market is subject to failures and inefficiencies and this causes effects on the aggregate economic activity (Greenwald et al., 1984). In particular, it is recognized that

[1] Core Principles for Banking Supervision, principles 17 and 18.

problems of information create a set of mechanisms that propagate and amplify initial shocks to the economy (Bernanke, 1983). There are two main types of such mechanisms, called credit channels: (i) the lending channel, which emphasizes the existence of shocks that can affect the ability/willingness of banks to supply credit to bank-dependent firms, and (ii) the balance sheet channel, which emphasizes the existence of shocks that can affect the financial position of firms and households and thus their ability to access the credit market (Hubbard, 1995; Bernanke and Gertler, 1995).

Despite the fact that empirical evidence regarding the functioning of monetary policy through the risk-taking channel is scarce and focused on monetary policy, the available literature is useful to understand the link between monetary policy and financial stability.

The risk-taking channel refers to how changes in monetary policy rates affect either risk perceptions or risk tolerance (Borio and Zhu, 2012). According to this perspective, easy monetary conditions represent a standard element in boom-bust type business fluctuations, i.e., low interest rates may lead to financial imbalances through a reduction in risk aversion of banks, affecting the supply of credit, the credit spread and, as a consequence, economic decisions, causing business fluctuations. Although several authors have studied the relationship between monetary policy and business fluctuations, Borio and Zhu (2012) argue that insufficient attention has been paid to the link between monetary policy and the perception and pricing of risk by economic agents, i.e., to the risk-taking channel.

Regarding the relationship between monetary policy (through the basic interest rate) and the risk-taking channel, Altunbas et al. (2014) and Gambacorta (2009) emphasize that there are two main ways in which low interest rates can influence bank risk-taking. First, low interest rates affect valuations, incomes and cash flows, which in turn can influence how banks measure risk (Adrian and Shin, 2009a and 2009b; Borio and Zhu, 2012). Second, low returns on investments, such as government (risk-free) securities, may increase incentives for banks, asset managers and insurance companies to take on more risk for behavioral, contractual or institutional reasons, for example to meet a nominal return target (Brunnermeier, 2001; Rajan, 2005).

Unequivocally, monetary policy influences the risk-taking of banks. However, there are other possible causes of changes in banks' risk perception. The work of Tabak, Noronha and Cajueiro (2011) analyzes the relationship between economic cycles and capital buffers held by banks in Brazil. They evaluate the effects of bank capital on lending activity and how these effects vary among banks with different ownership structure. They use unbalanced panel data of Brazilian institutions from 2000 to 2010 to estimate an equation for capital buffers and for loan growth. The results reveal that the economic cycle negatively affects the surplus capital. These results have important implications in terms of capital regulation.

The work of Tabak, Laiz and Cajueiro (2010) investigates the effects of monetary policy on banks' loans growth and non-performing loans for the period 2003-2009 in Brazil. The results suggest the existence of a bank lending channel by showing that during periods of monetary tightening/loosing, banks' outstanding loan amounts decreased/increased. They also found that the financial crisis had a large impact on lending activity and that state-owned banks seem to respond more to monetary policy changes than foreign and domestically owned private banks. Moreover, by analyzing the impacts of monetary policy on non-performing loans, they found that during periods of interest rate increase/decrease, banks present a higher/lower growth rate of non-performing loans, which may aggravate/alleviate their performance. In addition, state-owned banks have a different lending profile, since they present a lower amount of non-performing loans. Furthermore, the results also support the existence of a risk-taking channel, in which lower monetary policy rates increase banks' risk-taking. During periods of low interest rates, large and liquid banks increase their credit risk exposure.

Despite the increase in the number of papers concerning the risk-taking channel after the crisis, there is still sparse literature associating it with financial regulation in emerging economies. In this regard, the work of Montes and Peixoto (2014) is a first step in this direction. They found evidence that both the lending channel and the risk-taking channel operate in the Brazilian financial system. Banks react to monetary policy by altering the amount of provisions (expected loss) of their loan portfolios and also the spread charged. In an environment of lax monetary policy, banks take more risks, reducing expected loss (provisions) and spreads. Moreover, this study found evidence that banks increase loans when the economy booms, enhancing the procyclical nature of the banking system. Besides confirming the criticism found in the literature concerning the procyclicality of the banking system, the approach used in Montes and Peixoto (2014) sets the stage to explore banking solvency in terms of the loan provisions. As defined by the Basel Accords, loan provisions (expected loss) directly affect the equity of banks, so it is a crucial constituent of the CAR.

The expected trade-off between provisions (expected loss) and the CAR (unexpected losses) is the main tool used by banking supervisors. When banking supervisors ask for additional provisions, they expect that the impact on banks' capital and CAR creates an incentive for banks to be more cautious regarding the quality of the assets originated. However, considering the influence that monetary policy has on banks' provisioning levels, its effect must be taken into account in banking supervision strategy. Accordingly, this study is a counterpoint to the works of Altunbas et al. (2014) and Jiménez et al. (2014). The former found evidence that low interest rates over an extended period contribute to an increase in bank risk. The latter identified that a lower interest rate induces lower capitalized banks to expand credit to riskier firms. We analyzed the risk-taking channel in Brazil, an economy that experienced high interest rates for more than 10 years. Therefore, understanding the impact of the risk-taking channel in economies with different features is crucial to improve the tools used for banking supervision. To do this, it is necessary to fill in the blanks of the risk-taking channel. This can be done by including economic variables that explain the aggregate behavior of the CAR in the analysis.

4. Empirical Analysis

4.1 The Brazilian Banking system, implementation of the capital requirements and macroeconomic adjustments

In the Brazilian financial system's current arrangement, the main institutions are universal banks, which provide a wide range of banking services. Two characteristics dominate the financial system in Brazil: market concentration and state control over some of the major institutions. According to the IMF (2012a), the Brazilian financial system is large, concentrated, and highly interconnected domestically. There are 1,475 deposit-taking financial institutions, with assets exceeding 100 percent of GDP, including 137 banks, 4 development banks, and one savings bank as of November 2011. The set of the five biggest universal banks accounts for two-thirds of total assets. These banks are usually part of larger financial conglomerates, which often include insurance and asset management. The banking system reports high levels of capitalization, liquidity and profitability. In September 2011, Brazilian banks, in general, were capitalized above minimum regulatory levels. The average CAR was 17.17 percent, well above the 11 percent required in Brazil, and above the 8 percent required by the Basel I and Basel II methodologies. The leverage ratio (9.57) and liquidity ratio (around 1.08) were also prudentially adequate. (IMF, 2012a, p. 5).

In Brazil, the implementation of Basel II began in 2007. According to the IMF (2012a), Brazil has a well-defined banking supervision process supported by a legal framework that

grants the CBB broad enforcement powers for corrective action and weak powers for bank resolution. The supervisory process is risk-based and intrusive. The process is based on a supervisory cycle that includes a mix of onsite and offsite activities and concludes with a rating of the bank on a scale of one to four based on quantitative and qualitative factors. The timeliness of corrective action has been improved by the adoption of regulations (resolutions) that enable the CBB to impose corrective action based on judgmental factors, such as the adequacy of corporate governance. Prior to the implementation of the Pillar 2 style resolutions, the CBB enforcement was focused on corrective enforcement, while now it takes a more preventive approach that can correct unsafe and unsound practices before they impact the bank's condition. Banks are subject to corporate law in the area of dividend payout, which establishes that a 25 percent minimum of profits must be paid to preferred shareholders. Although the CBB could mitigate the requirement by asking for additional capital to offset the dividend, this requirement hinders the ability of the CBB to preserve capital in a weak bank situation (IMF, 2012a, p. 3).

The positive performance of the Brazilian economy, even after the worsening of the global crisis in the second half of 2008, reflects the efforts to consolidate macroeconomic fundamentals. Regarding the macroeconomic environment, long before the crisis – since the mid-1990s – Brazil had adopted standard macroeconomic policies to control inflation and anchor expectations, including an IT framework (adopted in 1999). Fiscal policies were strengthened to ensure that markets perceived debt dynamics as sustainable. Moreover, Brazil opted for a flexible exchange rate regime as a first buffer against capital market mood swings and volatility. Last but not least, Brazil did not embark on the fashionable financial deregulation movement of the 1990s, keeping a conservative prudential regulatory framework for its financial sector, which remained tightly supervised and well capitalized. Nevertheless, the crisis caught emerging and advanced economies in quite different positions in the spectrum of macro and financial fragility: the former were ending a cycle of macro policy consolidation and had stronger financial sectors that had been tested through crises; the latter were at the peak of a cycle of credit-fueled consumption growth and had allowed their financial sectors to become highly vulnerable to shifts in confidence and changes in asset price valuation in their balance sheets. Fortunately, many emerging markets could also implement countercyclical policies to support activity thanks to the robust fundamentals and policy credibility built throughout a decade-long adjustment effort (Silva and Harris, 2012).[2]

The cornerstone of Brazil's monetary stability is the IT framework, adopted in June 1999. This framework includes all the features of a full-fledged IT regime, including: 1) the announcement of multi-year inflation targets; 2) assigning to the National Monetary Council the responsibility for setting the inflation targets and tolerance ranges based on a proposal by the minister of finance; 3) giving to the CBB full responsibility to implement the policies needed to attain the inflation targets; 4) establishing procedures to increase the central bank's accountability (specifically, if the target range is breached, the central bank president would have to issue an open letter to the minister of finance explaining the causes of the deviation, the measures that will be taken to eliminate it, and the time it will take to get inflation back inside the tolerance range) and, 5) taking actions to improve the transparency of monetary policy. The CBB conducts monetary policy in order to minimize deviations of inflation relative to the inflation target and fluctuations in the output gap, but also in order to guide agents' expectations about inflation and future monetary policy.

Financial and monetary stability are crucial to create a favorable macroeconomic environment, but how do they impact each other? Hence, in order to estimate the impact of

[2] For more details about the effects of the global financial crisis on Brazil and the action taken by Brazilian authorities, see Tabak, Laiz and Cajueiro (2010) and Silva and Harris (2012, section II "*The effects of the global financial crisis on Brazil*" and section III "*Brazil's policy responses to the crisis*").

monetary policy on Brazil's financial system stability, we conducted an empirical analysis using ordinary least squares (OLS), generalized method of moments (GMM) and a GMM system. One reason for using GMM is that while OLS estimations have problems of serial autocorrelation, heteroskedasticity or non-linearity, which is typical in macroeconomic time series, this method provides consistent estimators for the regressions (Hansen, 1982). As pointed out by Wooldridge (2001, p. 95), "to obtain a more efficient estimator than two-stage least squares (or ordinary least squares), one must have overriding restrictions." The weighting matrix in the equation was chosen to enable the GMM estimates to be robust, considering the possible presence of heteroskedasticity and autocorrelation of unknown form.

As pointed out by Cragg (1983), overidentification analysis has an important role in the selection of instrumental variables to improve the efficiency of the estimators. We performed a standard J-test with the objective of testing this property for the validity of the overidentifying restrictions (Hansen, 1982). The chosen instruments were dated to the period t−1 or earlier to help predict the contemporaneous variables, which are unavailable at time t. This procedure for the choice of instrumental variables follows Johnston (1984).

4.2 Data

The period of analysis runs from July 2001 to December of 2013. The monthly series used in this study are:

Capital Adequacy Ratio (CAR) - The CAR is treated as an indicator of solvency of a financial institution. The higher the index above the minimum rate set by the supervising authority, the greater the surplus of equity, or equity, to conduct transactions that generate additional risks. This variable represents the capital to risk-weighted assets ratio. National regulators track a bank's CAR to ensure that it can absorb a reasonable amount of loss and complies with statutory capital requirements. This series is obtained from the CBB (series 21424).

Provision (PROV) - This variable represents the expected losses, the amount provisioned by banks in relation to loans. The calculation of this indicator was used by Tabak, Noronha and Cajueiro (2011), and the indicator is the difference between "Provisions for credit transactions in the private financial system" and "Provisions for credit transactions in the private financial system (total H)", which are in arrears for more than 180 days, divided by "credit transactions in the private financial system (total credit to private sector)". All series used in the calculation of this variable are provided by the CBB (series 12929, 12977 and 4444). In considering the risk transactions (risk H) as losses, this measure can be viewed as a proxy for the perception of ex-ante risk.

Return on assets (ROA) - The series of return on assets represents how profitable a bank is relatively to its total assets. It is calculated by dividing a bank's annual earnings by the average of the last three months of total assets. The series was obtained from the CBB (series 21440).

Default rate (DEFAULT) - The default rate represents the ratio between the non-performing loans (in arrears for more than 90 days) and the total amount of credit transactions in the private financial system. It is expected that an increase in the default level worsens the credit market conditions, i.e., the level of provisions. The series is provided by the CBB (series 13673).

Credit gap (C_GAP) - The credit gap is obtained following the method of the Basel Committee on Banking Supervision (BCBS) (2010). The gap is the difference between the credit/GDP ratio and its trend (calculated by the Hodrick-Prescott filter). The series of credit/GDP ratio is available from the CBB (series 17474). Considering the new recommendations of the BCBS (2010), formalized in the document "Guidance for National

Authorities Operating the Countercyclical Capital Buffer", this indicator should be used by regulators of the financial system as a criterion for activation of countercyclical capital buffers. The goal is to increase the capacity of financial institutions to absorb losses above the minimum in good times of the economic cycle, so that in times of stress, the increased capital can be used.[3]

Basic interest rate (IR) - In Brazil, the basic interest rate (Selic) is the main monetary policy instrument under the regime of IT. The series used is provided by the CBB (series 4189). According to Tabak, Noronha and Cajueiro (2010), the idea of including this variable in the analysis is to assess the impact of monetary policy on the financial system's exposure to credit risk. A positive relationship is expected between the variable IR and the degree of perceived risk in the financial system posed by PROV. This relationship is explained by the presence of asymmetric information in financial markets, leading banks to increase provisions on credit transactions when the basic interest rate increases.

Reserve requirement rate (R_REQ) - This monetary policy instrument has a direct impact on the volume of credit and thus on the willingness of the financial system to take risks. The data used to construct this series are available at the website of the CBB (series 1883, 1884, 1886 and 17633). An increase in this rate should imply fewer available resources for applications by banks and greater aversion to losses of the financial system, which in turn promotes a decrease in credit supply and an increase in provisions.

Output gap (O_GAP) - This indicator was constructed from the series of GDP accumulated in 12 months, provided by the CBB (series 4190). The output gap is obtained by the difference between the GDP series and its long-term trend obtained through the Hodrick-Prescott filter. Variations in the economic cycle are expected to affect the process of lending and, consequently, the amount provisioned by banks. Because increased economic activity stimulates lending, a negative relationship is expected between O_GAP and PROV.

Dummy - To capture the effect of international financial shocks on the Brazilian economy from the subprime mortgage crisis and the crisis of government debt in Europe, we included a dummy variable, which assumes value 1 for the period from 2008.10 to 2011.01 and zero otherwise.

This work explores the connection between prudential regulation and monetary policy in consonance with the ideas presented by Borio and Zhu (2008)[4]. Thus two different models are presented. First, we estimated the connections between monetary policy and provisions following Montes and Peixoto (2014). Second, the variable PROV, used by Montes and Peixoto (2014) in their work about monetary policy, is included as an explanatory variable of CAR to estimate the impact of monetary policy in prudential regulation, as shown in figure 1. In turn, the choice of PROV as a monetary policy transmission mechanism through the risk-taking channel is justified by the results found by Montes and Peixoto (2014). We also checked the robustness of the results. For this we estimated a system of equations through GMM. Besides, variables that reflect the macroeconomic context and the behavior of banks are considered in the analysis.

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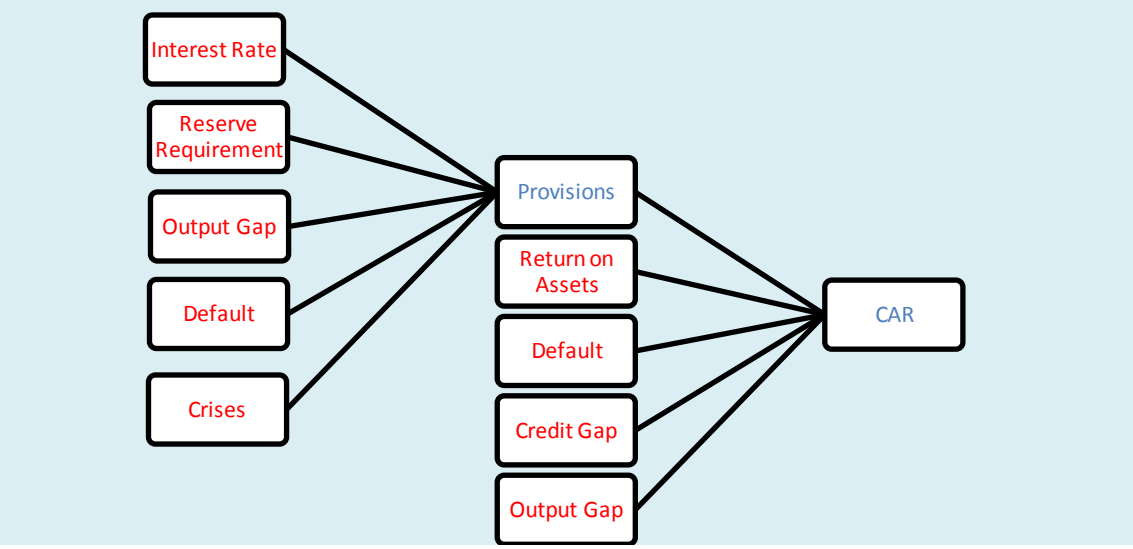
[3] According to BCBS (2010, p. 9): "*The specification of the credit-to-GDP gap has a number of advantages over credit growth. Being expressed as a ratio to GDP, the indicator variable is normalised by the size of the economy. This means it is not influenced by the normal cyclical patterns of credit demand. Being measured as a deviation from its long-term trend, the credit-to-GDP gap allows for the well known secular financial deepening trend. Being a ratio of levels, it is smoother than a variable calculated as differences in levels, such as credit growth, and minimises spurious volatility (no large quarter-to-quarter swings).*"

[4] Borio and Zhu (2008) states that the understanding of the interaction between prudential regulation and transmission mechanism is still limited.

Figure 1 - Scheme of analysis



Prepared by the authors

As a prerequisite to apply the estimations, the series were checked on the existence of unit roots, through the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests (Table A.1, Appendix).

4.3 Estimates of the influence of macroeconomic variables and monetary policies on provisions

Following the estimation presented by Montes and Peixoto (2014) to explain the behavior of provisions, we estimated equation 1 below:

$$(1)\ PROV_t = \alpha_0 + \alpha_1 IR_t + \alpha_2 DEFAUL_t + \alpha_3 R\_REQ_t + \alpha_4 O\_GAP_{t-2} + \alpha_5 Dummy + \epsilon_t$$

Where, ϵ is a random error term.

Table 1 shows the estimates. Due to the problems of autocorrelation and heteroskedasticity, the reported t-statistics in the OLS estimates are based on the estimator of Newey and West (1987). [5] In terms of GMM estimations[6], the J-statistic indicates that we cannot reject the hypothesis that the model is correctly specified.

Concerning the risk-taking channel and therefore the influence of monetary policy on provisions, the estimates confirm the expected relations. Thus, the positive relation between IR and PROV can be interpreted as a result of information asymmetries (adverse selection and moral hazard) that arise in the credit market when, for example, the central bank raises the short-term interest rate. Besides, regarding the link between monetary policy and risk perceptions and attitudes, the findings are in agreement with the ideas presented by Borio and Zhu (2008) and Adrian and Shin (2009b) and corroborate the findings of other econometric studies (Altunbas et al., 2014; Gambacorta, 2009; Jiménez et al., 2014).

[5] Regarding OLS estimates, the F-statistic of all equations indicates that the regressions are significant. Furthermore, the outcomes of the Ramsey RESET test indicate that the estimations do not present problems of model specification.

[6] Instrumental variables: $PROV_{-1}$,$PROV_{-2}$, $PROV_{-3}$ IR_{-1} ,IR_{-2}, IR_{-3}, IR_{-4}, IR_{-5}, IR_{-6}, O_GAP_{-3}, O_GAP_{-4}, O_GAP_{-5}, O_GAP_{-5}, O_GAP_{-6}, O_GAP_{-7}, O_GAP_{-8} O_GAP_{-9} , R_REQ_{-1}, R_REQ_{-2}, R_REQ_{-3}, R_REQ_{-4}, R_REQ_{-5}, R_REQ_{-6}, $DEFAULT_{-1}$, $DEFAULT_{-2}$, $DEFAULT_{-3}$, $DEFAULT_{-4}$, $DEFAULT_{-5}$, $DEFAULT_{-6}$.

Regarding the influence of the R_REQ, the estimates show that by limiting the resources available for lending, this monetary policy instrument makes credit transactions more costly and increases, at the same time, the risk aversion of financial institutions. The results found for R_REQ and IR corroborate the findings presented by Montes and Peixoto (2014) and Tabak et al. (2010) for the risk-taking channel in Brazil.

In turn, regarding the influence of economic activity, the variable O_GAP showed statistical significance and the estimated coefficients presented the expected signs. Therefore, the inverse relation between the level of activity and the variable PROV is explained by the procyclicality of banking activity. Thus, as shown by the evidence, in times of economic expansion, the expectations of default decrease and the degree of exposure to risk increases. Regarding the influence of the variable DEFAULT on the variable PROV, the evidence indicates that an increase in DEFAULT promotes an increase in PROV. DEFAULT represents the effective loss and PROV means the expected loss. Therefore, banks increase provisions when the default rate increases. Estimates related to this variable presented the expected sign and statistical significance. The findings for the influence of both variables (O_GAP and DEFAULT) on PROV are in agreement with those presented by Montes and Peixoto (2014).

Moreover, the dummy variable presented the expected sign and statistical significance. In this sense, the evidence indicates that banks increased provisions during periods of crisis. In other words, banks react to the economic environment changing the expected loss.

Table 1 – OLS and GMM estimates (dependent variable: PROV)

	OLS			GMM		
Explanatory variables	Eq(1a)	Eq(1b)	Eq(1c)	Eq(1a)	Eq(1b)	Eq(1c)
C	0.7913 **	0.5476*	0.5093	0.7633 ***	0.5292**	0.2745
	(0.309)	(0.324)	(0.343)	(0.153)	(0.205)	(0.220)
	[2.5572]	[1.6858]	[1.4805]	[4.9630]	[2.5771]	[1.2458]
IR	0.0164 ***	0.0143 ***	0.0155 ***	0.0234 ***	0.0194 ***	0.0198 ***
	(0.005)	(0.005)	(0.005)	(0.002)	(0.003)	(0.003)
	[2.7881]	[2.8182]	[2.6578]	[9.5046]	[5.6117]	[5.1481]
DEFAULT	0.4468***	0.4432***	0.4041***	0.4304***	0.4134***	0.3849***
	(0.062)	(0.064)	(0.056)	(0.003)	(0.038)	(0.034)
	[7.1779]	[6.9153]	[7.0916]	[12.8435]	[10.7525]	[11.2532]
R_REQ		1.0045	1.6838**		1.2187	2.5294***
		(0.775)	(0.8360)		(0.839)	(0.776)
		[1.2959]	[2.0268]		[1.4516]	[3.2584]
O_GAP(-2)			-2.1292*			-2.0628***
			(1.084)			(0.638)
			[-1.9631]			[-3.2293]
DUMMY	0.2285	0.3265*	0.4010 **	0.3769***	0.5340 ***	0.6990***
	(0.163)	(0.191)	(0.175)	(0.009)	(0.146)	(0.127)
	[1.4004]	[1.7039]	[2.2913]	[3.9819]	[3.6419]	[5.4733]
R2	0.61	0.60	0.64	0.60	0.59	0.58
Adjusted R^2	0.60	0.61	0.63	0.59	0.58	0.57
F-statistic	78.06	61.76	51.54			
Prob(F-statistic)	0.00	0.00	0.00			
J-statistic				18.25	17.86	17.50
Prob. (J-statistic)				0.83	0.80	0.78
Ramsey RESET (1)	0.98	0.19	0.31			
Prob.(Ramsey RESET)	0.32	0.84	0.75			
Heteroskedasticity ARCH (1)	259.76	275.95	223.27			
Prob.(Heteroskedasticity)	0.00	0.00	0.00			
Breusch-Godfrey-LM Test (1)	386.85	366.25	328.58			
Prob.(Breusch-Godfrey-LM Test)	0.00	0.00	0.00			

Source: authors' estimates. Note: Marginal Significance Levels: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Standard errors in parentheses ant t-statistics in square brackets.

4.4 Estimates for the influence of macroeconomic variables and provisions on bank solvency

In order to verify the relation between bank solvency and provision, we tested the following specification for the CAR:

$$(2)\ CAR_t = \beta_0 + \beta_1 PROV_t + \beta_2 ROA_t + \beta_3 DEFAULT_t + \beta_4 C\_GAP_t + \beta_5 O\_GAP_t + \xi_t$$

Where, ξ is a random error term.

Table 2 shows the estimates. The reported t-statistics in the OLS estimates are based on the estimator of Newey and West (1987) which is consistent in the presence of both heteroskedasticity and autocorrelation of unknown form.[7] In terms of GMM estimations[8], the J-statistic indicates that we cannot reject the hypothesis that the model is correctly specified.

The results suggest, with statistical significance, a positive relation between PROV and CAR. It is important to stress that, in a microprudential view, this result differs from the expected by financial regulators, but, in a macroprudential approach, it can be explained through the risk-taking channel. Both PROV and CAR mean risk, credit risk and solvency risk, so under a macroeconomic environment they react in a similar way, in agreement with the ideas presented by Goodhart (2009)[9]. The dichotomy observed indicates a need for a better articulation between the banking supervision strategy and the macroprudential policy, once evidence indicates that there is no trade-off between PROV, an important tool in banking supervision, and CAR, a proxy of financial stability.

Regarding the influence of ROA on CAR, the evidence indicates that an increase in ROA causes an increase in CAR. Therefore, banks increase CAR and become more solvent when their profitability increases. Profits represent one of the ways through which banks can raise capital and consequently CAR. The estimates related to this variable presented the expected sign and statistical significance.

Regarding C_GAP, when it increases, CAR decreases. The negative sign of the estimated coefficient shows the adherence of the countercyclical indicator proposed in Basel III to the Brazilian case. The estimated coefficients show statistical significance for all estimations.

Regarding the influence of DEFAULT on CAR, the evidence indicates that an increase in the default rate promotes a decrease in CAR. Therefore, banks decrease CAR and reduce the risk exposure when the default rate increases. Estimates related to this variable presented the expected sign and statistical significance.

Evidence points to a positive relationship between DEFAULT and PROV and a negative relationship between DEFAULT and CAR. There should be a positive relationship between DEFAULT and PROV since an increase in the amount of credit in arrears for more than 90 days demands an increase in the provisioning level. The negative relationship between DEFAULT and CAR is also expected, since the additional provisioning caused by DEFAULT is exogenous to the banks' will and leads to a reduction in capital, thus reducing CAR. However, provisioning is not just an objective decision based on default. If so, there would be a negative relationship between PROV and CAR, mimicking the negative relationship found between DEFAULT and CAR. However, provisioning has also an expectational component,

[7] In terms of OLS estimates, the F-statistic of all equations indicates that the regressions are significant. Moreover, the outcomes of the Ramsey RESET test indicate that the estimations do not present problems of model specification.

[8] Instrumental variables: CAR_{-1} ,CAR_{-2}, CAR_{-3},$PROV_{-1}$, $PROV_{-2}$, $PROV_{-3}$, ROA_{-1}, ROA_{-2}, ROA_{-3}, $DEFAULT_{-1}$, $DEFAULT_{-2}$, $DEFAULT_{-3}$ C_GAP_{-1}, C_GAP_{-2}, C_GAP_{-3} ,O_GAP_{-1}, O_GAP_{-2}, O_GAP_{-3}.

[9] For an analysis regarding the combination of more risk-sensitive methods using CAR, see Goodhart (2009).

which links it to the risk-taking channel. The provisioning level can be altered as a reaction to shocks transmitted through the risk-taking channel.

Therefore, additional provisioning is a deliberate practice and should only be performed in accordance with the maintenance or increase of CAR, sending a message of safety and soundness above any suspicion.

In turn, regarding the influence of economic activity, O_GAP showed statistical significance and the estimated coefficients presented the expected signs. Therefore, the inverse relation between the level of activity and CAR is explained by the procyclical nature of banking activity. Thus, as shown by the evidence, in times of economic expansion, the degree of exposure to risk increases.

Table 2 – OLS and GMM estimates (dependent variable: CAR)

	OLS			GMM		
Explanatory variables	Eq(1a)	Eq(1b)	Eq(1c)	Eq(1a)	Eq(1b)	Eq(1c)
C	10.187***	10.7110***	11.8173***	9.128***	9.863***	10.687***
	(1.069)	(1.223)	(1.108)	(0.723)	(0.870)	(0.848)
	[9.521]	[8.753]	[10.665]	[12.621]	[11.334]	[12.602]
PROV	2.3130***	2.3137***	2.2424***	1.987***	2.476***	2.330***
	(0.321)	(0.484)	(0.377)	(0.205)	(0.295)	(0.278)
	[5.192]	[4.777]	[5.939]	[9.664]	[8.376]	[8.356]
ROA	0.921***	0.8498***	0.9640***	0.968***	0.8493***	1.030***
	(0.122)	(0.155)	(0.160)	(0.105)	(0.129)	(0.132)
	[7.514]	[5.455]	[6.014]	[9.190]	[6.919]	[7.792]
C_GAP	-0.459*	-0.4102*	-0.3853*	-0.352*	-0.286*	-0.301**
	(0.242)	(0.245)	(0.203)	(0.147)	(0.154)	(0.131)
	[-1.894]	[-1.671]	[-1.891]	[-2.387]	[-1.850]	[-2.296]
DEFAULT		-0.5232*	-0.7672***		-0.461**	-0.619***
		(0.304)	(0.284)		(0.231)	(0.231)
		[-1.718]	[-2.698]		[-1.995]	[-2.674]
O_GAP			-12.9770***			-12.942***
			(2.839)			(2.286)
			[-4.570]			[-5.660]
R2	0.46	0.46	0.57	0.38	0.41	0.41
Adjusted R^2	0.45	0.45	0.55	0.36	0.40	0.40
F-statistic	42.127	42.127	38.581			
Prob(F-statistic)	0.00	0.00	0.00			
J-statistic				16.74	17.78	17.78
Prob. (J-statistic)				0.33	0.21	0.21
Ramsey RESET (1)	1.18	1.18	1.35			
Prob.(Ramsey RESET)	0.23	0.23	0.17			
Heteroskedasticity ARCH (1)	102.79	75.48	69.16			
Prob.(Heteroskedasticity)	0.00	0.00	0.00			
Breusch-Godfrey-LM Test (1)	295.88	241.89	188.96			
Prob.(Breusch-Godfrey-LM Test)	0.00	0.00	0.00			

Source: authors' estimates. Note: Marginal Significance Levels: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Standard errors in parentheses ant t-statistics in square brackets.

4.5 System of equations for provisions and bank solvency

The previous analysis indicates that the conduction of monetary policy through interest rate and reserve requirements affect provisions and provisions affect bank solvency. An additional step to grant robustness to the equations and coefficients previously obtained through OLS and GMM, preserving the transmission channel, is the estimation through a system of simultaneous equations.

Therefore, to test if provision is a channel that transmits the influence of monetary policy on the bank solvency, we estimated a system of equations. To deal with possible problems of endogeneity, the use of a system of equations which applies GMM is adequate to estimate unbiased coefficients.[10] Thus, we estimated the following system of equations (where ϑ and φ are random error terms).

$$\textbf{\textit{System}} \begin{cases} PROV_t = \gamma_0 + \gamma_1 IR_t + \gamma_2 R\_REQ_t + \gamma_3 DEFAUL_t + \gamma_4 O\_GAP_{t-2} + \gamma_5 Dummy + \vartheta_t \\ CAR_t = \theta_0 + \theta_1 PROV_t + \theta_2 ROA_t + \theta_3 DEFAULT_t + \theta_4 O\_GAP_t + \theta_5 C\_GAP_t + \varphi_t \end{cases}$$

Table 3 shows the estimation of the system.[11] All coefficients have signs in accordance with the theoretical view, and with statistical significance. It is noteworthy that the coefficients obtained by the system are more accurate than those estimated in the individual specifications, since the standard errors are smaller.

Table 3 – System GMM (PROV and Capital Adequacy Ratio)

Dependent Variables	**PROV**		**CAR**
Explanatory Variables		Explanatory Variables	
C	0.2286	*C*	10.8161***
	(0.1835)		(0.7961)
	[1.2456]		[13.5855]
IR	0.0179 ***	PROV	2.6430 ***
	(0.0036)		(0.1634)
	[4.9299]		[16.1729]
R_REQ	2.5169***	ROA	1.0134 ***
	(0.5612)		(0.1319)
	[4.4843]		[7.6780]
DEFAULT	0.4004 ***	DEFAULT	-0.8477 ***
	(0.0272)		(0.1618)
	[14.6905]		[-5.2386]
O_GAP(-2)	-2.2234***	O_GAP	-12.0385 ***
	(0.5662)		(1.7698)
	[-3.9263]		[-6.8022]
DUMMY	0.6507***	C_GAP	-0.4300***
	(0.1046)		(0.1038)
	[6.2199]		[-4.1420]
R^2	0.60		0.50
Adjusted R^2	0.59		0.48
J-statistic		0.17	
Prob. (J-statistic)			

Source: authors' estimates. Note: Marginal Significance Levels: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Standard errors in parentheses ant t-statistics in square brackets.

The estimates confirm the expected relations. The evidence found suggests that monetary policy affects financial stability in a high interest rate economy in the same way as in a low interest rate economy. This result suggests that the coordination between monetary policy and financial stability matter, corroborating Cecchetti and Kohler (2014). A second finding is that banks react to the macroeconomic environment differently from what is expected by banking supervision. Therefore, an important microprudential tool used by banking supervisors – the demand for additional provision – does not have the desired effect in a macroprudential way. The result supports the conclusion of Osiński, Seal and Hoogduin (2013) on the need for greater alignment between macro and microprudential policies.[12]

These conclusions allow one to project the following sequence of events: a rise in the basic interest rate (due to a rise in the inflation rate) results in an increase in banks'

[10] The System-GMM applies the same instrumental variables as the GMM.
[11] Instruments and lags are the same as those applied in the estimation of the individual equations.
[12] For more details, see Osiński, Seal and Hoogduin (2013).

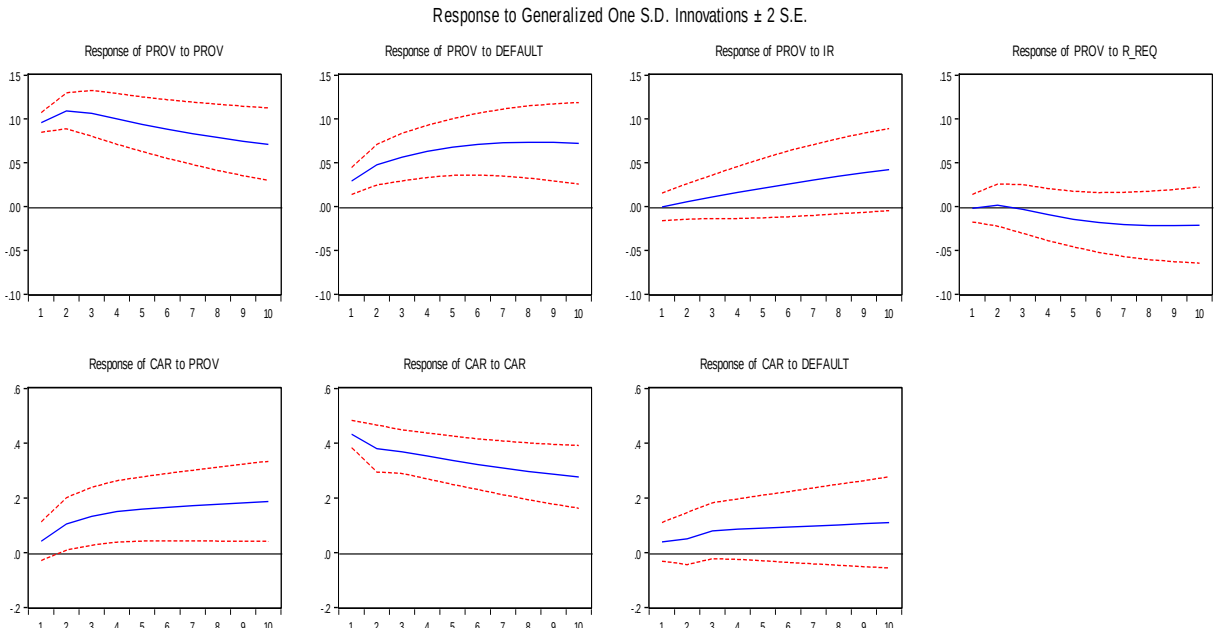
provisioning level, which in turn leads to an increase in CAR. The former is a reaction to express a riskier credit portfolio and the latter is a counter-measure to face future losses in the credit portfolio without the undesirable outcome of a reduction in CAR. On the other hand, a reduction in the interest rate brings about a reduction in the provisioning level, since banks believe the credit portfolio is less risky, and also reduces CAR and solvency, once smaller expected future losses do not demand additional capital. Therefore, the evidence that banking solvency responds to shocks from monetary policy and provisioning strengthens the idea that both aspects of the risk-taking channel, provision and banking solvency, are operating in Brazil, providing the link stated by Borio and Zhu (2012) in an emerging market economy.

4.6 Dynamic analysis through vector autoregression (VAR)

In general, the dynamic analysis of a vector autoregressive (VAR) model is performed through methods such as impulse response functions because it permits evaluation of the impulse on key variables caused by shocks (or innovations) provoked by residual variables over time (Sims, 1980). As pointed out by Lutkenpohl (1991), the conventional method applies the "orthogonality assumption" and thus the result can depend on the ordering of variables in the VAR model. Koop et al. (1996) and Pesaran and Shin (1998) developed the idea of the generalized impulse response function as a way to eliminate the problem of ordering of variables in VAR models. The main argument is that the generalized impulse responses are invariant to any re-ordering of the variables in the VAR.

Thus, aiming at eliminating the known problem in the results caused by the order of variables in the VAR model, we employ the generalized impulse response function here. The variables used in the analysis are: PROV, CAR, DEFAULT, IR and R_REQ. The choice of the VAR lag order was determined using the Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ) (Table A.2, appendix). Based on SIC and HQ, the VAR lag order is 2 and both tests indicate that the model is without a constant. The stability test for the VAR is shown through Figure A.1 in the appendix. Figure 2 below shows the results.

Figure 2 – Impulse response analysis



Prepared by the authors

It can be seen that an unexpected positive shock on *ir* causes an increase in PROV. In turn, regarding the relationship between R_REQ and PROV, an unexpected positive shock on R_REQ has no effect on PROV. The impact of the main instrument of monetary policy (the basic interest rate) on bank behavior is an important aspect for financial stability policy efforts. This result is in agreement with the previous estimations in Table 1.

In relation to DEFAULT, a positive shock on DEFAULT increases both PROV and CAR. In terms of the effect on CAR, this is an ambiguous result due to the previous estimation in Tables 1, 2 and 3. Moreover, the statistical significance and the signs reinforce the positive indirect effect of DEFAULT on CAR.

Furthermore, an unexpected positive shock on PROV increases CAR (banking solvency) with statistical significance. The observed CAR response can be explained by banks' decision to increase solvency in order to send a message of safety and soundness to the market.

Based on the different methods of analysis (OLS, GMM, System GMM and VAR), the following finding is important: there is a statistically significant positive relation between PROV and CAR. This result confirm the absence of the trade-off between provisions and banking solvency, indicating that the strategy of financial stability based on provision and CAR must be better articulated.

5. Concluding remarks

The present study explored the link involving capital regulation, the risk-taking channel and monetary policy under inflation targeting in an emerging market economy. In this sense, we made use of the literature on monetary transmission mechanisms, with emphasis on the risk-taking channel.

The findings indicate that the risk-taking channel operates in Brazil. Banks react to monetary policy (either when the central bank changes the basic interest rate or reserve requirements) by changing the amount of provisions and also the solvency (CAR). When interest rates and reserve requirements increase/decrease, banks take less/more risks by means of increasing/decreasing provisions and become more/less solvent, increasing/decreasing CAR. Understanding the relationship between monetary policy and financial stability is crucial to define new regulatory strategies, as well as more effective banking supervision.

Moreover, we found evidence of an important side effect due to high interest rates. The policy of high interest rates, which has been used in Brazil under inflation targeting for a long period, caused high resilience of the financial sector in terms of banking solvency. High interest rates mean high risk, so banks react with more spread and less credit supply (in accordance with the bank lending channel, as pointed out by Montes and Peixoto, 2014) and increase provisions and solvency (in accordance with the risk-taking channel).

An important novelty of the study is the evidence found that there is no trade-off between provisions and CAR. The absence of this trade-off means that banks react in the same way regarding provisions and solvency because these two aspects of banking strategy are related to the same aspect, namely banking expectation. Banking expectation is a forward-looking behavior that has to be considered when formulating banking supervision strategy. This absence of trade-off suggests that a provision based banking supervision may not be effective producing just the opposite of the desired outcome. In consequence, a better coordination between monetary policy and banking supervision becomes necessary and recommended.

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Appendix

Table A.1 – Unit root tests

	ADF			PP			KPSS		
Series	Lags	Test	Critical value 10%	Bandwidth	Test	Critical value 10%	Bandwidth	Test	Critical value 10%
CAR	0	-2.924 a	-2.577	5	-2.832 a	-2.577	9	0.162 a	0.347
PROV	1	-2.517 a	-2.577	7	-2.681 a	-2.577	9	0.132 a	0.347
ROA	12	-0.623 c	-1.615	3	-2.956 a	-2.577	9	0.312 a	0.347
O_GAP	3	-6.054 c	-1.615	8	-3.394 c	-1.615	9	0.029 a	0.347
IR	1	-4.780 b	-3.145	1	-4.780 b	-3.145	9	0.090 b	0.119
R_REQ	1	-2.691 a	-2.577	6	-2.748 a	-2.577	9	0.107 a	0.347
DEFAULT	6	-4.811 b	-3.145	7	-2.684 a	-2.577	9	0.100 b	0.119
C_GAP	0	-3.056 c	-1.615	1	-3.155 c	-1.615	9	0.064 a	0.347

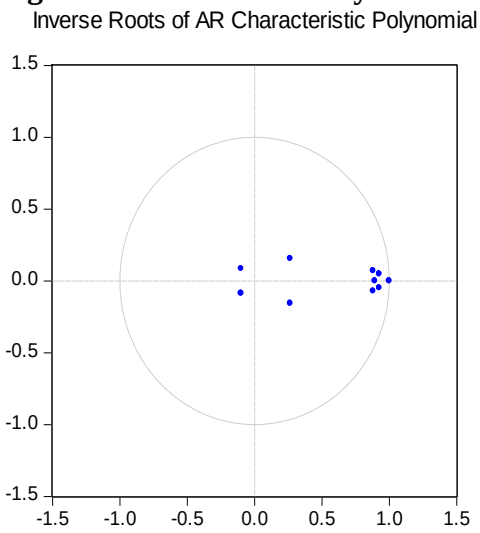
Source: author's elaboration. Note: ADF - the final choice of lag was made based on Schwarz criterion. PP and KPSS tests - lag is the lag truncation chosen for the Bartlett kernel. "a" denotes constant; "b" denotes constant and trend, and; "c" denotes none.

Table A.2 – VAR Lag Order

	with constant		without constant	
Lag	**SC**	**HQ**	**SC**	**HQ**
0	6.63	6.57		
1	-5.22	-5.59	-5.08	-5.39
2	-5.80*	-6.48*	-5.82*	-6.44*
3	-5.32	-6.3	-5.37	-6.29
4	-4.82	-6.12	-4.88	-6.11
5	-4.3	-5.91	-4.35	-5.89
6	-3.6	-5.51	-3.64	-5.5
7	-3.19	-5.42	-3.23	-5.4
8	-2.58	-5.11	-2.61	-5.08

Source: author's elaboration. Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ)

Figure A.1 – VAR Stability



Source: author's elaboration.