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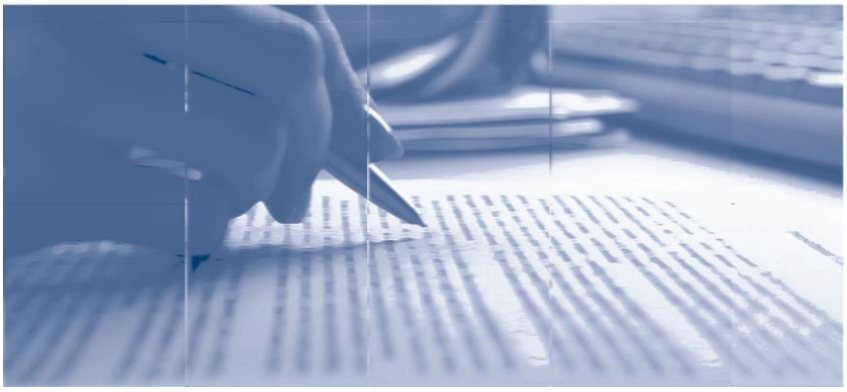

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Macroprudential and Monetary Policy Interaction: a Brazilian perspective*

Fabia A. de Carvalho **

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Abstract

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This paper discusses the interaction between monetary and macroprudential policy in Brazil under both normative and positive perspectives. We investigate optimal combinations of simple, implementable macroprudential and monetary policy rules that react to the financial cycle using a DSGE model built to reproduce Brazilian particularities, and estimated with Bayesian techniques with data from the inflation targeting regime. We also investigate whether recent macroprudential policy announcements that targeted credit variables had important spillover effects on variables targeted by monetary policy in Brazil. To this end, we use a rich daily panel of private inflation forecasts surveyed by the Central Bank of Brazil's Investor Relations Office and investigate the impact of announcements of macroprudential policy changes on the gap between inflation forecasts and the inflation target. The paper also presents an overview of the challenges facing macroprudential policy in Brazil after the global financial crisis and glimpses at a few important future challenges.

Keywords: Macroprudential policy, monetary policy, optimal policy, DSGE, credibility
JEL Classification: E37, E44, E50, E61

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1. Introduction

The last episode of a banking crisis in Brazil immediately followed the implementation of the inflation stabilization plan – the Real Plan – in 1994[1]. At that time, inflation stabilization had eliminated an important source of bank revenues and exposed banks' practices and vulnerabilities that could undermine financial stability. To address these risks, in the first years of the inflation stabilization period the government implemented two major bank restructuring programs: the Program of Incentives to the Restructuring and Strengthening of the National Financial System (PROER) and the Program of Incentives to the Reduction of the State-Level Public Sector in Bank Activity (PROES).

Local government banks had had a long history of concentrating significant troubled credit portfolios, with high default rates, posing systemic risks to the financial system and feeding fiscal imbalances. PROES addressed these problems through either the privatization of public banks or the transformation of public commercial banks into development banks, which were prohibited to extend loans to their public controllers. The Fiscal Responsibility Law, enacted in 2001, outlawed credit operations between any public banks and their public controllers, further enhancing fiscal discipline.

PROER was a milestone in the regulatory framework of the Brazilian financial system. One of the pillars of this program was the enhanced framework under which the central bank – which is also the regulatory and supervisory authority – was authorized to intervene in troubled financial institutions. The program also comprised a number of other important measures, including a deposit-insurance facility.

In addition to these major restructuring programs, Brazil adopted best practices with respect to its bank regulatory and supervisory framework by adhering to the first Basle accord in 1994, adopting a strict regulatory and supervisory stance thereafter[2]. Basel III capital regulations were first published in March 2013, to start phasing in only a few months later, in October. The Basel Committee on Banking Supervision performed its last assessment of Basel III regulations in Brazil in December 2013, and found that the country

[1] Reinhart and Rogoff (2011).

[2] Agénor and Silva (2013) have qualified Brazil's bank supervisory environment as "strong, sophisticated and intrusive" with a "robust regulatory environment", which differentiates the country from the other middle income countries.

was compliant with the terms of the agreement. The financial regulatory and supervisory framework ranks well amongst those evaluated by the Financial Stability Board (FSB), and ranked first in IMF's 2012 assessment of countries' adequacy to Basle principles. The Brazilian financial system is well capitalized and shows comfortable levels of liquidity indicators, with a Basle index of 16.7, a provisions-to-capital ratio, net of delinquencies, of 11%, and a net assets-to-short term liabilities ratio of 202.2[3].

Since the country had not adhered to the deregulatory practice adopted in the developed world, the global financial crisis reflected in the Brazilian financial system mostly through the liquidity channel[4]. Brazilian banks were not exposed to subprime loans or troubled assets. However, uncertainties with respect to the viability of small banks that were negatively affected by the shortage of foreign credit lines caused a temporary disruption in interbank liquidity provision, especially in detriment of the smaller banks.

To even out liquidity positions in the interbank market, the Brazilian central bank implemented unconventional changes in reserve requirement regulations. These instruments were important to give the central bank an important margin of maneuver in moments of distress. As the immediate effect of the crisis was subdued, and credit began to pick up, a diverse mix of macroprudential policy instruments were actively used by the central bank, mainly with the purpose of reducing vulnerabilities identified in specific markets. In this respect, in addition to traditional and unconventional changes in reserve requirements, the central bank changed risk weight factors, loan-to-value and debt-to-income caps, maturity limits, among several others.

According to IMF (2013), monetary and macroprudential policies were complementary in Brazil during the post-crisis period. Both were used countercyclically, leaning against the business and the financial cycle, which were synchronized during the period analyzed in that report. In more recent times, however, this synchronization has been challenged, and while monetary policy became more contractionist given inflationary pressures, some macroprudential measures were implemented with the purpose of easing credit conditions in specific segments.

[3] Data from IMF FSI.
[4] Silva and Harris (2012) provide an extensive report on the measures adopted in Brazil to fight the global financial crisis.

Given the fact that Brazil has actively used monetary and macroprudential policies, and that the central bank has a mandate over both price and financial stability, the Brazilian central bank has made important efforts to communicate its regulatory decisions by informing on targeted vulnerabilities or weaknesses spotted in the financial system. On the other front, monetary policy has attempted to follow the textbook practice of inflation targeting, setting aside leaning against the wind behavior[5].

This paper explores two fronts related to the interaction between macroprudential and monetary policy in Brazil. First, we find the optimal combination of a wide set of macroprudential policies that may react to the financial cycle and monetary policy that is also allowed to react to the financial cycle, using the model in Carvalho and Castro (2015), a tailored-made DSGE model for Brazil, estimated with Bayesian techniques for the inflation targeting period[6]. We take a further step to compare the comprehensive optimal set of policies with subsets of policies that can be more easily and timely implemented. Second, we investigate whether announcements of macroprudential policy measures have affected the anchoring of inflation expectations in Brazil.

With respect to the first front, the ideal monetary and macroprudential policy mix for Brazil is still an unexplored issue. This paper tries to fill some of this gap by finding the optimal combination of sets of macroprudential and monetary policies that may react to the credit gap, given ample evidence that this indicator is a good, if the not best, early warning indicator of financial crisis (see, for instance, Silva et al (2012) for the Brazilian case and Taylor (2015) and Drehman and Tstsaronis (2014), among several others, for cross country studies). Basel III also recommends the use of the credit gap to justify changes in the countercyclical capital buffer.

In order to find the optimal policy combinations, we follow the method proposed by Schmitt-Grohé and Uribe (2007) and focus on implementable, simple policy rules[7]. We also investigate the properties of more easily implementable rules given the Brazilian reality.

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[5] See http://www.bcb.gov.br/pec/appron/apres/BCRA%20Pres%20LAPDS%20Nov%202014%20FINAL.pdf

[6] Our approach of using a realistic model of the Brazilian economy, estimated with actual data, adds robustness to our results. De Fiore and Tristani (2009), for instance, recognize that their numerical findings of optimal rules are illustrative and the quantitative features derived from them should be validated through more complex models.

[7] Ramsey-type optimal policy analysis requires an arbitrary weight of each class of agents in the model. Lambertini et al (2013) find an important role for heterogeneity with respect to classes of agents in welfare implications. They cannot find a uniform ranking of policy frameworks for both classes of agents in the

Several studies have investigated the optimality of monetary policy reacting to financial conditions. Some have found that alternative monetary policy rules that react to financial variables have negligible stabilization gains when compared with strict inflation targeting or traditional Taylor rules (Bernanke and Gertler (2001), Gilchrist and Leahy (2002), Iacoviello (2005), and Faia and Monacelli (2007)[8]). Other studies find that it can be welfare improving to let monetary policy react to financial variables (De Fiori and Tristani (2009)[9], Curdia and Woodford (2010), Benigno et al (2012), Angeloni and Faia (2013)[10], Fendoglu (2014)[11], and Kannan et al (2012)[12]). These studies are heterogeneous with respect to the model structure, the financial frictions, the financial targets and the parametrization. The conclusions might be model dependent[13] and, for a particular model, they can also be sensitive to the parametrization. They are also highly sensitive to the set of disturbances allowed in the model[14].

Our study distinguishes from others in a number of aspects. First, we include a varied -- and practical -- set of macroprudential policy instruments interacting with monetary policy, while most of the literature focuses only on monetary policy as the single instrument to stabilize multiple targets, including financial conditions[15]. Second, our model is of a small open economy with foreign trade and financial flows, while most of the literature focuses on closed economies[16]. Third, our model has features that are necessary to

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model. In addition, rules that deviate from the optimal in individual terms have important welfare effects for only one class of agent, the borrower, which is more directly affected by the financial constraint.

[8] In their work, monetary policy faces a tradeoff between stabilizing consumer inflation or asset prices.

[9] In their model, the credit spread shows in the marginal cost of the firm, given the assumption that credit should be used to finance payroll.

[10] In their work, financial targets are asset prices or bank leverage.

[11] In their work, financial targets are asset prices or credit spread. They study optimal policy with costly-state verification-type financial frictions, but focus on monetary policy rules.

[12] In this work, the financial friction occurs in housing loans, but the external finance premium is assumed, rather than obtained from first order conditions. Monetary policy is allowed to react to credit growth.

[13] Brzoza-Brzezina et al (2013) provide an extensive analysis of model-implied differences in responses of the main economic variables by examining credit constraint and external finance premium financial accelerators vis-a-vis a standard New Keynesian model.

[14] For a detailed description of the impact of the set of disturbances allowed in a particular model on optimal policy rules, please refer to Lambertini et al (2013).

[15] Some exceptions that introduce a second policy instrument are Benigno et al (2012) and Cesa-Bianchi and Rebucci (2015), who study the interaction of monetary policy with macroprudential policy when borrowing constraints bind, Angeloni and Faia (2013), who introduce a countercyclical capital rule that interacts with monetary policy, and Lambertini et al (2013), who study the optimality of countercyclical LTV ratio caps in a model based on Iacoviello and Neri (2010), focused on the mortgage market.

[16] An exception is Benigno et al (2012), but the financial frictions they incorporate are significantly different from ours. They assume eventually binding collateral constraints with a reduced set of nominal rigidities and

reproduce the main aspects of the Brazilian credit market, such as the heavy regulation on housing loans and savings deposits and a consumer credit segment in which credit originations are strongly based on households' future labor income, but that face significant default ratios. Conducting optimal policy analysis in models intended for practical use at central banks is a strikingly different approach compared to what has been usually adopted in the literature. The preferred choice of prototype models in this literature is most likely due to the dimension of practical models and the challenges faced in their estimation.

We find that combinations of reserve requirements and risk weight factors, with optimized reaction coefficients to the credit gap, can achieve losses that are very close to the optimum that comprises a more complete combination of rules that includes Basel III countercyclical capital buffer. The more restricted combination of optimal rules also results in dynamic responses very close to the more complete set of optimal rules. Given the fact that reserve requirements and risk weight factors are more easily implementable, this finding gives support to Central Bank of Brazil's extensive use of reserve requirements and risk weight factors to affect credit, and the non-variability of the overall capital requirement ratio to this date.

With respect to the second front, although most of the literature is concerned with the issue of whether monetary policy should react to financial variables, the reverse argument has not been explored. Given the possible de-synchronization of macroprudential and monetary policy in some recent episodes in Brazil, it is important to investigate whether macroprudential policy announcements can potentially affect the anchoring of inflation expectations. To this purpose, we use a panel of private inflation forecasts surveyed on a daily basis by the Central Bank of Brazil's Investor Relations Office to estimate the impact of some macroprudential policy events -- which explicitly targeted the credit market -- on the formation of inflation expectations. We draw on the work of Carvalho and Minella (2012) to find a representative expectations' formation rule, but we augment it with the investigated events in addition to some other necessary controls.

Among fourteen events analyzed in our study, we find a subset of six events that suggest that macroprudential policy announcements affected the gap between inflation

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borrowing occurs in foreign currency, while our financial frictions in the borrowing side of the model come from costly-state verification and bank borrowing is carried out in domestic currency. Notice that our model has other important frictions that constrain banks' balance sheet allocations and have real effects.

expectations and the inflation target. In four of these events, the impact was in the direction of widening the gap. When we group the events that were expected to increase credit into two different sets, one when monetary policy was contractionist and the other when monetary policy was expansionist, we find that the former had a positive significant impact on inflation expectations, while the latter was not significant. This can be interpreted as evidence that when macroprudential policy announcements are desynchronized from monetary policy, the anchoring of inflation expectations can be challenged.

This paper is organized as follows. Section 2 brings an overview of the main macroprudential measures implemented in Brazil in the aftermath of the financial crisis and over the post-crisis period. Section 3 presents the optimal policy exercise using the DSGE model that was tailored-made for the Brazilian economy. Section 4 empirically investigates the impact of macroprudential policy announcements on monetary policy credibility. Finally, the last section concludes.

2. Monetary and macroprudential policy in Brazil after the financial crisis: a brief overview

The global financial crisis reflected in the domestic Brazilian financial system mainly in the form of a liquidity stress. During that initial period, several reserve requirement changes were put in place, not only to increase overall liquidity in the system but also, and more importantly, to encourage credit transfers among banks and help even out liquidity in the wholesale market.

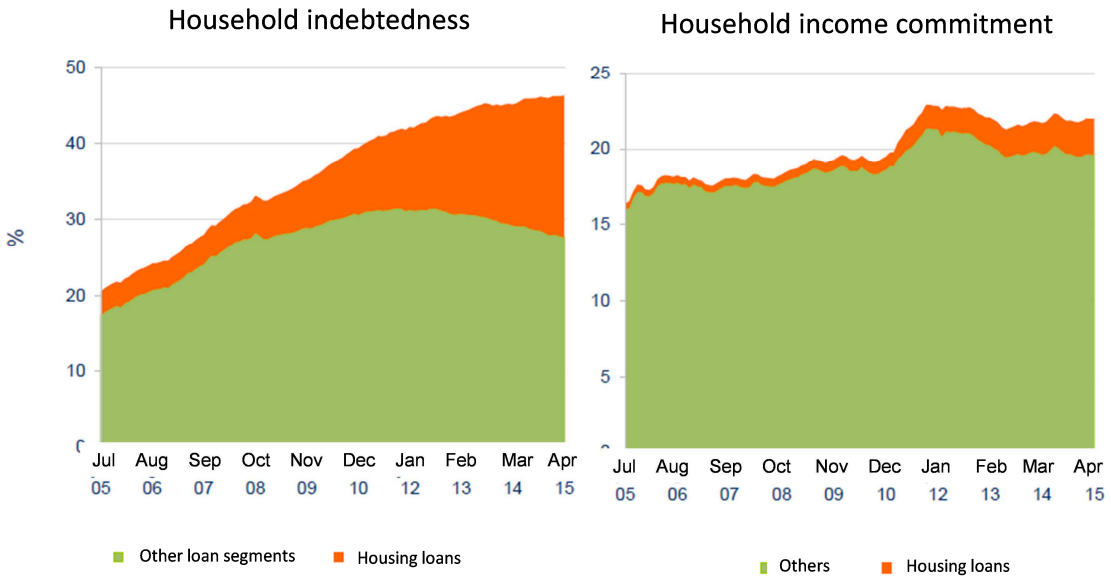
On another front, policy measures were adopted to reduce the volatility caused by strong international liquidity inflows to the country, a response of quantitative easing programs and unconventional policies adopted by the developed world. Some of these policies aimed at reducing the incentives for foreign investors to invest in short term assets while others implemented stricter requirements on banks' FX exposure.

The signs of a possible credit crunch led to a set of regulatory reliefs, also triggering the intensification of interventions of public banks in the credit market mainly through looser credit origination conditions. The strong response of public banks changed the composition of credit in the system and fueled an important acceleration of consumer

indebtedness, to a point where the country ranked 6th in the world in terms of household debt service and principal payments to income[17]. More recently, household indebtedness with housing loans shows signs of accommodation, while indebtedness with other credit segments is clearly decelerating (Figure 1).

Figure 1

Household indebtedness and income commitment in Brazil



Source: Central Bank of Brazil

The evolution of consumer indebtedness has not posed important threats in terms of financial stability, given the low base of credit-to-GDP, but the overall looser terms of credit origination ended up fueling vulnerabilities in some market segments.

The regulatory policy response to this was either specific to spotted vulnerabilities in specific markets or of a more general nature. For instance, the implementation of risk weight factors directly related to the maturity and loan-to-value of credit operations proved effective to constrain their impact to their specific targets. Martins and Schechtman (2013) and Afanasieff et al (2015) provide evidence supporting the precision of the measures adopted in 2010 for auto loans. In some instances, the direction of macroprudential

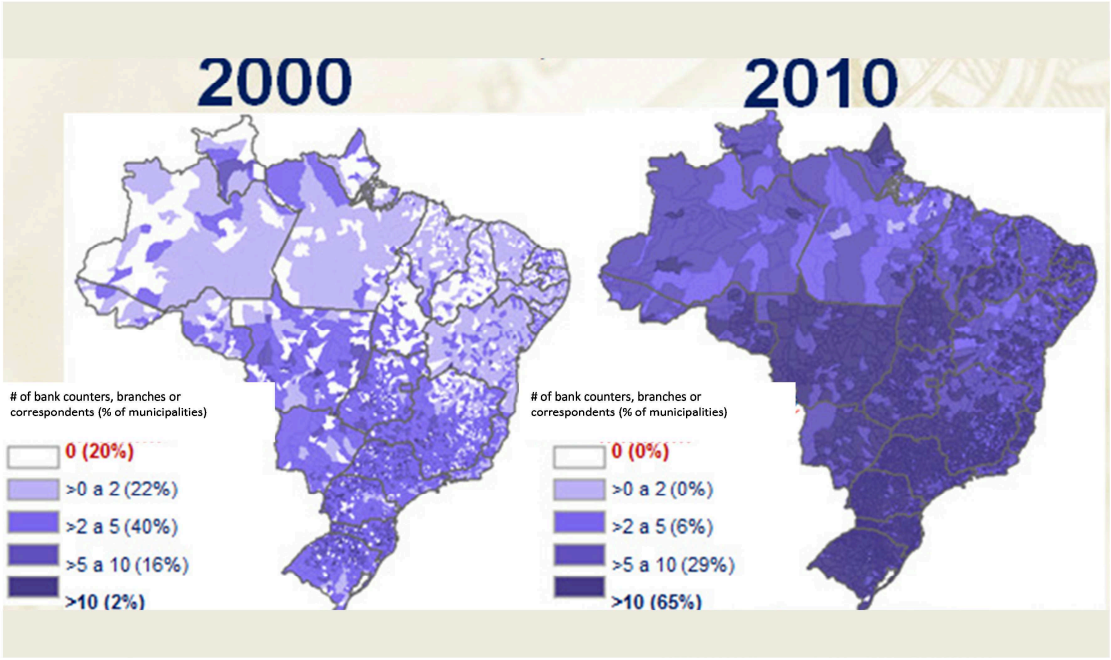
[17] IMF 2014 Financial Soundness Indicators (FSI). http://fsi.imf.org/Default.aspx

measures was in line with the monetary stance of the economy, but that did not apply to all measures.

An important challenge facing both the regulatory and the monetary authority has been the fast and intense financial deepening process to which Brazil has undergone over the past decades. Figure 2 shows the evolution of bank regional presence in Brazil and Figure 3 shows the migration of social classes over the past decades. Financial inclusion has been a result of technological improvements in the financial system, income distribution policies, public banks' credit origination policies, and a stable macroeconomic environment.

Figure 2

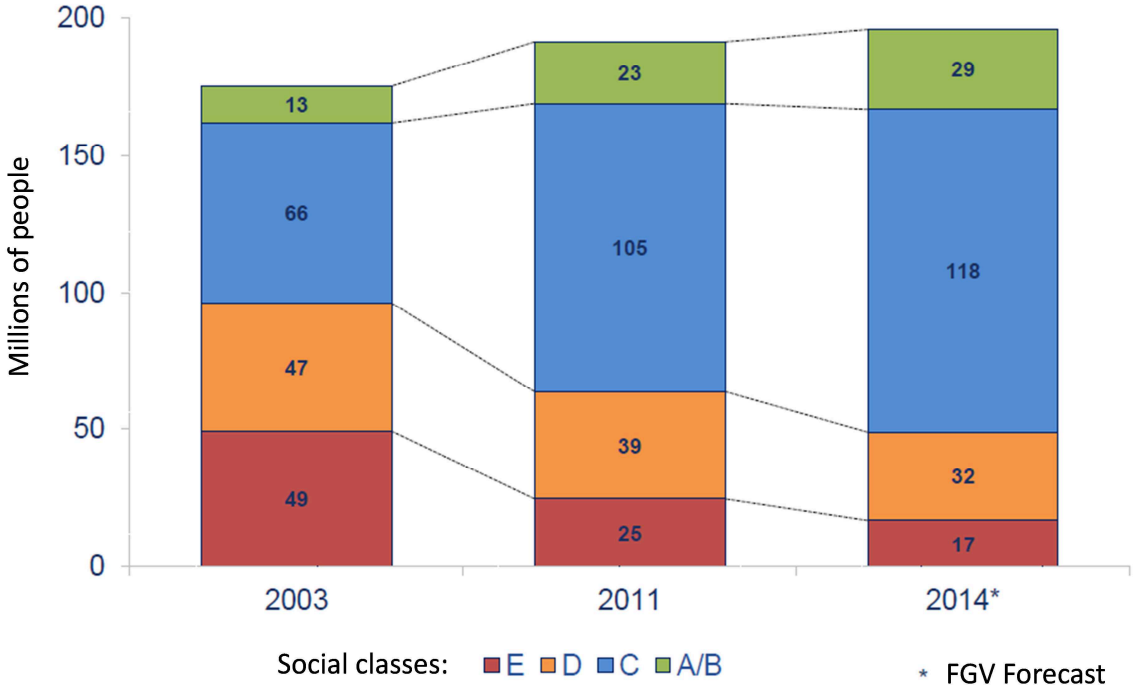
Evolution of bank regional presence in Brazil



Source: Central Bank of Brazil

Figure 3

Social mobility in Brazil



Source: Central Bank of Brazil, Fundação Getulio Vargas (FGV)

Sahay et al (2015) find a positive relationship between the pace of financial deepening and the risk of crisis and macroeconomic instability, conditional on the efficiency of financial system's regulation and supervision. To avoid these risks, the Brazilian central bank has closely monitored the financial deepening process and the quality of credit origination so that credit growth and income commitment are kept within sustainable boundaries. Essential to this task is the Credit Bureau, created in 1997, and restructured in 2008, which collects detailed information on each and every credit origination in the banking system above R$ 1,000 (about USD 300), currently amounting to 99% of the entire credit portfolio of the Brazilian financial system. The Credit Bureau is managed by the Central Bank and the information available is processed and analyzed on a daily basis not only by the supervisory and regulatory departments of the central bank, but also by economic departments, constituting an important input to a broad set of policy decisions.

Other important risk mitigating measures have been put in place. Among those was the approval of the Credit Default Law in 2005[18], improvements in the Deposit Guarantee Fund, including the introduction of a similar fund for cooperative credit unions that target low-income borrowers, the enactment of a law that approved the creation of a positive borrowers' record, in addition to the creation of credit registries (e.g., C3) and a derivatives exposure registry (CED).

As a matter of fact, central bank's capacity to monitor the Brazilian financial system is in many respects unique in the world. Not only is it comprehensive in terms of banks' operations, portfolios and exposures but it is also timely and adequately designed to monitor and detect inconsistencies in the wide range of information given to the central bank. Table 1 glimpses at the dimension of database monitoring at the Central Bank of Brazil.

Another factor that has limited the impact of higher default rates of low-income borrowers to the rest of the financial system is the fact that these loans have been mostly originated by a public bank (Caixa Econômica Federal) as part of a wider policy of social inclusion[19].

3. Interaction between monetary and macroprudential policy

Monetary and financial stability are the core missions of the Central Bank of Brazil. The Monetary Policy Committee (COPOM) was created by the central bank in 1996 with the purpose of setting the monetary policy stance[20], and, since 1999, its decisions must be oriented towards achieving the inflation targets set by the National Monetary Council[21].

[18] Ponticelli and Alencar (2013) show that the Credit Default Law allowed for a significant increase in the probability of collateral recovery in case of liquidation of a borrowing firm. It also had significantly positive effects on loan originations to companies in the transformation industry (which was the only industry examined in the study). The law generated an overall impact in the form of lower lending rates, longer maturities, and lower collateral requirements. The effects particularly more noticeable in regions where judges are faster to analyze these cases.

[19] This could increase the pro-cyclicality of housing loans since the fiscal stance of the economy could play an important role in the capacity to originate new loans.

[20] Central Bank of Brazil's Circular # 2698, of June 20, 1996, created both the Copom and its monetary policy instrument, the rediscount (TBC) rate, which would be the official monetary policy instrument until 1999, when it was informally replaced by the base (Selic) rate. Circular # 2966, of February 8, 2000, formalized the Selic rate as central bank's monetary policy instrument.

[21] The National Monetary Council comprises the Minister of Finance, the Minister of Planning and Budget and the Central Bank of Brazil's Governor.

The Financial Stability Committee (COMEF) was created by the central bank in 2011 to set directives and guidelines for central bank conduct in order to preserve financial stability, assess systemic risk and carry out macroprudential oversight[22]. Although COMEF's guidelines are enforced, the board of governors is not constrained to the meeting days of COMEF or COPOM to set central bank's policy instruments (with the exception of the monetary policy interest rate). In addition, both COPOM and COMEF are comprised of exactly the same members: Central Bank of Brazil's board of governors. Board members have restated that the separation principle is observed and, although communication is seen as essential to avoid misperceptions that could undermine the achievements in each of the policy fronts, it is still a challenge.

The advantages of having supervision and financial regulation within the central bank are several. The IMF (2013) mentions the benefits from macroprudential policy decisions drawing on central bank's expertise in financial and macroeconomic analyses in addition to data availability, which facilitates the analysis of the side effects of each policy. The report also mentions the gains from shielding macroprudential policy more from political influence than when this function is assigned to a separate regulatory body. Among the disadvantages, the report mentions time consistency issues and communication challenges. As a matter of fact, the IMF considers this double assignment a vulnerability of the overall Brazilian regulatory and supervisory framework.

In addition to continuously improving the regulatory and supervisory stance of the Brazilian financial system, the central bank has actively used a variety of instruments to try to influence the financial cycle, with either narrow or broader purposes. Important policy choices for these purposes have been risk weight factors, reserve requirements, and taxation of foreign capital inflows, while overall capital requirement ratios remained unchanged since the implementation of Basel I. In most occasions, communication of the targeted

[22] Central Bank of Brazil's Portaria # 65180, of May 18, 2011, created COMEF to define strategies and guidelines for central bank policy conduct aiming at preserving financial stability and mitigating systemic risk, to guide central bank's conduct at the Regulatory and Supervisory Committee of Financial, Capital and Insurance Markets and Pension Funds (COREMEC) and at other international forums, to assign responsibilities within central bank departments, to ensure integrated and coordinated action, and to command studies, research and work on financial stability and preventing systemic risk. Central Bank's "Portarias" are legal instruments issued by central bank Governor. The "Circulares" should be approved by central bank Board of Directors.

impact of policy decisions has not been detailed, while the macroprudential policy decision framework remains highly discretionary.

During the inflation targeting period, monetary policy has followed the traditional IT framework, with the (Selic) interest rate being the central policy instrument. Very rarely were reserve requirements explicitly used to reinforce the monetary policy stance[23]. In fact, most of their use has been associated with either macroprudential purposes or to help drain liquidity from the large inflows of foreign capital or in times of distress in government bonds issuances.

National Monetary Council Resolution # 4193, of March 1, 2013, instituted the additional conservation and countercyclical bank capital requirement to come into effect in 2016. According to Central Bank of Brazil Comunicado # 20615, of February 17, 2011 the countercyclical capital requirement will be activated in case of excessive credit growth that potentially builds up systemic risk. Any changes in the countercyclical capital requirement should be announced one year in advance, and so far the decision framework for the activation of this instrument is still work in progress.

Given that currently available policy instruments have been used to affect the financial cycle and a new one is soon to be implemented, a genuine question arises: how should these instruments interact, how strongly should they respond to the financial cycle, and should all of them be used for the same purpose? In addition, given the unsettled debate on whether monetary policy should be concerned with financial stability, what would be the recommendation for Brazil?

Our contribution to the normative perspective of macroprudential regulation in Brazil is to use a model that was adequately built and estimated for Brazil to find an optimal combination of macroprudential and monetary policies that are allowed to react to the financial cycle, which in this study is represented by the credit gap. We focus on the (wide) set of macroprudential instruments that have been more intensely used in Brazil to influence credit markets, especially after the financial crisis, namely reserve requirements on time, savings and demand deposits, risk weight factors on consumer, commercial and housing loans, in addition to the new countercyclical capital buffer and monetary policy.

[23] For a more detailed overview of reserve requirements in the pre-global crisis period, please refer to Carvalho and Azevedo (2008)

To seek for the optimal monetary and macroprudential policy combination, we use the DSGE model with financial frictions in Carvalho and Castro (2015), which incorporates the main features of the Brazilian credit market, including the heavily regulated housing loans market. This model was estimated with Brazilian data from the inflation targeting regime and was successful to reproduce the moments of several targeted variables from a monetary and macroprudential perspective. The model was carefully built to allow for relevant policy analysis at the Central Bank of Brazil.

Consumer loan origination in the model is tightly dependent on expectations with respect to borrowers' capacity to pay their future loans with labor income, with endogenous default. This has been a marked feature of the Brazilian credit market during the model's estimation period. Housing loans take houses as collateral, but indebtedness in this market affects borrowers' available income, affecting their decisions with respect to consumer credit. Housing loan payments have seniority over consumer loans in the model so as to replicate the very low default rates compared with the consumer credit segment. Commercial credit takes capital as collateral and also faces endogenous default.

In addition to financial frictions that are representative of the Brazilian credit markets, the model also incorporates important features regarding Brazil's connection with the rest of the world, with respect to both trade and financial transactions. All major balance of payment accounts are carefully introduced in the model, with a special attention to foreign direct investment, which has been the most important source through which foreign capital has accumulated in the country. The interaction of FDI with the financial system is indirect. The recipients of foreign direct investment flows are the entrepreneurs, who fund their projects with FDI in addition to the share of their net worth held by domestic residents and to bank loans.

The real sector of the economy is modeled in line with the standard DSGE literature. Households are distributed in groups of savers and borrowers, both supplying labor to a continuum of labor unions that operate under monopolistic competition, and consuming consumption goods and housing. Savers have a wider array of possible investment opportunities and are more patient than borrowers, who take risky loans for consumption and for housing. Entrepreneurs manage productive capital. Domestic producers combine capital and labor to produce intermediate goods which will be combined

with imported intermediate goods to produce final goods for consumption (private and public), investment and for exports. Price frictions are introduced in both domestic and imported intermediate goods retailers/distributers problem. The model also incorporates capital and housing investment producers. Exporting firms face adjustment costs on quantum changes and take working capital loans from domestic banks. Figure 4 shows the structure of the real economy.

The financial sector comprises a retail money market fund , which takes deposits from savers and issues foreign debt to invest in banks' time deposits and government bonds. The banking conglomerate is composed of a continuum of competitive banks that get funding from deposit branches and extend credit to households, entrepreneurs, and export firms through their lending branches. They optimally choose their balance sheet composition, subject to regulatory requirements and several frictions intended to replicate banks' incentives to deal with regulatory constraints. They can accumulate capital by retaining profits, which is, in fact, the choice variable in the intertemporal dynamic optimization problem of the bank. Figure 5 shows the financial structure of the model.

The model has the following macroprudential instruments: reserve requirements on demand, savings and time deposits, risk weights on consumer, commercial and housing loans, tax on credit, and standard minimum capital requirement ratios. Reserve requirements on demand deposits are not remunerated, whereas the other types of reserve requirements are remunerated at exactly the same rate that accrues on bank deposits. In the benchmark (estimated) model, neither macroprudential policies nor monetary policy respond to the credit cycle.

Figure 4

The real sector of Carvalho and Castro (2015)'s open economy DSGE model with financial frictions for Brazil

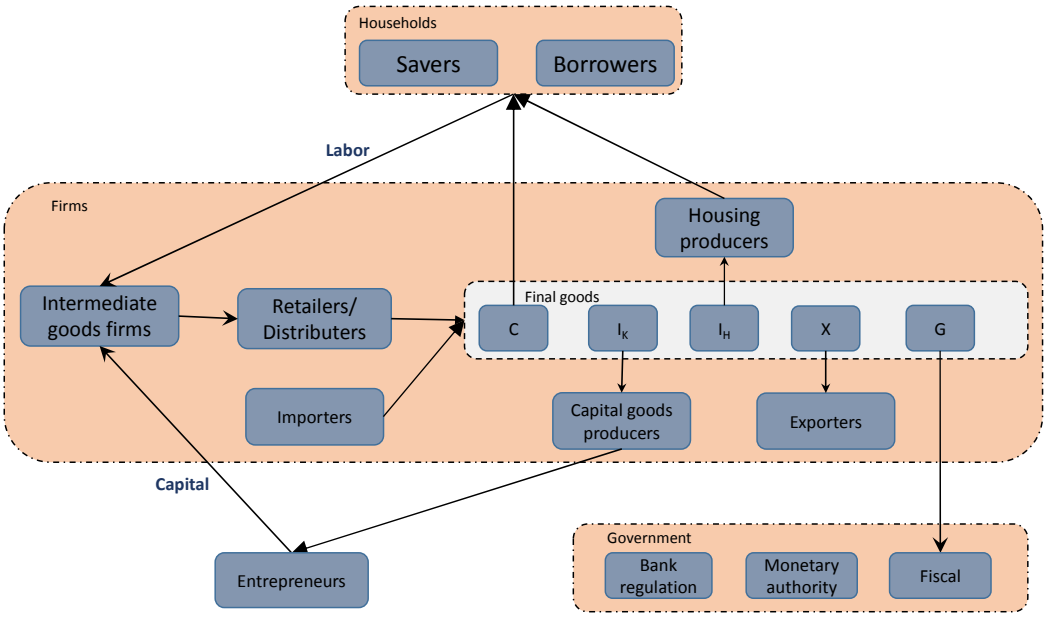
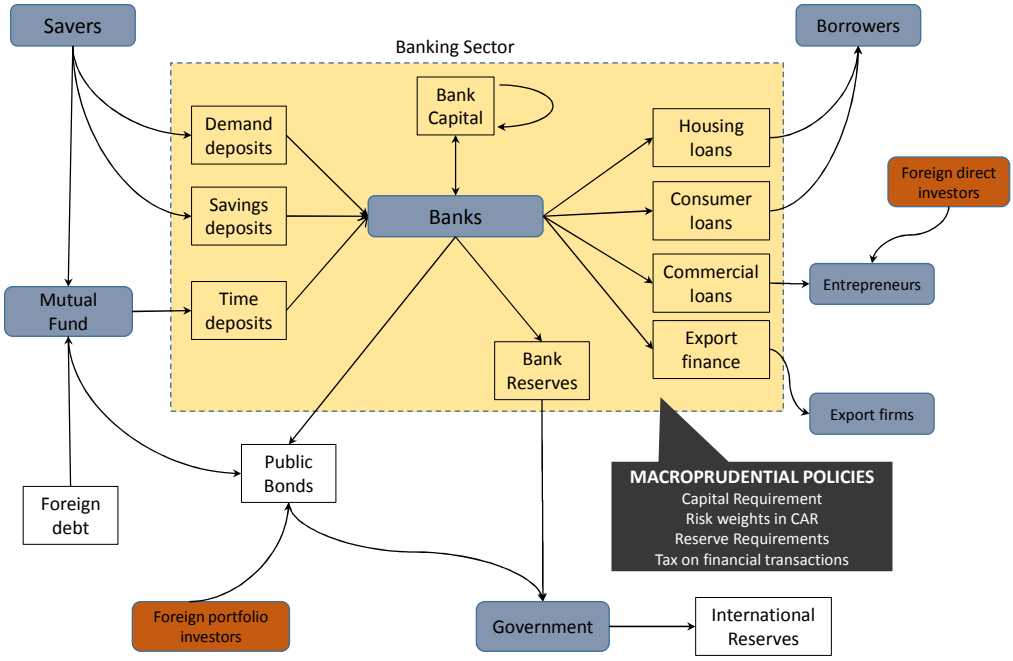


Figure 5:

The financial flows in Carvalho and Castro (2015)'s open economy DSGE model with financial frictions for Brazil



One advantage of analyzing the interaction between monetary and macroprudential policies using DSGE models is that these models can account for the side effects that the use of one policy tool has on the targets of the others.

We use the model to seek for an optimal combination of macroprudential and monetary policy that can react to the credit gap. For each of the exercises we perform, the optimal policies are obtained from the minimization of a loss function comprising the volatility of output, inflation, policy interest rate and total credit[24]. The weights of output, inflation and interest rate in this cost function are obtained in such a way that the minimization of a cost function comprising only these three variables would result in an optimal monetary policy rule just equal to the one estimated in the benchmark model, using the model structure that exactly matches the benchmark model. The weight attributed to credit is arbitrary[25]. Optimization takes into account all sources of fluctuation in the model, an approach that is also adopted by Lambertini et al (2013). Since the model is estimated, the influence of each shock in the optimal solution will rely on realistic values of the stochastic processes governing the shocks. Several studies address the optimal responses to a few selected shocks, but given the fact that in practice a lot of judgment is involved in assessing the real-time source of shock driving economic variables, it is equally important to find an optimal rule that could be transparent to and predictable by the public, especially in countries where coordination of market expectations is challenging.

The optimal simple monetary and macroprudential policies are allowed to react to the credit gap. Monetary policy follows an augmented, forward looking, Taylor-type rule:

$$R_t = R_{t-1}^{\rho} \left(R \left(\frac{\pi_{t+3}}{\bar{\pi}_t} \right)^{\gamma_\pi} \left(\frac{y_t}{y} \right)^{\gamma_y} \right)^{1-\rho} \left(\frac{b_{E,t} + b_{C,t} + b_{H,t}}{b_{E,ss} + b_{C,ss} + b_{H,ss}} \right)^{\chi} \exp(\varepsilon_{R,t}) \quad (1)$$

where $\bar{\pi}_t$ is the non-zero inflation target, y_t is GDP detrended by permanent technology and population growth shocks, y is steady state GDP, and $\varepsilon_{R,t}$ is a white noise shock.

[24] Credit in the model is composed of consumer, housing and commercial credit. For all of these credit segments, the model allows for endogenous default due to imperfect monitoring. Consumer credit is extended based on borrowers' future labor income, net of payments related to housing loans. Housing loans are subject to LTV constraints and they constrain borrowers' available income. Commercial loans are taken by the entrepreneurs and are subject to LTV constraints.

[25] We show below some sensitivity analysis on the impact of different weights on the credit gap in the loss function.

The capital requirement ratio is augmented by the countercyclical capital buffer:

$$\Gamma_{K,t} = \bar{\Gamma}_{K,t}\ \Gamma_{CC,t} \tag{2}$$

where the traditional component is centered on the current required ratio (11%):

$$ln\left(\frac{\bar{\Gamma}_{K,t}}{0.11}\right) = \rho_{\Gamma}\, ln\left(\frac{\bar{\Gamma}_{K,t-1}}{0.11}\right) + \varepsilon_{\bar{\Gamma},t} \tag{3}$$

and the countercyclical capital buffer follows:

$$ln(\Gamma_{CC,t}) = \rho_{\mathrm{CC}}\, ln(\Gamma_{CC,t-1})\ + (1-\rho_{\mathrm{CC}})\,\gamma_{CC}\left(ln\left(\frac{b_{E,t}+b_{C,t}+b_{H,t}}{b_{E,ss}+b_{C,ss}+b_{H,ss}}\right)\right) + \varepsilon_{CC,t} \tag{4}$$

Reserve requirement ratios on demand, savings and time deposits react to the total credit gap, according to the following policy rules:

$$\tau_{D,t} = \rho_D\tau_{D,t-1} + (1-\rho_D)\tau_{D,ss} + \gamma_D\left(ln\left(\frac{b_{E,t}+b_{C,t}+b_{H,t}}{b_{E,ss}+b_{C,ss}+b_{H,ss}}\right)\right) + \varepsilon_{D,t} \tag{5}$$

$$\tau_{S,t} = \rho_S\tau_{S,t-1} + (1-\rho_S)\tau_{S,ss} + \gamma_S\left(ln\left(\frac{b_{E,t}+b_{C,t}+b_{H,t}}{b_{E,ss}+b_{C,ss}+b_{H,ss}}\right)\right) + \varepsilon_{S,t} \tag{6}$$

$$\tau_{T,t} = \rho_T\tau_{T,t-1} + (1-\rho_T)\tau_{T,ss} + \gamma_T\left(ln\left(\frac{b_{E,t}+b_{C,t}+b_{H,t}}{b_{E,ss}+b_{C,ss}+b_{H,ss}}\right)\right) + \varepsilon_{T,t} \tag{7}$$

where $\tau_{D,t}$, $\tau_{S,t}$, and $\tau_{T,t}$ are reserve requirement ratios on demand, savings and time deposits, $b_{E,t}$, $b_{C,t}$, and $b_{H,ss}$ are commercial, consumer and housing credit gaps from the stationary trend driven by permanent technology and population growth shocks, $\varepsilon_{D,t}$, $\varepsilon_{S,t}, \varepsilon_{T,t}$ are white noise shocks, and all variables indexed as "ss" represent steady state values.

Actual capital adequacy is calculated as the ratio between bank capital and risk weighted assets:

$$CAR_t = \frac{K_{B,t}}{RWA_t} \tag{8}$$

and risk weighted assets are computed according to:

$$RWA_t = \varsigma_{E,t}b_{E,t} + \varsigma_{C,t}b_{C,t} + \varsigma_{H,t}b_{H,t} + \varsigma_{B,t}b_t + \upsilon_t \tag{9}$$

where $\varsigma_{E,t}$, $\varsigma_{C,t}$, and $\varsigma_{H,t}$ are risk weight factors on commercial, consumer and housing loans, $\varsigma_{B,t}$ is the risk weight factor on banks' portfolio of liquid assets, which in the model is comprised of risk-free public bonds, and hence $\varsigma_{B,t} = 0$. The last term, υ_t, is an AR(1) process to account for the share of Brazilian financial system assets that are not formally included in the model.

Risk weight factors are allowed to react to their specific credit segments, since Carvalho and Castro (2015) show that these instruments have a primary impact on their specific credit segments[26]. They can be expressed according to the following policy rules:

$$\varsigma_{E,t} = \rho_E \varsigma_{E,t-1} + (1-\rho_E)\varsigma_{E,ss} + \gamma_E \left(ln\left(\frac{b_{E,t}}{b_{E,ss}}\right)\right) + \varepsilon_{E,t} \tag{10}$$

$$\varsigma_{C,t} = \rho_C \varsigma_{C,t-1} + (1-\rho_C)\varsigma_{C,ss} + \gamma_C \left(ln\left(\frac{b_{C,t}}{b_{C,ss}}\right)\right) + \varepsilon_{C,t} \tag{11}$$

$$\varsigma_{H,t} = \rho_H \varsigma_{H,t-1} + (1-\rho_H)\varsigma_{H,ss} + \gamma_H \left(ln\left(\frac{b_{H,t}}{b_{H,ss}}\right)\right) + \varepsilon_{H,t} \tag{12}$$

where $\varepsilon_{E,t}$, $\varepsilon_{C,t}$, and $\varepsilon_{H,t}$ are white noise shocks.

We follow Schmitt-Grohé and Uribe (2007) and focus on simple, implementable policy rules. We find the optimal coefficients $\{\rho, \rho_{CC}, \rho_D, \rho_S, \rho_T, \rho_E, \rho_C, \rho_{H,} \gamma_\pi, \gamma_y, \chi, \gamma_{CC}, \gamma_D, \gamma_S, \gamma_T, \gamma_E, \gamma_B, \gamma_H, \}$ of the policy rules in (1), (4), (5), (6), (7), (10), (11), and (12) that minimize the loss function[27] [28].

Table 2 shows the optimization results for three possible weights for the credit gap in the loss function, considering all policy instruments operating simultaneously. For each weight, we proceed with two types of optimization: one in which we do not constrain the support of the policy parameters and another in which we constrain the reaction of

[26] The volume of housing loans is not very sensitive to its corresponding risk weight factor. The reason for this is that this market is heavily regulated with respect to both interest rates and funding sources.
[27] We use the Optimal Simple Rule routine in Dynare, which is based on Sims' minimization algorithm. The results that we report here are obtained after testing different initial points and comparing the value of the objective function obtained in each of these trials.
[28] We find the optimal rules given all sources of disturbance estimated in the model of Carvalho and Castro (2015). The rule obtained from the setup that we adopt can be more easily compared with actual estimated rules that use comprehensive information sets.

monetary policy to the credit gap to the non-negative support. Constraining the set of possible solutions for optimal simple rules is common in the literature[29].

In the constrained solution, we find that, in general, increasing the weight of the credit gap in the loss function increases the volatility of inflation and of the interest rate in the optimal solution, but reduces the volatility of credit and output. The relative magnitude of the former is substantially higher than the latter, implying that increasing the importance attributed to the financial cycle in monetary policy comes with an important cost in terms of the inflation target. In addition, the optimized constrained rules require a very aggressive response of monetary policy to inflation. As the weight of the credit gap in the loss function increases, so does the optimal monetary policy reaction to the output gap. Only with very high weights of the credit gap is it optimal for monetary policy to react to the credit gap within the constrained solutions. For low values of the weight associated with the credit gap, the constrained solutions achieve losses that are very close to the unconstrained solutions. With respect to unconstrained solutions, in all of them the optimal reaction of monetary policy to the credit gap is found to be negative. Although this result is not unprecedented in the literature (see Faia and Monacelli, 2007, for instance)[30], it is unlikely that the monetary policymaker will implement such a response. In addition, as mentioned earlier, the gains from adopting these policy combinations are only relevant when the weight of the loss function with respect to the credit gap is very high. Hence, we shall restrict our analysis to the solutions where the monetary policy reaction to the credit gap is non-negative.

In Brazil, changes in minimum capital requirement ratios have to be authorized by the National Monetary Council (CMN), which comprises not only Central Bank of Brazil's governor, but also the Minister of Finance and the Minister of Budget and Planning. With the implementation of Basel III, the countercyclical capital buffer can be set by the central bank, but needs to be announced twelve months in advance of its implementation. This constraint does not exist for reserve requirements or risk weight factors. Hence, timely policy reactions to imbalances in the financial system are easier to be implemented through

[29] Schmitt-Grohé and Uribe (2007) is such an example. They constrain the optimal parameter search to a particular set of so called "realistic" values.
[30] Faia and Monacelli (2007) find, in a model with agency costs and nominal frictions, that monetary policy should react to increases in the asset price by lowering the nominal interest rate.

alternative policy instruments than with minimum capital requirements or even the countercyclical buffer. As mentioned earlier, since the adoption of Basle I in 1994, the minimum capital requirement ratio has not been changed from the initial 11%. Only with Basel III will the overall minimum capital ratio change as of January 2016. On the other hand, events of changes in risk weight factors, reserve requirements, in addition to caps on maturity, loan-to-value and debt-service-to-income ratios, tax on household credit, FX exposure limits, provisioning rules and profit distribution restrictions abound.

Hence, given the fact that a number of macroprudential instruments are available to the Brazilian central bank and can be more easily and immediately changed than capital requirements, we investigate whether optimal simple rules that comprise only subsets of the available macroprudential tools can perform as well as the entire optimal set of macroprudential policy rules that react to the credit gap.

The following subsets are analyzed: (a) monetary policy with all macroprudential instruments; (b) monetary policy and the countercyclical capital buffer; (c) monetary policy, risk weight factors and reserve requirements; (d) monetary policy, the countercyclical capital buffer, and risk weight factors; (e) monetary policy and the risk weight factors; (f) monetary policy and reserve requirements; (g) all of the former combinations except for monetary policy.

Table 3 shows the optimum for each subset of optimal policy rules that include monetary policy[31]. In most optimized combinations, the solution is pushed towards a very aggressive response of monetary policy to inflation and to output. The most important result in this exercise is that the subset of macroprudential policy that includes monetary policy, risk weight factors and reserve requirements achieves almost the same loss that obtains from the complete set of rules.

However, the optimal responses of monetary policy to inflation and output obtained in this exercise are very far from the values usually obtained in Taylor rule estimations using actual data. Hence, we proceed with a search for optimal simple rules that take these traditional parameters of the monetary policy as given, setting them according to the mode of the posterior distribution of the parameters estimated in Carvalho and Castro (2015). In

[31] For this exercise, we choose the weight of the credit gap in the loss function to be 0.001. We only show the results for constrained optimization.

other words, we find optimal simple macroprudential rules (reserve requirements, risk weight factors and countercyclical buffer) that can react to the credit gap, also allowing the reaction coefficient of monetary policy to the credit gap to be obtained optimally.

Table 4[32] shows the results of this exercise. For the constrained optimal simple rules, we find that some subsets of macroprudential policy can perform almost as well as the complete set. The following subsets yield losses that are merely about 2% higher than the one with the complete set: 1) reserve requirements and the countercyclical capital buffer; 2) monetary policy reaction to the credit gap together with reserve requirements; and 3) monetary policy reaction to the credit gap together with risk weight factors and reserve requirements. The combination of monetary policy, reserve requirements, and risk weight factors reacting together to the credit gap requires a milder countercyclical response of each instrument. If only reserve requirements are allowed to help monetary policy react to the financial cycle, the optimal response of each of these instruments to the credit gap becomes very aggressive. Instead, if the countercyclical capital buffer is used together with reserve requirements and monetary policy, the latter loses its importance to directly target the credit cycle.

In Table 5[33], we show the subsets of optimal simple macroprudential rules obtained when we do not include the possibility that monetary policy reacts to the credit gap. In this case, most subsets achieve very similar losses. However, the loss is the highest when only risk weight factors are allowed to react to the credit gap.

Since reserve requirements and risk weight factors have been actually used in a number of occasions for macroprudential purposes in Brazil, especially after the financial crisis, and some of them countercyclically, our results corroborate to the perception that the direction of these policy can be used to help correct the build-up of risks in the Brazilian financial system with a similar efficiency as the combination with countercyclical capital.

Next, we compare the dynamic responses of the model under four different combinations of policy rules. In the first (Benchmark), the policy rules do not react to credit, and the model is exactly the one estimated in Carvalho and Castro (2015). The second combination (OSR MoP CapitalReq RWF RR) comprises optimal simple rules for

[32] For this exercise, we choose the weight of the credit gap in the loss function to be 0.001. We show the results for constrained optimization.
[33] For this exercise, we choose the weight of the credit gap in the loss function to be 0.001.

the countercyclical capital buffer, reserve requirements, risk weight factors, and monetary policy (all parameters in the augmented Taylor rule are included in the optimization but are constrained to the non-negative support). The third combination (OSR Capital Req RWF RR) refers to optimal simple rules for the countercyclical capital buffer, risk weight factors and reserve requirements, taking all monetary policy parameters as given, set at the mode of the posterior estimated in Carvalho and Castro (2015). The last combination (OSR RWF RR) comprises optimal simple rules for risk weight factors and reserve requirements, also taking all monetary policy parameters as given, also set at the mode of the posterior estimated in Carvalho and Castro (2015). As mentioned earlier, the complete set of optimal simple rules that includes monetary policy requires a very aggressive response to inflation.

Figures 6 and 7 focus on exogenous shocks originating in the banking sector. In Figure 6, the model is perturbed by a negative shock to bank capital, which is close in meaning to what Gertler et al (2012) dub a "crisis shock". This shock simulates, for instance, the impact of a drop in bank capital due to losses that negatively impact banks' net worth. In Figure 7, the model is shocked with a drop in banks' preference for liquidity, which simulates a situation in which banks reduce their risk aversion and try to increase their exposure to the credit risk. This would result in lax credit origination conditions. For both shocks, the responses under countercyclical macroprudential policy rules are strikingly different from those obtained in the benchmark model. The optimal policies sharply reduce the volatility of total credit and the dynamics of the main economic variables under subsets of active policy rules are very close to the complete set of active rules. The main difference stands in the banks' decisions concerning balance sheet allocations and dividend distribution. For the bank capital shock, the subsets of optimal policies usually generate stronger responses in bank variables. With respect to the shock on bank liquidity preferences, since the complete policy combination requires a very strong response of reserve requirements to credit conditions, bank liquidity is more severely impacted than in the case of subsets of optimal policy rules. Dividend distribution is also more strongly impacted in the case of the complete set.

The monetary policy shock makes it more clear how aggressive the complete set of optimal simple rule is in terms of its impact on the real economy (Figure 8). To stabilize credit under a monetary policy shock, the complete set of optimal simple rules requires a

more sluggish response of interest rates, substantially affecting output, consumption, labor market conditions and housing investment. The subset of optimal policies does almost as well as the complete set in stabilizing credit, but it also has a potential to stabilize real economy variables. In fact, the subsets of optimal simple rules improve the stabilization of the real economy compared to the benchmark model, a feature that cannot be observed in the complete set.

Figures 9 to 12 compare the model dynamics after external shocks. In the estimated benchmark model, a drop in world output has a recessionary impact on the domestic economy, with a significant reduction in investment and consumption. An increase in foreign direct investment inflows has an expansionist impact on domestic credit, but the impact on inflation and output is contractionist given the appreciation of the domestic currency. An increase in the world interest rate leads to a depreciation of the exchange rate, which calls for a response of monetary policy. A commodity price boom, which in the model is represented by a shock to export prices[34], has an expansionist impact on credit, through the increase in available income and a surge in investment. In all cases, the optimal simple rules stabilize credit, and the impact of each subset of rules on real economy variables will depend on the credit segment that is most significantly affected by each policy combination. The main difference in the dynamic responses of the model to different subsets of optimal policies will actually be on banks' balance sheet variables, given that each subset requires a different reaction from each macroprudential instrument, affecting banks' incentives distinctly.

In Carvalho and Castro (2015)'s benchmark model, macroprudential policy instruments that do not react to economic or financial cycles are more effective to stabilize credit-to-GDP when shocks originate in the financial system. In fact, each instrument will have a potential niche where its impact is more pronounced. In general, macroprudential policies have a greater impact on financial variables, whereas monetary policy has a stronger effect on real variables, except for the case of housing loans, which are strongly influenced by monetary policy. Capital requirements have a strong impact on capital investment given the sensitivity of the value of capital to available funding from bank

[34] The export sector is modeled in accordance with a commodity-based economy.

loans. Risk weight factors have a substantial impact on actual capital adequacy ratios. Reserve requirements have the most important impact on bank liquidity.

4. The impact of macroprudential policy announcements on inflation expectations

A strand in the literature advocates that monetary policy can help build up risks to financial stability. In the case of Brazil, very few studies have investigated this risk-taking channel. Tavares et al (2013) study the impact of monetary policy on bank risk perception, associating the stance of monetary policy with lending spreads and on insurance hired by borrowers against credit default. They find that contractionist monetary policy induces banks to hire more insurance (the reverse is true in case of expansionist monetary policy). The same is observed for reserve requirements. They also affect the risk taking behavior of banks through insurance. Montes and Peixoto (2012) also find a positive relation between bank risk perception and the stance of monetary policy in Brazil.

To the best of our knowledge, the reverse channel has not been explored, especially for Brazil. Macroprudential policy announcements can have an impact on variables that are targeted by the monetary authority, and, depending on the coordination of business and financial cycles, macroprudential policy announcements can have an impact on the anchoring of inflation expectations.

To investigate whether macroprudential policy announcements had a significant influence on the anchoring of inflation expectations in Brazil, we select events when macroprudential policy was changed by explicitly targeting credit-related variables and assess their impact on the gap of inflation expectations from the inflation target[35] pursued by the monetary policy authority. Table 6 lists the events that classify under this category.

To assess the impact of the events on inflation expectations in Brazil, we use a panel of 12-month ahead private inflation forecasts, surveyed on a daily basis by Central Bank of Brazil's Investor Relations Office, from 2011 to 2014. To control for other factors influencing inflation expectations, we follow Carvalho and Minella (2012) by estimating an expectations-formation type rule, except that we augment it to account for the events we are investigating, in addition to dummy controls for the week of monetary policy meetings (and

[35] We use the upper bound of the inflation target interval, and not the mid-point target.

the preceding week) and for times when the consensus forecast was above the upper bound of the inflation target[36]. The estimated equation is:

$$\begin{aligned}\hat{\pi}_{i,t}^{e,12m} = \alpha + \beta_1 \hat{\pi}_{i,t-5}^{e,12m} + \beta_2 \hat{\pi}_{median,t-5}^{e,12m} + \beta_3 Std_{t-5}^{e,12m} + \beta_4 \Delta_{20} FX_{t-3} \\ + \beta_5 \Delta_{20} Embi_{t-3} + \beta_6 \, \Delta_{20} Selic_{t-3} + \beta_7 (\pi_{t-3} - \pi_{t-4}) \\ + \beta_8 D_{copom,t} + \beta_9 D_{median,t} + \sum_i \beta_{10,i} D_{event,i,t} + u_{i,t}\end{aligned} \quad (13)$$

where *t* corresponds to each day in the sample, and the variables are described as:

- $\hat{\pi}_{i,t}^{e,12m}$ is the gap between the 12-month ahead inflation forecast for each participant *i* and the center of the inflation target band. Inflation forecasts are collected from the survey conducted on a daily basis by the Central Bank of Brazil's Investor Relations Office;
- $\hat{\pi}_{median,t}^{e,12m}$ is the gap between the median of 12-month ahead inflation forecasts and the center of the inflation target band. Inflation forecasts are collected from the survey conducted on a daily basis by the Central Bank of Brazil's Investor Relations Office;
- $Std_t^{e,12m}$ is the standard deviation of 12-month ahead inflation forecasts surveyed on a daily basis by the Central Bank of Brazil's Investor Relations Office;
- $\Delta_{20} FX_t$ is the change in the BRL/USD daily quote over the past 20 days;
- $\Delta_{20} Embi_t$ is the change in JP Morgan's Embi Brazil over the past 20 days;
- $\Delta_{20} Selic_t$ is the change in the annualized monetary policy (Selic) rate over the past 20 days;
- $D_{copom,t}$ takes the value 1 in the days included in the following interval: the Friday immediately preceding a monetary policy meeting and the Monday immediately following it. For the other days, it takes the value 0;
- $D_{median,t}$ takes the value 1 in the days when the median of 12-month ahead inflation forecasts are above the upper bound of the inflation target. For the other days, it takes the value 0;
- $D_{event,i,t}$ takes the value 1 in the event window days according to Table 2. For the other days, it takes the value 0.

[36] The dummy for times when inflation expectations exceeded the upper inflation target controls for possible regime changes in the dynamics of inflation expectations.

We perform a fixed effects panel regression applying a covariance matrix that is robust to heteroscedasticity, autocorrelation with MA type-errors, and cross-sectionally dependent errors. The routine is implemented in Stata through the "xtivreg2" command, which applies Driscoll-Kraay (1998)'s covariance matrix estimator. Since forecasts are made for 12 months ahead, the MA structure duly considers this time span. Table 7 shows the regression results, where "Forecast gap" corresponds to the variable $\pi_{i,t}^{e,12m}$ in equation (13), "Median gap" corresponds to the variable $Median_t^{e,12m}$, and "Panel std" corresponds to the variable $Std_t^{e,12m}$.

We find that in 6 different occasions macroprudential policy announcements had an impact on the gap between inflation expectations and the inflation target. Events # 1, 4, 5, and 9 contributed to increase the gap. Event # 1 was not particularly intended to increase credit, but the movement was in the direction of relaxing credit constraints. In event # 4, while the increase in the maximum value of the real estate that could be financed with more favorable rates would contribute to expanding credit, the implementation of a loan-to-value cap could have the opposite effect on credit. In any case, market participants seem to have interpreted it as possibly inflationary. Event # 9 was particularly intended to stimulate credit origination through changes in the way banks could comply with reserve requirements on demand deposits. Events # 8 and 12 contributed to reducing the gap between inflation expectations and the inflation target. Event # 8 corresponded to the announcement of the implementation of Basle III. Event # 12 did not have an intention of reducing credit. Hence, the negative sign obtained in the estimation seems at odds with the intention of the event. An alternative specification was tested, including shorter lags of the controlling variables, and events # 4, 5 and 9 remained significant[37], and suggested that these events had an important impact on the anchoring of inflation expectations.

To test whether the cycle of monetary policy matters for the impact of macroprudential announcements on inflation expectations, we perform the same regression except that, instead of using individual events, we separate those that would likely have an expansionist impact on credit in two groups. Group A comprised events that happened when the cycle of monetary policy was contractionist. Group B comprised those that happened in expansionist monetary policy cycles. Our monetary policy cycle classification

[37] Since the panel used in the estimation is highly unbalanced, changing the lag structure of the regressors can have important implications for the number of observations actually used in the estimation.

was as follows. If the change in the policy rate that immediately preceded the event was in the direction of increasing it, the monetary policy stance was considered to be contractionist. If policy rate was stable, but the previous cycle was of an increase in interest rates, the monetary policy stance was also considered to be contractionist. If the change was to reduce policy rates or if the current cycle was of stable rates immediately following a reduction cycle, the monetary policy stance was considered to be expansionist. Hence, group A comprised events # 1, 2, 3, 4 and 5. Group B comprised events # 9, 10, 11, 12, 13, and 14. Events # 7 were not included in neither of these groups since the expected impact would be either neutral or of a reduction in credit. They were treated separately in the estimation.

Table 8 shows the estimation results. We find a significantly positive coefficient for the events in group A, but the coefficient for group B is not significant. The strict interpretation of this result is that macroprudential policy announcements that are interpreted to increase credit in moments when monetary policy is contractionist negatively affect the anchoring of inflation expectations. This certainly creates challenges for monetary policy conduct and for central bank communication.

5. Conclusion

This paper discusses the interaction between monetary and macroprudential policy in Brazil from both normative and positive perspectives. From the normative perspective, we use a DSGE model built to reproduce Brazilian particularities, and estimated with Bayesian techniques with data from Brazil, to investigate optimal combinations of simple, implementable macroprudential and monetary policy rules that react to the financial cycle. We find combinations of reserve requirements, risk weight factors and monetary policy that can achieve results, in terms of central bank's loss function, that are very close to those of a more comprehensive optimal combination of macroprudential policy, which includes the countercyclical buffer together with all other macroprudential policy instruments considered in this study. We argue that the smaller sets of optimal policy rules are also easier to implement in Brazil. Since reserve requirements and risk weight factors have been actually used in a number of occasions for macroprudential purposes in Brazil, especially after the financial crisis, and some of them countercyclically, our results corroborate to the

perception that the direction of these policy can be used to help correct the build-up of risks in the Brazilian financial system with a similar efficiency as the combination with countercyclical capital.

From the positive perspective, we investigate whether recent macroprudential policy announcements that targeted credit variables had important spillover effects on the inflation target pursued by monetary policy in Brazil. To this end, we used a rich survey panel of private inflation forecasts collected by the Central Bank of Brazil's Investor Relations Office on a daily basis and investigate the impact of announcements of macroprudential policy changes on inflation forecasts. We find that some events increased the gap between inflation forecasts and inflation targets. When we group the events that were expected to increase credit into two different sets, one when monetary policy was contractionist and the other when monetary policy was expansionist, we find that the former had positive significant impact on inflation expectations, while the latter did not have a significant effect. This can be interpreted as evidence that when macroprudential policy announcements are desynchronized from monetary policy, the anchoring of inflation expectations can be challenged. This stresses the importance of improving communication of central bank's policy intentions.

The paper also presents an overview of the challenges facing macroprudential policy in Brazil after the global financial crisis and glimpses at a few important future challenges. Financial deepening, foreign capital flows, and the impact of fiscal policy on the credit cycle have been particularly relevant challenges that deserve further analysis. Financial deepening has resulted from financial inclusion, following technological improvements in the financial system, income distribution policies, public banks' credit origination policies, and a long period of stable macroeconomic environment. Household indebtedness increased substantially and credit accelerated, but several risk mitigating measures have been put in place to strengthen the resilience of the financial system, in addition to a tight supervisory and regulatory policy stance. However, since a substantial part of the risk inherent to the financial deepening process has been taken by public banks, and in some occasions transferred to the National Treasury, the impact of the fiscal policy stance on the Brazilian credit cycle should be constantly monitored and anticipated.

References

Afanasieff, T., F. Carvalho, E. Castro, R. Coelho and J. Gregório (2015). Implementing Loan-to-Value Ratios: The Case of Auto Loans in Brazil (2010-11). Central Bank of Brazil Working Paper Series, 380.

Agenor, P. and L. Silva (2013). Inflation Targeting and Financial Stability: A Perspective from the Developing World. Central Bank of Brazil Working Paper Series, 324..

Angeloni, I. and E. Faia (2013). Capital regulation and monetary policy with fragile banks. Journal of Monetary Economics. 60 (3), 311-324

Benigno, G., H. Chen, C. Otrok, A. Rebucci, and E. Young (2012). Monetary and Macro-Prudential Policies: An Integrated Analysis. IMF Twelfth Jacques Polak Annual Research Conference.

Bernanke, B., and M. Gertler (2001). Should Central Banks Respond to Movements in Asset Prices? American Economic Review, 91(2): 253-257.

Brzoza-Brzezina, M., and M. Kolasa (2013). Bayesian Evaluation of DSGE Models with Financial Frictions. Journal of Money, Credit and Banking, vol. 45(8), pp. 1451-1476, Dec. 2013.

Carvalho, F. and A. Minella (2012) Survey Forecasts in Brazil: A Prismatic Assessment of Epidemiology, Performance, and Determinants. Journal of International Money and Finance, vol. 31, no. 6, pp. 1371-1391, Oct. 2012

Carvalho, F. and C. Azevedo (2008) The Incidence of Reserve Requirements in Brazil: Do Bank Stockholders Share the Burden?. Journal of Applied Economics, vol. XI (1), May 2008.

Carvalho, F. and M. Castro (2015). Foreign Capital Flows, Credit Growth and Macroprudential Policy in a DSGE Model with Traditional and Matter-of-Fact Financial Frictions. Central Bank of Brazil Working Paper Series, 387.

Cesa-Bianchi, A and A. Rebucci (2015). Does Easing Monetary Policy Increase Financial Instability? IMF Working Papers, 139.

Curdia, V. and M. Woodford (2010). Credit frictions and optimal monetary policy. Journal of Money, Credit and Banking. 42, 3–35.

De Fiore, F. and O. Tristani (2013). Optimal Monetary Policy in a Model of the Credit Channel. Economic Journal, Royal Economic Society, vol. 123(571), pages 906-931, 09.

Drehman, M. and K. Tsatsaronis (2014). The Credit-to-GDP Gap and Countercyclical Capital Buffers: questions and answers. BIS Quarterly Review March 2014.

Driscoll, J., and A. C. Kraay (1998). Consistent Covariance Matrix Estimation with Spatially Dependent Data. Review of Economics and Statistics 80: 549-560.

Faia, E. and T. Monacelli (2007). Optimal Interest Rate Rules, Asset Prices, and Credit Frictions. Journal of Economic Dynamics and Control, 2007, vol. 31-10, p.p. 3228-3254.

Fendoğlu, S. (2014). Optimal monetary policy rules, financial amplification, and uncertain business cycles. Journal of Economic Dynamics & Control, 46, 271–305.

Gertler, M., N. Kiyotaki, and A. Queralto (2012). Financial crises, bank risk exposure and government financial policy. Journal of Monetary Economics, 59, S17-S34.

Gilchrist, S. and J. Leahy (2002). Monetary Policy and Asset Prices. Journal of Monetary Economics 49, 75-97.

Iacoviello, M. (2005). House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle. American Economic Review, vol. 95(3), pp 739-764, June.

Iacoviello, M., S. Neri (2010). Housing market spillovers: evidence from an estimated DSGE model. American Economy Journal: Macroeconomics 2 (2), 126-164.

International Monetary Fund (2013). The Interaction of Monetary and Macroprudential Policies. (Washington). http://www.imf.org/external/np/pp/eng/2013/012913.pdf

Kannan, P., P. Rabanal, and A. Scott (2012). Monetary and Macroprudential Policy Rules in a Model with House Price Booms. The B.E. Journal of Macroeconomic, vol. 12(1).

Lambertini, L., C. Mendicino, and M. Punzi (2013). Leaning against boom-bust cycles in credit and housing prices. Journal of Economic Dynamics and Control, 37, 1500-1522.

Martins, B. and R. Schechtman (2013). Loan Pricing Following a Macro Prudential Within-Sector Capital Measure. Central Bank of Brazil Working Paper Series, 323.

Montes, G. and G. Peixoto (2012). Risk-taking Channel, Bank Lending Channel and the "Paradox of Credibility": Evidence for Brazil. Encontro Nacional de Economia – ANPEC.

Ponticelli, J. and L. Alencar (2013). Celeridade do Sistema Judiciário e Créditos Bancários para as Indústrias de Transformação. Central Bank of Brazil Working Paper Series, 327.

Reinhart, C. and K. Rogoff (2011). From Financial Crash to Debt Crisis. American Economic Review 101 (August 2011): 1676–1706.

Sahay, R., Čihák, M., N'Diaye, P., Barajas, A., Bi, R., Ayala, D., Gao, Y., Kyobe, A., Nguyen, L., Saborowski, C., Svirydzenka, K., and Yousefi, S. (2015). Rethinking Financial Deepening: Stability and Growth in Emerging Markets. IMF Staff Discussion Note, SDN/15/08, May 2015.

Schmitt-Grohé, S. and M. Uribe (2007). Optimal Simple and Implementable Monetary and Fiscal rules. Journal of Monetary Economics 54 (2007) 1702–1725.

Silva, L. and R. Harris (2012). Sailing through the Global Financial Storm: Brazil's recent experience with monetary and macroprudential policies to lean against the financial cycle and deal with systemic risks. Central Bank of Brazil Working Paper Series, 290.

Silva, L., A. Sales, and W. Gaglianone (2012). Financial Stability in Brazil. Central Bank of Brazil Working Paper Series, 289.

Tavares, D., G. Montes and O. Guillén (2013). Transmissão da Política Monetária pelos Canais de Tomada de Risco e de Crédito: uma análise considerando os seguros contratados pelos bancos e o spread de crédito no Brasil. Central Bank of Brazil Working Paper Series, 308.

Taylor, A. (2015). Credit, Financial Stability, and the Macroeconomy. NBER Working Paper Series, 21039.

Figure 6
Comparing combinations of optimal simple macroprudential and monetary policy rules: Negative shock to bank capital: 10% drop on impact

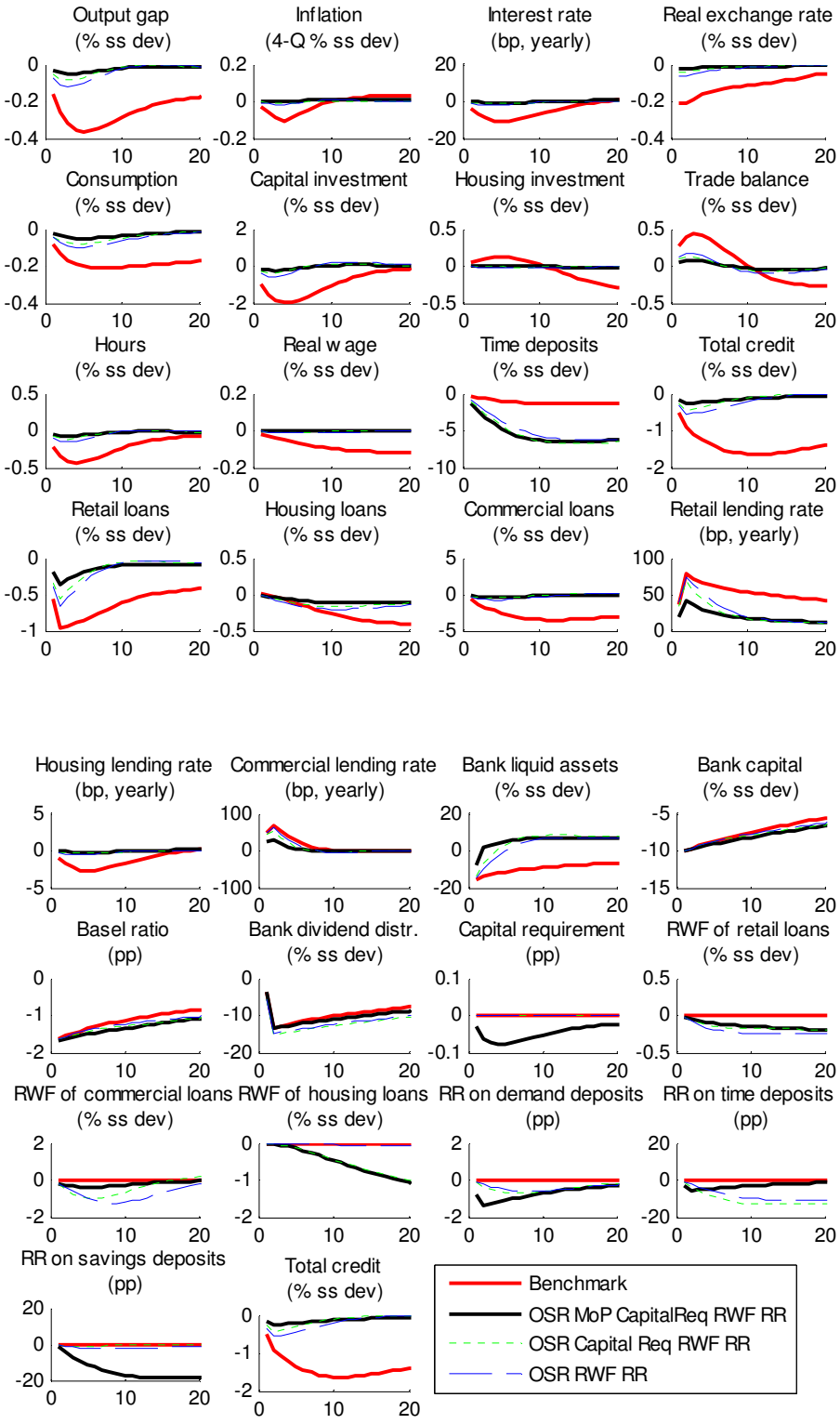


Figure 7
Comparing combinations of optimal simple macroprudential and monetary policy rules:
Bank liquidity preference shock: 65% drop on impact

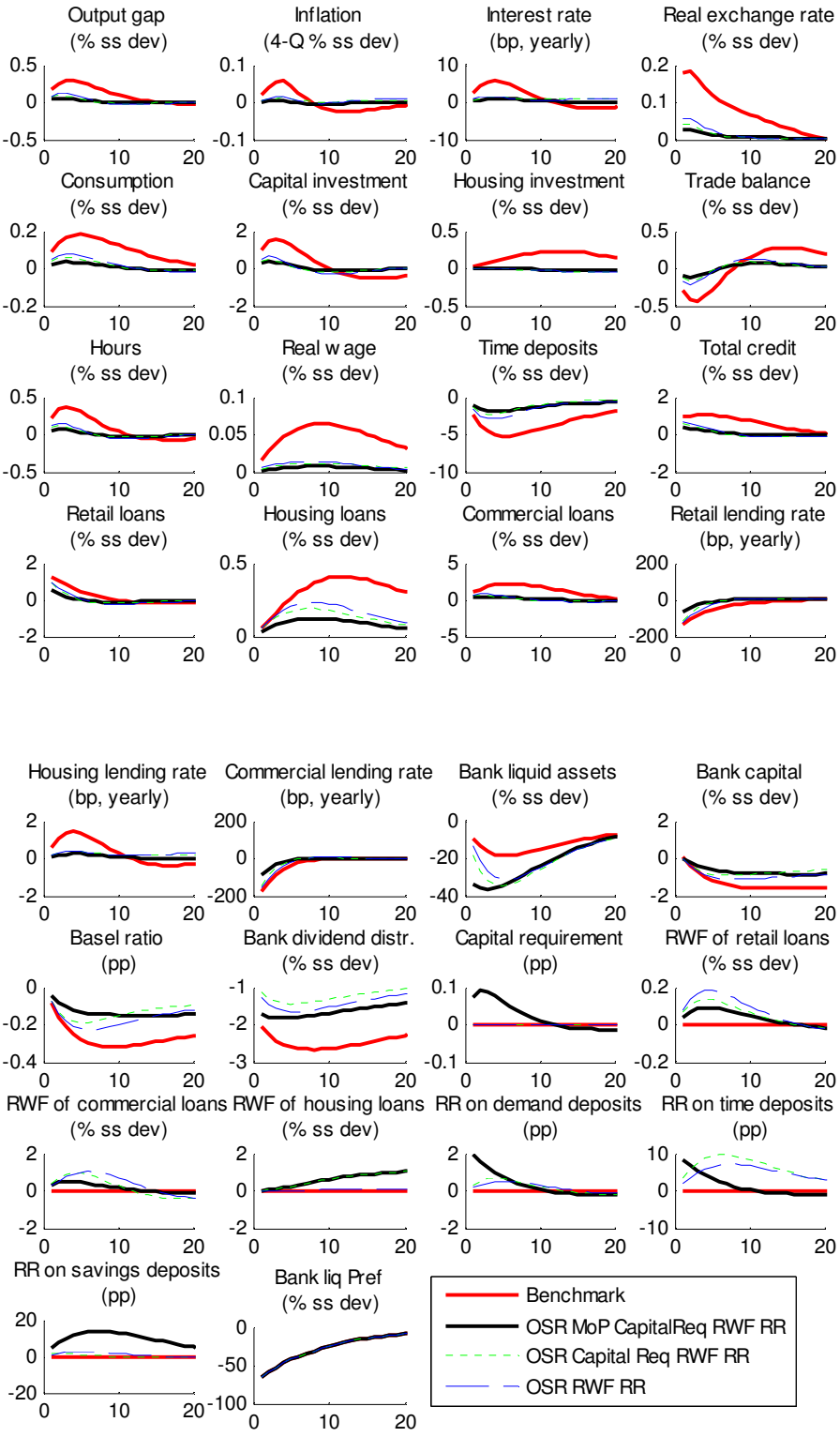


Figure 8
Comparing combinations of optimal simple macroprudential and monetary policy rules:
Monetary policy shock: 100 bps increase on impact

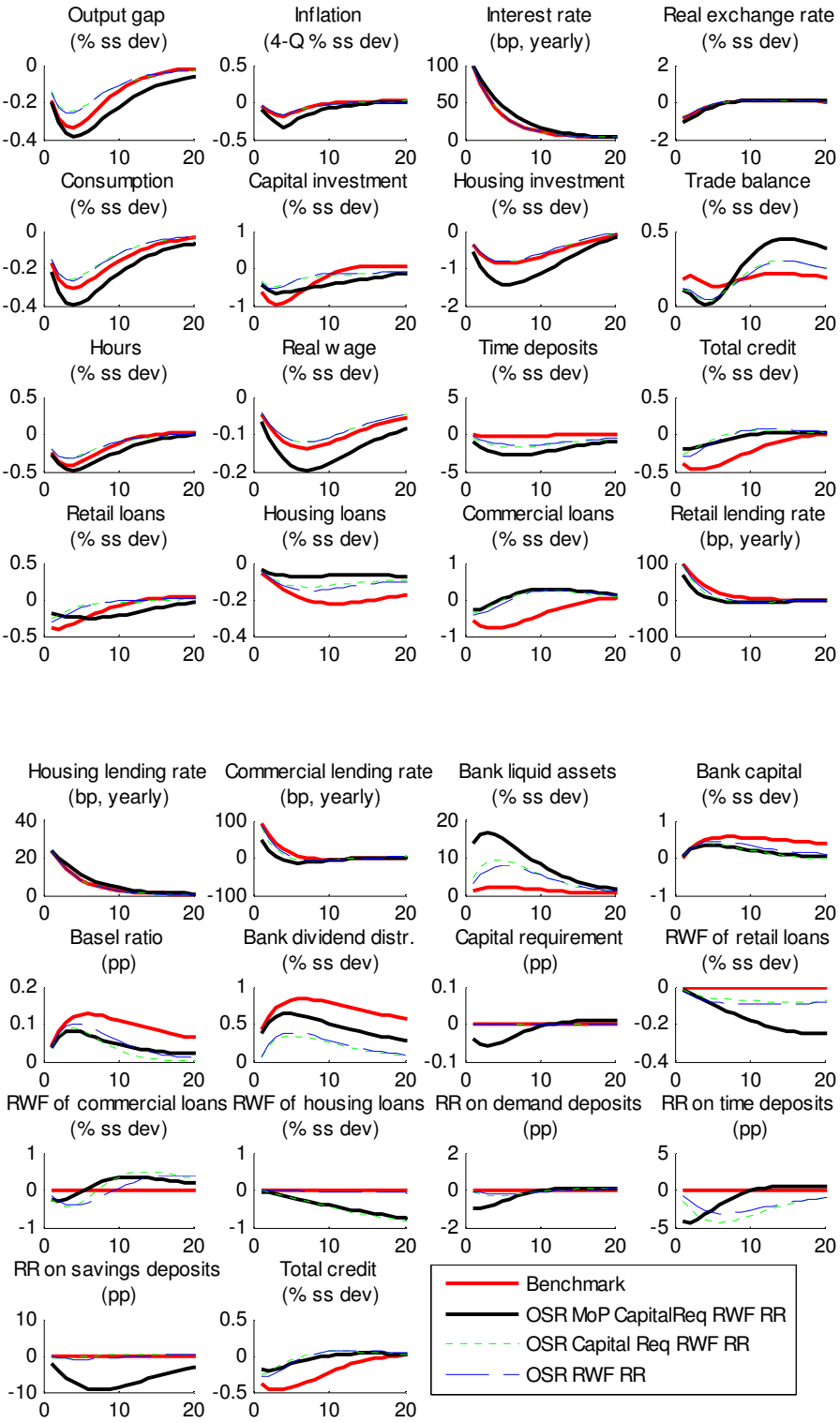


Figure 9
Comparing combinations of optimal simple macroprudential and monetary policy rules: Shock to world output: 1% drop

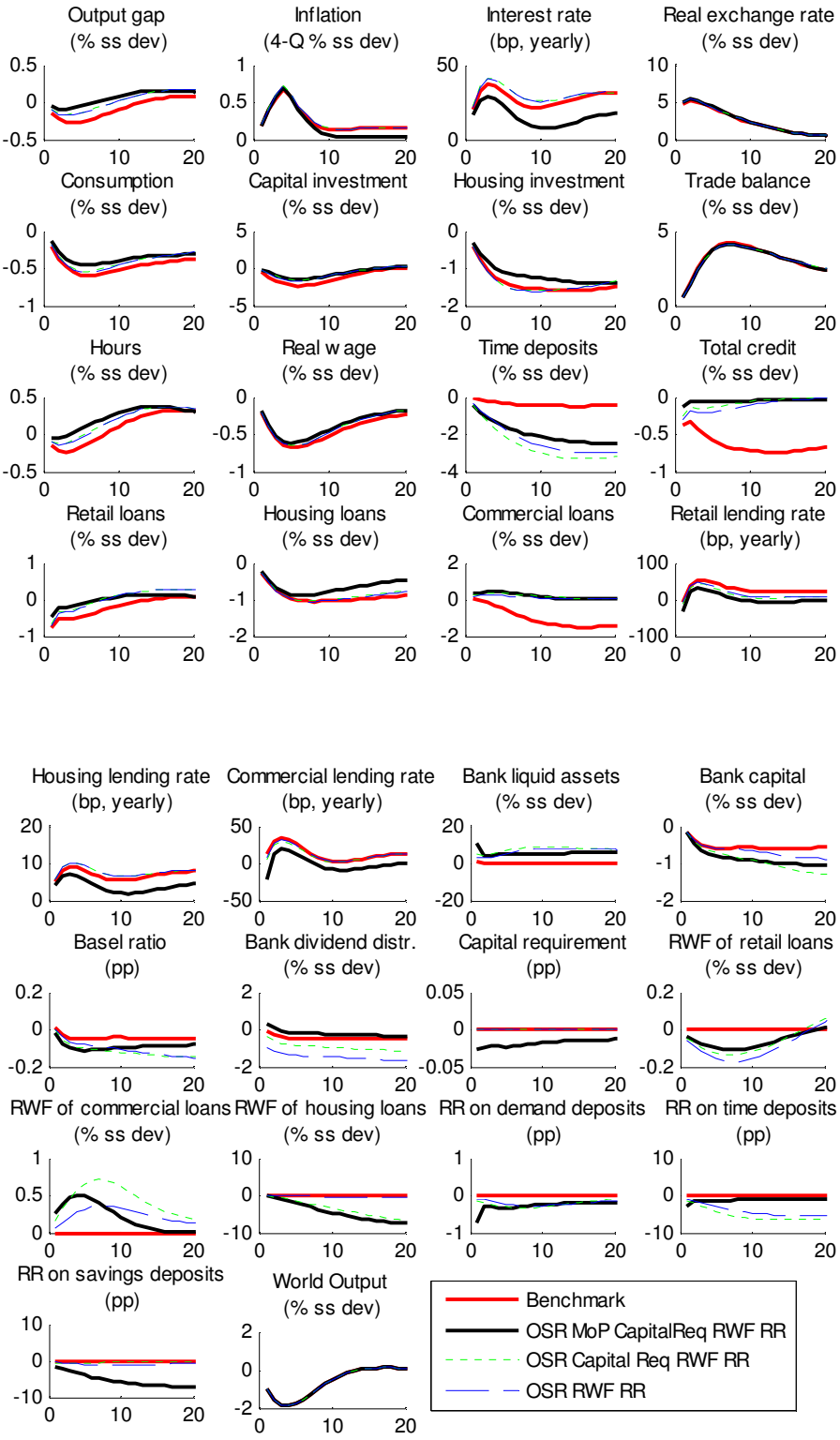


Figure 10
Comparing combinations of optimal simple macroprudential and monetary policy rules: Shock to foreign direct investment flows: 1p.p. increase

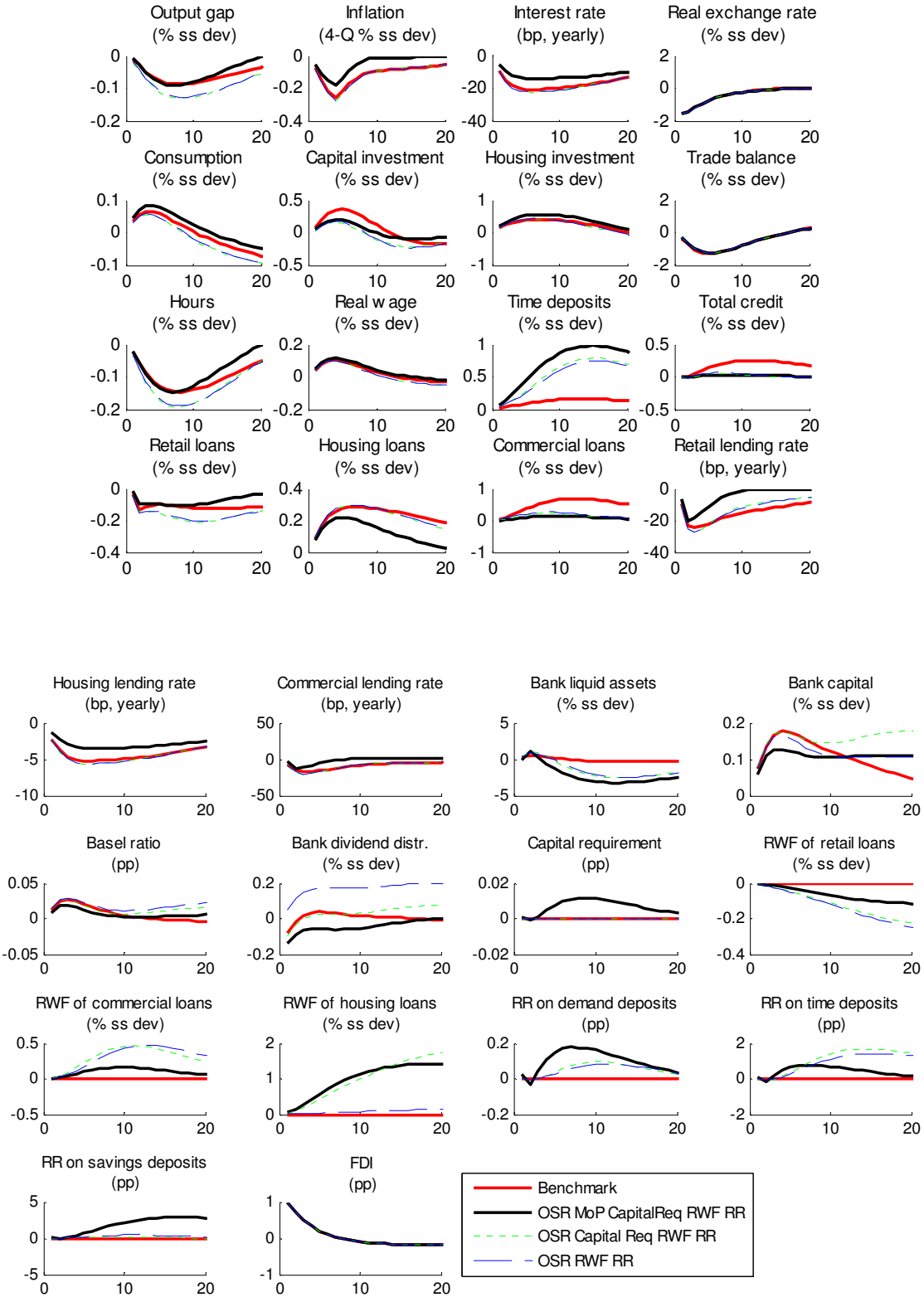


Figure 11
Comparing combinations of optimal simple macroprudential and monetary policy rules: Shock to foreign interest rates: 100 bps drop

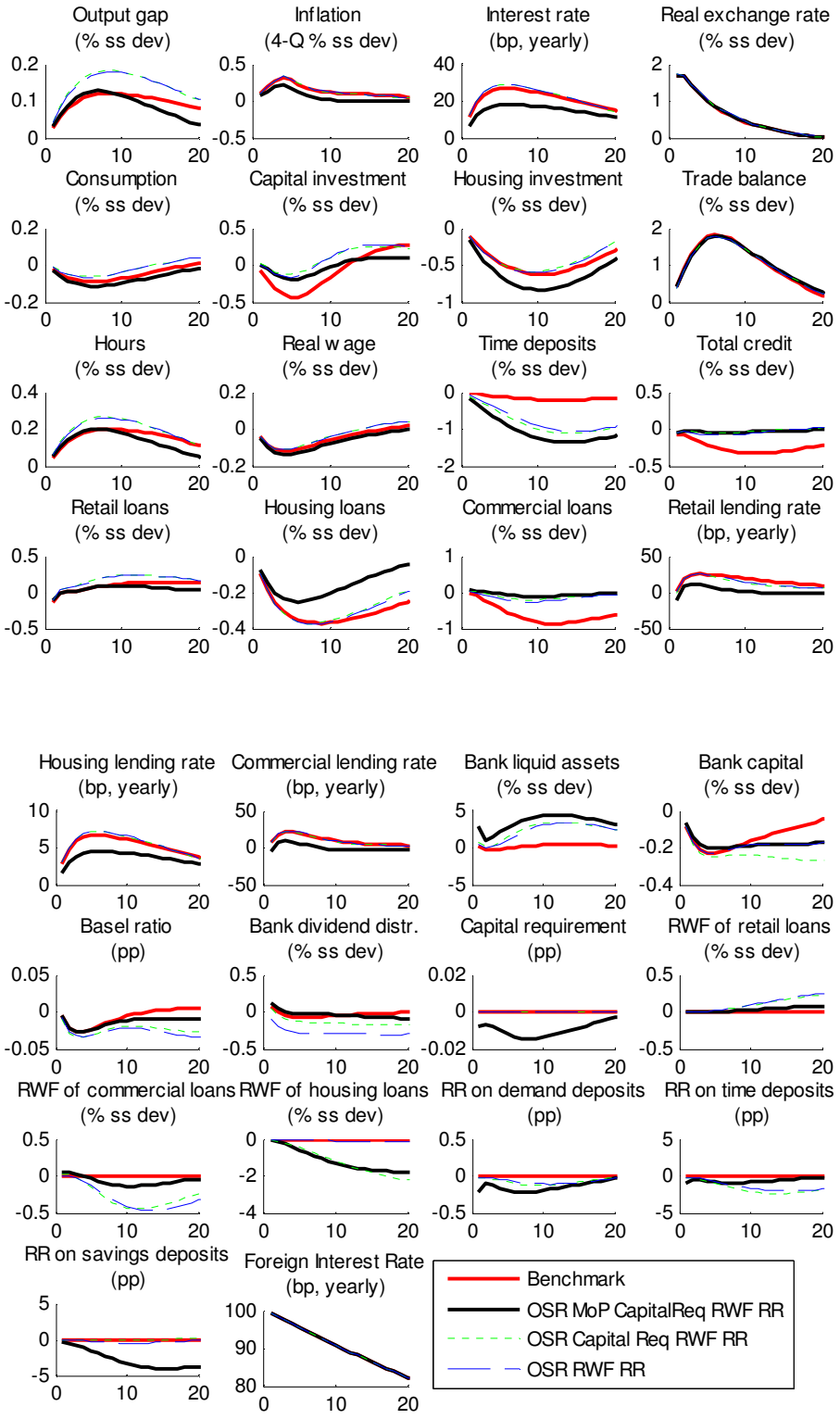
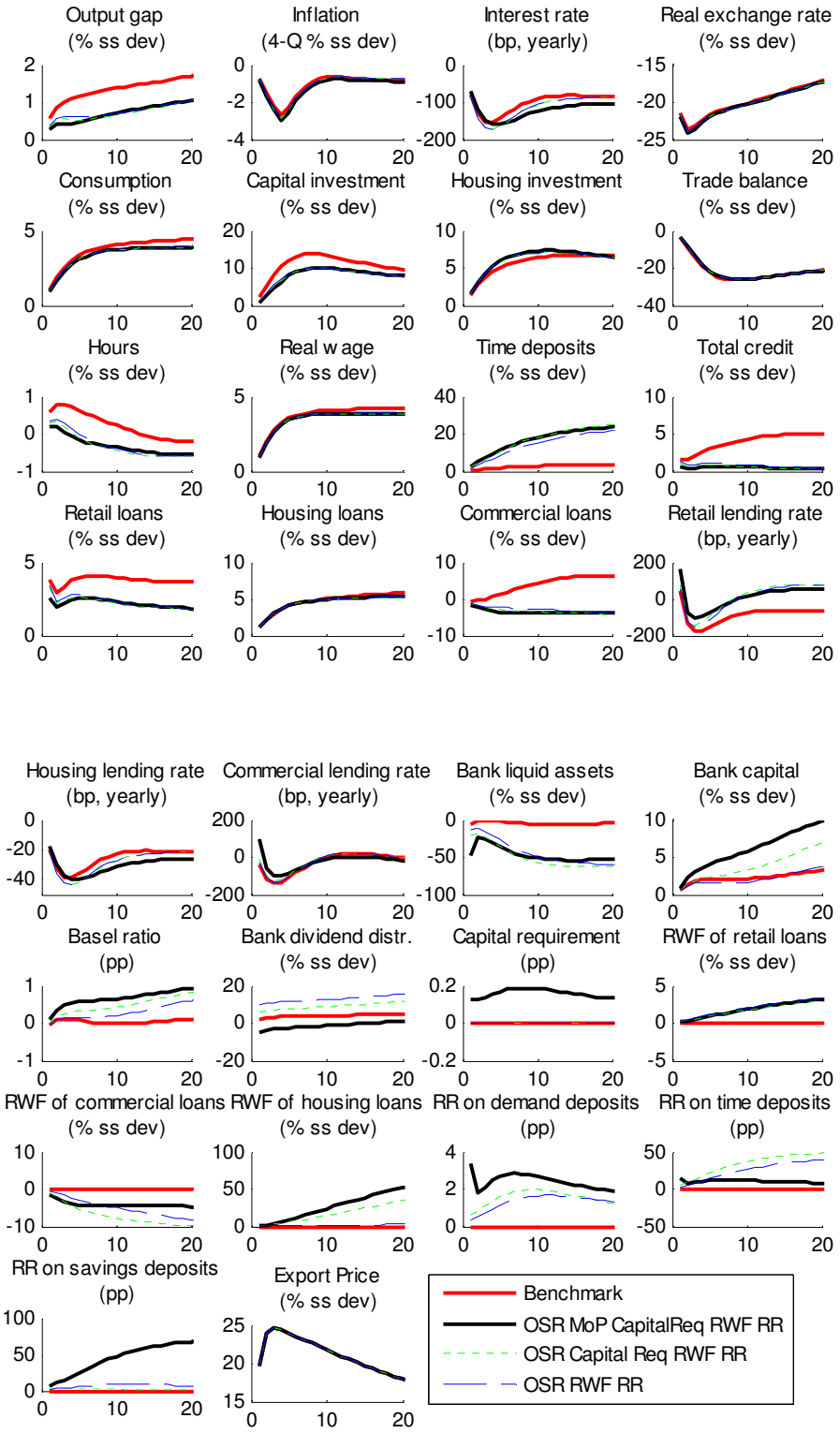


Figure 12
Comparing combinations of optimal simple macroprudential and monetary policy rules: Shock to export prices: 20% increase



Tables

Table 1
Data Base Monitoring at the Central Bank

Assets and securities markets	• Data sources: Selic, Cetip, BM&F Bovespa, Brazilian Payments System and all financial institutions • Processes 40 million registers per day • Processes over 900 documents per month • Produces daily macro and microprudential analysis on liquidity and market risks of the financial system • Daily monitors the market of public bonds and the behavior of banking funding • Releases information at Central Bank of Brazil's website
Credit operations	• Data sources: monthly information from financial institutions o 480 million operations o Credit operations outstanding of 75 million clients o Each operation has 36 information fields • Produces monthly micro and macroprudential analysis on credit risks of the financial system • Manages the Credit Bureau System and publishes information to the public and to financial institutions on credit operations • Releases information on Central Bank of Brazil's website
Purchasing consortium groups	• Information on 13.7 million quotas, distributed among 21 thousand groups • Data on 9 million quotas with past-due earnings • 880 million data registers received on a quarterly basis and 60 thousand received on a monthly basis • Produces individual and aggregate quarterly analysis on the purchasing consortium segment • Releases information at Central Bank of Brazil's website
FX operations	• FX system: o 207 authorized financial institutions o 7.8 million operations per year ▪ 31 thousand operations per day • BCB receives additional 25.5 million operations per year via monthly files • Produces daily microprudential analysis on FX operations carried out by financial institutions • Daily monitors foreign inflows and the FX flow • Releases information at Central Bank of Brazil's website
Accounting information	• Receives 1,136 bank financial statements on a monthly basis and 2,267 limit statements (600,000 monthly registers) • Receives over 7,300 documents on a quarterly basis (2,2 million quarterly registers) • Produces monthly macro and microprudential analysis on the financial-economic situation of the financial institutions • Monthly monitors the adherence of financial institutions

	to regulatory operational limits • Releases information at Central Bank of Brazil's website
Others	• Other sources of information: ○ Regulators ○ Deposit guarantee fund ○ Custody chambers ○ Registry chambers ○ External auditors ○ Rating agencies ○ International organizations – FSB ○ Government data bases ○ Private data bases – SERASA ○ Institutions that are not regulated by the Central Bank of Brazil

Source: Central Bank of Brazil

Table 2
Optimal simple rules: comparing constrained and unconstrained optima at different credit gap weights in the loss function

Rules	Reaction parameters of the rules	Credit gap weight=0.001		Credit gap weight=0.01		Credit gap weight=0.5	
		Unconstrained optimum	Constrained optimum	Unconstrained optimum	Constrained optimum	Unconstrained optimum	Constrained optimum
Monetary Policy	Coefficient of reaction to inflation	4.44	4.41	4.04	4.04	1.81	4.39
	Coefficient of reaction to output	0.90	0.89	1.72	0.85	2.69	5.95
	Coefficient of reaction to total credit gap	-0.06	0.00	-0.11	0.00	-0.35	0.75
	Autoregressive coefficient	0.93	0.93	0.93	0.94	0.91	0.93
Risk Weight Factors	RWF of consumer loans: reaction to consumer credit	0.10	0.12	0.09	0.09	0.27	0.33
	RWF of consumer loans: autoregressive coefficient	0.99	0.99	0.99	0.99	0.84	0.96
	RWF of commercial loans: reaction to commercial credit	0.83	0.84	0.84	0.84	-0.93	0.00
	RWF of commercial loans: autoregressive coefficient	0.29	0.30	0.31	0.31	0.56	0.56
	RWF of housing loans: reaction to housing credit	0.63	0.62	0.61	0.61	0.49	0.49
	RWF of housing loans: autoregressive coefficient	0.98	0.98	0.98	0.97	0.00	0.00
Reserve requirements	RR on time deposits: reaction to total credit gap	20.96	20.96	20.96	20.96	20.91	21.07
	RR on time deposits: autoregressive coefficient	0.03	0.02	0.00	0.00	0.67	0.98
	RR on demand deposits: reaction to total credit gap	5.02	5.02	5.02	5.02	5.02	5.16
	RR on demand deposits: autoregressive coefficient	0.00	0.00	0.00	0.00	0.76	0.84
	RR on savings deposits: reaction to total credit gap	10.97	10.96	10.96	10.96	10.87	11.26
	RR on savings deposits: autoregressive coefficient	0.89	0.95	0.90	0.91	0.27	0.48
Countercyclical capital buffer	CC capital buffer: autoregressive coefficient	0.46	0.45	0.44	0.44	0.46	0.48
	CC capital buffer: reaction to total credit gap	3.11	3.11	3.11	3.11	3.10	10.21
	Value of the objective function	0.00107	0.00108	0.00189	0.00194	0.00404	0.00462
	Variation coefficient						
	Inflation	0.013	0.013	0.015	0.015	0.025	0.024
	Interest rate	0.012	0.012	0.014	0.014	0.023	0.024
	Output	0.057	0.056	0.052	0.050	0.047	0.038
	Credit-to-GDP	0.075	0.076	0.069	0.070	0.046	0.054

Table 3
Optimal simple rules: comparing constrained optima using different subsets of policy rules for a loss function credit-gap weight of 0.001

Rules	Reaction parameters of the rules	Complete set: MonPol & CC & RR & RWF*	MonPol & CC & RWF*	MonPol & CC*	MonPol & CC & RR*	MonPol & RWF & RR*	MonPol & RWF*	MonPol & RR*
Monetary Policy	Coefficient of reaction to inflation	4.41	2.86	4.40	4.87	5.42	6.73	6.73
	Coefficient of reaction to output	0.89	0.40	0.88	1.63	1.30	0.42	1.15
	Coefficient of reaction to total credit gap	0.00	1.00	0.00	0.10	0.01	0.00	0.08
	Autoregressive coefficient	0.93	0.90	0.93	0.95	0.95	0.94	0.95
Risk Weight Factors	reaction to consumer	0.12	1.24			1.20	1.51	
	RWF of consumer loans: autoregressive coefficient	0.99	0.97			0.92	0.96	
	RWF of commercial loans: reaction to commercial credit	0.84	0.90			0.56	7.64	
	RWF of commercial loans: autoregressive coefficient	0.30	0.96			0.93	0.72	
	RWF of housing loans: reaction to housing credit	0.62	0.22			0.07	0.18	
	RWF of housing loans: autoregressive coefficient	0.98	0.95			0.98	0.89	
Reserve requirements	reaction to total credit gap	20.96			16.49	7.38		22.01
	RR on time deposits: autoregressive coefficient	0.02			0.99	0.99		0.00
	RR on demand deposits: reaction to total credit gap	5.02			1.34	0.64		0.21
	RR on demand deposits: autoregressive coefficient	0.00			0.45	0.89		0.94
	RR on savings deposits: reaction to total credit gap	10.96			7.80	3.42		33.83
	RR on savings deposits: autoregressive coefficient	0.95			0.99	0.00		0.99
Countercyclical capital buffer	autoregressive coefficient	0.45	0.50	0.00	0.51			
	CC capital buffer: reaction to total credit gap	3.11	0.16	13.76	0.29			
	Objective	0.00108	0.00149	0.00126	0.00114	0.00108	0.00140	0.00116
	Variation coefficient							
	Inflation	0.013	0.013	0.013	0.014	0.013	0.011	0.012
	Interest rate	0.012	0.013	0.012	0.013	0.012	0.012	0.012
	Output	0.056	0.062	0.061	0.055	0.055	0.064	0.062
	Credit-to-GDP	0.076	0.147	0.104	0.076	0.081	0.143	0.082

* MonPol = monetary policy, RR = reserve requirements, RWF = risk weight factors, CC = countercyclical capital buffer

Table 4

Optimal simple rules: comparing constrained optima using different subsets of policy rules for a loss function credit-gap weight of 0.001 and for given monetary policy reaction to inflation and output

Rules	Reaction parameters of the rules	MonPol & RR & RWF & CC*	MonPol & RWF & CC*	MonPol & RWF & RR*	MonPol & RR & CC*	MonPol & RR*	MonPol & RWF*
Monetary Policy	Coefficient of reaction to total credit gap	0.00	0.00	0.01	0.00	0.20	0.00
Risk Weight Factors	RWF of consumer loans: reaction to consumer credit	0.65	2.32	0.39			8.06
	RWF of consumer loans: autoregressive coefficient	0.96	0.93	0.99			0.80
	RWF of commercial loans: reaction to commercial credit	0.30	3.73	0.23			16.75
	RWF of commercial loans: autoregressive coefficient	0.68	0.99	0.73			0.90
	RWF of housing loans: reaction to housing credit	0.07	0.26	0.04			90.30
	RWF of housing loans: autoregressive coefficient	0.71	0.95	0.99			0.13
Reserve requirements	RR on time deposits: reaction to total credit gap	4.39		2.35	17.42	66.32	
	RR on time deposits: autoregressive coefficient	0.98		0.73	0.94	0.99	
	RR on demand deposits: reaction to total credit gap	0.36		0.18	0.26	9.28	
	RR on demand deposits: autoregressive coefficient	0.85		0.73	0.87	0.99	
	RR on savings deposits: reaction to total credit gap	1.99		1.11	1.66	34.97	
	RR on savings deposits: autoregressive coefficient	0.12		0.73	0.59	0.99	
Countercyclical capital buffer	CC capital buffer: autoregressive coefficient	0.50	0.50		0.50		
	CC capital buffer: reaction to total credit gap	0.11	0.29		0.05		
	Objective	0.00138	0.00167	0.00141	0.00141	0.00141	0.00152
	Variation coefficient						
	Inflation	0.015	0.015	0.015	0.015	0.015	0.015
	Interest rate	0.015	0.015	0.015	0.015	0.015	0.015
	Output	0.060	0.064	0.061	0.062	0.063	0.061
	Credit-to-GDP	0.087	0.142	0.092	0.081	0.080	0.122

* MonPol = monetary policy, RR = reserve requirements, RWF = risk weight factors, CC = countercyclical capital buffe

** In this exercise, monetary policy reaction to inflation and output is set according to the mode estimated in Carvalho and Castro (2015), i.e., $\rho = 0.829, \gamma_\pi = 1.961$, $\gamma_y = 0.185$.

Table 5
Optimal simple rules: comparing constrained optima of subsets of policy rules for a given monetary policy rule and a loss function credit-gap weight of 0.001[**]

Rules	Reaction parameters of the rules	RR & RWF & CC*	RWF & CC*	RWF & RR*	RR & CC*	RR*	RWF*
Risk Weight Factors	RWF of consumer loans: reaction to consumer credit	0.11	0.17	0.12			3.31
	RWF of consumer loans: autoregressive coefficient	0.99	0.99	0.99			0.91
	RWF of commercial loans: reaction to commercial credit	0.73	-0.04	0.38			5.28
	RWF of commercial loans: autoregressive coefficient	0.71	0.99	0.85			0.99
	RWF of housing loans: reaction to housing credit	0.37	0.15	0.03			0.36
	RWF of housing loans: autoregressive coefficient	0.99	0.99	0.99			0.95
Reserve requirements	RR on time deposits: reaction to total credit gap	5.23		2.68	20.68	17.42	
	RR on time deposits: autoregressive coefficient	0.98		0.99	0.96	0.94	
	RR on demand deposits: reaction to total credit gap	0.52		0.27	2.03	0.26	
	RR on demand deposits: autoregressive coefficient	0.84		0.88	0.45	0.60	
	RR on savings deposits: reaction to total credit gap	2.64		1.33	10.11	1.64	
	RR on savings deposits: autoregressive coefficient	0.38		0.89	0.33	0.49	
Countercyclical capital buffer	CC capital buffer: autoregressive coefficient	0.50	0.50		0.51		
	CC capital buffer: reaction to total credit gap	0.05	25.58		0.23		
	Objective	0.00136	0.00136	0.00138	0.00140	0.00141	0.00167
	Variation coefficient						
	Inflation	0.015	0.015	0.015	0.015	0.015	0.015
	Interest rate	0.015	0.015	0.015	0.015	0.015	0.015
	Output	0.059	0.060	0.059	0.062	0.062	0.064
	Credit-to-GDP	0.085	0.084	0.089	0.080	0.081	0.141

* RR = reserve requirements, RWF = risk weight factors, CC = countercyclical capital buffer

** In this exercise, we set the monetary policy parameters according to the mode estimated in Carvalho and Castro (2015), i.e., $\rho = 0.829, \gamma_\pi = 1.961\,, \gamma_y = 0.185\,,\ \chi = 0.$

Table 6
Macroprudental policy events

Event #	Event window	Event description	Authors' interpretation of the expected impact on credit	Current nominal policy interest rate cycle	Time span since last change in policy direction	Previous nominal policy interest rate cycle
1	19-aug-2014 to 22-aug-2014	Reduces RWF for long term retail credit operations (Circular 3714)	Increase	Stability	4 months	Increase
2	24-jul-2014 to 28-jul-2014	Changes the compliance terms of reserve requirements on time deposits by introducing optional compliance with credit origination. Increases the set of institutions that can partially comply with reserve requirements on demand deposits with credit origination related to a specific development program. (Circular 3712). Changes the calculation of risk weight factors for retail loans. (Circular 3711)	Increase	Stability	3 months	Increase
3	23-jun-2014 to 25-jun-2014	Postpones the implementation of a stricter mandatory allocation of funds to rural credit (Resolução 4336) and gives more flexibility to compliance with mandatory rural credit originations (Resolução 4348)	Increase	Stability	2 months	Increase
4	30-sep-2013 to 2-oct-2013	Increases the maximum value of real estate authorized to be financed with lower interest rates. Sets loan-to-value caps on housing loans. (Resolução 4271)	Ambiguous	Increase	5 months	Stability
5	9-aug-2013 to 13-aug-2013	Sets risk weight factors on rural credit inversely related to lending rates. (Resolução 4259)	Increase	Increase	4 months	Stability
6	2-jul-2013 to 4-jul-2013	Changes the time window for computing the incidence base of mandatory allocation of demand deposits on microcredit originations (Resolução 4242) Speeds up the schedule for normalization of the remuneration of reserve requirements on time deposits (the previous regulation reduced the remuneration of required reserves on time deposits if banks did not purchase credit portfolios of small financial institutions) (Circular 3660)	Neutral Reduction	Increase	3 months	Stability
7	19-jun-2013 to 21-jun-2013	Changes several regulatory pieces concerning mandatory rural credit origination (Resoluções 4233, 4234 and 4235)	Neutral	Increase	2 months	Stability
8	28-feb-2013 to 4-mar-2013	Implements Basle 3	Neutral	Stability	4 months	Reduction
9	27-dec-2012 to 2-jan-2013	Changes the compliance terms of reserve requirements on demand deposits by introducing optional compliance with credit origination, with a potential impact of R$ 15 billion in new credit origination. (Circular 3622)	Increase	Stability	2 months	Reduction
10	14-sep-2012 to 17-sep-2012	Cancels additional reserve requirement on time deposits. Reduces the reserve requirement ratio on time deposits. (Circular 3609)	Increase	Reduction	12 months	Increase
11	23-aug-2012 to 27-aug-2012	Changes required allocation of funds to rural loans, giving incentives for credit originations at low lending rates (Resolução 4127). Adds flexibility to the requirements for issuing long term bank instruments (Letra Financeira) (Resolução 4123),	Increase	Reduction	11 months	Increase
12	28-jun-2012 to 2-jul-2012	Increases the set of institutions allowed to obtain export credit (Circular 3604). Increases mandatory allocation of demand deposits on rural credit (Resolução 4096) and reduces additional reserve requirement on demand deposits (Circular 3603)	Increase	Reduction	9 months	Increase
13	21-may-2012 to 23-may-2012	Increases the set of credit operations allowed to be used as compliance with reserve requirements on time deposits (Circular 3594). Requires the registry of collateral on housing and vehicle loans in authorized asset exchange systems.	Increase	Reduction	8 months	Increase
14	10-feb-2012 to 14-feb-2012	Increases the set of financial institutions allowed to partly comply with traditional and additional reserve requirements on time deposits with purchases of credit portfolios from other institutions and other operations. Increases the set of institutions exempted from these reserve requirements. (Circular 3576).	Increase	Reduction	5 months	Increase

Table 7

Panel regression results: single events

Number of obs = 68722
Number of groups: 138
F(23,1020)=7659.44
Prob>F = 0.0000
Centered R2 = 0.7249
Uncentered R2 = 0.7249
Root MSE = 0.2702

Total (centered) SS = 18196.84949
Total (uncentered) SS = 18196.84949
Residual SS = 5006.060219

Forecast gap	Robust Coef.	Std. Err.	z	P>z	[95% Conf Interval]	
Forecast gap (-20)	0.657	0.012	53.90	0.000***	0.633	0.681
Median gap (-20)	0.109	0.082	1.32	0.187	-0.053	0.270
Panel std (-5)	0.458	0.247	1.86	0.064*	-0.026	0.942
Δ FX (-5)	0.496	0.214	2.31	0.021**	0.076	0.916
$\Delta \Pi$ (-5)	0.876	0.120	7.29	0.000***	0.640	1.112
Δ Embi (-5)	0.109	0.129	0.85	0.398	-0.144	0.362
Δ R (-5)	0.577	0.453	1.27	0.203	-0.311	1.464
Dummy: Copom week	-0.004	0.018	-0.20	0.839	-0.038	0.031
Dummy: Median above target	0.250	0.081	3.10	0.002***	0.092	0.408
Dummy: event 1	0.212	0.027	7.84	0.000***	0.159	0.265
Dummy: event 2	-0.032	0.038	-0.86	0.392	-0.106	0.042
Dummy: event 3	0.005	0.043	0.12	0.908	-0.078	0.088
Dummy: event 4	0.177	0.068	2.60	0.009***	0.043	0.311
Dummy: event 5	0.203	0.048	4.24	0.000***	0.109	0.298
Dummy: event 6	-0.039	0.046	-0.85	0.395	-0.129	0.051
Dummy: event 7	-0.040	0.047	-0.84	0.399	-0.133	0.053
Dummy: event 8	-0.253	0.037	-6.77	0.000***	-0.326	-0.180
Dummy: event 9	0.226	0.044	5.10	0.000***	0.139	0.313
Dummy: event 10	-0.000	0.026	-0.01	0.994	-0.051	0.051
Dummy: event 11	0.053	0.036	1.46	0.144	-0.018	0.123
Dummy: event 12	-0.150	0.016	-9.14	0.000***	-0.182	-0.118
Dummy: event 13	-0.033	0.033	-0.99	0.324	-0.098	0.032
Dummy: event 14	0.025	0.040	0.61	0.544	-0.055	0.104

Fixed effects estimation

Statistics robust to heteroskedasticity and time clustering and kernel-robust to common correlated disturbances (Driscoll-Kraay). Kernel=Bartlett; bandwidth=242 days

Table 8
Panel regression results: grouped events

Events group A: events expected to increase credit when monetary policy stance was contractionist
Events group B: events expected to increase credit when monetary policy stance was expansionist

Number of obs = 68722
Number of groups: 138
F(13,1018)=1748.76
Prob>F = 0.0000
Total (centered) SS = 18196.84949 Centered R2 = 0.7236
Total (uncentered) SS = 18196.84949 Uncentered R2 = 0.7236
Residual SS = 5030.205607 Root MSE = 0.2708

Forecast gap	Robust Coef.	Std. Err.	z	P>z		[95% Conf Interval]	
Forecast gap (-20)	0.657	0.012	53.140	0.000	***	0.633	0.681
Median gap (-20)	0.105	0.081	1.30	0.192		-0.053	0.263
Panel std (-5)	0.433	0.243	1.78	0.074	*	-0.043	0.910
Δ FX (-5)	0.503	0.211	2.39	0.017	**	0.090	0.916
$\Delta \Pi$ (-5)	0.876	0.120	7.30	0.000	***	0.641	1.112
Δ Embi (-5)	0.097	0.129	0.76	0.450		-0.155	0.350
Δ R (-5)	0.656	0.437	1.50	0.134		-0.201	1.513
Dummy: Copom week	-0.003	0.018	-0.15	0.877		-0.037	0.032
Dummy: Median above target	0.252	0.080	3.17	0.002	***	0.096	0.409
Dummy: events group A	0.121	0.054	2.22	0.026	**	0.014	0.227
Dummy: events group B	0.015	0.036	0.41	0.683		-0.055	0.084
Dummy: event 7	-0.041	0.047	-0.87	0.382		-0.132	0.051
Dummy: event 8	-0.251	0.038	-6.63	0.000	***	-0.326	-0.177

Fixed effects estimation
Statistics robust to heteroskedasticity and time clustering and kernel-robust to common correlated disturbances (Driscoll-Kraay). Kernel=Bartlett; bandwidth=242 days