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Three Essays on Macroprudential Policy

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A thesis submitted to the Universidade Federal do Rio de Janeiro in fulfillment of the requirements for the degree of Doctor of Philosophy in Economics

Universidade Federal do Rio de Janeiro – UFRJ

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This thesis is dedicated to my beloved family,
especially my husband, my mother and my late father, for their sacrifices and support of my education.

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"But the wisdom that comes from heaven
is first of all pure; then peace-loving,
considerate, submissive, full of mercy
and good fruit, impartial and sincere."
(Holy Bible, James 3, 17)

Abstract

The economics literature related to the financial system seeks to define the concepts of financial stability, systemic risk and macroprudential instruments for the purpose of drafting a policy that essentially "leans against the wind", that is, a policy that monitors macroeconomic vulnerabilities and combats system instability. Such a policy should cover all financial institutions involved in credit intermediation (not just banks), consider the pro-cyclical and intrinsic nature of risk in the financial system, and account for the spillovers effects of policies in other countries, that is, the global context. This thesis propose three essays concerning macroprudential policy: The first summarizes the main concepts related to macroprudential policy discussed in the economics literature after the 2008 financial crisis. In addition, we describe macroprudential policy in the context of the Brazilian financial system, specifically major policies implemented in the banking regulatory environment related to Basel III and non-bank regulations related to shadow banks. The second essay analyzes the macroprudential policies implemented in Brazil from 2007-2015, providing a descriptive analysis and econometric models of the available data series. Finally, the third essay proposes a theoretical macroeconomic model including a reserve requirement (RR) as a macroprudential instrument. The dynamic stochastic disequilibrium (DSDE) model includes intertemporal optimization and the rational expectations of agents in the economy with Keynesian features, such as demand-driven adjustment, precautionary saving motive and non-accommodating collective wage bargaining. Macroprudential policy depends on a combination of factors, financial firm types, financial system structures, and inter-connectivity with itself, with the real economy and with other countries. This type of policy monitors macroeconomic instability and demonstrates effects on the real economy given the transmission of RRs in the DSDE model. However, the instruments are not used exclusively macroeconomically; many of them are carried out microeconomically and/or at a point in time and effectively depend on the instrument type and risk targeting.

Keywords: Macroprudential. Systemic Risk. Financial Stability.

Resumo

A literatura econômica relacionada com sistema financeiro procura definir conceitos de estabilidade financeira, risco sistêmico e instrumentos macroprudenciais com o propósito de desenhar uma política essencialmente "lean against the wind", ou seja, uma política que monitora as vulnerabilidades econômicas e combate instabilidade do sistema. Esta deve cobrir todas as instituições financeiras envolvidas na intermediação do crédito (não só bancos), considerar a pró-ciclicalidade e a natureza intrínseca do risco no sistema financeiro, e ainda, efeitos transbordamentos de políticas em outros países, sobretudo, contexto global. A tese propõe três ensaios concernentes a política macroprudencial: o primeiro resume os principais conceitos relacionados a política macroprudencial discutidas na literatura econômica pós-crise de 2008. Além disso, a política macroprudencial é detalhada no contexto do sistema financeiro brasileiro, mais especificamente, aponta as principais políticas implementadas e ambiente regulatório bancário relacionado com Basiléia III e regulatório não-bancário relacionado com os shadow banks. O segundo ensaio estuda as políticas macroprudenciais implementadas no Brasil entre 2007-2015 com uma análise descritiva e um modelo econométrico das séries de dados disponíveis. Por último, o terceiro ensaio propõe um modelo teórico macroeconômico que inclui o depósito compulsório como um instrumento macroprudencial. O modelo de Desequilíbrio Estocástico Dinâmico (DSDE) inclui a otimização intertemporal e as expectativas racionais dos agentes na economia com características keynesianas como ajuste impulsionado pela demanda, motivo de poupança precaucional e negociação coletiva salarial não-acomodatória. A política macroprudencial depende da combinação de vários fatores, tipos de firmas financeiras, estrutura do sistema financeiro e inter-conectividade dentro dela mesmo, com a real economia e com outros países. Este tipo de política monitora instabilidades macroeconômicas e demonstram efeitos pela economia real, dado a transmissão do depósito compulsório no modelo DSDE. Todavia, os instrumentos não são utilizados somente de forma macro, muitos realizados micro-economicamente, ou pontualmente no tempo e depende efetivamente do cada tipo de instrumento e do direcionamento do risco.

Palavras-chave: Macroprudêncial. Risco Sistêmico. Estabilidade Financeira.

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List of abbreviations and acronyms

ABCP	Asset-Backed Commercial Paper
ADL	Autoregressive Distributed Lag
BCB	Brazilian Central Bank
AIC	Akaike Information Criterion
AP	Advanced Payments
CCA	Contingency Claims Analysis
CCP	Central Counterparty Clearing
CDS	Credit Default Swaps
CMN	National Monetary Council
COMEF	Financial Stability Committee
CR	Capital Requirement
DL	Distributed Lag
DSDE	Dynamic Stochastic Disequilibrium
DSGE	Dynamic Stochastic General Equilibrium
FSB	Financial Stability Board
FIDC	Direct Credit Investment Funds
ILE	Structural Liquidity Ratio
IOF	Financial Operations Tax
IPCA	Consumer Price Index
IRFs	Impulse-Response Functions
GDP	Gross Domestic Product
GLS	Generalized Least Squares
GMM	Generalized Method of Moments

LCR	Liquidity Coverage Ratio
LTI	Loan to Income
LTV	Loan to Value
OFC	Other Financial Corporations
OTC	Over the Counter
RWF	Risk Weighting Factor
RR	Reserve Requirement
RP	Repurchase Agreement
US	United States
VaR	Value at Risk
VAR	Vector Autoregression
VIX	Volatility Index

Contents

Introduction

The term "macroprudential" resurfaced[1] after the global financial crisis, when international organizations and academics moved to debate these issues and rectify the instability of the entire financial system, especially because this situation occurred in the context of price stability.

This thesis reviews this concept in order to present a selective summary of conceptual and empirical developments. First, it summarizes the concept of macroprudential policy in recent academic discussions on this subject. Second, it focuses on the Brazilian context and on the more intense recent adoption of macroprudential policy. Finally, it returns to the theoretical field by developing a macroeconomic model in order to investigate the effects of this type of policy on individuals in the context of general equilibrium in the economy.

The first chapter considers the following main questions: What is macroprudential policy? What are its goals and instruments? What are the main focuses of the analysis? What is the Brazilian context of macroprudential policy? The chapter summarizes the academic debate about this concept and notes the main Brazilian policies implemented from 2007 to 2015 in banking regulation related to Basel III and non-banking regulations associated with shadow banks.

The objective of the second chapter is to identify the effects of macroprudential policies implemented in Brazil from 2007 to 2015. A descriptive analysis is conducted based on the available data series and econometric models. The idea is to select some variables that may represent some facets of the stability of the financial system and demonstrate some situations of systemic risk in a macroeconomic approach. Four variables are selected (credit growth, leverage, liquidity and capital flows) as dependent variables in the econometric analysis of the effects of macroprudential policies. Distributed lag (DL), autoregressive distributed lag (ADL) and vector autoregression (VAR) estimations are performed.

Finally, the main objective of the last chapter is to examine the effects of macroprudential policy in the context of a theoretical model, in particular, a dynamic stochastic disequilibrium (DSDE) model. The DSDE model is a dynamic and stochastic general equilibrium model with intertemporal optimization of the agents in the economy, which is similar to dynamic stochastic general equilibrium (DSGE) models. The economic models are populated by households (active and inactive). The active households face the risk of dropping out of the labor force (i.e., risk permanent income loss), losing labor and

[1] Discussion in Clement (2010).

profit sources of income and becoming inactive. Once the household is inactive, it cannot reenter the labor force and thus faces a probability of death. The firm sells final consumer goods to households in a perfectly competitive market and buys differentiated goods from a continuum of intermediate firms. These intermediate firms borrow from households to finance a part of its capital stock. The central bank sets monetary policy using a Taylor rule with inflation stabilization. The model assumes that nominal wage inflation is subject to bargaining between workers and firms, that is, labor market do not clear through an accommodating nominal wage. The model is expanded in chapter 3 to include the RR directly in the budget constraint of the active households in order to include a macroprudential instrument implemented by the central bank.

Part I

Literature Review

1 Macroprudential policy debate, concepts and the Brazilian context

Introduction

The economics literature and the practices of central banks have been under discussion in order to rethink macroeconomic policy in light of a prudential approach. Given the causes and effects of the international financial crisis of 2008, it was noticed that a single monetary policy instrument, originating from the inflation targets adopted by most central banks, is unable to ensure the stability of the entire financial system.

The current debate in economic theory is over the inclusion of prudential policies in the macroeconomic framework. The literature has not produced consensus regarding definitions and macroprudential objectives or even regarding an exact list of which types of instruments are more effective for systemic risk management. Few studies have documented the effectiveness of macroprudential instruments, and their relationship with systemic risk reduction is still unclear. Lack of data is also a problem because the implementation of these policies is very recent, and only a few countries, including Brazil, have used instruments in addition to monetary policy.

The present chapter summarizes the context of and debate in the economic literature regarding macroprudential policy. The aim is to show the main definitions of prudential policy in the context of macroeconomic management, including attempting to provide strict definitions of systemic risk, financial stability, and macroprudential instruments. It also highlights some issues that should be considered in the implementation of macroprudential policy, such as the pro-cyclical and systemic nature of risk, global risks channels and coverage of policies that regulate the shadow banking system. How is Brazil included in debates over those concepts? This chapter aims to analyze macroprudential policy in the Brazilian context and outlines the main policies implemented, the banking regulations associated with Basel III and non-bank regulations related to shadow banks.

The chapter is organized as follows. The first part summarizes the economic consensus that existed around financial stability policy before the 2008 global financial crisis. The second section summarizes the main concepts, objectives and instruments of macroprudential policy and provides some important considerations. Section three describes some characteristics of the Brazilian financial system. The first subsection describes the macroprudential policies implemented in 2007-2015, the implementation of Basel III in the Brazilian scene and some of its criticisms, and finally, the shadow banking system. Final considerations are also presented.

1.1 Macroeconomic framework - traditional theory

In 1999, academics and practitioners in central banks had reached consensus about the core of macroeconomic theory and, in particular, monetary policy. This was not a general consensus but various elements were well accepted by many academic economists and central bankers, which allowed convergence and greater interaction between economic theory and practical application (GOODFRIEND, 2007).

Money neutrality holds that, in the long run, the trade-off between permanent inflation and unemployment is non-existent among the elements that guide the core of macroeconomic theory. However, in the short term, a trade-off exists, which is caused mainly by the temporary rigidity of prices and nominal wages. In the case of monetary policy, the priority was the pursuit of price stability (low and credible inflation) using a core inflation target supported by transparency about the policy objectives and procedures of its main (and unique) tool: the interest rate (GOODFRIEND, 2007).

Blanchard, Dell'Ariccia and Mauro (2010) note that within this theoretical framework, financial regulation was framed in the microeconomic context of the financial system. These authors also cite implications of the Great Moderation[1] period, noting that declines in the volatility of output and inflation may have been influenced by monetary policy, but it is unclear whether this result stems from luck, small shocks, structural changes or even improved policies.

Thus, price stability is a separate policy goal from financial stability (Tinbergen Proposition)[2], and the latter was achieved by microprudential regulation and supervision (EICHENGREEN et al., 2011). From the macro perspective, price stability policy is sufficient to influence short-term expected interest rates given the arbitrage mechanism in which interest rates would correspond to the expectation of the long-term interest rate plus a risk premium. Therefore, asset prices are in accordance with the fundamentals (BASTO, 2013).

Bean et al. (2010) add that monetary policy plays a primary role in controlling aggregate demand, altering the interest rate of an independent central bank in order to modify long-term interest rates, asset prices and inflation expectations. Intermediate monetary targets were no longer used, as authors believed in the efficiency of markets in the innovation, distribution and pricing of risks; moreover, systemic financial crises "were seen only in history books and emerging markets" (BEAN et al., 2010, p.2). Thus, an understanding of financial crises was generated by a combination of academic theory and

[1] The Great Moderation refers to the period between the mid-1980s and the mid-2000s during which there was a reduction in the volatility of business cycle fluctuations. The term was first used in Stock, James; Mark Watson (2002). "Has the business cycle changed and why?" NBER Macroeconomics Annual.

[2] The Tinbergen proposition is that if there are n goals in an economic policy problem, then n linearly independent tools are needed to solve the problem.

supported by empirical facts (the Great Moderation). This combination contributed to the inadequate regulation of financial markets, lack of prevention measures and methods of crisis management, especially in the international sphere; thus, few economists were able to foresee the 2008 global financial crisis (G30, 2015).

1.2 Financial stability: is the introduction of macroprudential policy necessary?

The 2008 financial crisis showed that financial system instability can have extreme consequences, especially for the real economy. The deviation of asset prices, even in a scenario with price stability, and dissemination of instability throughout the entire economy revealed a problem inherent in the financial system: systemic risk. This episode highlighted that macroeconomic aspects must be taken into consideration by financial authorities to contain financial crises. The crisis provoked internal critiques within mainstream economic theory, since the majority of macroeconomic models did not include the financial system, the credit creation of money, or their relationships with the real economy. The belief that prudential regulation solely focused on individual banks would be able to ensure the robustness of the financial system as a whole has been questioned in discussions of macroprudential policy. Moreover, the fallacy of composition argument that solely microprudential measures do not ensure the stability of the financial system and do not avoid the growth of systemic risk among financial institutions and in the real economy (GOODHART, 2010).

Due to this episode, central banks and economists have endeavored to develop an approach that effectively includes the issue of financial stability. The main idea is to monitor possible threats and their relationships with other macroeconomic policies. The debate is recent and has produced neither consensus on the inclusion of financial stability policy in the current model nor agreement on the most appropriate way to ensure system stability. ENGLAND (2009) suggests that the main goal should be stability in the provision of financial intermediation services for the entire system and the real economy. In other words, the goal should be to provide an efficient payment system that ensures credit intermediation, insures against market agent risk, and ensures the resilience of the financial system over time (over upswings and downswings of the economic cycle). Borio and Drehmann (2009) emphasize the financial system as a whole (rather than individual institutions) as the focus of macroprudential policy; they define financial stability as the opposite of financial instability and explain that shocks associated with a set of system conditions could cause financial crises[3].

[3] Financial crises, according to the authors, are the material failure or fundamental losses incurred by any financial institution that transmits its effects to the real economy (BORIO; DREHMANN, 2009).

Therefore, the economic literature approached prudential policy in the macroeconomic sense with a sense of urgency, setting targets, objectives and instruments to support the financial stability of the economy as a whole in order to prevent financial crises instead of adopting exclusively microprudential policies for individual financial institutions (BLANCHARD; DELL'ARICCIA; MAURO, 2010; EICHENGREEN et al., 2011; BEAN et al., 2010; BORIO; DREHMANN, 2009). Macroprudential policy has multiple dimensions based on its objectives and operation in the financial system, since the scope of activities is extremely broad and takes into account various aspects, including the determination of its tools.

This new perspective faces some challenges. What are its main objectives? How should system stability be measure and evaluated? What tools should be used? Would the regulator be the central bank or a set of institutions? Can a single tool accomplish prudential goals, as when the monetary policy of the "New Consensus" was adopted? The following subsections gather the ideas of economists, international groups and central banks and focus on defining and outlining the macroprudential framework.

1.2.1 Objectives of macroprudential policy

The term "macroprudential", as used by Clement (2010), appeared in the mid-1970s in the unpublished documents of the Cooke Committee[4]. The term was used to relate systemic supervision to macroeconomics, and its use became more common after the 2008 financial crisis, especially in the economic literature related to monetary policy and financial stability. The academic literature generally highlights the pursuit of financial stability as the overall objective of macroprudential policy. However, a consensus definition of financial stability has not yet been formed in the literature.

Galati and Moessner (2013) distinguish between two approaches in the literature: the first specifies a robust financial system to external shocks; the second, a financial system resilient to shocks that originate within the system itself (endogenous shocks). The latter approach stresses the endogenous nature of financial crises. Macroprudential policy seeks to strengthen the financial system against shocks, to reduce pro-cyclicality and the magnitude of financial failure (CGFS, 2010; FSB, 2011) and to ensure the financial system's contribution to economic growth (COLLIN et al., 2014). Financial stability is often synonymous with mitigating asset price/credit/leverage boom and bust cycles (CANUTO; CAVALLARI, 2013; GOODHART, 2010) and reducing the fragility of bank liabilities (SHIN, 2013) such that macroprudential policy seeks to reduce the probability of financial crises and their impacts (VINALS et al., 2011; G30, 2015) by placing the credit supply on a sustainable path (WEF, 2015) and limiting the macroeconomic costs (GALATI; MOESSNER, 2014).

4 Formed to address banking supervision prior to the formation of the Basel Committee.

According to some authors (SILVA; SALES; GAGLIANONE, 2013; BORIO; DREHMANN, 2009; VINALS et al., 2011), stability means a financial system that is resilient to normal shocks and that can return to and perform its standard functions (e.g., intermediation, saving allocation, maturity transformation) within a particular time interval. Borio (2011) emphasizes the endogenous character of shocks and the macroeconomic causes of financial instability that is closely connected to business cycle fluctuations. The author claims that "the boom does not just *precede*, but *causes* the bust. Financial instability is a symptom of deep-seated forces that drive the economy *at all times*, although financial distress emerges only infrequently" (p. 22, author's emphasis).

The endogeneity arises from the credit mechanism and its generation of purchasing power, as well as from cross-sectional and intertemporal coordination failures[5]. According to Borio (2011), the focus of macroeconomic models should shift away from the equilibrium point and representative agent toward more classic and detailed analyses of credit risk and disequilibrium models incorporating the expansion and contraction of credit and monetary factors.[6]. Claessens, Ghosh and Mihet (2013) mention the growing recognition in the literature of the endogenous character of the financial cycle. The authors indicate that the collective cognition of market participants, which is amplified by experience-based expectations (waves of optimism and exuberance), and the divergence of expectations eventually creates greater risk aversion and mood swings, starting a downturn in the financial cycle.

Furthermore, Carvalho (2009), Goudard and Terra (2015), Prates and Cunha (2012) rely on the financial instability hypothesis of Minsky and the psychological effect of Keynes' agents to explain the endogenous nature of financial instability. The state of confidence and optimism of expectations about the future lead agents to take riskier leveraged positions with a reduction of precautionary margins, so a once-robust financial system becomes fragile "because even a small disappointment, like a small rise in interest rates or the deceleration of the growth in the supply of credit, or a disappointment in profit expectations can lead to a massive de-leveraging process" Carvalho (2009, p. 15).

The general view is the prevention and mitigation of systemic risk (sometimes referred to as financial vulnerability)[7] as a specific objective of macroprudential policy

[5] He suggests that those who want work with microfoundations models should relax the omniscient representative agent assumption and include financial distress with credit risk and many forms of default, for instance, based on different opinions, imperfect knowledge, heuristic expectation formation, and financial deviations from historical standards.

[6] The author mentions Wicksell, K (1898): Geldzins und Guterpreise. Eine Untersuchung uber die den Tauschwert des Geldes bestimmenden Ursachen. Jena. Gustav Fischer (tr., 1936. Interest and prices: A study of the causes regulating the value of money, London: Macmillan); Fisher, I (1932): Booms and depressions, New York: Adelphi Co.; Mises, L von (1912): The theory of money and credit, Foundation for Economic Education 1971, reprint, New York; and Hayek, F (1933): Monetary theory and the trade cycle, Cliffon, New Jersey: Augusts M Kelly reprint 1966.

[7] The next subsection defines systemic risk based on a recent debate in the literature.

(GALATI; MOESSNER, 2013; BASTO, 2013; PRATES; CUNHA, 2012; CGFS, 2010; LIM et al., 2011; FSB, 2011; ENGLAND, 2009; COLLIN et al., 2014; SHIN, 2013; BORIO, 2011). It should be emphasized that the scope of the policy operationalization is the reduction of risk in the financial system as a whole and its integration with the real economy, with a focus on the economic cycle (evolution over time) and the cross-sectional dimension (problems between institutions). For instance, the policy framework must prevent excessive credit growth in a country and identify joint exposures and risk concentrations among certain financial institutions that can eventually lead to contagion to other institutions and to the real economy.

Borio (2011) argues that there is a problem with defining the concept of macroprudential policy as one that seeks to reduce systemic risks or to achieve financial system stability: this interpretation may be very broad. Any policy, including fiscal and monetary policy, can substantially influence the financial system. A clearer definition should consider aspects such as establishing a successful criterion for policy, choosing instruments aimed at systemic risk, and balancing between aggregate and sectoral approaches and between rules and discretion.

Therefore, macroprudential policy should limit the build up of financial fragility and improve the resilience of the financial system, generating a system that is robust to adverse shocks and reducing the amplitude of the financial system cycle. Macroprudential policy tends to be forward-looking with a horizon that is longer than that of monetary policy because risk tends to take time to build up (CGFS, 2010). This treatment of risk underscores a policy of leaning against the wind that tries to identify the imperfections and conditions of the financial system, leading the financial authority to evaluate the present in order to predict its consequences in the future. Additionally, the financial authority seeks to prevent these vulnerabilities from being forwarded and amplified throughout the economy as a whole. This macroeconomic framework supposes financial authorities and policy makers that are active supervisors of the financial system such that macroprudential policy acts beyond the previous idea of cleaning up after financial bubbles.[8]

1.2.2 Systemic risk

Almost all authors have reoriented macroprudential policy toward reducing systemic risk, but how do they define it? In the recent literature, the definition stands as "a risk of disruption to financial services that is caused by an impairment of all or parts of the financial system and has the potential to have serious negative consequences for the real

[8] Before the 2008 financial crisis, there was a debate in the monetary policy literature between leaning against asset-price bubbles ("lean") and cleaning up after a bubble ("clean"). The latter, also referred to as the Greenspan doctrine, was well accepted among mainstream economists who argued that it is difficult to identify financial bubbles and that raising interest rates may be ineffective, affect only a fraction of assets, and cause bubbles to burst more severely.

economy" (CGFS, 2010, p.2).[9]

The measurement of systemic risk is based on indicators that can reveal problems and disturbances in the financial services that compromise the aggregate financial system. Therefore, these measures need to identify broad financial system aspects, such as financial institution leverage, currency and maturity mismatches, interconnectivity measures, excessive credit growth and aggregate evolution of asset prices. The policy focus is to reduce the amplitude of the financial cycle associated with systemic risk (CANUTO; CAVALLARI, 2013).

There are two dimensions of systemic risk in the macroprudential approach: the evolution of risk over time (time dimension) and at a given point in time, which is structural and transverse (cross-sectional dimension). The first reflects the pro-cyclicality of the financial system as a source of stress (often associated with credit/asset price/leverage boom and bust cycles); the second, the risk factors associated with interconnections and joint exposure of the individual financial institutions and markets (with respect to the cross-sectional treatment of risk) (GALATI; MOESSNER, 2014; GALATI; MOESSNER, 2013; FSB, 2011; BORIO, 2011; CANUTO; CAVALLARI, 2013). Silva, Sales and Gaglianone (2013) emphasize that systemic risk must be captured by the probability of disruption in financial services given the dimensions of risk (changes over time and between institutions).

The economics literature has not reached consensus on which indicators should be used, but it is converging on a set of measures that provide an information base for policy actions (quantitative and qualitative analysis). Vinals et al. (2011) systematize a list of indicators separated by the two dimensions of systemic risk. The time dimension measures are (a) credit for GDP[10], (b) macroeconomic aggregates and their predictions, (c) fundamental analyses[11], (d) asset prices (especially for houses, properties and equities), (e) value-at-risk models (VaR), and (f) macroeconomic stress tests.

In the cross-sectional dimension, the measures include the size and concentration of financial institutions as a percentage of the market or GDP (includes analyses of assets, equity, credit, and deposits); verification of joint exposure in the balance sheets of financial institutions, such as capital and liquidity positions; default probability measures of a group of financial institutions based on dependency indicators such as stock prices and credit default swaps (CDS); and contingency claims analysis (CCA), a measure of the risk-adjusted balance sheets of financial institutions that quantifies the contribution of a specific institution to systemic risk. As cross-sectional systemic risk includes a multiplicity of factors, an indicator base and standard methodology does not yet exist.[12]

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9 Referenced in this manner in G30 (2015), FSB (2011).

10 Used as the main indicator of the stage of the financial cycle (SHIN, 2013; CGFS, 2010; VINALS et al., 2011). Some studies have already signaled its effectiveness (DREHMANN et al., 2010; GONZALEZ et al., 2015).

11 Indicators of bank balance sheet liabilities (funding) related to the financial cycle. See Shin (2013).

12 The effectiveness of each indicator has been built, measured, and analyzed by central banks and

1.2.3 Instruments

Scholars categorize the instruments in various ways. For example, Lim et al. (2011) split them into credit, liquidity and capital, whereas Collin et al. (2014) divides them into equity-based, liquidity-based and lending limits. CGFS (2010) divide the instruments by vulnerability: leverage, liquidity and interconnectivity. All authors recognize the difficulty of finding an instrument that addresses prudential objectives for the entire financial system, so they realize that multiple aspects must be considered in prudential policy, each with a proper tool.

Table 1 lists macroprudential tools based on the classification of Galati and Moessner (2014)[13]. The authors identify three intermediate goals: credit booms/leverage/asset prices; risk and market liquidity; and interconnectivity/market structure/financial infrastructure. The first two essentially manage the time dimension risk; the third, cross-sectional dimension.

Shin (2013) distinguishes between two types of banks liabilities on balance sheets: core and non-core. Galati and Moessner (2014) adopts this terminology in an instrument related to liquidity risk/market. A core liability refers to bank funding provided by domestic non-bank creditors, i.e., through retail deposits from households (which are typically more stable), and non-core liabilities are related to obligations to other banks and foreign creditors. These categories will depend on the degree of openness and the financial development of the country. In countries with less advanced financial systems that are more closed to the global system, non-core liabilities are concentrated in the domestic deposits (term) of non-financial firms (which are financed in the capital market by issuing bonds and depositing their funds into banks). In an open financial system, Shin (2013) notes that international capital flows directed to the financial system are a source of funding for firms and financial institutions that may increase their balance sheet liabilities in terms of international currency, which increases the vulnerability of the financial system somewhat. The next section takes up topics such as financial cycles, shadows banks and the risk channel of capital flows.

The matter of international capital flows in macroprudential policy is closely related to capital controls, which have been recently referred to (in a more impartial form) by Vinals et al. (2011) as capital flow management. Shin (2013) identifies three types of instruments: the prudential use of indicators with a domestic focus, such as the LTV, DTI and other ratios; the currency-based use of indicators born of global liquidity concerns,

international agencies. An example is the bank stability index (VINALS et al., 2011) or the financial stress index that includes five indicators (CANUTO; CAVALLARI, 2013). A greater challenge is building an indicator that captures liquidity risk.

[13] The authors provide an alternative taxonomy of macroprudential instruments with a focus on market failure. They distinguish among three types of risk externalities: strategic complementarities, fire sales and interconnectivity.

Table 1 – Macroprudential instruments for intermediate objectives

Credit booms/leverage/asset prices	**Liquidity risk/market[a]**	**Interconnectivity/market structure/financial infrastructure**
Countercyclical capital buffers	Time-varying systemic liquidity surcharges	Higher capital charges for trades not cleared through CCPs
Through-the-cycle valuation of margins or haircuts for collateral used in securitized funding markets (repo)	Levies on non-core liabilities	Systemic capital surcharges
Countercyclical changes in risk weights for exposure to certain sectors	Time-varying limits in currency mismatch or exposure (e.g., real estate)	Systemic liquidity surcharges
Time-varying loan-to-value (LTV) ratio, debt-to-income (DTI) and loan-to-income (LTI) ratio caps	Time-varying limits on loan-to-deposit ratios	Power to break up financial firms based on systemic risk concerns
Dynamic provisioning and time-varying caps and limits on credit or credit growth	Stressed VaR to build additional capital buffer against market risk during a boom	Deposit insurance risk premia sensitive to systemic risk
Rescaling risk-weights by incorporating recessionary conditions into the probability of default assumptions		Restrictions on permissible activities (e.g., bans on proprietary trading for systemically important banks)

Source: Galati and Moessner (2014)
[a] Only two instruments are related to the cross-sectional dimension in this objective: Capital charges on derivative payables and levies on non-core liabilities.

such as limits on mismatching currency (the constraints of macroprudential tools are based on the distinctions between currencies); and the use of traditional capital controls that impose restrictions based on the investor's country of residence. According to the author, capital controls have two objectives: avoiding the appreciation of the exchange rate and achieving financial stability.

In the context of the non-banking financial sector, ESRB (2017) suggest the macroprudential use of margins and haircuts in securities financing transactions given the collateral requirements of those transactions. The report focuses on the procyclicality of collateral requirements and market failure, as margin and haircut practices may exacerbate systemic risk and contribute to the accumulation of excessive leverage (deleveraging) during upswings (downswings) in the financial system[14]. Some tools are thought to

[14] For instance, during upswings, increases in asset prices increase the values of securities that have been provided as collateral, leading to lower collateral requirements for securities for a given exposure

address this problem: fixed numerical floors and/or time-varying floors on initial margins and haircuts; margin add-ons (extra margins used in a time-varying manner); collateral pool buffers (authorities may require to deposit an amount of collateral); margin and haircut ceilings; and others. Regulatory arbitrage, modification of relative costs of central cleared transactions (CCT) compared to over-the-counter (OTC), and overlaps with others regulatory tools may be some practical challenges for the tools implementation. Numerical haircut floor framework of Financial Stability Board (FSB) are due to be implemented in 2018.

1.2.4 Some features of macroprudential policy

The matters of financial stability and the prevention of crises have long been discussed in the economics literature, and central banks usually were established to fulfill this function (GOODHART, 2010). The 2008 financial crisis influenced the direction of the debate over more active macroeconomic policy for the financial system as a whole, which was proposed in the prudential sense and as a complement to monetary policy. Therefore, this section examines some important perspectives on this issue should be taken into account in policy.

Macroprudential policy involves two different aspects: financial instability prevention policy during normals times and management and resolution during crises. The latter uses different types of macroprudential actions than are listed in Table 1 (where the main focus is the *prevention* of vulnerabilities). Following a burst bubble (e.g., deleveraging of agents and institutions, asset deflation, debt accumulation), central banks coordinated with governments and played a crucial role in resolving crises by taking measures such as providing liquidity support to banks, balance sheet restructuring, recapitalization of the financial sector, and conventional and unconventional monetary policy implementation (quantitative easing and forward guidance) (GOODHART, 2010; G30, 2015).

In this latter respect, it is important to stress the central role of the monetary authority's leadership in pursuing macroprudential stability given its role in liquidity generation, control of the main instruments, operation of the open market and providing

and, thus, the build-up of leverage.

> automatic valuation effects may be compounded by the characteristics of the risk-based models used by central counterparties and by participants in bilateral markets. These models generally link the calculation of margins and haircuts to price volatility, which means that margin and haircut requirements will tend to decrease when conditions in financial markets are benign, and increase when volatility rises. The procyclical aspect of margin and haircut requirements can exacerbate "leverage cycles" in which market participants use the collateral freed up by higher asset prices and lower margin and haircut requirements to increase their borrowing and contingent commitments from derivatives, thereby accumulating financial and synthetic leverage. (ESRB, 2017, p.4,5)

loans to banks (lender of last resort), especially in financial crises. However, the central bank should not be the only active agent of macroprudential policy. In the event of a crisis, when liquidity is not sufficient to eliminate the problem, capital support for financial institutions may be required; thus, the government treasury fulfills this function (GOODHART, 2010).

Several elements of institutional arrangements and policies dedicated to a macroprudential policy framework are being adopted in various economies. IMF-FSB-BIS (2016) reinforce that this is not a "one-size-fits-all" approach. Usually, central banks play an important role[15], involving a macroprudential regulatory and supervisory authority in coordination with other relevant authorities. In addition, the ministers of finance of the UK, Poland, France, Germany and the US participate in the decision-making arrangements, or independent external experts are involved in these structures. The decision-making body must have well-defined objectives, transparency and accountability mechanisms, frequent formal meetings, and powers that ensure the ability to act within the countries.[16]

Regarding macroprudential policy during normal times, there are two views[17] in the literature, which are extremely closely related to the conduct of monetary policy. The first view proposes that macroprudential policy must be separate from monetary policy. The use of macroprudential policy is strict and only applies in a few sectors, playing a role in crisis prevention, particularly in credit-supported booms in the housing sector (G30, 2015). Various authors (G30, 2015; BEAN et al., 2015) mention that there is no consensus about the effectiveness of macroprudential measures in other sectors or in spillover effects from other countries. This interpretation derives from a "saving glut" [18] argument in which the natural real interest rate was very low for a long period before the 2008 crisis and generated financial stability. For those authors, the role of the central bank in addressing systemic risk allows for more political influence, and in this case, can jeopardize the price stability target and central bank independence. This argument is based on the separation principle of inflation and financial stability. The former should be the focus of monetary policy; the latter, of macroprudential policy. The disequilibrium notion of the business cycle is based on an inflation signal, and financial instability arises from purely financial

[15] The decision-making body is the central bank board (or governor) in Ireland and New Zealand. In Malaysia, South Africa and the United Kingdom (UK), the governor chairs the policymaking committee. Systemic risk and proposed policy actions are analyzed by the central bank in France and Germany, and in the US, the role of the central bank is to regulate and supervise systemically important financial institutions (IMF-FSB-BIS, 2016).

[16] Powers can be "hard direct" – policy makers have direct control over macroprudential tools; "semi-hard" – they can make formal recommendations to regulatory authorities; or "soft" – policy makers can warn or express opinions about financial instability (IMF-FSB-BIS, 2016).

[17] The theoretical debate over the relation between macroprudential policy and monetary policy is still in its infancy among economists. This section provides only limited guidance on the main differing assumptions.

[18] This term was coined by Ben Bernanke to explain desired savings that exceed desired investment as the cause of low interest rates. Bernanke, B. (2005) "The Global Saving Glut and the U.S. Current Account Deficit." Sandridge Lecture, Richmond, Va., March 10.

(not real) aspects. The combination of central bank and market participants' actions determines the equilibrium or natural real interest rate, which was persistently low before the crisis:

> a world of persistently low interest rates may be more prone to generating a leveraged "reach for yield" by investors and speculative asset-price boom-busts. While prudential policies should be the first line of defence against such financial stability risks, their efficacy is by no means assured. In that case, monetary policy may need to come into play as a last line of defense. (BEAN et al., 2015, p.2)

The second view differs. The equilibrium notion (and monetary policy) has to be analyzed from a broader viewpoint and includes the financial stability perspective. Borio (2016) says that the equilibrium rate of the latter approach is narrow and suggests that output deviations from potential must be at financial cycle (not business cycle) frequencies. Based on empirical studies, he recognizes that money (monetary policy) is not neutral over policy-relevant time horizons (over the medium term and even over the long term), and it is important to distinguish supply-driven deflation (depressed prices and increased output) from demand-driven deflation (decreased prices and output). Thus, the low real interest rate before the crisis is perceived as a disequilibrium phenomenon[19] with a combination of asymmetrical monetary policy (especially in a financial bust), global disinflationary forces (due to globalization of the real economy and technological innovation) and unsustainable financial booms. This combination was caused by downward bias in interest rates and upward bias in debt, which induced a self-validating pattern of low interest rates over long horizons: "In other words, policy rates are not simply passively reflecting some deep exogenous forces; they are also helping to shape the economic environment policymakers take as given ("exogenous") when tomorrow becomes today" (BORIO, 2016, p.228).

Therefore, this approach changes the monetary policy perspective and its conduct in which the central bank should use the available tools and monetary policy to mitigate financial booms and busts. Since macroprudential and monetary policy influence credit expansion, assets prices and risk-taking, it does not make sense to separate their effects. Borio notes that the current analytical framework needs to include flexibility and adjustments in order to describe the financial cycle:

> there is a need to adjust monetary policy frameworks to take financial booms and busts systematically into account. This, in turn, would avoid that easing bias and the risk of a debt trap. Here I highlighted that it is imprudent to rely exclusively on macroprudential measures to constrain the build-up of financial imbalances. Macroprudential policy must be part of the answer, but it cannot be the whole answer. (BORIO, 2016, p.233)

[19] "Then it follows that if we think of an equilibrium rate more broadly as one consistent with sustainable good economic performance, rates cannot be at their equilibrium level if they are inconsistent with financial stability" (BORIO, 2016, p.217).

Another important perspective emphasizes the inclusion of the shadow banking system in the macroprudential policy debate. Shadow banks are entities or activities that fall outside of the traditional banking system but that participate in credit intermediation (FSB, 2015; POZSAR et al., 2010). This means that shadow banks do not have protections such as deposit insurance and liquidity lines offered by central banks to banks to protect against risks to solvency[20] and liquidity risk[21], respectively. Moreover, those entities are less regulated than traditional banking in most countries. Shadow banks contribute substantially to systemic risk based on their connections with traditional banks, and they are "structured to perform bank-like functions (e.g. maturity and liquidity transformation, and leverage)" (FSB, 2015, p.1). That is, shadow banks involve the activities and, consequently, the risks typical of banks, such as providing long-term credit to the financial system through funding and short-term leverage. Given the complexity of the system, the Financial Stability Committee (FSB, 2015) classifies the shadow banking system (strictly) by economic activity or function for more comprehensive monitoring of credit intermediation risks in the non-bank segment. These activities are related to securitization, collateral services, providing funding to banks (repo), granting loans and receiving non-bank deposits from households and entities[22].

The importance of this parallel banking system in this literature grew after the 2008 financial crisis. As these institutions played a key role in the complex transformation of credit, maturity and liquidity in the banking systems of the United States (US) and Europe, they contributed substantially to the outbreak of the crisis. Mehrling (2010) define a shadow bank as an institution that operates money market funding of capital market lending in which they face a similar liquidity risk as a banking institution because of the maturity transformation of their activities: short-term funding with long-term lending. Table 2 compares the financial instruments in the balance sheets of shadow banks compared to those of traditional banks[23]. Banks address solvency risk by managing their capital buffers and treat liquidity risk with bank reserves and/or deposit insurance and the discount window provided by the central bank. Shadow banks address solvency risk with CDS and liquidity risk through the issuance of asset-backed commercial paper (ABCP) and repurchase agreements (RPs) for the wholesale money market (securitized loans provide collateral in these operations) (MEHRLING, 2010).

The FSB uses a broader definition of the shadow banking system in which all entities outside of traditional baking performing credit intermediation and maturity/liquidity

[20] When the market value of an institution's assets falls below that of its obligations.

[21] When the institution cannot convert assets to currency to pay its obligations because its market assets are illiquid.

[22] Section 6 details these activities in describing the Brazilian shadow banking system.

[23] This representation is inspired by the operations carried out by US financial institutions before the 2008 crisis.

Table 2 – Simplified balance sheet

Traditional bank		Shadow bank	
Assets	Liabilities	Assets	Liabilities
Bank reserves	Deposits	Securitized loans	Money market funding
Loans	Capital buffers	CDS	ABCP
			RP

Source: Mehrling (2010)

transformation without a central bank backstop are included.[24,25] Despite regulation and supervision, the sector is still in the process of formulating and debating whether the monitoring of the shadow banking system, especially in the microeconomic sphere, is the prerogative of macroprudential policy, since the system is susceptible to runs, is essentially connected to the banking system and involves activities with pro-cyclical and systemic characteristics. Furthermore, the alignment of norms across countries is a challenge of great importance given that the system is global. Supervisors can also act indirectly, for example, by controlling the supply of instruments from regulated banks to the shadow bank system (providing collateral for operations) or limiting the transactions of other too-big-to-fail entities.

Macroprudential policy seeks to monitor systemic risk within the context of the economic cycle. Empirical studies (CLAESSENS; KOSE; TERRONES, 2011b; CLAESSENS; KOSE; TERRONES, 2011a) demonstrate a strong interaction between business cycles and financial cycles, where the latter are usually more persistent, deeper and shaper than the former. The business cycle is highly synchronized with the credit cycle and house prices, and yet, recessions accompanied by financial disruptions[26] tend to be more pronounced and longer. The business cycle upturns also show faster GDP growth when combined with credit booms and higher house prices. The financial cycle is characterized by financial disruptions that are longer than the boom phases; equity and house price cycles are typically longer and more intense than the credit cycle; and finally, some features change over time, such as the shortening of equity price cycles. When analyses have focused on interactions between countries, high synchronization of credit cycles and house prices are also observed and intensify over time. Moreover, compared with advanced countries, emerging countries demonstrate more pronounced business and financial cycles.

Shin (2013), Claessens, Ghosh and Mihet (2013) note the procyclicality of the financial system arising from changes in the values of assets and leverage on the balance sheets of financial institutions amplifies the business cycle. If banks manage their balance

[24] (FSB, 2015) includes money market funds in the activities and entities of the shadow banking system as they provide the banks with short-term funds and credit intermediation funding for non-bank deposits. Furthermore, these funds are susceptible to runs.

[25] The concept of liquidity transformation is similar maturity transformation (short-term funds are used to lend over a longer term): they use cash-like liabilities to purchase harder-to-sell assets (such as loans).

[26] Intense downturns in the financial cycle are compared to all the valleys of credit cycles, equity and houses prices, that is, the authors strictly define financial crisis within a financial cycle.

sheets and maintain a desirable leverage target, an increase in asset prices (any productivity shock[27] increases the value of total bank assets represented by loans and securities) causes an increase in its capital position[28], and consecutive purchases of those assets increase their share of the bank balance sheet. If all institutions face the same situation, the increase in demand for assets leads to further increases in asset prices, generating a feedback effect on asset prices and an expansion of bank balance sheets (the opposite is also true). This mechanism (an increase in asset prices), causes a credit boom in a country and leaves the financial system as a whole more leveraged and vulnerable.

Due to the expansion (reduction) of bank balance sheets during an economic upturn (downturn), Shin (2013) states that non-core liabilities (the proportion of these in relation to the balance sheet) are an important indicator of the stage of the financial cycle. During an upturn in the financial cycle, banks will expand their balance sheets through debt issuance, i.e., by raising funding with financial instruments from banks, shadow banks and foreign currency obligations. According to this author, there is an intrinsic relationship among three elements of boom phases: the elevation of asset prices (an increase in total bank assets) and, consequently, an increase in bank lending; a high proportion of non-core liabilities to total liabilities; and systemic risk arising from the increased joint exposure of intermediaries (some institutions issue and others purchase financial instruments that are characterized as non-core liabilities).

Another important intrinsic relationship exists between the exchange rate and financial stability. Avdjiev, McCauley and Shin (2015) highlight the international currency risk-taking channel in the global context and the corresponding large capital flows between countries, i.e., dollar movements disturb domestic conditions, particularly in emerging countries. Depreciation of the international currency strengthens the balance of borrowers (not only financial institutions but also corporate agents) whose assets are denominated in the domestic currency and whose liabilities are denominated in dollars, increasing their ability to pay and, in the case of banks, their ability to borrow, reinforcing the riskiest behaviors and worsening the currency mismatch on balance sheets. In contrast, appreciation of the international currency weakens the balance sheet of the borrower, reducing the quality of balance sheet liabilities denominated in US dollars.

The monitoring logic for global financial instability, according to the authors, has two aspects beyond the issue of international currency movements. Macroeconomic analyses should consider gross capital flows and take a more sectoral approach (the expense of net flows and balance of payments consolidation of a country). The first argument is

[27] By increased market value of the security or stock that reflects in bank equity, also the asset risk measure decreases or bank issuing new capital in order to buy more assets, among other factors.

[28] If the bank has a target leverage x (assets to equity) and the asset price rises, the value of equity rises by the same amount, reducing leverage. To maintain the value of x, the bank will issue more debt to buy more assets (SHIN, 2013).

based on the financial intermediation chain of the 2008 global crisis among European banks, shadow banks and US residents. European banks provided financial instruments for the US money market[29] (represented as dollar funding) and bought products from shadow banks (financial institutions that issued ABCP derived from loans to US residents). The analysis of net flows in the balance of payments does not capture the extent of the deterioration of the country financial condition with the growth of shadow banks, increased leverage in European and US financial institutions, and even a preference for riskier financial instruments. The second argument asserts that the problem of consolidated macroeconomic analysis does not reveal the differences between sectors positions, since a country may have a surplus position of foreign assets, while the corporate sector is a net debtor (relative to the rest of the world), as in the case of Korea during the 2008 crisis. The appreciation of the dollar led to the deterioration of Korean firms' positions and output growth despite a positive investment position in the balance of payments (AVDJIEV; MCCAULEY; SHIN, 2015).

1.3 Brazilian context

1.3.1 Macroprudential policy in Brazil

Particularly between 2010 and 2011, the Brazilian government and central bank took macroprudential measures in the foreign exchange and credit markets. These measures were supported by credit growth in the Brazilian market and increased capital flows due to US monetary stimulus policies. Brazilian authorities also implemented contractionary fiscal and monetary policies during this period. In 2011, the government proposed a cut in public spending (R$ 50 billion), and by the end of the year, it delivered a primary surplus of 3.1% of GDP. It also raised the benchmark interest rate by 375 basis points between 2010 and 2011 (SILVA; HARRIS et al., 2012).

Furthermore, in September 2011, the Brazilian National Monetary Council (Conselho monetário nacional - CMN), a regulatory agency, issued resolution No. 4.019 establishing standards for preventive prudential measures for financial institutions. The resolution divides the implementation of macroprudential policy by the Brazilian Central Bank (BCB) into three main parts: conditions that may lead to the adoption of prudential measures, indicators of such conditions and possible measures that can be adopted. For instance, conditions such as exposure to risks not included or inadequately considered when calculating the required reference equity, non-compliance with operational limits and deficient internal controls, among others, are listed. Moreover, the resolution listed leverage, liquidity, stress tests, and risk management structures (among others) as indicators of vulnerabilities and some macroprudential measures: reducing the degree of risk exposure,

[29] An activity that is also considered shadow banking by the FSB (2015).

compliance with more restrictive operational limits, recomposition of liquidity levels, and limitation or suspension. This resolution formalized the measures that have already been taken in previous years.

Table 3 summarizes the main measures taken in the credit market between 2008 and 2014. In 2010, the reserve requirement (RR) increased from 15% to 20% for time deposits and from 8% to 12% for additional eligibility of demand deposits and time deposits. In that same year, the government exempted financial letters of credit from the RR. In 2008, a RR was also used to inject liquidity into the banking system, so the RR for demand deposits was reduced from 45% to 42% and the additional requirement from 8% to 5%. In addition, the selective release of resources (from the RR for time deposits and additional liabilities) was another measure that applied to large banks, which should apply those resources to the acquisition of assets or deposits from small and medium-sized banks (institutions with reference equity up to seven billion reais)[30]. However, it was observed that these funds were not used by major banks. (BCB, 2012)

Table 3 – Macroprudential measures in the Brazilian credit market

Reserve requirements				
	Oct. 2008	Sep. 2009	Feb. 2010	Jun. 2010
Demand deposits	42%	-	-	42%
Time deposits	15%	13,5%	15%	20%
Additional eligibility	5%	-	8%	12%
IOF - financial operations tax - maximum				
	Apr. 2011	Dec. 2011	May. 2012	Jan. 2015
Credit operations for individuals	3%	2.5%	1.5%	3%
Capital requirements - risk weighting factor				
	Dec. 2010	Nov. 2011	Mar. 2013	Aug. 2014
Personal loan (between 24 and 60 months)	150%	[b]75% à 150%	75% à 150%	75%
Personal loan (> 60 months)	150%	300%	[c]150%	75%
Payroll-deducted loan (between 36 and 60 months)	150%	75% ou 100%	75%	75%
Payroll-deducted loan (> 60 month	150%	300%	150%	75%
Vehicles (between 24 and 60 months)	[a]150%	75% ou 100%	75%	75%
Vehicles (> 60 months)	150%	150%	150%	75%
Others consumer loans	100%	75%	75%	75%
In Dec. 2010, exemption of bank-issue debenture (letras financeiras) of reserve requirements				
In Nov. 2010, higher minimum payment of credit card of 15%				

Source: Brazilian Central Bank; (SILVA; HARRIS et al., 2012)
[a] Maturity between 24 and 36 months and LTV of 80%; maturity between 36 and 48 months and LTV of 70%; maturity between 48 and 60 months and LTV of 60%.
[b] For a maturity of less than 36 months, the risk weighting factor (RWF) is 75% or 100%; for a maturity between 36 and 60 months, the RWF is 150%.
[c] Application of an RWF of 300% to personal loans with terms of over sixty months with no specific limit on the contractual period.

The financial operations tax (IOF) on credit operations for individuals was increased in April 2011. In practice, the maximum IOF increased from 1.5% to 3%. In December 2011, the rate was reduced to 0.0068% per day, and in May 2012, it was further reduced to 0.0041%. In January 2015, the Brazilian authorities increased the IOF on loans for a non-prudential reason: the goal was to increase budget resources in the context of a fiscal deficit.

[30] In September 2009, this measure was reversed.

Another instrument in the credit measures package passed in December 2010 was the adjustment of the minimum capital requirement (CR). In practice, the minimum CR increased from 8% to 16.5% for household loans, including personal loans (over 24 months), payroll-deducted loan (over 36 months), and vehicles (financing and leasing).[31] Most of these measures were reversed at the end of 2011. However, as the measures had modest effects on long-term credit operations, the central bank raised the RWF for personal and payroll loans over sixty months to 300% and maintained an RWF of 150% for those related to vehicles (SILVA; HARRIS et al., 2012). In August 2014, the central bank reduced the RWF for loans to 75% in order to continue convergence toward the international standards set by the Basel Committee and the reversal of the macroprudential measures implemented since 2010.

The Brazilian government, jointly with the central bank, introduced macroprudential measures for the foreign exchange market to mitigate the intensity and volatility of capital flows (Table 4). In October 2010, the IOF on the portfolio investments of non-residents for fixed income increased from 2% to 6%. Additionally, to limit large, short-term and speculative capital inflows, particularly in carry trade operations[32], the IOF on margin deposits in derivative contracts, such as stocks, commodities and futures trades, increased from 0.38% to 6%. This revision of macroprudential measures began in December 2011 and was completed in June 2013.

Table 4 – Macroprudential measures for the Brazilian foreign exchange market

IOF - financial operations tax								
Portfolio	Dec.2007	Mar.2008	Oct.2008	Oct.2009	Oct.2010	Dec.2010	Dec.2011	Jun.2013
Fixed income	zero	1,5%	zero	2%	6%	6%	6%	zero
Equity	zero	zero	zero	2%	2%	2%	zero	zero
Derivative margin	zero	0,38%	0,38%	0,38%	6%	6%	6%	zero
IPO	zero	zero	zero	2%	2%	2%	zero	zero
Funds[a]	zero	1.5%	zero	2%	6%	2%	zero	zero
External credit	Dec.2007	Jan.2008	Mar.2011	Apr.2011	Mar.2012	Jun.2012	Dec.2012	Jun.2014
90 days	5%	5,38%	6%	6%	6%	6%	6%	[b]6%
360 days	zero	zero	6%	6%	6%	6%	6%	zero
720 days	zero	zero	zero	6%	6%	6%	zero	zero
1080 days	zero	zero	zero	zero	6%	zero	zero	zero
1800 days	zero	zero	zero	zero	6%	zero	zero	zero
Tax rate for external purchases on credit cards rose in Dec. 2010 to 2.38% and in Mar. 2012 to 6.38%								
Tax rate of 1% on excessive short positions in contracts for foreign exchange derivatives (Jul. 2011 to Jun. 2013)								
In Mar. 2012, advance payment for Brazilian exporters only by the current importer (period of 360 days) [c]								
In January 2011, the RR was 60% for dollar short positions								

Source: Brazilian Central Bank; (SILVA; HARRIS et al., 2012)
[a] Emerging Companies Investment Fund (FIEE) and Private Equity Funds (FIP).
[b] Decree 8,263 / 2014 reduced the IOF on foreign loans with minimum average term of 180 days.
[c] This operation has an IOF of 0%.

Preceding macroprudential policies to limit flows of speculative capital, in January 2011, the central bank instituted a RR of 60% (not remunerated) for dollar short positions in the spot forward exchange market that exceeded US$ 3 billion, that is, “Tier 1” capital.

[31] It was applied to rural credit, mortgages, credit for trucks and similar purchases.

[32] Speculative operations pressing exchange rate appreciation. "A synthetic carry trade can be performed in the derivatives market by acquiring long positions on a high yield currency (i.e., Brazilian real) and short position on a funding currency (i.e., dollars, yens, etc)" Silva, Harris et al. (2012, 28).

In July, the size limit decreased to US$ 1 billion. The Brazilian government also stipulated a tax rate of 1% on the net change in short positions for foreign exchange derivatives traded on the stock exchange (changes in the forward exchange market below US$ 10 million with a ceiling of 25% are stipulated by law) and made some changes to legislation. Only with these measures could the central bank affect carry trade operations in the derivative market because the IOF was applied to the notional value of the derivative, unlike earlier measure that only affected the value of the margin (with an IOF of 6%). In March 2011, the IOF on foreign direct loan or debt securities issued by residents with maturity of 360 days increased to 6% (in the same month, this period changed to 720 days). This IOF adjustment stretched the loan terms.

The goal of the measures implemented in the first half of 2011 was to create a disincentive for banks to take risky positions in derivative and credit markets due to abundant liquidity in the foreign exchange market. The measures were introduced in order to limit the funding of assets in dollars. For instance, in 2010, banks began the year with a net long position in the open market exchange of three billion, and by the end of the year, achieved a net short position of almost seventeen billion dollars. The Brazilian authorities took action intended to discourage currency mismatch in operations:

> banks open a short cash position when they sell foreign currency borrowed abroad resulting from drawings on external credit lines. Under those same regulations, although the operation is similar in accounting terms, when a bank contracts a direct loan or issues securities abroad (e.g. commercial paper), it opens a long position. (SILVA; HARRIS et al., 2012, p. 30)

All measures for the foreign exchange market are complementary: while the IOF on foreign loans purchased operates in the exchange rate long position, the RR operates on short positions in the spot market. The future foreign exchange market was affected by the introduction of the IOF on 1% of the increase in short operations in currency derivatives and the IOF on portfolio investments. In March 2012, to prevent arbitrage between foreign currency loans, financial transactions with advance payment (AP) from Brazilian exporters that could be made by any entity and without time limits were changed so that only the current importer can provide AP for a limited period of 360 days (this operation has a 0% IOF).

The measures for capital flows can also be defined as capital controls (based on the investor's residence) and are based primarily on the market. According to Garcia and Chamon (2013), they were effective in making financial assets more costly, reducing the incentive to pursue carry trade strategies. However, if the motivation of capital controls was to avoid currency appreciation, the measure was not efficient (with an influence of less than 5% (GARCIA; CHAMON, 2013)). In contrast, Araujo and Leão (2015) stress that capital controls had an impact on the non-financial sector, suggesting that banks passed the costs of new macroprudential measures to non-deliverable forward contracts. These operations are usually carried out by companies (importers, for example) seeking hedging instruments. Acharya et al. (2015) show that cross-country interest rate differentials create incentives of external bond insurance for non-financial corporations in Latin America. Those movements were more pronounced in the presence of capital controls such that firms maintain cash holdings to engage in carry trade activities: "The ability of capital controls to create room for autonomous monetary policy, allowing for greater independence from global financial conditions, is limited by the ability of nonfinancial corporates to issue international bonds" Acharya et al. (2015, p.41).

1.3.2 Basel III and implementation in Brazil

Given the processes that generated the 2008 crisis and its repercussions for the global financial system, the Basel Committee has corrected some regulatory shortcomings and recognized that financial institutions face liquidity risk in addition to insolvency risk, which was the exclusive focus of the Basel I and II agreements. The recognition that two types of risk lead to bank failure and cause financial instability was a breakthrough. In 2010, the Basel III agreement adjusted the minimum CR[33] of institutions by increasing the percentage of risk-weighted assets included in core capital (4.5%), Tier 1 (6%) and total capital (10.5%) and by adding two types of capital buffers, conservation (2.5%) and countercyclical (between 0% and 2.5%). The committee also established minimum leverage rates and created liquidity ratios that banks must observe.

Before the Basel III agreement, the Brazilian regulatory system had set a CR rate of 11%. In 2013, the BCB adjusted these rules in accordance with international recommendations, which are to be gradually implemented between 2013 and 2019. The CR is aligned with international standards according to the RWFs of assets and the levels and types of capital. Banks in the Brazilian financial system had high capitalization between 2006 and 2015: the Basel index[34] reached values greater than 15% in a majority of months. However, the CRs of core capital and Tier 1 capital were higher than 10% between 2013 and 2015 (BCB, 2015a).

The BCB also implemented a liquidity ratio[35] that is similar to the liquidity coverage ratio (LCR) recommended in the Basel III accord. The index for all types of banks – public, private and foreign – remained over one unit throughout the decade, except in a few months during the 2008 crisis, as shown in Figure 1. The BCB initiated the

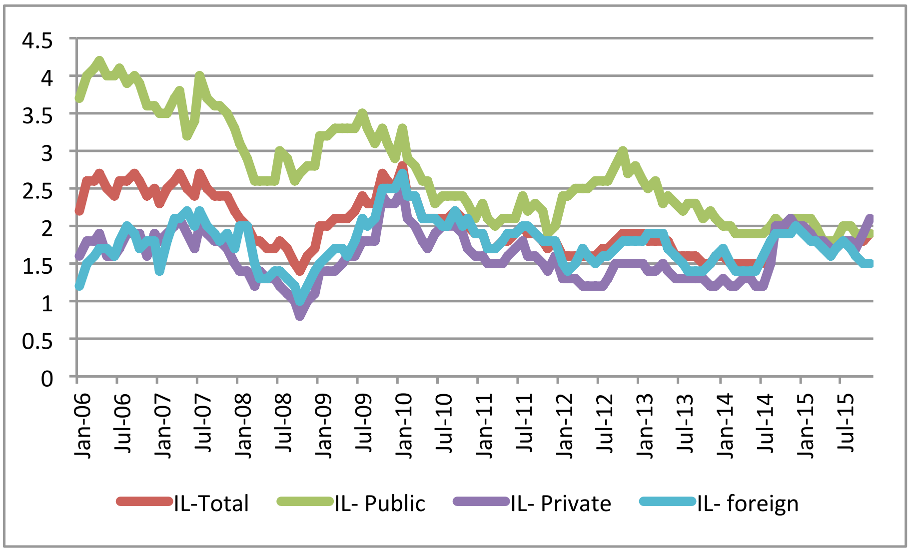
[33] To be gradually implementation between 2013 and 2019.

[34] The Basel ratio applies to consolidated banks I and II composed of multiple banks, commercial banks with and without commercial portfolios, banking conglomerates with and without commercial portfolio, investment banks and savings banks.

[35] Ratio of highly liquid assets and the stressed cash flow (expected disbursements for the subsequents 30 days in a stress scenario). Banks with total assets greater than R$ 100 billion should accomplish a liquidity index greater than 1 (100%).

calculation of structural liquidity ratio[36] (ILE) that incorporates the notion of funding liquidity risk, which checks whether banks have enough available and stable resources to finance its long-term activities (here, those over 1 year). According to BCB (2015a), the ILE decreased from 1.12 % in 2011 to 1.07 % in the first half of 2015.

Figure 1 – Brazilian liquidity index



Source: Brazilian Central Bank.
Notes: IL-Total: liquidity index for all financial institutions; IL-Public: liquidity index for government financial institutions; IL-Private: liquidity index for private financial institutions; IL-foreign: liquidity index for foreign financial institutions.

There are some criticisms related to systemic risks, macroprudential policy and Basel III. Despite concerns about the liquidity and solvency risk of financial institutions, the main focus of Basel III is still on individual institutions. There has been no effort to identify *when* the risks faced by an institution generate systemic risks for the financial system. For example, the CR focuses only on the microprudential risks of financial institutions. Furthermore, the use of risk-weighted asset factors may exacerbate systemic risk by encouraging banks to maintain the risk in their portfolios. The dynamics of the endogenous underlying risks of assets are ignored insofar as the realization of the risk of an asset class will lead all financial firms to face liquidity risk because they are exposed to the same asset class (ACHARYA, 2013).

Shin (2010) claims that the problem with seeking greater loss absorbency of bank capital through the higher CRs of the Basel III accord is that it does not necessarily contain the excessive growth of assets during phases of exuberance. It also diverts attention from dysfunctions in bank liabilities, which are subject to unstable short-term funding and short-term foreign currency debt. Hence, these measures cannot be considered macro-

[36] Ratio of available stable resources on the horizon of a year and required stable resources (total assets). Implementation is expected in 2018.

prudential. Acharya (2013) suggests more robust and countercyclical macroprudential tools: concentration limits on asset class exposure for the economy as a whole, leverage restrictions and restrictions on risk assets (LTV). The author notes, "the Basel risk-weight approach is an attempt to target relative prices for lending and investments by banks, rather than restrict quantities or assets risks directly" [p.68].

1.3.3 Macroprudential policy and shadow banks in Brazil

The BCB divides shadow banks in two types using broad and strict measures following the FSB characterization. The first concept seeks to measure financial assets focusing on non-bank entities that perform the credit intermediation[37]. The strict concept focuses on the typical activities of shadow banks held by any entity outside the traditional banking system.

Table 5 summarizes the five main economic functions. The first are the funds involved in maturity and/or leverage transformation and credit intermediation activities that are subject to runs. Financial companies (leasing companies, credit for microenterprises, real estate credit companies and real estate credit redistributors) with rates of credit to financial assets of more than 10% compose the second function of the shadow bank economy, because they do not have access to credit guarantor funds (FGC – i.e., deposits insurance) or the central bank's liquidity provision. Moreover, organizations with the third function (brokers and distributors of stocks and securities not linked to banking conglomerates) are monitored because of their engagement in short-term funding to provide financing for their customers. The fourth function includes insurance companies and the financial assets of entities that perform an insurance role parallel to a financing agreement or loan. Finally, the fifth function comprises direct credit investment funds (FIDC).

Table 5 shows the financial assets of the investment funds representing the majority of shadow banking, based on the strict estimate. In Brazil, these activities have a total value of R$ 308 billion (79.3% of the total). According to theBCB (2015b), the majority of investment funds assets (almost 60% in December 2013) are composed of government securities and RPs (guaranteed by those government securities), reducing liquidity and credit risk. Total shadow banking assets grew from R$ 338 billion in 2013 to R$ 382 billion in 2014. This value is scarcely representative compared to the total assets of the traditional banking system, since it represents only 6.6% of the total in 2014. Regarding the connection between banks and banking conglomerates and shadow banks, banks have 0.3% of their assets invested in shadow banks, while the latter invest 25.5% of their assets in the banking system. A total of 2% of bank funding comes from shadow banks, mainly represented by

[37] Investment funds, investment funds in credit rights, real estate investment funds, brokers and distributors of stocks and securities, financial companies – leasing companies, real estate credit companies and microenterprise credit companies – capitalization companies and non-bank credit card companies.

bank-issued debentures (letras financeiras) and not including (in this measure) RPs with federal securities (BCB, 2015a).

Table 5 – Economic functions of shadow banking and Brazilian estimates

Economic function	Typical activities	Assets (R$ millions)
1	Collective investment vehicles: investment funds[a]	308.772
2	Loan provision dependent on short-term funding	2.917
3	Intermediation of market activities dependent on short-term funding or on secured funding of client assets	5.697
4	Facilitation of credit creation	16.393
5	Securitization-based credit intermediation and funding of financial entities	55.350
		389.129

Source: BCB (2015a), BCB (2015b)

[a] Investment funds with leverage higher than 25% or ratio of net assets to total financial assets of less than 37% for referenced funds, 28% for fixed-income funds, and 26% for hedge funds.

In accordance with FSB (2015) estimates, the growth rate of the shadow banking system during the 2011-2014 period was 15% in Brazil. Compared to other emerging countries – Mexico (7.2%), Turkey (8.6%) and Chile (12.4%) – this percentage is high, but it is well below the growth rates of countries such as China (48.7%), Argentina (47.7%) and Russia (32%). The FSB measures the size of this system by comparing the size of banks and other financial intermediaries (OFI)[38] as a percentage of GDP (Figure 2). Note that the shadow banking systems of countries such as Argentina, Russia, Saudi Arabia, and Turkey exhibit share of GDP that are lower than 10%. In Brazil, the share is 33% of GDP. Regarding the total assets of the global system, FSB (2015) points out that the US and the UK had the first- (40%) and second-largest (29%) shares of total assets of the shadow banking system, respectively, in 2014. The Brazilian system had 1.9% of the total.

Regulatory and supervisory agencies in Brazil operate with a broad view of the financial system including shadow banking entities. Brazilian authorities include normative agencies[39] and supervisory agencies[40], and they are arranged according to the scope of their activity in the market. Coordination among the supervisory bodies is performed by Coremec (the Committee for Regulation and Supervision of Financial, Capital, Insurance, Pension Fund and Capitalization Markets), which receives information about the stability of the Brazilian financial system from Sumef (the subcommittee monitoring national financial

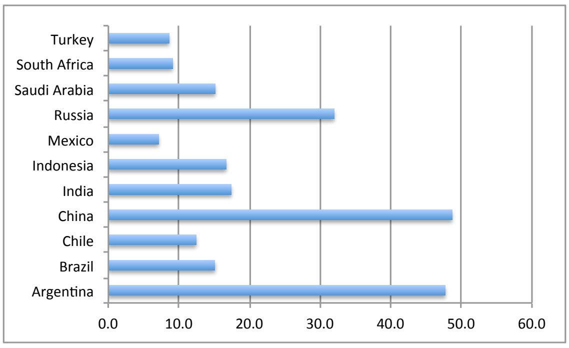
[38] Financial Intermediaries not classified as banks, insurance companies, pension funds, public financial institutions, central banks or financial auxiliaries (FSB, 2015).

[39] National Monetary Council (Conselho monetário nacional - CMN), National Council of Private Insurance (Conselho Nacional de Seguros Privados - CNSP) and National Council of Supplementary Pension (Conselho Nacional de Previdência Complementar - CNPC).

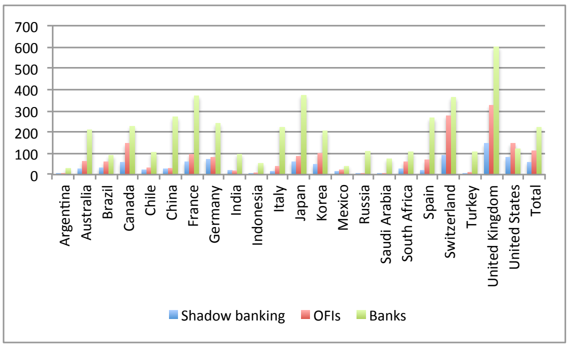
[40] BCB, Brazilian Securities Commission (Comissão de Valores Mobiliários - CVM), Superintendency of Private Insurance (Superintendência de Seguros Privados - SUSEP), and the National Superintendency of Supplementary Pension (Superintendência Nacional de Previdência Complementar - PREVIC).

Figure 2 – Shadow banks across countries

(a) Growth rate of shadow banks, 2011-2014



(b) Shadow banking, other financial intermediaries (OFI) and banks as a % of GDP



Source: FSB (2015)

system stability). The BCB also established a financial stability committee (COMEF) to act within the entity itself and to provide guidance to Coremec (BCB, 2015b).

Financial companies, brokers, and distributors are regulated and supervised similarly to the traditional banking system. Those entities must manage liquidity, structural, market, credit and operational risks, and they must submit quarterly financial reports to supervisors. They also provide prudential information on a monthly basis[41]. Depending on the relevance of their activities to the market, institutions are subject to the same minimum CRs and market, credit and operational risks. The regulation and supervision of investment funds is vast with jurisdiction over redemption policies (e.g., suspension of redemptions in extreme liquidity situations), portfolio composition (e.g., concentration limits of assets/issuers, derivatives and repos), leverage (e.g., funds cannot borrow/lend and all derivatives are registered with a clearinghouse) and risk management. Like investment funds, the FDIC is regulated and supervised by the CMN and CVM, and it should also engage in liquidity risk control (e.g., redemptions policy), perform stress testing, and report monthly (BCB, 2015b).

Conclusion

The economics literature has been converging on the implementation of macroprudential policy, seeking the stability of the financial system and, especially, the mitigation of systemic risks. The endogenous nature of risks in the financial system has gained increasing acceptance within the post-crisis mainstream literature, because of the recognition that some mechanisms within the financial system (credit creation) and financial cycle (interaction between agents) that may cause financial system instability. Therefore, macroprudential policy seeks to monitor the stability of the aggregate system through

41 Companies that provide credit to microenterprises send data in order to calculate realized capital limits, equity, debt and credit risk for the customer.

indicators that represent the evolution of systemic risk between institutions and throughout the financial cycle. This allows the specific and targeted use of macroprudential tools for each type of risk indicator in the event of growth vulnerabilities. These measures are associated with credit growth, leverage, and asset prices, taking into account liquidity and market risks, as well as connections between firms and within the market structure and financial infrastructure.

Macroprudential policy should include other financial institutions and banks, such as shadow banks, due to their connections to the banking system and participation in credit intermediation and credit, leverage, maturity and liquidity transformation and because they are sources of weakness propagation into the system. The interconnectedness of financial institutions is closely related to the expansion of their balance sheets by financial instruments transacted between themselves, to the procyclicality of the financial cycle and to their feedback effects on asset prices, credit growth and leverage. That said, macroprudential policy should follow the deterioration of risk channels indicated by systemic risk measures such as increases in non-core funding between banks, shadow banks and foreign currency obligations.

In the case of the Brazilian financial system, regulation and supervision play a broad role, including the shadow banking system. According to BCB data, this shadow system has a weak connection with the Brazilian banking system and is small relative to the financial assets of the national and global financial systems. Despite its focus on individual financial institutions, Brazilian authorities have adopted the recommendations of the Basel III accord, such as new types of and rates for CRs and liquidity ratios. In that matter, Brazilian banks have high capitalization and low liquidity risk (even before implementing these recommendations). Regarding the policies conducted in Brazil, the Brazilian government and central bank have a comprehensive set of macroprudential tools used mainly during and after the crisis of 2008. In 2010 and 2011, Brazilian authorities adopted disciplinary measures for credit growth and capital flows into the country. An important observation is that few studies have verified the effectiveness of these measures specifically as macroprudential instruments to reduce systemic risk. This topic is the subject of next chapter.

Part II

Data Analysis

2 Exploratory analysis of macroprudential policy in Brazil between 2007 and 2015

Introduction

This chapter intends to describe the macroprudential measures implemented by the Brazilian government between 2007 and 2015 and to analyze systemic risk by using some selected variables. This chapter considers four main principles of systemic risk analysis: leverage, capital flows, credit growth and liquidity indices. This concept is taken from Lim et al. (2011). The intention is to characterize the evolution of risk from 2007 to 2015 using a descriptive analysis and an econometric model. The choice of period is determined mainly by the intense use of macroprudential measures in these years and by the availability of data from the BCB, as some calculations were released recently or, as the credit data did in 2007, experienced a change of methodology. The data series allow a descriptive analysis that shows that macroprudential policy reduces systemic risk at a given point in time but does not change the series trend. This result was confirmed by the econometric analysis, which generally displays no significant models and, hence, no significant average changes in data series that represent the systemic risk of the financial system. The unique favorable result is that macroprudential instruments interact with GDP growth in the econometric model, reducing the pro-cyclicality of the credit series with GDP. However, this result must be interpreted with caution, since the previous regression does not reveal the same pattern. The contribution of this chapter to the macroprudential discussion is to detail the principal tools implemented in Brazil during 2007-2015, and it concludes, through descriptive and econometric analyses, that these policies were not effective in changing the systemic risk proxy variables.

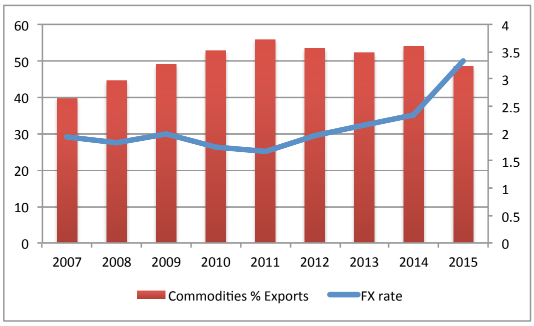
The chapter proceeds as follows. The first section provides the descriptive analysis of macroprudential policies in Brazil. Next, relevant studies that present econometrics analyses of macroprudential data are discussed. Then, an exploratory econometric analysis is performed with Brazilian data for the period from 2007 to 2015. Final considerations and some conclusions are then presented.

2.1 Brazilian macroprudential policy between 2007 and 2015

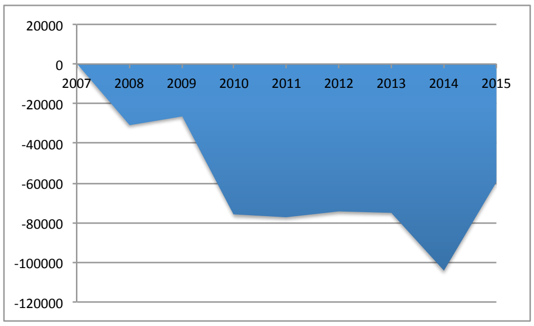
After the global financial crisis of 2008, economists and policy makers focused their attention on policies that combat imbalances in financial markets. Brazilian authorities also implemented some measures. In particular, the central bank and federal government identified potential threats to financial stability between 2009-2010 with the overheating of the economy. It is important to note that Brazil is dependent on external investment flows, since current account deficits usually occur (Figure 3b), and its main export products are commodities. Figure 3a displays an average commodity share of total exports of 50% from 2007-2015.

Figure 3 – Brazilian annual series between 2007-2015

(a) Commodity share of total exports and the FX rate



(b) Current account - net - US$ (million)



Source: Brazilian Central Bank and MDIC (Ministry of Development, Industry and Foreign Trade)
Figure 3a: Main axis: commodities as a % of exports. Secondary axis: free exchange rate (sale) period average -R$/US$ Note: main commodities exported by Brazil are cocoa, coffee, tobacco, sugar, soy, meat, aluminum ore, iron ore, orange juice and oil.

The next two subsections explain the main macroprudential policies implemented in Brazil from 2007 to 2015. The policy orientation of these measures can be divided in two markets: credit and foreign exchange. Brazilian authorities aimed to minimize the financial instability caused by the rapid grow of credit in certain sectors and massive international capital inflows into the Brazilian financial market (and the resulting spillovers to the real economy).

2.1.1 Credit market

The credit market in Brazil had a strong upward trend between mid-2000 and 2014. The average credit expansion between 2005 and 2011 was 22% p.y, and the credit-to-GDP ratio increased from 30.66% in March 2007 to 44.08% in December 2010. By 2015, the credit-to-GDP ratio had continued to grow, reaching 53.37% by June 2015 (Figure 4). Despite the intense expansion of credit in those years, the Brazilian credit-to-GDP ratio is low compared with international standards (IMF, 2013). Credit expanded especially rapidly for consumer credit and earmarked credit[1], where the latter was boosted by mortgage loans, the Brazilian Development Bank (Banco Nacional de Desenvolvimento Econômico e

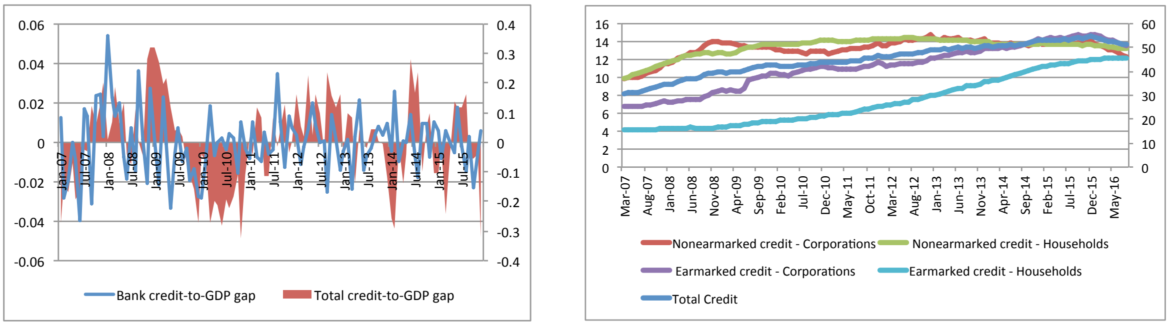
[1] There are three types of earmarked credit: public – municipal, state and federal employees, including the military; private – formal private sector workers; and the retirees and pensioners of the National Social Security Institute (INSS). Payroll-deductible loans show higher growth rates than other lines of credit, especially public and INSS credit.

Social - BNDES) and increased labor market formalization through 2013. Consumer credit has expanded through several changes in the credit market as institutional improvements (e.g., credit intermediation with better quality collateral and loan contracts, automatic payroll deductions) and social changes (forty million individuals accessing credit with upward social mobility). By 2009 and 2010, instability had built up in the financial system, especially in the credit market. Thus, at the end of 2010, Brazilian authorities started to implement macroprudential measures to curb those imbalances. In particular, the general conditions in credit markets were positive for the overall economy and concentrated in some low-risk sectors. However, there was risk imbalance in certain modalities and maturities of credit in the household sector, especially among consumer loans (SILVA; HARRIS et al., 2012).

Figure 4 – Credit-to-GDP evolution

(a) Credit-to-GDP gap

(b) Outstanding credit operations (non-earmarked and earmarked) - % of GDP



Source: Brazilian Central Bank

Figure 4a: Secondary axis: total credit-to-GDP gap. Figure 4b: Secondary axis: total outstanding credit as a % of GDP. Notes: Outstanding credit operations of non-financial corporations and households. Credit series are non-earmarked new operations for the bank-credit-to-GDP gap and total claims on the private sector of depository corporations and other financial corporations for the total credit-to-GDP gap.

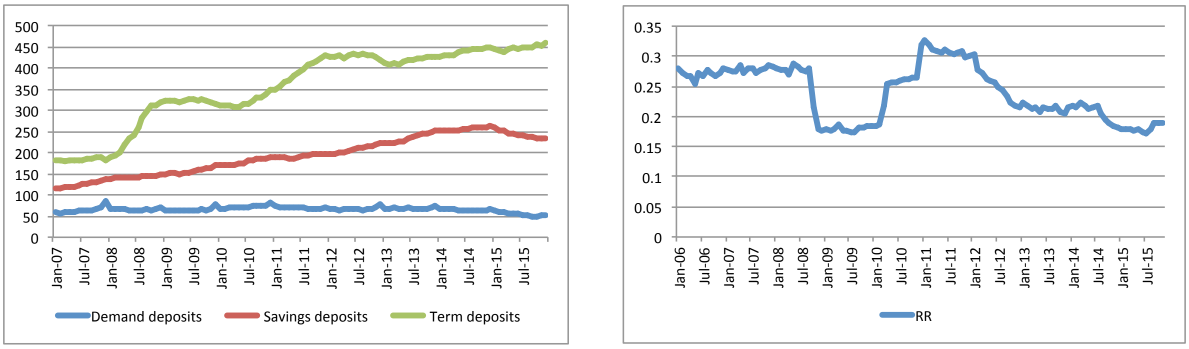
Due to the assumption of accumulated instability in the Brazilian credit market, the federal government, in conjunction with the central bank, established three main measures: A **financial operations tax (the IOF)** - the maximum rate was increased from 1.5% to 3% in April 2011. **Capital requirements** - measures of personal consumer loans, as described in Table 6, were implemented in December 2010, and the BCB raised the risk weight on loans with longer maturities in light of the higher potential risk of indebtedness of those loans (and reduced loans with shorter maturities). It removed the LTV ratio rule in November 2011. **Reserve requirement** - the RR was revised in 2010 to reverse measures taken during the 2008 financial crisis that reduced the RR in order to reallocate liquidity between banks (Figure 5). In February 2010, the central bank raised the RR on term deposits to 15%; in June, to 20%. It also increased the RR on additional eligibility of demand deposits and term deposits in February to 8%; in June, to 12%.

The central bank took two additional measures: in November 2010, it raised the minimum credit card payment to 15%, and in December of the same year, it exempted

Figure 5 – Bank deposits and reserve requirements

(a) Broad money supply - deposits - (end-of-period balance) deflated by IPCA

(b) Financial institutions reserve requirement effective rate - RR over deposits



Source: Brazilian Central Bank

Table 6 – Capital requirements

	December 2010		
Operation	Maturity and LTV	Risk Factor	Capital requirement
Personal loan	More than 24 months	150	16.5
Payroll-deducted loan	More than 36 months	150	16.5
Vehicles	Between 24 and 60 months and LTV > 80%	150	16.5
	Between 36 and 48 months and LTV > 70%	150	16.5
	Between 48 and 60 months and LTV > 60%	150	16.5
	More than 60 months and any LTV	150	16.5
Others consumer loans		100	11
	November 2011		
Operation	Maturity	Risk Factor	Capital requirement
Personal loan	Less than 36 months	75	8.25
	Between 36 and 60 months	100	11.0
	More than 60 months	300	33.0
Vehicles	Less than 60 months and classified as retail	75	8.25
	Less than 60 months and not classified as retail	100	11.0
	More than 60 months	150	16.5
Others consumer loans		100	11
Others consumer loans	classified as retail	75	8.25

Source: Brazilian Central Bank; (SILVA; HARRIS et al., 2012)

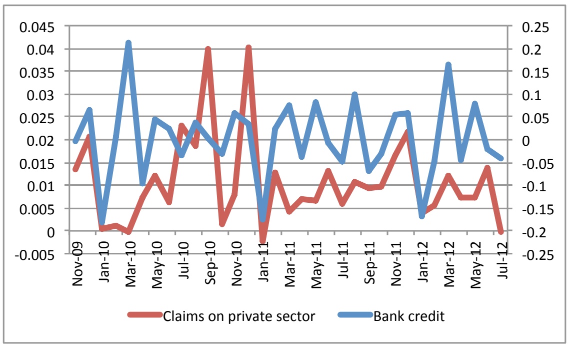
bank-issued debentures (Letras Financeiras) from the RR. These debentures had maturities of two years and were charged as term deposits before this exemption. The reversal of macroprudential measures with respect to the IOF started in December 2011 (rate of 2.5%) and continued in May 2012 (3%). The RR on demand deposits was raised to 44% in July 2012 and to 45% in June 2014, reversing the liquidity easing conducted in 2008. Furthermore, the RWF on the CRs of loans with the highest maturities was lowered to 150% in March 2013. In August 2014, the central bank reduced the RWF on all consumer loans to 75%.

Figure 6 show charts related to the evolution of credit between 2007 and 2015. Especially in the period in which the macroprudential measures were implemented (with a combination of policy interest rate hikes), the volume of new loans, the maturity and the average rate were affected, mainly in acquisition of vehicles credit. The change in the trend can be seen only in news loans and average maturity of acquisition of vehicles in Figure 6.

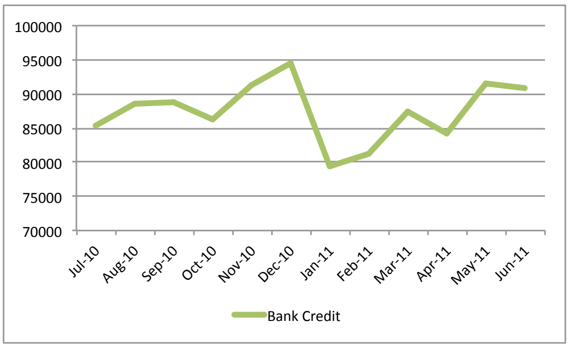
Also, the credit growth rate, especially bank credit, contract in the figure. Non-earmarked credit decreased by 17% between December 2010 and January of 2011; however, the data do not reveal a particular change in credit trend over the entire period.

Figure 6 – Credit evolution from 2007-2015

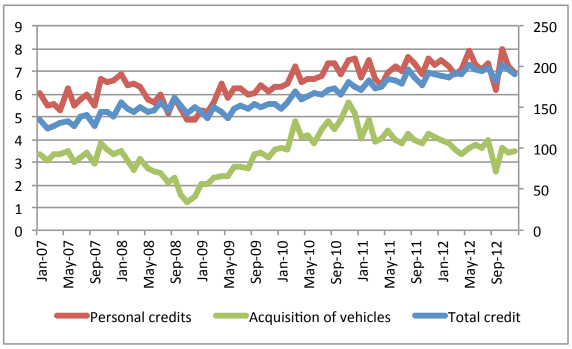
(a) Credit growth rate



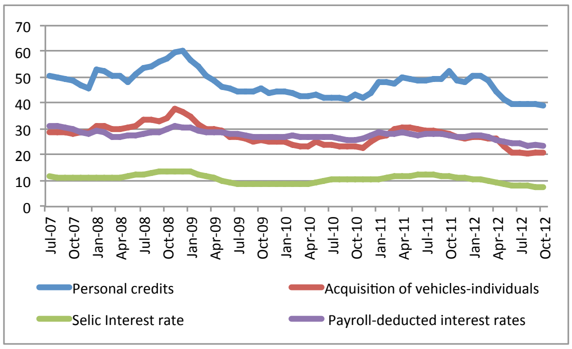
(b) Non-earmarked new operations - deflated by IPCA



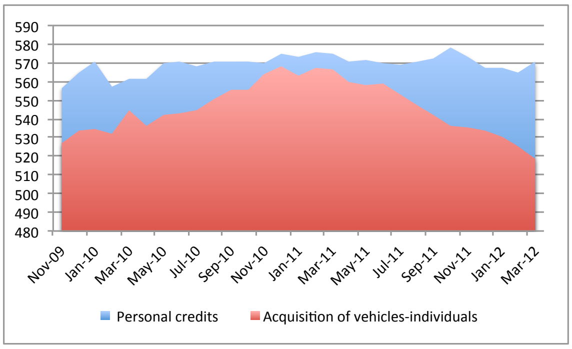
(c) Non-earmarked new operations - deflated by IPCA and seasonally adjusted in billions



(d) Non-earmarked credit operations (individuals) - monthly average rate and SELIC rate accumulated in the month in annual terms - % p.y.



(e) Non-earmarked credit operations - consolidated average maturity in days



Source: Brazilian Central Bank database

Figure 6a: Secondary axis: bank credit: non-earmarked new operations in growth rate. Figure 6c: Secondary axis: total non-earmarked new operations.

2.1.2 Foreign exchange market

Massive capital flows are another source of risk in emerging markets, especially given their effects on the financial system and spillovers into the real economy. Between mid-1990 and 2015, the Brazilian economy was an attractive destination for foreign capital due to structural factors (relatively stable macroeconomic environment, investment opportunities, adoption of public policies and a developed financial system). Particularly after the crisis, elements such as high interest rates and excessive global liquidity (quantitative easing policies from developed countries to address the 2008 financial crisis) increased short-term capital flows and domestic currency appreciation in Brazil. This a potential source of systemic risk.

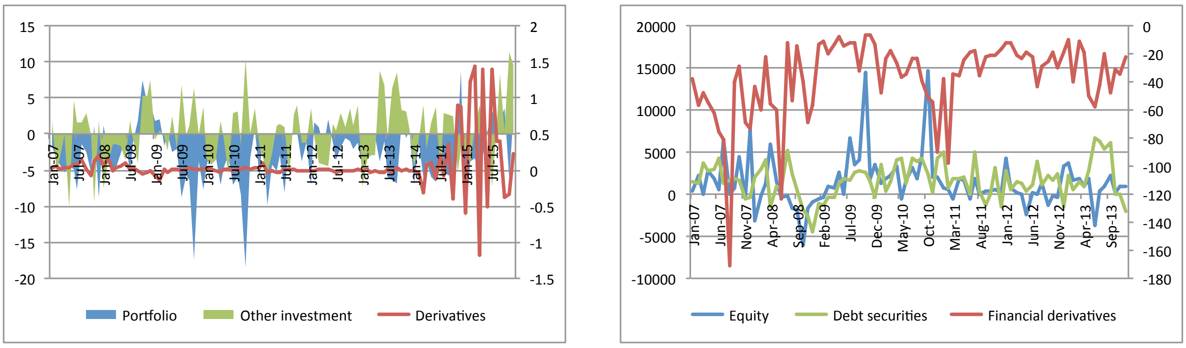
The central bank determined that excessive capital flows were affecting the credit market after the crisis period through abundant international liquidity that was transformed into a source of low-cost foreign funding for banks, creating potential internal imbalances in the risk taking of agents/financial institutions and asset price misalignments. The potential risk was described in Avdjiev, McCauley and Shin (2015) as the international currency risk-taking channel. Domestic borrowers with liabilities denominated in dollars and assets denominated in domestic currency face the risk-taking channel when they expand their liabilities with international currency depreciation. In the case of capital flow reversal and depreciation of the domestic currency, domestic conditions can be disturbed, especially in emerging markets such as Brazil.

Figure 7 describes the financial flows during the 2006-2015 period in Brazil. Figure 7a shows two large spikes in financial flows, specifically net portfolio inflows of US$ 17 billion in October 2009 and US$ 18 billion in October 2010, mainly as equity inflows (US$ 14,448 million in October 2009 and US$ 14,536 million in October 2010; see Figure 7b). Those years have a specific characteristic of abundant liquidity, leading to significant currency appreciation and vast international reserve accumulation in which the central bank aimed to reduce exchange rate volatility with those reserves. The value of international reserves reached US$ 200 million in 2009; in 2011, US$ 300 million (SILVA; HARRIS et al., 2012).

The measures Brazilian authorities took to address the exchange market were intended to reduce the intensity and volatility of capital flows, particularly to discourage banks from taking risky positions given abundant international liquidity. Especially in 2010, banks finished the year with a net short position of seventeen billion in the open market exchange, and they conducted operations similar to carry trades when a bank contracts a direct loan or issues securities abroad (long position) and sell this currency in the domestic market (short position). To curtail this growing imbalance in the Brazilian economy, the central bank implemented measures along different fronts of the foreign exchange market. **Spot market**: In January 2011, an RR of 60% (unpaid) in dollars on the short position in the FX spot market exceeding US$ 3 billion or Tier 1 capital (in July, this amount was reduced to US$ 1 billion). In March 2011, the IOF on inflows

Figure 7 – Financial flows in Brazil during the 2007-2015 period

(a) Financial account - net flows US$ (billion) (b) Portfolio liability positions - US$ (million)



Source: Brazilian Central Bank. Figure 7: Secondary axis: financial derivatives. Notes: net acquisition of financial assets - positive sign. Net incurrence of liabilities - positive sign. (Account balance = acquisition - incidence = +/-) Each account is split into assets and liabilities, that is, there is an item to register flows involving foreign assets held by residents in Brazil and another to register the issuance of liabilities by residents whose lenders are non-residents.

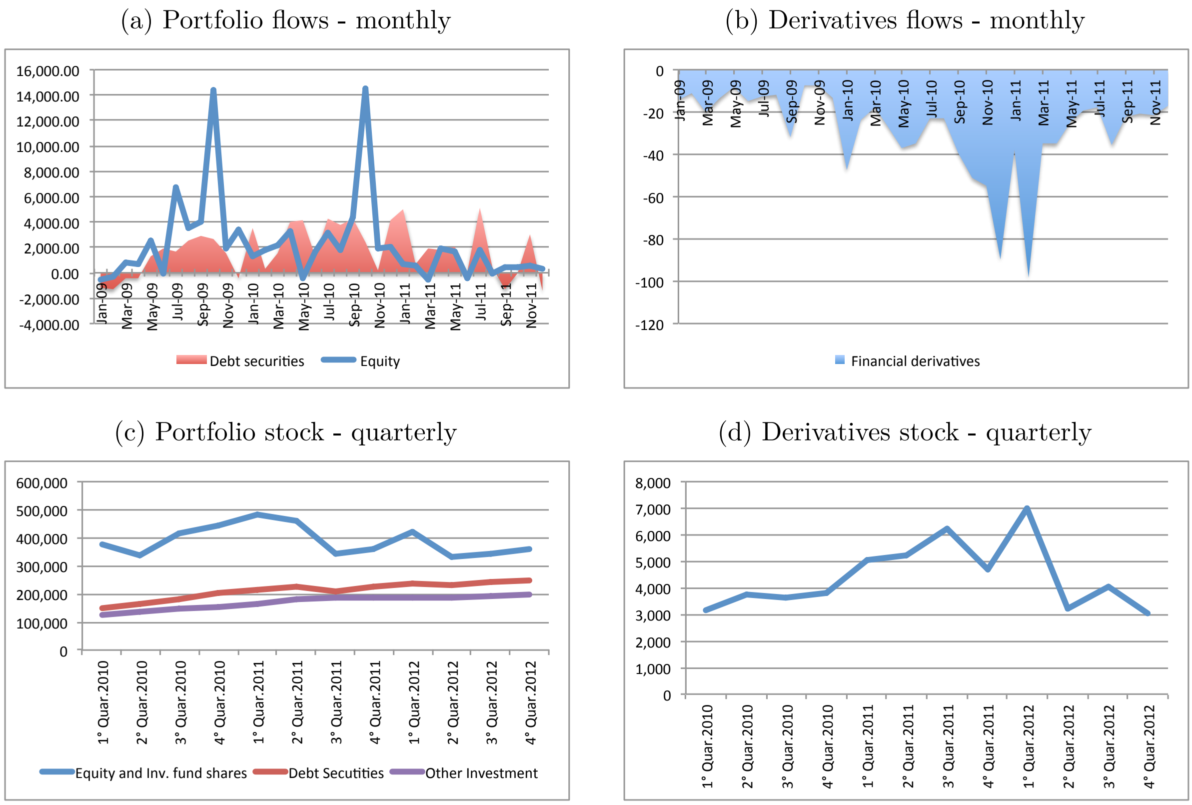
related to direct external borrowing or debt securities issued by residents with a maturity below 720 days was raised. **Future market**: By the end of 2010, Brazilian authorities had raised the IOF on portfolio investments (funds, fixed income) and on margin deposits on derivatives by non-residents (they are usually the counterparts of banks' long foreign exchange positions in the derivatives market). Macroprudential measures were initiated the year before (in October 2009) for portfolio investments, including equity, with a tax rate of 2%. The IOF was raised to curb intense capital flows, which were commonly short term and speculative, and to lengthen the flow position. The Brazilian government applied an additional measure to the derivatives market in July 2011: an IOF of 1% on the reference value of the contract, not on the margin of deposits. The detailed measures are available in Table 4 in chapter 1. According to Silva, Harris et al. (2012), the financial mechanism for banks and foreign investors functioned in the following manner:

> Local banks usually perform an arbitrage transaction where they take a long foreign exchange position in the derivatives markets and hedge their exposures in the underlying cash market by drawing on an external credit line and selling the proceeds to the Central Bank, to another bank or in the primary market (i.e. to an importer) and invest it in BRL-denominated assets. They earn a currency risk-free arbitrage profit resulting from the difference between the onshore foreign currency interest rate - named cupom cambial - and the offshore external borrowing cost (Libor rate plus a spread). [p.31, footnotes]

In March 2012, the Brazilian government implemented an additional measure on credit designed to finance production for Brazilian exporters, Advanced Receipts of Export Agreements, which had favorable tax treatment (0% IOF). Circular 3.580 limited APs to the actual importer for a period of 360 days (before this change, AP could be made by any legal entity without a time limitation). This measure was implemented because of concerns that credit had deviated (APs grew 46% between January and February 2012, but exports did not follow that pace (SILVA; HARRIS et al., 2012)).

Figure 8 reveals the portfolio and derivative flows for the years with IOF measures, especially between 2009 and 2011. Portfolio inflows plummeted at the end of 2010, showing the effectiveness of those measure at that time. Debt securities did not show spikes in the data as large as those of equities; nor did they show significant changes in trends over the entire period (Figure 7). Figure 8b also displays considerable shrinkage in derivative flows after macroprudential measures were implemented at the end of 2010 and the beginning of 2011. The effect of the July 2011 measure on the national value of derivatives is small compared to the behavior of the series throughout the period, and they are visualized in Figure 8d (series details the stock of non-resident investors in financial derivatives).

Figure 8 – Financial flows - US$ (Millions)



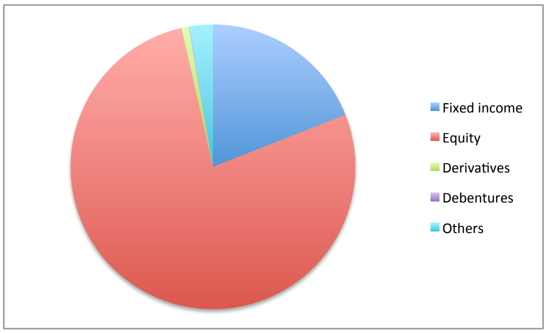
Source: Brazilian Central Bank.
Note: The financial flows series is from the balance payment data, which encompasses the net incurrence of liabilities of residents and non-residents. The financial stock series is the liabilities of non-resident investors (data obtained from the BCB via the CVM database).

Figure 9 describes some characteristics of foreign investors during the analyzed period. Equity represents a larger share of the portfolio investment of foreign investors at 77.39% in 2007 and 66.77% in 2010. Also, charts 9a and 9b show the growth of participation in fixed income investment between 2007 (19.05%) and 2010 (31.33%). The measures did not reduce the fixed income investments of foreign investors whose fixed income share of total investment was 35.02% in 2011 and 39.25% in 2012. In 2014, that share was 48.45%. Participation in derivatives of total investment was 0.83% in 2007, 0.99% 2010 and 1.33% in 2011. The percentage was lower in 2012 (0.76%), but it increased again in 2013 (1.69%)

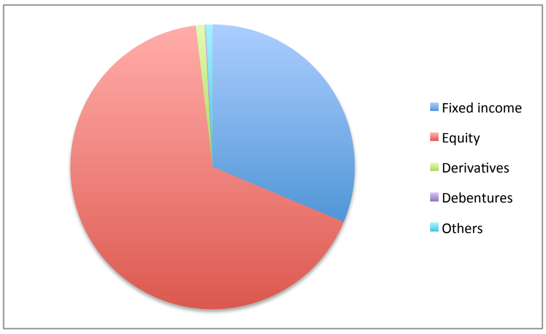
and 2014 (9.52%). Figure 9c displays the portfolios flows in annual terms from the CVM data. The flows declined between 2009 and 2011. Portfolio inflows decreased by more than US$ 100 billion between 2008 and 2011. However, in 2012, the upward trend recovered and reached US$ 397 billion in 2014.

Figure 9 – Foreign investors in Brazil's financial market

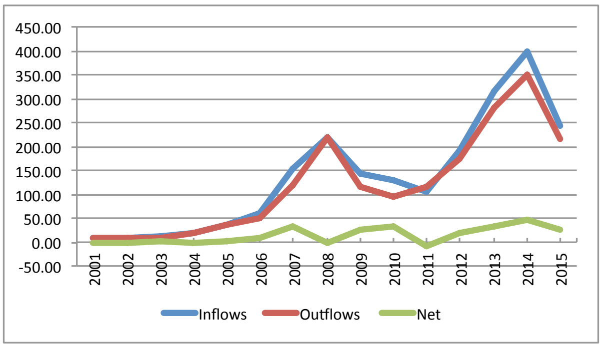
(a) Portfolio - value of investments (%) - 2007



(b) Portfolio - value of investments (%) - 2010



(c) Portfolio annual flows - US$ (Billions)



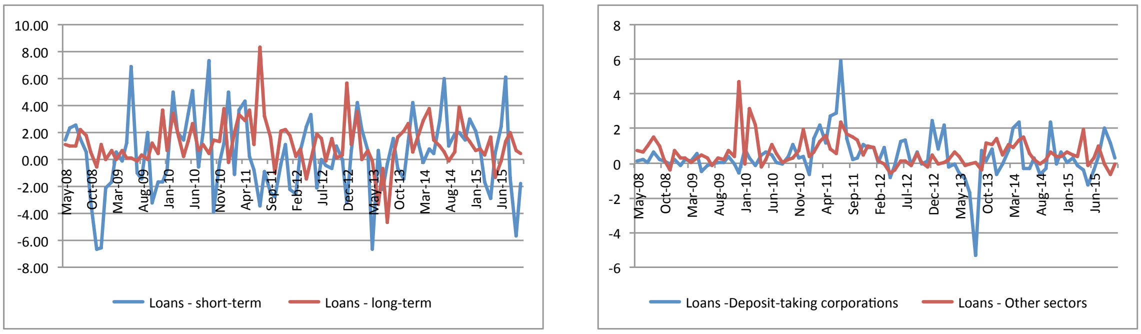
Source: CVM

Figure 10 indicates that short-term external borrowing declined after the first measure in April 2011, while long-term loans showed a large increase (peaking in July 2011), followed by a reduction in September. Figure 10b displays a spike in external bank borrowing in the first months of 2011 and after the IOF on external loans was increased to 6% in March (on 90- and 360-day loans) and April (720 days) 2011. External borrowing had a steep decline between April and September.

Another way of analyzing the growth of financial imbalances is to observe the balance sheets of banks and other financial institutions in order to verify whether this period of large financial flows changed the series behavior of those institutions. This would also highlight the role of other financial institutions, which also perform credit intermediation and maturity transformation activities that could involve myriad connections with banks and be a source of instability. Figure 11 shows that in terms of absolute values, banks have the largest volumes and the highest balances. Banks have the highest value claims on the private sector (which is considered credit for the private sector). Annual growth was 14% between 2007 and 2014. Regarding the liabilities of residents, banks smoothly reduced

Figure 10 – External loans (Billions)

(a) Loans - net incurrence of liabilities - US$ (b) Loans - net incurrence of liabilities - US$



Source: Brazilian Central Bank

their volume after the 2008 financial crisis, while other financial corporations increased their liabilities to non-residents between 2011 and 2013. The series does not indicate any significant changes in 2010 or 2011 when the main macroprudential measures were implemented. The exception is the increase in the liabilities of other financial institutions to non-residents after 2011.

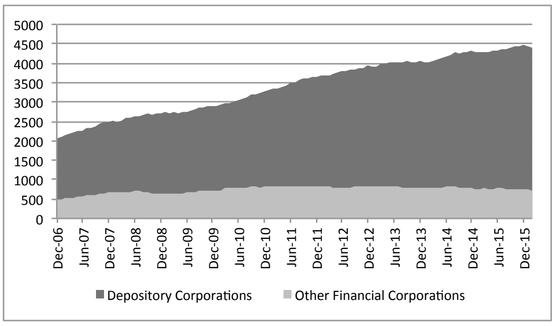
2.2 Econometric references

In order to investigate the macroeconomic policies implemented in various countries, several articles analyze the role of macroprudential instruments in the economy and in the financial system as a whole. Some econometric studies seek to verify the effects of the RR on important variables such as credit growth, output, and capital flows. The BCB (2011) analyzes the macroeconomic effects of the RR using a structural model for the period from 1999 to 2011. The model is represented by five main equations: a Phillips curve, a Taylor rule, a gap product, a yield curve and a credit market (the RR is the equation affecting the interest rate and the credit volume of free resources). The application of the model was represented as a permanent shock to the RR equivalent to an increase of R$ 69 billion in the total volume of the RR. According to the model, the impact on inflation would occur in the third or fourth quarter after the change in the rate.

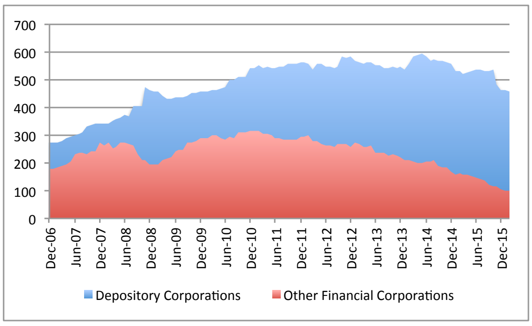
Two papers examine the macroeconomic effects of RRs using vector autoregressive (VAR) models: Mora, Garcia-Escribano and Martin (2012) and Glocker and Towbin (2012). The former estimate a VAR model using panel data from 2003 to 2011 for five Latin American countries: Brazil, Chile, Colombia, Mexico and Peru. The authors want to identify the differences between countries that use macroprudential tools more assiduously (Brazil, Colombia and Peru) and those that tend not to use them. They observe a modest and temporary reduction in bank credit growth. The marginal RR effects are negligible in the short term. Moreover, they note that macroprudential shocks reinforce tightening monetary policy, that is, rising interest rates. Glocker and Towbin (2012) perform a similar

Figure 11 – Assets and liabilities - depository corporations and other financial corporations deflated by the consumer price index (IPCA) in billions

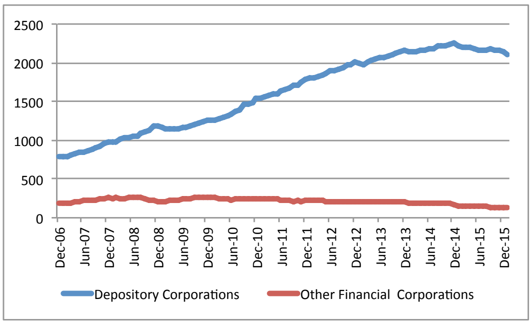
(a) Assets



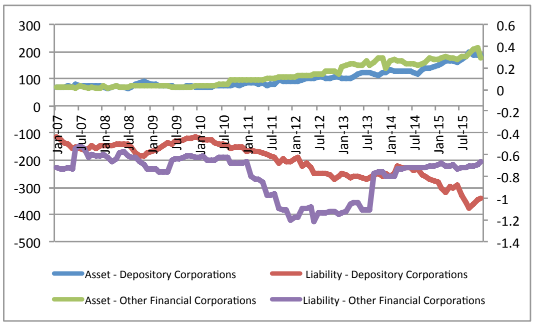
(b) Shares and other equity



(c) Claims on private sector by financial institutions



(d) Claims on non-residents (assets) and liabilities to non-residents (liabilities)



Source: Brazilian Central Bank database Figure: 11d Secondary axis: Asset and liability of other depositary corporation.

Notes: 1- Depository corporations: commercial banks; multiple banks; federal savings banks; credit cooperatives; investment and development banks; credit, finance and investment companies; savings and loan institutions; mortgage companies; real estate credit companies; state savings banks (which existed until November 1998); and financial investment funds (short-term, fixed-income, multi-market, referenced and exchange funds).
2- Other financial corporations (OFC): leasing companies, exchange banks, development agencies, corporations of loan for small entrepreneurs, brokerage companies, securities dealers, equity funds, foreign debt funds and pension funds.

analysis for Brazil between 1999 and 2010. The difference is that they use other control variables and three different measures of compulsory deposits (weighted average of all reserves, weighted non-remunerated RR and effective rate). The control variables are the price level, unemployment rate, spread rate, policy rate, exchange rate, total credit, current account, total reserves, Fed funds rate, and commodity prices. The authors found that a discretionary increase in the RR decreases domestic credit but increases unemployment, the current account surplus, exchange rate depreciation and, unexpectedly, the price level. After an interest rate shock, prices fell in the model.

Dawid and Takeda (2011) evaluate the impact of macroprudential measures on credit in three ways (with disaggregated models for each type of credit): 1) the impact of measures in 2010 and 2011 on individuals, corporations, personal credit and vehicle financing (passed between 2006 and 2011); 2) whether small banks were affected; and 3) whether there are long-term relationships between the RR and credit (from 2000-2011).

For the estimations, 1) the dependent variables are credit concessions (separate equations for each) with control variables such as volumes; interest rates; delays and maturities; and dummies for crisis years, seasonality and macroprudential measures. A dynamic fixed effects model is estimated by panel generalized method of moments (GMM) (for each bank credit concession). 2) In addition to the variables above, micro variables (liquid assets, deposits, funding), macro variables (policy rate, industrial production, real exchange rate, unemployment, direct BNDES and transfers), control variables for small banks, and a combined dummy for small banks and macroprudential measures are included. The model is estimated by OLS with the robust option. 3) The analysis is based on the portfolio management of a bank, with the variables of interest separated by bank size (large, small and total) and type of credit (working capital, guaranteed account of double discount, firms goods, vendor, personal loans, individuals vehicles, overdraft, firms assets). The control variables include micro (all the above plus equity) and macro features, as well as two variables for the effective RR rate (one general and one for each bank). The estimation method was individual fixed effects with a robust covariance matrix.

They conclude that, in general, the granting of credit to smaller banks seems to be the most affected. They also indicate that the implemented measures had important impacts on lending credit for individuals. The long-term analysis reveals the expected negative coefficient on the RR rate on outstanding aggregate credit and segments of individuals and corporate firms.

Other articles, such as IMF (2013), analyze the effects of other macroprudential instruments such as the effect of government taxes on bond and equity purchases in foreign currencies. Wong et al. (2011) consider the LTV ratio, and Tabak et al. (2013) consider capital buffers. The IMF (2013) verifies that taxes on portfolio investments in Brazil reduces short-term capital flows and increase long-term capital (the three variables of interest are short-term capital, long-term capital, and total capital) in a regression using data from 2001 to 2011. The control variables are the interest rate, expected appreciation of the exchange rate, economic activity index, investment risk (three factors – VIX index, EMBIG sovereign spread, ICRG index), current account (pull factors of investments) and the Fed funds rate (a push factor). The model is estimated using GLS, GARCH (1,1) and GMM approaches, and the results indicate that taxes were effective in reducing the volume of portfolio inflows and were able to shift the composition of capital inflows toward long-term categories. Finally, a VAR model was estimated for the period between 2003 and 2011 to examine the impact of an increase in the RR on portfolio flows (% GDP), credit growth, lending and deposit rates, interest rate spread, and money growth (includes crisis and seasonal dummies). The results of the impulse-response functions indicate an increase in the interest rate spread and a decrease in credit growth.

Wong et al. (2011) compare the use of the LTV ratio in thirteen economies. The analysis includes two models: A and B. In model A, the idea is to examine the effect on the mortgage default rate (variable interest) of changes in property prices and economic fluctuations with or without the LTV instrument. Thus, they estimate regressions that include dummies with and without the LTV. Model B includes a dummy for a policy implemented after the 2008 crisis (called the MIP policy) and examines whether it reduced the effectiveness of the LTV policy. Two panel models were estimated by GLS. As the authors show, " (1) LTV policy enhances banking stability mainly by reducing the responsiveness of mortgage default risk to property price shocks and (2) although in principle MIPs may reduce the effectiveness of LTV policy, there is no clear evidence to support this concern." (WONG et al., 2011, p.4).

Tabak et al. (2013) analyze the determinants of bank profitability and the effects of capital buffers on this profitability. The variables of interest are the return on assets or the return on equity. Using panel data, the models were estimated by fixed effects GMM (Arellano and Bond) and controlled for the specific bank, capital controls, macroeconomics and concentration. They note that profit is positively correlated with GDP growth, loans to total assets, financial intermediation costs and capital buffers and negatively correlated with total assets, share of public banks, default rates, market concentration and the interest rate (the SELIC rate).

The econometric model of Dell'Ariccia et al. (2008) suggests that macroprudential tools reduce the incidence of credit booms that end in financial crisis. The authors construct the variable of interest (credit booms) as a dummy of the credit-to-GDP gap to define an ad hoc rule for select periods. The control variables are GDP per capita, GDP growth, capital inflows (% GDP), financial reform, inflation, current account transactions (% GDP), open trade (sum of exports and imports divided by GDP), trade liberalization, exchange rate flexibility, monetary policy, fiscal policy and macroprudential controls (the sum of various measures). The model is estimated by OLS.

The effectiveness of macroprudential measures in 2010/2011 was examined in Brazil and 46 other countries by Ioannidis (2014). The variable of interest was the growth of external obligations to the BIS, and the control variables are dummies for Brazil and other 2010 measures (in addition to variables such as the VIX index and the exchange rate). All coefficients for the dummy variables for Brazilian macroprudential policies were non-significant.

Lim et al. (2011) separate macroprudential instruments into three types of measures: credit, liquidity and capital. The first category includes tools such as limits on the LTV ratio, DTI ratio, loans denominated in foreign currencies, credit and credit growth. The measures associated with liquidity include the RR, mismatching maturities and currency limits (or open currency positions). The application of counter-cyclical capital, dynamic provisioning and profit distribution restrictions are among those related to capital. The enumeration of these ten kinds of measures is based on a study of the systems of forty-nine countries. The authors also conduct a panel data regression in order to verify the effects of eight instruments used by forty-nine countries between 2000 and 2010 on four measures of risk: credit growth, systemic liquidity, leverage and capital flows. The regression compares two scenarios with or without the introduction of the instrument. The main idea is to determine the correlation between the risk measure and GDP growth, that is, to determine whether macroprudential tools reduce the procyclicality of risk measurements. They include control variables for monetary policy (interest rate) and fiscal policy (GDP growth), as well as dummies to correct for levels of flexibility in the exchange rate and individual country effects. The panel regression was estimated using GMM (Arellano-Bond estimator). The main results show that these eight instruments can limit the procyclicality of credit and leverage.

Some papers investigate macroprudential policies using similar approaches to compare the effects of macroprudential instruments in different countries using panel data, including Akinci and Olmstead-Rumsey (2015), Aysan et al. (2015), Neanidis et al. (2015), Bruno, Shim and Shin (2014), McDonald (2015), Cerutti, Claessens and Laeven (2015), Zhang and Zoli (2014). All these articles explore the effects of macroprudential instruments similarly to Lim et al. (2011) using panel data to compare countries. Bruno, Shim and Shin (2014), Zhang and Zoli (2014), Neanidis et al. (2015) focus on the effects of capital flows, while Akinci and Olmstead-Rumsey (2015), Aysan et al. (2015), Cerutti, Claessens and Laeven (2015) focus on credit growth. In general, all the specifications use dummy variables for macroprudential instruments to verify their impacts on measures of systemic risk (for instance, credit growth or capital flows). All the models include GDP and the interest rate as control variables. Capital flow specifications usually include a measure of volatility, such as the VIX index. The main finding of those articles is that macroprudential policies generally helped curb credit growth and housing price growth. Their usage is usually associated with lower growth in credit, but they are less effective in busts and for economies with more developed or open financial systems (CERUTTI; CLAESSENS; LAEVEN, 2015). Additionally, capital flow management is effective in slowing down bank, bond and equity inflows. Akinci and Olmstead-Rumsey (2015) note that policies with a specific objective – for instance, to limit the growth of housing credit – are more effective. These are called targeted policies. Buch and Goldberg (2016) highlight the effects of macroprudential tools on cross-border spillovers, with leakages to shadow banks or to activities in other geographic regions. They provide empirical evidence that these tools spill across borders via bank lending, but the intensity depends on bank balance sheet conditions and business models.

Zdzienicka et al. (2015) analyze the impact of macroprudential instruments on credit growth and house prices (called financial condition variables) in the US using quarterly data from 1970 to 2008. The proxy for macroprudential instruments is a dummy for policy changes that takes the value 1 for expansionary policies and -1 for contractionary policies. This dummy is similar to that used in Romer and Romer (2010)[2]. They compare these with monetary policy shocks[3] and check for asymmetric effects. The DL estimation includes twelve lags, and in the robustness check, the model is re-estimated by VAR. They find that macroprudential policy, in general, has an immediate but short-term effect on financial condition variables. Regarding the asymmetric effects, macroprudential instruments have stronger effects on credit growth in recessions than in expansions.

Other works are not related to macroprudential measures, but they present interesting analyses. For example, Vasconcelos and Tabak (2014) attempt to articulate the relationships among exchange rate exposure, bank foreign funding, carry trades and systemic risk. Their main conclusion is that Brazilian banks have increased their share of foreign funding since 2003, with a significant link between this foreign funding and an increased credit portfolio, but this result does not represent an increase in systemic risk because they represent a small portion of Brazilian banking activity. Interestingly, they do not find a channel between a bank's foreign exchange rate exposure and its foreign funding, that is, they cannot relate foreign exchange risk to bank profit among banks involved in carry trades over the estimated period (2003-2011).

Finally, Schiozer and Oliveira (2014) examine whether increases or decreases in the liquidity of banks (deposits) have asymmetric effects on the supply of credit (loans). Their approach separates banks into categories by loan type, size, industry. They find a large, asymmetrical and heterogeneous effect on the loan supply. An decrease in banking liquidity has a larger effect than an increase, and the impact on the loan supply of small and medium firms is smaller than for large firms, on average.

2.3 Exploratory analysis

2.3.1 Distributed lag model

A regression analysis was conducted to analyze the effects of Brazilian macroprudential instruments on four measures of (financial stability) systemic risk (credit growth, systemic liquidity, leverage and capital flows), in particular, to assess the effectiveness of these measures on cyclical domestic financial conditions. Following Zdzienicka et al. (2015), we replicate the model for Brazil using monthly data.

The model is estimated by DL regression. In the regression specification, y_t is sys-

[2] They estimate the effects of tax changes on output growth in the US. The endogeneity of dependent and independent variables is a common problem in this kind of specification. The solution provided by the authors is identifying exogenous tax changes by using a narrative analysis of each action, that is, that tax changes are not taken in response to factors that are likely to affect output growth.

[3] They isolate exogenous monetary policy changes using an estimated Taylor rule and included it in the DL estimation.

temic risk, m is a constant, u_t is the error term, x_t represents the macroprudential dummy,[4] and y_t is expressed as a function of current and past values of macroprudential dummy x_t. The sample period is between 2007 and 2015, which is determined by the availability of a monthly systemic risk series and the recent intensification of macroprudential instrument use.

The DL model is as follows:

$$y_t = m + B(L)x_t + u_t \tag{2.1}$$

$$B(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + ... + \beta_q L^q$$

Stock and Watson (2010) call this DL regression the dynamic casual effect, since the objective is to estimate the effect on y_t of a change in x_t. The equation estimates the increase/decrease in systemic risk over the course of the month in which the macroprudential policy change occurs, that is, the coefficients of x_t are estimates as a unit increase in the constructed macroprudential dummy on current and future values of the systemic risk variable[5]. The dynamic causal effect allows for the possibility of capturing changes in one object over some variable on a time path as an attempt to conduct a randomized experiment, especially because of the observed data. It is unfeasible to conduct a controlled experiment with a treatment group based on macroeconomic variables. Stock and Watson (2010) called the coefficients of x_t in the DL regression the t-period dynamic multiplier (the effect of a change in x on y after t periods).

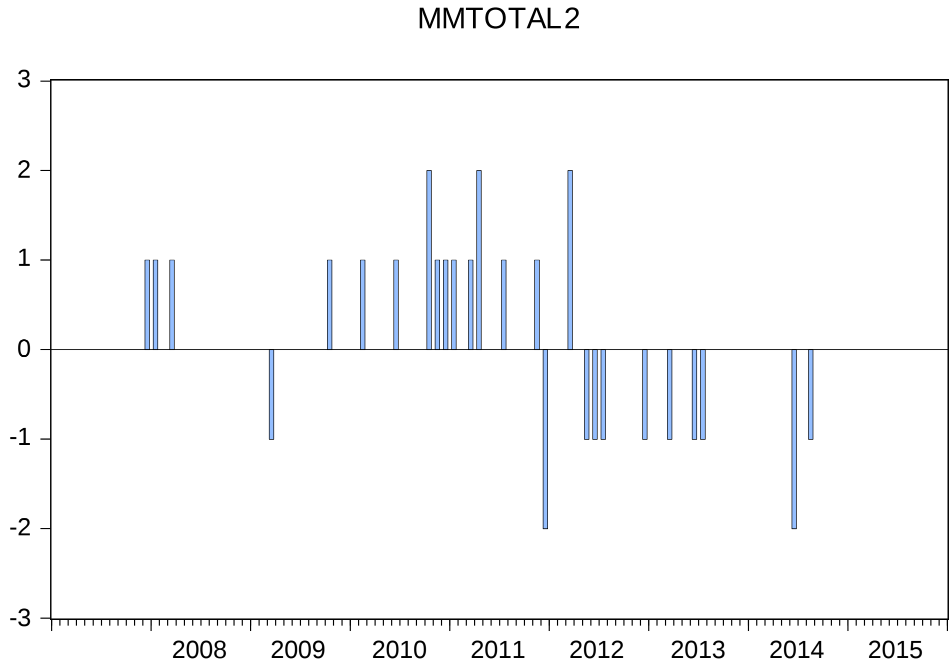
Following Zdzienicka et al. (2015), a variable (total dummy) that takes the value 1 in months when a macroprudential tightening measure is introduced, -1 in months when a macroprudential easing measured is taken, and zero otherwise is constructed. Figure 12 shows the overall measures.

Dummy variables for specific instruments and their use were also constructed. They take the value 1 during in periods when an instrument is introduced (tightening or easing) and 0 otherwise. This dummy construction, which is activated during the use period, follows Lim et al. (2011). For instance, there are six dummies, three with instruments focused on credit growth mitigation – the RR (RR-Credit), the IOF (IOF-Credit), and

4 Zdzienicka et al. (2015) compare macroprudential policy with monetary policy by estimating two regressions for each policy using US data. They isolate exogenous monetary policy changes from an estimated Taylor rule and include them in the DL estimation. We replicated the estimation using Brazilian data, but the results were not significant. Moreover, monetary policy did not display an effect on these data.

5 An additional macroprudential policy measure is estimated to vary systemic risk by β_1, while the first lag of x_t estimates the increase or decrease in systemic risk from a macroprudential policy passed in the preceding month, that is, β_2 estimates the effect of a unit increase in x_{t-1} one month after the macroprudential policy change occurs.

Figure 12 – Macroprudential measures



Note: Number of measures per month.

the CR (CR-Credit) – and three that concentrated on capital flows – the IOF on portfolio investment (IOF-Portfolio), the IOF on external loans (IOF-Loans) and the IOF on derivative contracts (IOF-Derivatives). Table 13 in Annex A describes these dummies.

The variable x_t is exogenous if it is uncorrelated with the regression error term. An endogenous variable is correlated with the error term and is determined within the model. Stock and Watson (2010) list four assumptions for valid statistical inferences from OLS estimation: $E(u_t|x_t, x_{t-1}, x_{t-2}...) = 0$; stationary distributions for x_t and y_t, and they continue to be independently distributed when the length of time separating them becomes large; large outliers are unlikely; and perfect multicollinearity does not exist. When using macroprudential policy as a dummy, endogeneity problems may arise in the estimation. For example, the probability of the occurrence of a macroprudential measure may be higher with an increase in credit growth, which leads to a biased and inconsistent OLS estimator. The modeling of macroeconomic variables always includes the possibility of feedback effects. One solution is to estimate a VAR model that considers this effect.

The selection of dummies for macroprudential policy may lead to endogeneity problems given the institutional nature of these policies, i.e., to curb financial instability. Thus, endogeneity is latent and perceptible in some policies related to the financial system. Romer and Romer (2010) address the endogeneity problem in their article by selecting dummies for fiscal policies over time and looking carefully at motivations for these policies to find ones that are not correlated with GDP growth (the dependent variable in the regression).

Unfortunately, macroprudential policies are not adopted very frequently, unlike fiscal policy changes, which lead to many series of observations and motivations for changes in tax rates. Therefore, this chapter considers macroprudential data in an exploratory way in order to investigate the statistical relationship between macroprudential measures and systemic risk measures through different types of regressions. We follow Zdzienicka et al. (2015) in first estimating a DL model that assumes that macroprudential policy for the designed dummies are exogenous variables and then estimating a VAR model.

2.3.2 Data

This exploratory analysis is intend to assess the efficiency of macroprudential policy in Brazil. To that end, we need to select variables that represent financial stability, in particular, a measure of systemic risk. The recent economics literature includes macroeconomic variables that can represent the time dimension of systemic risk for the whole financial system. The objective is to measure the evolution of risk over time for a set of financial institutions in Brazil.

As described in the literature review section, the majority of studies estimate credit growth and capital flows (although some estimate real property prices series) as cross-border borrowing in external claims and liabilities. We follow Lim et al. (2011) in selecting four variables: leverage, capital flows, liquidity and credit growth[6]. Zdzienicka et al. (2015) call these "financial condition variables", but we follow Lim et al. (2011) in calling them "systemic risk variables" given the recent work in the literature on the mitigation of systemic risk as a specific objective of macroprudential policy. The descriptions of variables are provided below and displayed in Figure 13.

Leverage is captured by two variables: capital over assets (as a percentage) as calculated by the BCB and assets over equity (as a percentage) for depositary corporations and other financial institutions.

Capital flows are captured as liabilities to non-residents over claims on non-residents of depositary corporations and other financial corporations, representing external indebtedness.

Liquidity is capture by two variables: the liquidity index calculated by the BCB and bank credit over deposits (demand and savings at the end of the period and seasonally adjusted).

Credit is captured by two variables (seasonally adjusted): the growth rate of non-

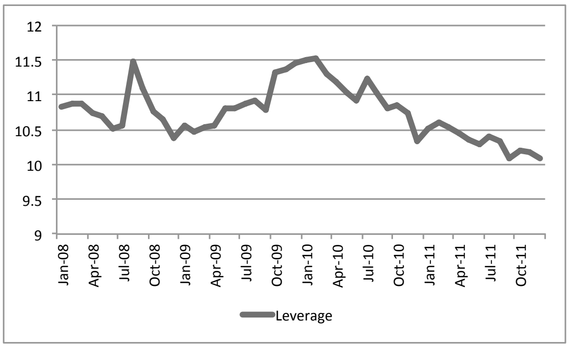
[6] The series of non-performing loans and household debt were also estimated as systemic risk measure, but in all estimation do not find statistically significant results

earmarked new operations – a series chained to reference credit deflated by a consumer price index (IPCA) – and private sector claims of depositary corporations and other financial institutions deflated by a consumer price index (IPCA).

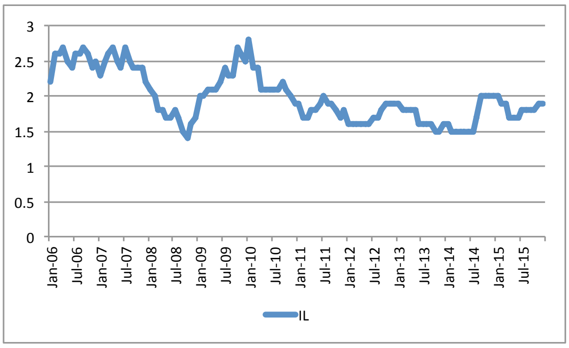
The choice of two series for some variables allows the analysis not only banks but of the financial sector as a whole. For instance, the liquidity index calculated by the central bank includes only banking institutions, whereas bank credit over deposits is a proxy intended to capture non-core funding, that is, credit expansion financed from sources other than deposits (wholesale funding). The variables were estimated as first differences (excluding credit variables that are already in growth terms and thus stationary).

Figure 13 – Systemic risk

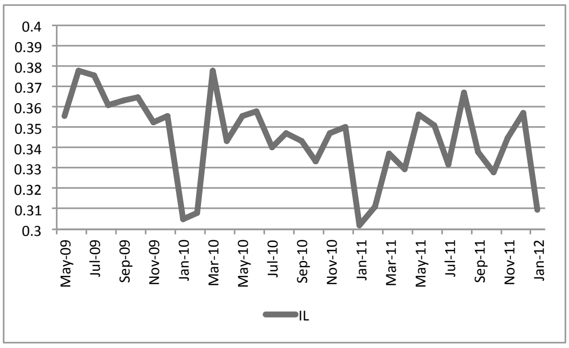
(a) Central bank leverage index - %



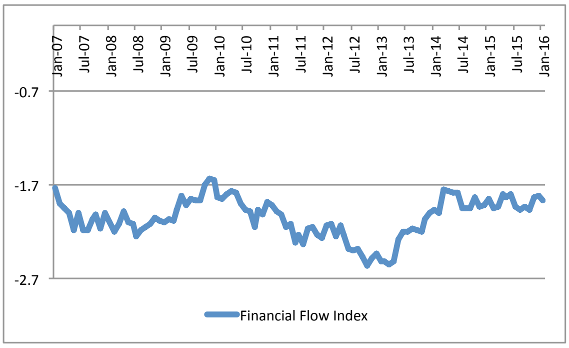
(b) Central bank liquidity index



(c) Liquidity index - credit over deposits



(d) Liabilities over assets of financial institutions with non-residents



Source: Brazilian Central Bank database

2.3.3 Distributed lag results

Unfortunately, all baseline models exhibit correlated errors. As a solution to this problem, Stock and Watson (2010) suggest the estimation of heteroskedasticity- and autocorrelation-consistent (HAC) standard errors. However, the DL model still displays autocorrelated errors. The coefficients of the total dummy showed broadly similar results to those of Zdzienicka et al. (2015)[7] across specifications with variables representing systemic

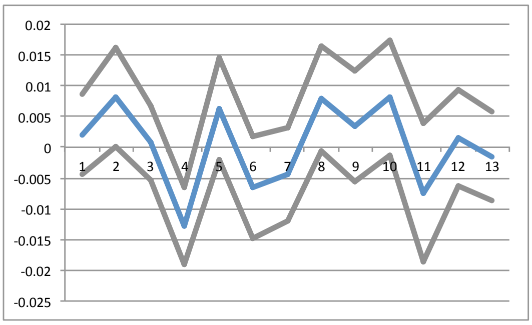
[7] All models are estimated with 12 lags, similarly to Zdzienicka et al. (2015).

risks, but they are not statistically significant (the have p-values larger than the common alpha level of 0.10). Since the estimations revealed no favorable models, only the credit growth model (non-earmarked new operations) is displayed in Figure 25. The DL results with the total dummy are presented in Figure 14a.

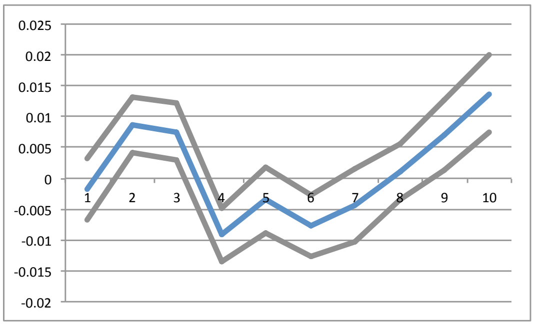
Specifications with dummies for specific instruments were also estimated, and the results exhibit error autocorrelation and, in some models, heteroskedasticity. Figure 14b displays the dummy coefficients for the RR (RR-Credit) over credit growth. Only capital flows with the IOF-Derivatives dummy specification passed autocorrelation and heteroskedasticity tests. A graphic of the coefficients is provided in Annex A2.

Figure 14 – Impact of macroprudential policy shocks on credit growth

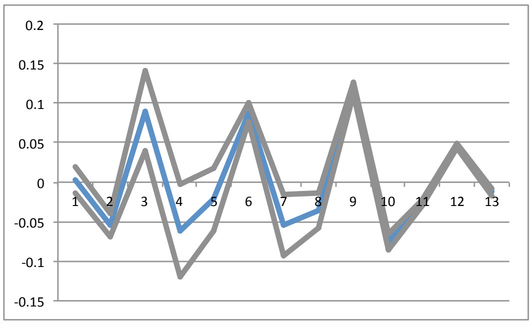
(a) DL model - total dummy



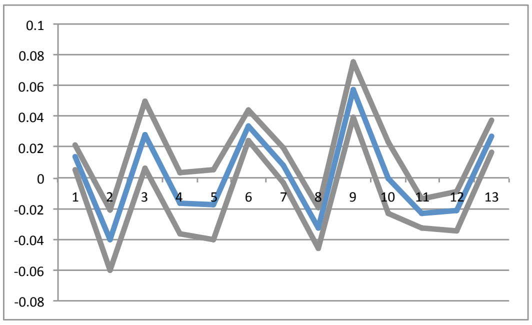
(b) ADL model - total dummy



(c) DL model - RR-Credit dummy



(d) ADL model - RR-Credit dummy



Note: All regressions were estimated by OLS using monthly data from January 2007 to December 2015. The dependent variable is credit growth. All regressions include an intercept, and Newey-West HAC standard errors are reported (grey lines). Figures 14a and 14c are DL regressions with the monthly number of macroprudential measures and 12 lagged values (total dummy) or a dummy that takes the value 1 during periods when the instrument is used and its lagged values. Figures 14b and 14d are the ADL regressions with the previously described dummies. The figures with DL and ADL estimations show the β coefficients of equation 2.1 on the y-axis (blue lines). In all figures, the x-axis indicates the months after the shock at t=0. All model have correlated errors, except the ADL model with the RR-Credit dummy.

2.3.4 Autoregressive distributed lag model

Given the autocorrelation problem with the DL specification, an ADL model is introduced. This alternative approach allows lags of the dependent variable in order to correct for autocorrelation of the errors and to include another effect in the regression. The lagged dependent variable may include the past effects of the lagged variable itself, which can be captured by its coefficients, generating more information within the regression.

The ADL(p, q) model is as follows:

$$A(L)y_t = m + B(L)x_t + u_t \tag{2.2}$$

with

$$A(L) = 1 - \alpha_1 L - \alpha_2 L^2 - ... - \alpha_p L^p$$
$$B(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + ... + \beta_q L^q$$

The general ADL$(p, q_1, q_2, ..., q_k)$ is:

$$A(L)y_t = m + B_1(L)x_{1t} + B_2(L)x_{2t} + ... + B_k(L)x_{kt} + u_t$$

Stock and Watson (2010) suggest an ADL model to eliminate autocorrelation of the error term u_t (i.e., a correlation with its own lagged values) but only if x_t is strictly exogenous. The assumption is that omitted factors included in the error term can be serially correlated. For instance, suppose that serial correlation in u_t follows an AR(1) process:

$$u_t = \phi_1 u_{t-1} + \tilde{u}_t \tag{2.3}$$

where ϕ_1 is a parameter, $\tilde{u}_t$ is not serially correlated, and $E(u_t) = 0$. Using a DL specification with one lag, lagging each side of the equation and subtracting ϕ_1 versus this lag from each side yields:

$$\begin{aligned} Y_t - \phi_1 Y_t &= (\beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + u_t) - \phi_1(\beta_0 + \beta_1 X_{t-1} + \beta_2 X_{t-2} + u_{t-1}) \\ &= \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} - \phi_1\beta_0 - \phi_1\beta_1 X_{t-1} - \phi_1\beta_2 X_{t-2} + \tilde{u}_t \\ Y_t &= \alpha_0 + \phi_1 Y_t + \delta_0 X_t + \delta_1 X_{t-1} + \delta_2 X_{t-2} + \tilde{u}_t \end{aligned} \tag{2.4}$$

where β_0 , β_1 and β_2 are coefficients of the DL model with one lag. Here, $\alpha_0 = \beta_0(1-\phi_1)$, $\delta_0 = \beta,\delta_1 = (\beta_2 - \phi_1\beta_1)$, and $\delta_2 = -\phi_1\beta_2$. Equation 2.4 is an ADL (1,2) representation of the DL model with the term error given in equation 2.3. Note that the coefficients of equation 2.4 are not estimates of the dynamic multipliers. The advantage of the ADL model is parsimony as a result of the approximation of the DL specification (especially in cases with complex and long models) using fewer unknown parameters.

That the x_t variable is strictly exogenous is a strong assumption; thus, the specifications is also tested by VAR and is described at the end of this chapter. The total dummy and instrument dummies will be tested in separate models.

2.3.4.1 Autoregressive distributed lag results

As in the DL model, the ADL estimations did not produce significant coefficients.[8] The model selection method was the Akaike information criterion. All regressions with the total dummy passed error autocorrelation and heteroskedasticity tests[9], but no statistically significant results were found for the dummy coefficients at a 10% level. The exceptions are the two specifications with the leverage variable and one with the liquidity variable, which are described in the Annex. The impact of the total dummy on leverage is positive in the first period and negative in the second and third periods. On the contrary, the total dummy is statistically significant (at the10% level) and positive in the liquidity index specification. The credit growth estimation is shown in Figure 25. Only lags 1, 3, 7 and 9 are statistically significant at the 10% level.

The systemic risk models with dummies for the instruments did not show favorable results in any specifications. Figure 14d displays the impact of the RR-Credit dummy on credit growth. Only this model and that with the CR-Credit dummy passed residual tests. Lags of 2, 3, 4, 6 and 9 are not statistically significant (at the 10% level). Nor did the capital flows and leverage specifications pass residual tests. Although the coefficients are not statistically significant (at the 10% level), the liquidity index model shows errors that are not correlated and not heteroskedastic.

2.3.5 Autoregressive distributed lag model with additional variables

A second type of ADL model is estimated by adding two more variables to control for monetary and fiscal policy influences in the baseline ADL. In particular, x_t in equation 2.2 includes three variables: interest rate, GDP growth and macroprudential dummy. The model is a combination of those ofLim et al. (2011) and Zdzienicka et al. (2015). The idea is to include a proxy variable to add information to the specification from a macroeconomic perspective, that is, to capture the interest rate and GDP influence (monetary policy and fiscal policy, respectively).[10]

The baseline analysis uses dummy variables representing each macroprudential instruments in level terms. Another estimation tests whether those instruments limit the procyclicality of systemic risk, that is, we add to the regression a macroprudential dummy interacted with GDP growth to capture the correlation between systemic risk and GDP

[8] Stock and Watson (2010) also suggest the generalized least squares (GLS) estimation in the case of error serial correlation. This model was also tested and no different results were found.

[9] Except the specification with the liquidity index.

[10] The model was also estimated with measures of industrial production and the prime interest rate; however, the effect on systemic risk did not vary from that of the baseline model. Volatility (the VIX index) and Fed funds rate were included in capital flow specification, but this did not significantly change the results.

growth.[11] [12]

2.3.5.1 Results

Tables 7 and 8 report the results of the estimation. The long-run dummy coefficients for the instruments are presented. The ADL models with control variables are more parsimonious, with statistically significant coefficients in the majority of estimations and without autocorrelation or heteroskedasticity of the errors. The estimation with the total dummy does not show favorable results. Some models show error autocorrelation and/or heteroskedasticity, and the majority of estimations do not have statistically significant coefficients. The exception is the model with the liquidity index (bank credit over deposits), with a long-run positive coefficient of 0.003924 (P-value = 0.0594).

The first table shows the results for leverage as calculated by the BCB.

The CR and IOF on capital flows (portfolio instruments, external loans and derivative contracts) suggest negative effects on leverage with significant coefficients (at a 5% level). The long-run RR-Credit and IOF-Credit dummies are not statistically significant in the leverage model.

Table 8 shows the significant coefficients of the other variables that represent systemic risk. The IOF on credit showed a positive coefficient (not expected) for the liquidity index. This may represent an increase in liquidity from other sources. The CR and IOF on external borrowing appear to be the macroprudential instruments that most affect capital flows. The estimation also suggests that macroeconomic-level instruments do not affect credit growth, since no coefficient was significant. The only exception was the IOF on external loans, but it had an unexpected positive sign.

In summary, leverage was the most affected factor, mainly by the IOF on external capital flows. The liquidity ratio was negatively affected by the IOF on portfolio investment. While the CR and IOF on external borrowing affect capital flows (in difference). This is an unexpected result: CRs affect capital flows but not credit. The influence channel is not clear and deserves additional scrutiny. Credit growth was apparently not impacted by macroprudential measures. Finally, the long-run GDP coefficient is non-significant across almost all specifications (less in credit).

Some results change in the specifications where the dummy of macroprudential policy interacts with GDP (note that the idea is to check the correlation between a systemic risk variable and the macroprudential dummy interacted with GDP as a proxy for the

[11] Lim et al. (2011) address three possible sources of endogeneity in this specification: the specification may result in autocorrelation (as in the DL model), systemic risk variables may be correlated with control variables, and, the models that show a high degree of procyclicality indicate an increased possibility of the macroprudential authority to use the instrument.

[12] Models with and without control variables were also estimated by GMM using lagged variables as instruments. The majority of the results were not different from those presented in this subsection.

Table 7 – Long-run coefficients - leverage

Variable	Leverage	Leverage	Leverage	Leverage
CR-Credit	-0.046637**			
P-value	0.0256			
IOF-Portfolio		-0.039552***		
P-value		0.0026		
IOF-Loans			-0.037344**	
P-value			0.0288	
IOF-Derivatives				-0.050881**
P-value				0.0195
F static	3.411	3.194	2.705	3.098
R-squared	0.448	0.522	0.547	0.371
Selected model	(4, 2, 7, 3)	(8, 3, 6, 5)	(12, 2, 7, 5)	(4, 2, 6, 1)

Note: All regressions were estimated by OLS using monthly data from January 2007 to December 2015. The dependent variable is leverage (in difference terms) as calculated by the BCB. All regressions include intercepts and Newey-West HAC standard errors. The table reports the ADL regression with the monthly number of macroprudential measures and 12 lagged values (total dummy) or a dummy that takes the value 1 during periods in which the instrument is used and its lagged values. The model selection method was the Akaike information criterion , and the selected model indicates the number of lags of the regression variables in this order: systemic risk, GDP, interest rate and dummy. *** $p<0.001$, ** $p<0.5$,* $p<0.1$

procyclicality of systemic risk. For example, credit growth with GDP growth versus the macroprudential dummy). Tables 9, 10 and 11 show the main results. The IOF on portfolio investment is associated with a reduction in the procyclicality of credit growth represented by the series of new credit concessions. On the other hand, when using the series claims with private sector of depositary corporation and other financial institutions, the IOF on credit and the CR and IOF on portfolio investment are also associated with a reduction in credit growth.

Some macroprudential instruments interacted with GDP are negatively associated with capital flows: the CR, the IOF on external loans and the IOF on credit loans. On the other hand, the coefficients of the liquidity and leverage dummies were statistically significant and positively correlated with the dummies, that is, the estimation suggests that these instruments raise the systemic risk of procyclicality. The RR interaction with GDP is, on average, positively correlated with the leverage variable and the liquidity index.[13]

[13] All the estimates presented F tests rejecting the null hypothesis (at a 5% level of significance). In most of the estimates, the long-term GDP coefficient was not statistically significant, but most of the short-term coefficients were significant.

Table 8 – Long-run coefficients - others

Variables	Liquidity	Capital flows	Capital flows	Credit
IOF-Credit	0.002931***			
P-value	0.0007			
CR-Credit		-0.035771**		
P-value		0.0383		
IOF-Loans			-0.039347**	0.002724*
P-value			0.0345	0.0818
F static	7.287	2.412	2.434	7.118
R-squared	0.849	0.191	0.192	0.843
Selected model	(10, 10, 12, 6)	(1, 0, 5, 0)	(1, 0, 5, 0)	(8, 11, 11, 8)

Note: All regressions were estimated by OLS using monthly data from January 2007 to December 2015. The dependent variables are liquidity - bank credit over deposits (in difference terms); credit series: growth rate of non-earmarked new operations; or capital flows - liabilities to non-residents over claims on non-residents of depositary corporations and other financial corporations (in difference terms). All regressions include intercepts and Newey-West HAC standard errors. The table reports the ADL regression with the monthly number of macroprudential measures and 12 lagged values (total dummy) or a dummy that takes the value 1 during periods in which the instrument is used and its lagged values. Model selection was based on the Akaike information criterion, and they selected model describes the lag number of the regression variables in the following order: systemic risk, GDP, interest rate and dummy. *** p<0.001, ** p<0.5,* p<0.1

2.3.6 Vector autoregression estimation

As in the DL estimation, the ADL estimation may be affected by endogeneity between the dependent and independent variables given the lagged dependent variable in the regression. VAR estimation addresses this problem and is an appropriate estimation method because it captures linear interdependencies among multiple variables. Macroprudential instruments may affect proxies for systemic risk, but the policy maker's choice of macroprudential tool may be caused by variation in the same systemic risk variable, for instance, an increase in credit growth. VAR estimation captures this endogenous effect among the variables.

We found models with congruent results (non-correlated and homoskedastic errors and roots that are all outside the unit circle); however, the impulse-response functions do not show statistically significant confidence intervals (with zero in the range). The estimation was conducted for the equations separately and for all systemic risks in the same estimation with the total dummy or instrument dummies. In other words, the VAR estimation was conducted in three ways: first, one type of systemic risk variable and one type of dummy (where each regression has two variables); second, one type of systemic risk variable with all dummies for specific instruments (where each regression has seven variables); and finally, all systemic risk variable with one type of dummy (where each regression has five variables). Two control variables, GDP and the interest rate, were added to each estimation, but this does not lead to new significant results. The number of lags

Table 9 – Long-run coefficients - credit growth

Variables	Credit[a]	Credit[a]	Credit[a]	Credit[b]
IOF-Credit × GDP growth	-0.034042*			
P-value	0.0753			
CR-Credit × GDP growth		-0.087847*		
P-value		0.0929		
IOF-Portfolio × GDP growth			-0.016447***	-0.035964**
P-value			0.0009	0.0274
F static	10.77	9.068	4.449	7.717
R-squared	0.478	0.523	0.635	0.869
Selected model	(5, 0, 0, 0)	(5, 0, 0, 3)	(4, 11, 6, 3)	(11, 9, 11, 10)

[a] Credit series: claims with private sector of financial institutions.

[b] Credit series: growth rate of non-earmarked new operations.

Notes: All regressions were estimated by OLS using monthly data from January 2007 to December 2015. The dependent variable is capital flows - liabilities to non-residents over claims on non-residents of depositary corporations and other financial corporations (in difference terms). All regressions include intercepts and Newey-West HAC standard errors. The table reports the ADL regression with the GDP series interacted with a dummy variable: the monthly number of macroprudential measures and 12 of its lagged values (total dummy) or a dummy that takes the value 1 during periods in which the instrument is used and its lagged values. Model selection was based on the Akaike information criterion, and the selected models describe the number of lags of the regression variables in the following order: systemic risk, GDP, interest rate and dummy. *** p<0.001, ** p<0.5,* p<0.1

varies in each regression, and the decomposition method is generalized impulses. Figures 15 and 16 display two models with more parsimonious impulse responses. The model is estimated with four systemic risk variables and one instrument dummy: the CR or the RR.

Conclusion

The BCB and other regulatory boards generally pursue policies that complement monetary policy. Recently, these policies have been called macroprudential. During and after the global financial crisis, macroprudential measures were used more intensively by policy makers. Macroprudential policies were expected to affect systemic risks given recent academic work pointing to their use, and despite few empirical studies, those conducted with panel data showed favorable results.

However, in general, the policies analyzed in this chapter do not affect the trends of the series. An analysis of the graphs of the specific policies does not reveal structural breaks, and the models produced unfavorable results using several types of estimations. A small share of the regressions presented in this chapter shows that the effectiveness of macroprudential policies must be interpreted with caution, since they do not point to clear outcomes and are not robust, especially because of endogeneity problems.

Endogeneity is a problem in the estimation of observable macroeconomic data,

Table 10 – Long-run coefficients - capital flows

Variables	Capital Flows	Capital Flows	Capital Flows	Capital Flows
IOF-Credit × GDP growth	-0.109335**			
P-value	0.0144			
CR-Credit × GDP growth		-0.105968***		
P-value		0.0028		
IOF-Loans × GDP growth			-0.102304***	
P-value			0.0086	
IOF-Deriv. × GDP growth				0.167297**
P-value				0.0487
F static	2.374	2.442	2.185	1.848
R-squared	0.327	0.250	0.309	0.448
Selected model	(1, 7, 5, 1)	(1, 7, 0, 1)	(1, 7, 5, 1)	(2, 7, 5, 12)

Note: All regressions were estimated by OLS using monthly data from January 2007 to December 2015. The dependent variable is the credit series. All regressions include intercepts and Newey-West HAC standard errors. The table reports the ADL regression with the GDP series interacting with a dummy variable: the monthly number of macroprudential measures and 12 of its lagged values (total dummy) or a dummy that takes the value 1 during periods in which the instrument is used and its lagged values. The model selection was based on the Akaike information criterion, and the selected model describes the lags of the regression variables in the following order: systemic risk, GDP, interest rate and dummy. *** p<0.001, ** p<0.5,* p<0.1

since it is not possible to isolate the effects of the variables, and it occurs mainly in macro analyses rather than in micro analyses. The sequence of casual effects on current and future values of Y may thus be affected by the error term u_t including omitted determinants of y_t or correlations between the regressors. Even with endogeneity problems, Zdzienicka et al. (2015) found macroeconomic impacts of macroprudential measures on financial conditions (credit growth and property prices) in the US, but they conclude that the impact is more immediate and short term. They argue that the temporary effect may reflect lags in policy implementation: "Also, single macroprudential measures in specific sectors might have different effects from the policy actions analyzed here. Finally, economy-wide effectiveness of macroprudential may be reduced by arbitrage and circumvention" [p.1]. Obviously, besides endogeneity, a small sample is a possible problem with the estimations presented in this chapter. Furthermore, we use the argument of Silva, Harris et al. (2012) to evaluate measures for the derivatives market, but this logic can be expanded to all measures: "The empirical basis for judging the effectiveness of restrictions on derivatives positions is limited, given that their effects were mixed with the worsening of the global economic situations... they were imposed in conjunction with others measures" [p.206].

Although macroprudential policy seeks to avoid macroeconomic disturbances of the financial system, they are carried out by sector and are directed toward specifically types of instability. According to the results of this chapter macrodiscretionary policies overall do not impact the financial system. The effects of macroprudential policies depend on various factors, including the structure of the financial system itself, as well as interconnections

Table 11 – Long-run coefficients - others

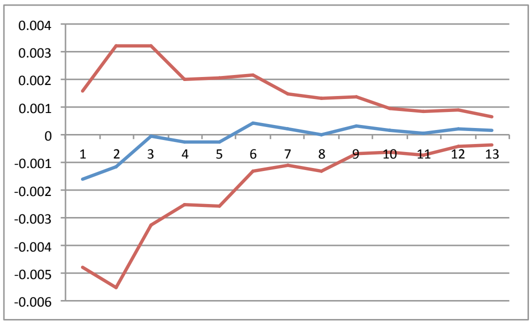
Variables	Liquidity	Leverage
RR-Credit × GDP growth	0.003079***	0.061852***
P-value	0.0016	0.0002
F static	37.478	3.06
R-squared	0.696	0.3351
Selected model	(2, 0, 0, 1)	(2, 2, 7, 0)

Note: All regressions were estimated by OLS using monthly data from January 2007 to December 2015. The dependent variables are liquidity series – bank credit over deposit – or leverage series as calculated by the BCB. All regressions include intercepts and Newey-West HAC standard errors. The table reports the ADL regression with GDP series interacting with a dummy variable: the monthly number of macroprudential measures and 12 of its lagged values (total dummy) or a dummy that takes the value 1 during periods in which the instrument and its lagged values are used. Model selection was based on the Akaike information criterion, and the selected model describes the lags in the number of regression variables in the following order: systemic risk, GDP, interest rate and dummy. *** p<0.001, ** p<0.5,* p<0.1

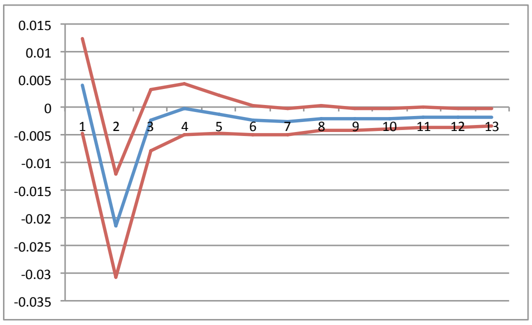
within the system, with the real economy and with other countries. As a specific policy, it is difficult to analyze from a macro perspective, and their goal is to prevent risk realization throughout the system (that is, to "lean against the wind"). As some papers have noted, targeted macroprudential policies are more efficient. Microeconomic disturbances may arise at a particular point in time. These micro disturbances can impact the entire system, but they are still managed microeconomically. In other words, macroprudential policies target the stability of financial system, but their tools have limited performance and are often sectoral.

Figure 15 – Impact of capital requirement dummy on systemic risk

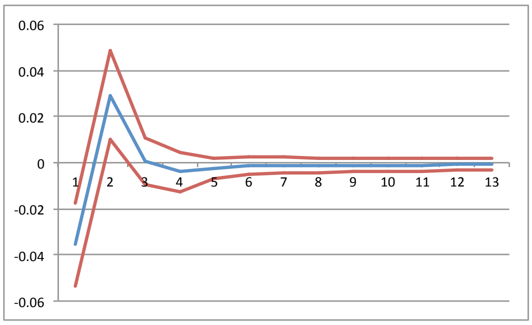
(a) Response of credit growth to CR-Credit dummy



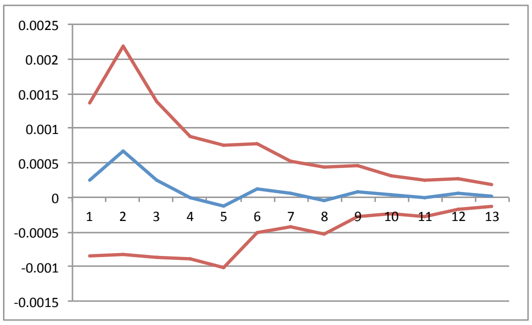
(b) Response of capital flows to CR-Credit dummy



(c) Response of leverage to CR-Credit dummy



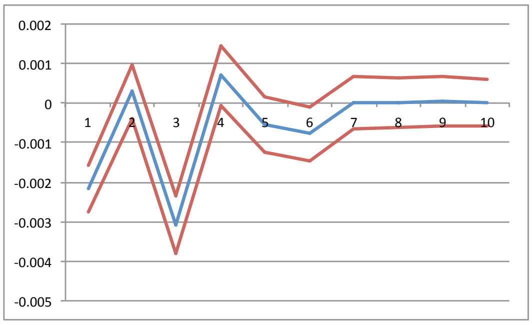
(d) Response of liquidity to CR-Credit dummy



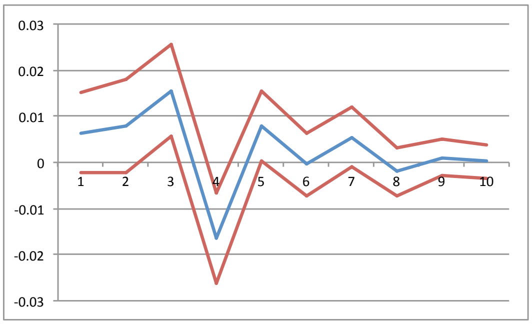
Note: The figures represent the impulse responses of VAR model with 2 lags and 5 variables: credit growth (non-earmarked new operations), capital flows, leverage (index calculated by the BCB), liquidity (bank credit over deposits) and the CR-credit dummy. The red lines indicate the standard errors. The decomposition method is generalized impulses.

Figure 16 – Impact of the reserve requirement dummy on systemic risk

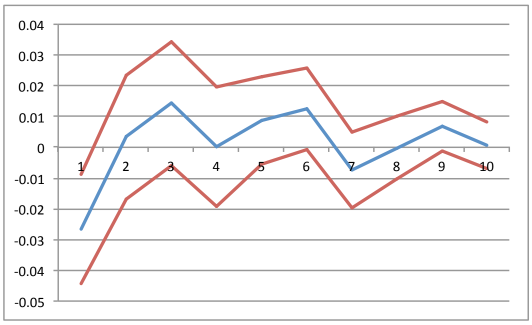
(a) Response of credit growth to the RR-Credit dummy



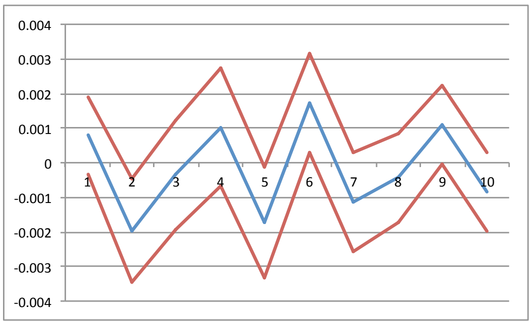
(b) Response of capital flows to RR-Credit dummy



(c) Response of leverage to RR-Credit dummy



(d) Response of liquidity to RR-Credit dummy



Note: The figures represent the impulse responses of the VAR model with 4 lags and 5 variables: credit growth (non-earmarked new operations), capital flows, leverage (index calculated by the BCB), liquidity (bank credit over deposits) and the RR-Credit dummy. The red lines indicate the standard errors. The decomposition method is generalized impulses.

Part III

Theoretical Model

3 Macroprudential policy in a dynamic stochastic disequilibrium model

Introduction

The general objective of this chapter is to analyze an economy through dynamic models with microfoundations that exhibit intertemporal optimization and rational expectations. The construction of a DSGE model that incorporates the general and dynamic aspects and behavioral interactions of firms, consumers and governments allows for analysis and simulation of the economy. Thus, the objective is to elaborate a model that facilitates the evaluation of the impacts of economic policies, including fiscal, monetary, and macroprudential policies[1], allowing the analysis of fluctuations in the main macroeconomic variables.

The use of DSGE models for macroeconomic analysis is recent. Few Brazilian studies have analyzed the mechanisms through which exogenous shocks, mainly in the financial sector, are transmitted to the real economy, and the relation between these policies and the reduction of financial instability is still obscure. Many DSGE models have already explored the monetary purpose of the instruments, although, in general, they focus only on the interest rate. A plethora of questions remain about the implementation and regulation of these macroeconomic models in the financial sector.

The present thesis intends to extend the DSDE model of Schoder (2016) to include a simple macroprudential policy hypothesis adapted from Vinhado and Divino (2016) and to simulate the model responses by calibrating the parameters.

The DSDE model is similar to DSGE in that its microfoundations feature intertemporal optimization and rational expectations. The DSDE model assumes that wage rate inflation is fixed by a collective bargaining process between firms and workers' representatives and that the risk of income loss faced by the household is permanent. Thus, the household accumulates precautionary savings. The former assumption implies that the nominal wage is not an equilibrating variable as in the DSGE model, and the latter assumption indicates a Keynesian consumption function relating consumption to current income and wealth. Finally, we add a monetary authority adopting an RR to control

1 The macroprudential policy debate incorporates instruments that are used periodically in the pursuit of the financial stability of the overall economic system (GALATI; MOESSNER, 2011).

the supply of funds directly to the household as a macroprudential policy problem. The remainder of this chapter is organized as follows. Section 3.1 provides some references for the DSGE model. Section 3.2 describes the DSDE model. Section 3.4 presents the results: first explaining the implications of the DSDE model, second indicating the model parametrization, and finally, displaying the simulation exercises for the DSDE model. A conclusion is provided in the final section of this chapter.

3.1 Theoretical references

Many DSGE models in New Keynesian economics seek to introduce rigidity and shocks so that economic theory approaches reality and, consequently, fits the observed data. Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2003) are references for DSGE models following the adjustment principle, which pursue adherence to the observed data (COSTA-JUNIOR, 2015). Models developed at IPEA (VEREDA; CAVALCANTI, 2010; CAVALCANTI; VEREDA, 2011) and the BCB (CASTRO et al., 2011), called SAMBA, consider large and medium-sized firms and are reference models compatible with the Brazilian economic context.

Some articles initially explored the assumptions that characterize the financial sector and are included in DSGE models. For example, the financial accelerator hypothesis (BERNANKE; GERTLER; GILCHRIST, 1999) and more complex forms, such as the banking sector (BRZOZA-BRZEZINA; MAKARSKI, 2011) and banking conglomerates (GERALI et al., 2010), consider the inclusion of financial friction on the demand and supply sides of credit.

Regarding financial sector models, Bernanke, Gertler and Gilchrist (1999) present one of the first DSGE models to include financial friction. The authors also include the financial accelerator mechanism so that the focus of financial friction is on the demand side of credit and the financial system amplifies the economic cycle. Brzoza-Brzezina and Makarski (2011) develop a model with more financial sector elements, including friction in the demand for credit requiring collateral from the borrower and a banking sector that charges different funding and lending rates than the established policy rate.

A second aspect of the literature explores another element of economic policy and regulation: stabilizing the financial system as a whole through macroprudential policy. That is, some papers study the role of macroprudential policies and try to incorporate them into modeling. Some economists (WOODFORD, 2011; SVENSSON, 2012) discuss the need to analyze the impacts of macroeconomic policies through modeling that includes a macroeconomic framework that is separate from monetary policy, with its own instruments and objectives (policy goals) to reduce the systemic risk of the overall economy. Some of the instruments that can be incorporated are compulsory deposits, CRs, government-imposed taxes, and capital controls in the case of open economies.

On the other hand, many recent articles highlight the role of macroprudential policy, its instruments and its objectives, including Galati and Moessner (2011), Vinals et al. (2011), Collin et al. (2014), ENGLAND (2009), Borio (2011), Shin (2010), CGFS (2010), among others. These authors agree that the general objective of macroprudential policy is financial stability. Galati and Moessner (2011) provide one definition of financial stability: a financial system that is robust to external shocks. This means a financial system that is resilient to normal-sized shocks such that it can reciver and perform its standard functions (SILVA; SALES; GAGLIANONE, 2013; BORIO; DREHMANN, 2009; VINALS et al., 2011).

To evaluate the conduct of macroeconomic policy, several papers analyze the role of macroprudential instruments in the economy and in the financial system as a whole. Some show that many countries use these as auxiliary instruments of monetary policy and/or as tools of financial stability. Brzoza-Brzezina, Kolasa and Makarski (2013) introduce CRs in order to examine their impact on the economic system using a DSGE model for the euro zone; moreover, Ferreira (2016), Brandi (2013) do so for the Brazilian system, Glocker and Towbin (2012), Agénor, Silva and Awazu (2011) assess the impact of the RR using a DSGE model in the Brazilian context, and Vinhado and Divino (2016) include the two instruments cited above in their model.

3.2 Model

The DSDE model proposed by Schoder (2016) is the reference for our analysis. The DSDE is a DSGE model with modifications to the labor market and household problems. In the latter case, the household faces an uninsurable risk of permanent income loss that creates precautionary saving motives, which in turn, lead to a consumption function that is related to current income and wealth. In the former case, the nominal wage is not an equilibrium variable that clears the labor market. The financial system is included in the model based on the adaptations of Vinhado and Divino (2016). The central bank sets monetary policy and macroprudential rules in order to ensure financial stability.

The economic model is populated by households (economically active and inactive). The final good firm sells consumer goods to households in a perfectly competitive market and buys differentiated goods from a continuum of intermediate firms. These intermediate firms borrow a part of the capital stock from the households. The central bank sets monetary and macroprudential policy, aiming first for a Taylor rule with inflation stabilization. For macroprudential policy, the central bank regulates the economically active households' wealth directly by setting an RR in the budget constraint. The model also considers the government budget to be balanced at all times. The model assumes that the labor market does not clear through an accommodating nominal wage; in particular, nominal wage inflation is subject to a bargaining process between workers and firms. In the simplest case, the rate of wage inflation is constant. The economy grows at deterministic rate given by labor-embodied productivity Γ. (Notation: $\tilde{X}_t \equiv \frac{X_t}{\Gamma^t}$ for any aggregated variable X_t.)

3.2.1 Households

There are two types of households: active and inactive. The first are born into generations of constant size (size 1) and are part of the labor force. They face a per-period risk U of permanent income loss, that is, of the risk of dropping out of the labor force, losing labor and profit sources of income and becoming economically inactive. Once a household is inactive, it cannot return to the labor force. An inactive household faces a per-period probability of death D. [2]

The representative inactive household i does not work or obtain income and faces a per-period probability of death (independent of age). The source of income is the wealth he accumulated during the active state. The stock of wealth is equal across households entering the inactive stage at the same time $(t-s)$, but it is different between households that become inactive at different times. Here, $b_{i,t-s,t}$ is the end-of-period t real wealth held by an inactive household when it becomes inactive in $t-s$ with $s \in \{0, 1, ..., \infty\}$. The household sells wealth at beginning of period t ($R_t P_t b_{i,t-s,t}$, where R_t and P_t are the nominal interest rate and the price level, respectively) to an insurance market in a framework similar to that proposed by Blanchard (1985) and considering that he may die between t and $t+1$ (that is, at beginning of period $t+1$). Thus, the inactive household receives a flow value of bequests from the insurance company (of households still alive $R_{t-1}P_{t-1}b_{i,t-s,t-1}$ and of dead households whose wealth is distributed by the insurance company to households that are still alive $DR_{t-1}P_{t-1}b_{i,t-s,t-1}$). The problem of inactive households is to choose the optimal paths for consumption $(c_{i,t-s,t})$ and wealth $(b_{i,t-s,t})$ subject the budget constraint[3] and conditional on staying alive in a dynamic program of the following form:

$$V_i(b_{i,t-s,t-1}) = \max_{c_i,t-s,t} \{lnc_{i,t-s,t-1} + \beta(1-D)E_t V_i(b_{i,t-s,t})\}$$
$$s.t. \quad c_{i,t-s,t} + b_{i,t-s,t} = \frac{R_{t-1}(1+D)}{\Pi_{p,t}} b_{i,t-s,t-1}$$

where β is the discount factor, $\Pi_{p,t}$ is the gross rate of price inflation, $V_i(b_{i,t-s,t-1})$ is the value function in t, $b_{i,t-s,t-1}$ is the state variable, and E_t is the expectations operator. The

[2] The law of motion of the active population size $\Theta_{a,t}$ is $\Theta_{a,t} - \Theta_{a,t-1} = 1 - U\Theta_{a,t-1}$, and the inactive population size $\Theta_{i,t}$ is $\Theta_{i,t} - \Theta_{a,t-1} = U\Theta_{a,t-1} - D\Theta_{it-1}$. The steady state values are $\Theta_a = 1/U$ and $\Theta_i = 1/D$.

[3] Budget constraint: $P_t c_{i,t-s,t} + P_t b_{i,t-s,t} = R_{t-1}P_{t-1}b_{i,t-s,t-1} + DR_{t-1}P_{t-1}b_{i,t-s,t-1}$.

model derivation is provided in Annex A1. The model aggregation is available in Schoder (2016).

The following equations display the problem of the active households as a dynamic program. The problem is to choose optimal paths for consumption (c_a, t) and wealth ($b_{a,t}$) subject the budget constraint. Active households consume and face a risk U of dropping out of the labor force (i.e., the risk of a permanent income loss), and to insure against this risk, the active households will accumulate precautionary savings.[4] They have the same wealth regardless of when they were born, and they cannot die and lose their income in the same period. The labor supply will be fixed at n, and every active household is affected by unemployment:

$$\begin{aligned} V_a(b_{a,t-1}) &= \max_{c_a,t}\{lnc_{a,t-1} + \beta(1-U)E_tV_a(b_{a,t}) + \beta U E_t V_i(b_{a,t})\} \\ s.t. \quad c_{a,t} + b_{a,t} &= \omega(1-u_t)n + \pi_{d,t} - t_t - \tau_t + \frac{R_{t-1}}{\Pi_{p,t}} b_{a,t-1} - \mu_t b_{a,t} \end{aligned}$$

where ω_t, u_t, $\pi_{d,t}$ and t_t are the real wage, the unemployment rate, distributed profits, and a lump-sum government tax, respectively; $V_a(b_{a,t-1})$ is the value function in t; $b_{a,t-1}$ is the state variable; $V_i(b_{a,t})$ is the value function of active households that become inactive at the beginning of t+1; and τ_t is a simplification for aggregation. It is assumed that wealth is equally distributed across active non-newborn and newborn households at any point in time. Therefore, a newborn receives $b_{a,t} - \tau_t$; in other words, the non-newborn transfer is τ_t of the household wealth. [5] Macroprudential policy is represented as $\mu b_{a,t}$. The central bank charges μ of the household's wealth as a direct RR in order to control the supply of funds.

Calculating the first-order conditions (FOC) of the household problem and their aggregation yields the following main equations. The FOCs of an inactive household are as in equation 3.1, which proportionately relates their consumption in period t to their beginning-of-period wealth by a factor κ, where $\kappa = (1 - \beta(1 - D))$. Since an active household internalizes the inactive household's solution, this gives rise to a crucial property of the household problem: a Keynesian-type consumption function at the steady state. This is because the consumption choice of an inactive household is proportional to its previously accumulated real wealth:

$$\tilde{C}_{i,t} = \kappa \frac{1}{\Gamma} \frac{R_{t-1}}{\Pi_{p,t}} \left(\tilde{B}_{i,t-1} + U\tilde{B}_{a,t-1} \right) \tag{3.1}$$

[4] The adoption of the savings buffer setup is from Carroll (1997), Rabitsch and Schoder (2016) in which the household faces the risk of a permanent income loss and will optimally accumulate precautionary savings. One of the main findings is that the level of steady-state consumption in the buffer stock savings model is lower than in conventional models.

[5] Schoder (2016) assumes that the transfer is financed by a tax on wealth ($\tau_t = \tau b_{a,t}$), and hence, $\tau = U$. This is because $(1/U - 1)\tau b_{a,t} = b_{a,t} - \tau b_{a,t}$; that is, the payment aggregated over all non-newborn active households must equal the receipts aggregated over all newborn active households.

where $\tilde{C}_{i,t}$, $\tilde{B}_{i,t}$ and $\tilde{B}_{a,t}$ are the aggregate consumption of inactive households, the real wealth of inactive households and the real wealth of active households, respectively (all de-trended). Note that $U\tilde{B}_{a,t-1}$ is the wealth that became inactive at the beginning of t. Equation 3.2 is the aggregate budget constraint of the inactive household, and 3.3 is the aggregate budget constraint of the active household, which are normalized by the trend Γ^t. Only active households receive wage and profit income, whereas newly inactive households receive funds from wealth carried over as a previously active household:

$$\tilde{C}_{i,t} + \tilde{B}_{i,t} = \frac{1}{\Gamma}\frac{R_{t-1}}{\Pi_{p,t}}\left(\tilde{B}_{i,t-1} + U\tilde{B}_{a,t-1}\right) \tag{3.2}$$

$$\tilde{C}_{a,t} + (1+\mu_t)\tilde{B}_{a,t} = \tilde{Z}_t + (1-U)\frac{1}{\Gamma}\frac{R_{t-1}}{\Pi_{p,t}}\tilde{B}_{a,t-1} \tag{3.3}$$

where the active household's de-trended aggregate real net income is:

$$\tilde{Z}_t = \tilde{\omega}_t L_t + \tilde{\Pi}_{d,t} - \tilde{T}_t \tag{3.4}$$

where $\tilde{\Pi}_{d,t}$ is the distributed profits of intermediate good firms, and $\tilde{T}_t$ is the lump-sum tax. The labor input L_t is derived from the definition of the unemployment rate:

$$1 - u_t = \frac{L_t}{N} \tag{3.5}$$

Finally, the FOC w.r.t. consumption yields the aggregate consumption Euler equation for the active households in which the discounted expected marginal utility of consumption in the next period includes the risk of permanent income loss and depends on real wealth. This equation is implied by the substitution of the inactive household FOCs for the active household FOCs, observing that the term $\frac{R_t}{\Pi_{p,t+1}}\kappa\tilde{B}_{a,t}$ is the consumption of the newly inactive household in t+1[6]:

$$\frac{1}{\tilde{C}_{a,t}} = \beta(1-U)\frac{1}{\Gamma}E_t\frac{R_t}{\Pi_{p,t+1}}\frac{1}{1+\mu_t}\frac{1}{\tilde{C}_{a,t+1}} + \beta U\frac{1}{\kappa\tilde{B}_{a,t}} \tag{3.6}$$

This equation can be written as follows:

$$\frac{1}{\tilde{C}_{a,t}} = \beta E_t\frac{1}{\Gamma}\frac{R_t}{\Pi_{p,t+1}}\left(\frac{(1-U)}{(1+\mu_t)}\frac{1}{\tilde{C}_{a,t+1}} + U\frac{1}{\frac{R_t}{\Pi_{p,t+1}}\kappa\tilde{B}_{a,t}}\right) \tag{3.7}$$

Final aggregate consumption is defined by:

$$\tilde{C}_t = \tilde{C}_{a,t} + \tilde{C}_{i,t} \tag{3.8}$$

6 Appendix A1 shows the household model derivation.

3.2.2 Firms

The representative final good firm buys a wide variety of intermediate inputs and sell them as a unique basket of consumption goods to households in a perfectly competitive market. The final good firm uses good y_t as an input and takes the price p_t as given for a continuum of differentiated intermediate firms. The minimization cost problem of the final good firms leads to a demand for intermediate good given the final good technology, the price of the intermediate good and the demand for the final good. In others words, the minimization cost problem is subject to final good firm's production function and leads to an inverse relationship between the input price and the demand for a given output of final goods:

$$\min_{\{y_t\}} \int_0^1 p_t y_t dy$$
$$s.t. \quad Y_t = \int_0^1 \left(y_t^{\frac{\epsilon-1}{\epsilon}} dy \right)^{\frac{\epsilon}{\epsilon-1}}$$

where Y_t is final good output and ϵ is the elasticity of substitution of inputs (given by technology and final good demand).[7] The demand of intermediate good can be obtained by FOC w.r.t. $y_{i,t}$:

$$y_t = \left(\frac{p_t}{P_t} \right)^{-\epsilon} Y_t$$

The intermediate good demand depends on the price of the intermediate good relative to the price of the final good.

There is an infinite continuum of intermediate good firms. The representative firm sells differentiated goods to the final firm with some market power under monopolistic competition; it is thus a price maker. The intermediate good y_t is produced using a constant-returns-to-scale Cobb-Douglas technology combining labor l_t and capital k_{t-1} as inputs and facing quadratic adjustment costs in investment and prices. The production function is the following:

$$y_t = (\Gamma k_{t-1})^{\alpha} (\Gamma^t l_t)^{1-\alpha}$$

where $0 \leq \alpha \leq 1$ is the output elasticity of capital, and $\Gamma^t l_t$ is the the labor-embodied productivity that grows at a deterministic rate. At the end of period t, the intermediate firm produces y_t using labor l_t and capital k_{t-1} as inputs (given capital adjustment costs) and choosing the capital good k_t to be used in production in the subsequent period. The

[7] Price elasticity of substitution of inputs is the relative change of the ratio of the intermediate goods $y_{i,t}$ over the relative change of the ratio of the according price $y_{i,t}$. The minimization cost problem is subject to the Dixit-Stiglitz(1977) aggregator, which aggregates technology including monopolistic competition and increasing returns in the short run. The elasticity is invariant to quantity of intermediate firms (infinite number), so the elasticity and markup are constant.

model includes a firm-specific capital assumption in which firms own their capital stock, and their initial capital stock cannot be reduced. For instance, the firm's capital cannot be rented or sold in the market because it is specific to a given firm. This is the case, for example, among real estate companies and firms that use specialized equipment. The following capital accumulation equation states that the capital stock available at the end of period t is equal to the capital stock available in the last period, k_{t-1}, net of period t capital stock depreciation, δK_{t-1}, with δ being the depreciation rate, plus the amount of capital accumulated during period t, which is determined by investments made during that period i_t:

$$k_t = i_t + (1-\delta)k_{t-1}$$

In addition, the intermediate firm's problem includes how much of its investment will be financed externally, that is, the supply of bonds d_t. Firms obtain resources from households, issuing bonds equal to the number of units of capital k_t, where the price of one unit of capital is equal to q_t. This constraint depends on a fixed portion of capital goods measured as an efficient price:

$$d_t = \lambda q_t k_t$$

where λ is the target debt-capital ratio, and q_t is Tobin's q.

Furthermore, the intermediate firm faces adjustment costs in prices and capital. We assume quadratic costs for both costs. This means that the adjustments costs increase disproportionally faster than the amount of capital (or good prices) to be adjusted. Additionally, the function assumes a zero value when there is no shock to increase the cost and when the investment covers depreciation (in the case of price adjustments, when prices do not change). In other words, in setting the nominal prices of their goods and installing new capital in their factories, firms face costly adjustments. The capital and price adjustment costs are assumed to evolve according to the respective equations:

$$\frac{\tau_i}{2}\left(\frac{i_t}{\Gamma k_{t-1}} - (1-(1-\delta)\frac{1}{\Gamma})\right)^2 k_{t-1} \quad and \quad \frac{\tau_p}{2}\Gamma^t\left(\frac{p_t}{p_{t-1}} - \Pi\right)^2$$

where τ_i and τ_p are the adjustment cost scaling parameters, namely, the degree of capital and price rigidity, respectively.

The optimization problem is that the intermediate firm chooses intertemporal paths for prices, labor demand, investment, capital stock and supply of bonds ($\{p_t, l_t, i_t, k_t, d_t\}_{t=0}^{\infty}$, respectively) to maximize the discounted sum of expected future distributed profits taking the total output, the overall price level, the predetermined capital stock and the laws of motion of capital, nominal wages, the production function, the demand function for intermediate goods and the target debt-capital ratio as given:

$$\max_{\{p_t,l_t,i_t,k_t,d_t\}_{t=0}^{\infty}} \left\{ \begin{array}{c} p_t y_t - \omega_t l_t - P_t i_t - P_t \frac{\tau_i}{2} \left(\frac{i_t}{\Gamma k_{t-1}} - (1-(1-\delta)\frac{1}{\Gamma}) \right)^2 k_{t-1} - \\ -P_t \frac{\tau_p}{2} \Gamma^t \left(\frac{p_t}{p_{t-1}} - \Pi \right)^2 + P_t d_t - R_{t-1} P_{t-1} d_{t-1} \end{array} \right\}$$

$$s.t. \quad k_t = i_t + (1-\delta) k_{t-1}$$

$$y_t = (\Gamma k_{t-1})^{\alpha} (\Gamma^t l_t)^{1-\alpha}$$

$$y_t = \left(\frac{p_t}{P_t} \right)^{-\epsilon} Y_t$$

$$d_t = \lambda q_t k_t$$

where ω is the nominal wage per unit of labor, and Λ is the stochastic discount factor (the value of a unit of real profit at time t+j in terms of the value of a unit of real profit at time t). The FOC w.r.t. d_t is:

$$\frac{P_t}{P_t} \Lambda_{t,t} P_t + \frac{P_t}{P_t} \Lambda_{t,t} P_t \eta - E_t \frac{P_t}{P_{t+1}} \Lambda_{t,t+1} R_t P_t = 0$$

$$1 + \eta - E_t \frac{R_t}{\Pi_{p,t+1}} \Lambda_{t,t+1} = 0$$

$$\eta = 0 \tag{3.9}$$

where

$$E_t \Lambda_{t,t+1} = \beta E_t \frac{(1-U) c_{a,t+1}^{-1} + U(1+D) c_{i,t+1,t+1}^{-1}}{c_{a,t}^{-1}} = E_t \left(\frac{R_t}{\Pi_{p,t+1}} \right)^{-1}$$

where η is the Lagrange multiplier with respect to d_t. The firm finances part of its capital acquisition in each period from the resources of the households. Changes in the firm's financing structure, for example, in the amount of cash borrowed, are not relevant from the household perspective. For instance, the household will not charge a higher interest rate for a larger amount of borrowed capital.

The FOC w.r.t. p_t describes the evolution of price setting. In addition, intermediate firms set the same price $p_t = P_t$; thus, a continuum of a mass one of firms produces $y_t = Y_t$:

$$(1-\epsilon) y_t - P_T \tau_p \Gamma^t \left(\frac{p_t}{p_{t-1}} - \Pi \right) \frac{1}{p_{t-1}} + \epsilon P_t \varphi_t \frac{y_t}{p_t} +$$

$$+ E_t \frac{P_t}{P_{t+1}} \Lambda_{t,t+1} P_{t+1} \tau_p \Gamma^{t+1} \left(\frac{p_{t+1}}{p_t} - \Pi \right) \frac{p_{t+1}}{p_t^2} = 0$$

$$(1-\epsilon) Y_t - \tau_p \Gamma^t (\Pi_t - \Pi) \Pi_t + \epsilon \varphi_t Y_t + E_t \Lambda_{t,t+1} \tau_p \Gamma^{t+1} (\Pi_{p,t+1} - \Pi) \Pi_{p,t+1} = 0$$

$$((\epsilon - 1) - \epsilon \varphi_t) \tilde{Y}_t + \tau_p (\Pi_t - \Pi) \Pi_t - E_t \Lambda_{t,t+1} \tau_p \Gamma (\Pi_{p,t+1} - \Pi) \Pi_{p,t+1} = 0 \tag{3.10}$$

All intermediate firms set their prices using the same markup over the same marginal costs. The elasticity of substitution of inputs is derived from the final firm demand for intermediate goods and determines the markup that the intermediate firms charge over their marginal cost (given the price adjustment cost). Consequently, the intermediate firm has a certain degree of market power in monopolistic competition and can set the prices of goods. Nevertheless, price setting incorporates nominal adjustment costs, as noted by Rotemberg (1982). In other words, the model includes nominal price rigidity in which prices are adjusted more slowly than ideal. This adjustment cost leads to good prices that are lower than they would be without nominal rigidity, and as a result, the markup over marginal costs is also smaller. The first term in equation 9 refers to the logic of the markup over the marginal cost; the last two terms are related to the price adjustment cost.

The FOCs w.r.t. i_t and k_t show that the intermediate firm decision is related to investment in terms of the capital stock by the shadow price of investment q_t, namely, by Tobin's theory of investment. It expresses the capital price measured as capital profitability and comes from the constraint – the law of motion of capital – from the firm's optimization problem (Lagrangian multiplier). For instance, the firm will optimally choose i_t given by q_t. In others words, the optimal investment choice in t depends on the value of q_t. Tobin's q in this model implies the marginal value of an additional unit of capital in terms of profits, taking into account capital adjustment costs, that is, when increasing investment today by a one unit, equation 10 (the marginal loss of an increase in i_t) must be equal to equation 11 (the marginal gain due to an extra unit of capital in the subsequent period). In other words, q_t "measure[s] how much profits the firm would gain by having one more unit of capital installed in the next period" Schoder (2016).

The FOC w.r.t. i_t:

$$
\begin{aligned}
-P_t - P_t\tau_i\left(\frac{i_t}{\Gamma k_{t-1}} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)\frac{1}{\Gamma k_{t-1}}k_{t-1} + P_t q_t = 0 \\
q_t = 1 + \tau_i\frac{1}{\Gamma}\left(\frac{i_t}{\Gamma k_{t-1}} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right) \\
q_t = 1 + \tau_i\frac{1}{\Gamma}\left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)
\end{aligned} \tag{3.11}
$$

The FOC w.r.t. k_t:

$$
P_t q_t + P_t\eta_{t+1}\lambda q_t = E_t\frac{P_t}{P_{t+1}}\Lambda_{t,t+1}\begin{bmatrix} P_{t+1}\tau_i\left(\frac{i_{t+1}}{\Gamma k_t} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)\frac{i_{t+1}}{\Gamma k_t} - \\ -P_{t+1}\frac{\tau_i}{2}\left(\frac{i_{t+1}}{\Gamma k_t} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)^2 + \\ P_{t+1}\varphi_{t+1}\alpha(\Gamma k_t)^{\alpha-1}(\Gamma^t l_{t+1})^{1-\alpha} + \\ +P_{t+1}q_{t+1}(1-\delta) \end{bmatrix}
$$

$$
q_t = E_t\Lambda_{t,t+1}\begin{bmatrix} \tau_i\left(\frac{i_{t+1}}{\Gamma k_t} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)\frac{i_{t+1}}{\Gamma k_t} - \\ -\frac{\tau_i}{2}\left(\frac{i_{t+1}}{\Gamma k_t} - \left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)^2 + \\ +\varphi_{t+1}\alpha\left(\frac{\Gamma k_t}{\Gamma^t l_{t+1}}\right)^{\alpha-1} + q_{t+1}(1-\delta) \end{bmatrix}
$$

$$q_t = E_t\Lambda_{t,t+1}\left[\begin{array}{l} \tau_i\left(\frac{\tilde{I}_{t+1}}{\tilde{K}_t}-\left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)\frac{\tilde{I}_{t+1}}{\tilde{K}_t}- \\ -\frac{\tau_i}{2}\left(\frac{\tilde{I}_{t+1}}{\tilde{K}_t}-\left(1-(1-\delta)\frac{1}{\Gamma}\right)\right)^2+ \\ +\varphi_{t+1}\alpha\left(\frac{\tilde{Y}_{t+1}}{\Gamma\tilde{K}_t}\right)^{\alpha-1}+q_{t+1}(1-\delta) \end{array}\right] \tag{3.12}$$

Equations 3.11 and 3.12 refer to the logic of q_t. Equation 3.12 reveals that the long-run desired level of capital is dependent on the long-run level of output (expected sales) $\tilde{Y}_{t+1}$, real wages (represented as real marginal costs φ_{t+1}) and real interest rates (represented in $E_t\Lambda_{t,t+1}$). The short-run dynamics of the desired capital stock are implied by the equations given changes in those variables. For instance, an increase in the real wage given a certain level of output (sales) and a real interest rate, leads to an increase in the desired capital stock (substitution effect). Alternatively, an increase in the real interest rate reduces the desired capital stock given the real wage and the level of output. Note that the short-run dynamics of the desired capital stock, that is, the response of investment to shocks and how long a response takes, also depend on the adjustment costs.

The FOC is obtained w.r.t. the labor demand l_t. The production function can be rewritten: $\left(\frac{yt}{\Gamma k_{t-1}}\right)^{\frac{\alpha}{1-\alpha}} = \left(\frac{\Gamma k_{t-1}}{\Gamma^t l_{t-1}}\right)^{-\alpha}$. The real marginal cost can be obtained:

$$-\omega_t + P_t\varphi_t\Gamma^{t(1-\alpha)}(1-\alpha)l_t^{-\alpha}(\Gamma k_{t-1})^{\alpha} = 0$$

$$\varphi_t = \frac{\omega_t}{P_t}\frac{1}{\Gamma^t}\frac{1}{1-\alpha}\left(\frac{\Gamma k_{t-1}}{\Gamma^t l_t}\right)^{-\alpha}$$

$$\varphi_t = \frac{\omega_t}{P_t}\frac{1}{\Gamma^t}\frac{1}{1-\alpha}\left(\frac{y_t}{\Gamma k_{t-1}}\right)^{\frac{\alpha}{1-\alpha}}$$

$$\varphi_t = \tilde{\omega}_t\frac{1}{1-\alpha}\left(\frac{\tilde{Y}_t}{\tilde{K}_{t-1}}\right)^{\frac{\alpha}{1-\alpha}} \tag{3.13}$$

The de-trended real distributed profits are aggregated as follows. Observing that λ is the debt-capital ratio maintained by the intermediate good firms:

$$\tilde{\Pi}_{d,t} = \tilde{Y}_t + \tilde{\omega}_t L_t + (1-\lambda)\tilde{I}_t + \\ +\frac{\tau_i}{2}\frac{1}{\Gamma}\left(\frac{\tilde{I}_t}{\tilde{K_{t-1}}} - (1-(1-\delta)\frac{1}{\Gamma})\right)^2\tilde{K}_{t-1} - \frac{\tau_p}{2}\left(\Pi_{p,t}-\Pi\right)^2 \tag{3.14}$$

3.2.3 Macroprudential policy

The model includes a RR as macroprudential instrument in the form of fraction μ_t of active household wealth $b_{a,t}$, which is held by the central bank. The macroprudential policy implemented by the central bank obeys the following rule in which μ react positively to variations in credit volume d_t:

$$\frac{\mu_t}{\mu} = \left(\frac{d_t}{d_{t-1}}\right)^{\varphi_{d,\mu}} V_{\mu,t} \tag{3.15}$$

where $V_{\mu,t}$ is an exogenous macroprudential policy shock.

3.2.4 Monetary and fiscal policy

The DSDE model includes government expenditures following an autoregressive process with an assumption of a budget that is balanced at all times and financed by lump-sum taxes:

$$\tilde{T}_t = \tilde{G}_t \tag{3.16}$$

$$\frac{\tilde{G}_t}{\tilde{G}} = V_{G,t} \tag{3.17}$$

where $\tilde{G}$ is steady-state government spending, and $V_{G,t}$ is an exogenous fiscal policy shock. The monetary authority defines monetary and macroprudential rules to ensure monetary and financial stability, respectively. The monetary authority sets the interest rate according to a simple Taylor rule that considers only inflation stabilization:

$$\frac{R_t}{R} = \left(\frac{\Pi_{p,t}}{\Pi}\right)^{\phi_{r\pi}} V_{R,t} \tag{3.18}$$

where R is the steady-state policy rate, Π is the steady-state inflation rate, $\phi_{r\pi}$ measures the elasticity (sensitivity) of the interest rate to deviations in inflation from the steady-state rate, and $V_{R,t}$ is a monetary policy shock.

3.2.5 Market clearing and model closure

The DSGE model assumes an accommodating nominal wage that ensures that the labor supply equals the labor demand. The DSDE has a Keynesian closure in the sense that the rate of wage inflation is subject to a bargaining process between worker and firm representatives, with a Nash solution to the optimization problem. In other words, nominal wage inflation is a non-accommodating variable in the labor market:

$$\max_{\Pi_{\omega,t}} (\tilde{\omega}(\Pi_{\omega,t}))^{\nu_t} (r(\Pi_{\omega,t}))^{1-\nu_t}$$

with

$$\frac{\nu_t}{\nu} = (1 - u_t)^{\phi_u} V_{\nu,t} \tag{3.19}$$

where V_t is an exogenous shock to bargaining power, $\tilde{\omega}(\Pi_{\omega,t})$ is the steady-state real wage, and $r(\Pi_{\omega,t})$ is steady-state profit rate. These last two variables represent the return functions of workers and firms, respectively, where the former increases with the rate of wage inflation and the later decreases. Thus, this is a game between the return functions of two agents concerned with the long-run implications of the bargaining process. The FOC shows the evolution of the desired rate of wage inflation ($\Pi_{\omega,t}$):

$$1 = (1 - 1/\nu_t)\frac{\tilde{\omega}(\Pi_{\omega,t})}{r(\Pi_{\omega,t})}\frac{r'(\Pi_{\omega,t})}{\tilde{\omega}'(\Pi_{\omega,t})} \tag{3.20}$$

The parameter ϕ_u can assume values of 0 or 2; that is, it is equal to 2 when there is feedback from the labor market to wage formation and 0 when there is no feedback effect. Thus, the rate of wage inflation is constant. The relation between the growth rate of real wage and wage or price inflation is given by:

$$\frac{\tilde{\omega}_t}{\tilde{\omega}_{t-1}} - 1 = \Pi_{w,t} - \Pi_{p,t} \tag{3.21}$$

The macroeconomic balance condition that aggregate demand equals output ensures that the good market clears:

$$\tilde{Y}_t = \tilde{C}_t + \tilde{I}_t + \tilde{G}_t + \frac{\tau_i}{2}\frac{1}{\Gamma}\left(\frac{\tilde{I}_t}{\tilde{K_{t-1}}} - (1 - (1-\delta)\frac{1}{\Gamma})\right)^2 \tilde{K}_{t-1} - \frac{\tau_p}{2}\left(\Pi_{p,t} - \Pi\right)^2 \tag{3.22}$$

Therefore, this model hypothesizes that the labor market is not cleared by the nominal wage, and the consequence is output determination by aggregate demand.

3.2.6 Exogenous shocks

The following equations exhibit the assumption of autoregressive exogenous shocks to monetary policy, fiscal policy, worker bargaining power and macroprudential policy. They evolve according to:

$$V_{R,t} = (V_{R,t-1})^{\rho_R} \exp \varepsilon_{R,t} \tag{3.23}$$

$$V_{G,t} = (V_{G,t-1})^{\rho_G} \exp \varepsilon_{G,t} \tag{3.24}$$

$$V_{\mu,t} = (V_{\mu,t-1})^{\rho_\mu} \exp \varepsilon_{\mu,t} \tag{3.25}$$

$$V_{\nu,t} = (V_{\nu,t-1})^{\rho_\nu} \exp \varepsilon_{\nu,t} \tag{3.26}$$

where $\varepsilon_{R,t}$, $\varepsilon_{G,t}$, $\varepsilon_{\mu,t}$ and $\varepsilon_{\nu,t}$ are assumed to be exogenous, i.i.d. and normal innovations ($\sim N(0,1)$).

3.3 Model results

The representation of the economy as a general equilibrium model with linearized equations derived from the dynamic optimization problem of the agents in the economy is subject to some restrictions, is not a trivial methodology and is dependent on a numerical solution and a state-space representation. Therefore, the adoption of these models generates requires the researcher to use complex mathematical methods to solve the optimization problems of the agents, including new hypotheses and linear approximations of these conditions around a chosen point, the steady state. Non-trivial effort is exerted to obtain the numerical solution to the model and its simulation in order to investigate the dynamics of the relations of interest. This process essentially depends on the calibration of the parameters and the assignment of values compatible with economic reality. The following section describes the parameter calibration and out-of-steady-state dynamics in order to analyze the economy characterized by the DSDE model, as well as the model implications of the DSDE hypothesis.

3.3.1 Implications of the hypothesis and steady state of the DSDE model

The intertemporal consumption problem includes the risk to active households of dropping out of the labor force. Moreover, active households consider the solution to the inactive household problem (consumption proportional to real wealth). In the Euler equation, the active household's expected utility of consumption depends on its previously accumulated wealth. The standard Euler equation includes consumption dependent on individual preferences; in contrast, the DSDE model includes current wealth as related to current consumption. Therefore, the DSDE Euler equation can be called a Keynesian-type consumption function (CARROLL, 1997; RABITSCH; SCHODER, 2016; SCHODER, 2016).[8] This can be seen since there is a equilibrium relationship among income, wealth and consumption. The equilibrium consumption and wealth conditional on income can be calculated :

> Then we have two equations (Euler equation and budget constrain of active household) in the consumption-income ratio and the wealth-income ratio for which the existence of a unique solution can be shown under certain parameter constellations. As we can see, introducing the risk of permanent income loss to the conventional consumer problem implies the existence of an equilibrium consumption-income ratio and wealth-income ratio. With rising income, consumption will increase by a fixed proportion which is very similar to a Keynesian consumption function. (SCHODER, 2016, p.6)

Another implication of the DSDE Euler equation is related to the interest rate. In the standard DSGE model with zero unemployment, the natural interest rate is implied by a parameter restriction on the Euler equation. The central bank's target interest rate also needs to equal the natural interest rate derived from the Euler equation for the steady state to be obtained. The DSDE model has a different logic. The steady-state interest

8 "In comparison with the standard model, the buffer-stock model predicts a much higher marginal propensity to consume out of transitory income, a much higher effective discount rate for future labor income, and a positive rather than negative sign for the correlation between saving and expected labor income growth" Rabitsch and Schoder (2016, p.2).

rate (derived from the Euler equation) needs to equal the target rate; however, the former rate is not implied solely by parameter restrictions. There is a new element of the Euler equation in which consumption is related to wealth and the real interest rate, that is, the steady-state interest rate is implied by the steady states of other variables. In other words, the real interest rate is implied by almost the entire system. Is this the natural interest rate? Not always. In the steady state, the unemployment rate can be different than zero, and with the assumption of a constant nominal wage (without labor feedback), the labor market will not be cleared by the nominal wage, leading to a steady-state interest rate that is different from a steady state in which there is no unemployment. The steady-state interest rate is calculated by using a given wage inflation rate that may or may not equal the natural rate (labor market clearing).

The steady state of the model is calibrated with zero unemployment for comparison (the labor supply clears the market). This means that the steady-state interest rate is equal to the natural rate in this calibration. It is important to note an additional implication of the interest rate mechanism. The real interest rate has to be lower than the deterministic growth rate for the existence of a meaningful steady state in the DSDE model. This restriction stems from the precautionary savings motive that needs a stock of wealth that grows slower than income; otherwise, wealth would increase exponentially. Schoder (2017) alludes to the fact that the DSDE model is dynamic inefficient (a criterion of Pareto efficiency), since the resources are underutilized in equilibrium.

Moreover, the nominal wage is not an accommodating variable that adjusts to clear the labor market, i.e., there is unemployment that is not merely frictional, and nominal wage movements do not eliminate unemployment entirely. As a consequence, business fluctuations (output changes) are not given by changes in the factor markets. This means that the equilibrium adjustment of aggregate output occurs through aggregate spending, which is demand-driven adjustment. Although there is an effect of supply shocks on demand and output through labor market feedback (a supply shock changes relative bargaining power, nominal wage inflation and, consequently, demand), the output is determined by aggregate demand. This is a feature of disequilibrium models.

3.3.2 Parameter calibration

The main parameters of the model are calibrated as in Schoder (2016). In the relevant part of the parameterization, it is appropriate to conduct a literature review of the Brazilian and international literature on the assigned values. The values can be based on the relevant literature and/or estimated via Bayesian techniques and the information contained in the data. This procedure is intended to test the ability of the model to fit the data and to represent stylized facts. The objective of this chapter is to first conduct a simulation exercise using the values assigned by Schoder and adding the parameter values related to macroprudential policy, particularly the RR, as in Vinhado and Divino (2016).

Table 12 lists the parameters and the values they were assigned for the model simulation. The probability of income loss of an active household (U) is such that the old age dependency ratio[9] is 0.3, that is, $U/D = 0.3$, κ is implied by $(1 - \beta(1 - D))$, and N is the aggregate labor supply calibrated such that there is no unemployment in the steady state since the analysis is centered on deviations from the steady state. Specifically, labor supply is equal to labor demand, as wage inflation is zero in the steady state, and the real wage is associated with a value that clears the labor market. Here, $\phi_{\upsilon,u}$ takes the value 0 for no labor market feedback and 2 for labor market feedback.

Regarding central bank macroprudential policy, ϕ_μ assumes the value 0.255, as stipulated in Vinhado and Divino (2016). The central bank response to credit volume fluctuations is assumed to be tepid (1/4 of the increase/decrease in credit volume) because the RR is only somewhat frequently used. This parameter is the only value calibrated as in Vinhado and Divino (2016), and we have defined a steady-state RR of 20% (0.2). The remaining parameters are defined as in Schoder (2016).

Table 12 – Parameter calibration

Parameters	Definition	Value
Household		
Γ	Growth factor of labor-embodied productivity	1.01
β	Household discount rate	0.998
D	Probability of death (inactive households)	0.002
U	Probability of income loss (active households)	0.0006
κ	Steady-state consumption-wealth ratio of inactive households	0.004
Firm		
α	Output elasticity of capital	0.4
δ	Rate of capital depreciation	0.025
ϵ	Elasticity of substitution of intermediate goods	3
λ	Target debt-capital ratio	0.15
τ_i	Investment adjustment cost scaling parameter	30
τ_p	Price adjustment cost scaling parameter	100
Central Bank		
$\phi_{r,\pi}$	Inflation elasticity of the interest rate	1.1
Π_p	Target inflation rate of the monetary authority	1
R	interest target of the monetary authority	1.002
$\tilde{G}$	Steady-state government expenditures	1
ρ_G	Persistence of a government spending shock	0.7
μ	Steady-state reserve requirement	0.2
ϕ_μ	Response of the reserve requirement to credit oscillations	0.255
Bargaining problem		
$\phi_{\nu,u}$	Unemployment elasticity of the workers' bargaining power	0 and 2
ρ_ν	Persistence of wage inflation	0.7

Source: (SCHODER, 2016; VINHADO; DIVINO, 2016)

[9] The number of elderly people as a share of those of working age.

3.3.3 Impulse-response analysis

This section presents a model simulation exercise for macroeconomic variables in the DSDE model given as exogenous shocks. The predicted macroeconomic effect is revealed by an impulse-response analysis over an interval of forty quarters. The model dynamics are reported given an exogenous shock to budget-neutral fiscal policy, monetary policy, macroprudential policy and worker bargaining power. The main idea is to understand not only the effect of macroprudential policy but also the overall transmission mechanism of the model. The following figures display the responses to exogenous policy economic shocks that cause deviations from the steady state.

3.3.3.1 Fiscal policy shock

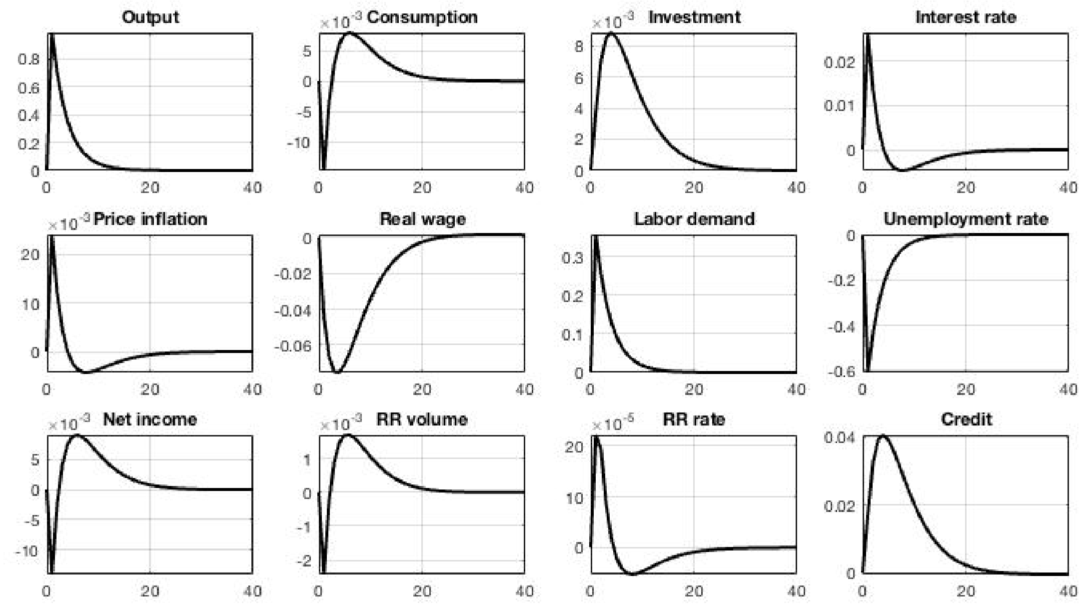
Figure 17 plots the impulse-response functions for a 1% budget-neutral government spending shock. The baseline model assumes constant wage inflation (unemployment elasticity of the workers' bargaining power $\phi_{\nu,u} = 0$) and lump-sum taxes of the same amount as government expending (the purpose is to maintain a balanced budget). The model dynamics work similarly to those in a textbook Keynesian model, with multiplier effects in output, consumption and investment for twenty quarters and without crowding-out effects for the last two variables. Output increases by approximately 1.00 units, and consumption increase by approximately 0.08 units in the sixth quarter and investment increase by about 0.09 units in the fourth quarter. Consumption and net income initially decrease after an interest rate hike.

Despite higher taxes and RRs at the beginning of the period, disposable income increases make it possible for households to spend more on consumption goods. The credit volume increases, and higher prices reduce the real wage at a given nominal wage, which in turn, decreases the unemployment rate and stimulates investment. The interest rate increases, reducing prices and elevating real wages. The propagation mechanism is the adjustment not only of prices but also of quantities.

3.3.3.2 Monetary policy shock

The transmission mechanism for a 1% interest rate shock in the economic model is displayed in Figure 18. Output, consumption and investment decrease, and the interest rate increases moderately as prices return to their steady-state values. Disposable income and credit volume decrease, as does the RR volume. The real wage increases given the initial fall in prices, but since firms consider real marginal costs when setting the prices of intermediate goods, the prices eventually increase and the real wage decreases, with some persistence after twenty periods. The prices and capital adjustment costs also contribute persistence to the aggregate demand variables and their components as they return to their steady-state levels. An increase in real wages is sufficient only for returning investment

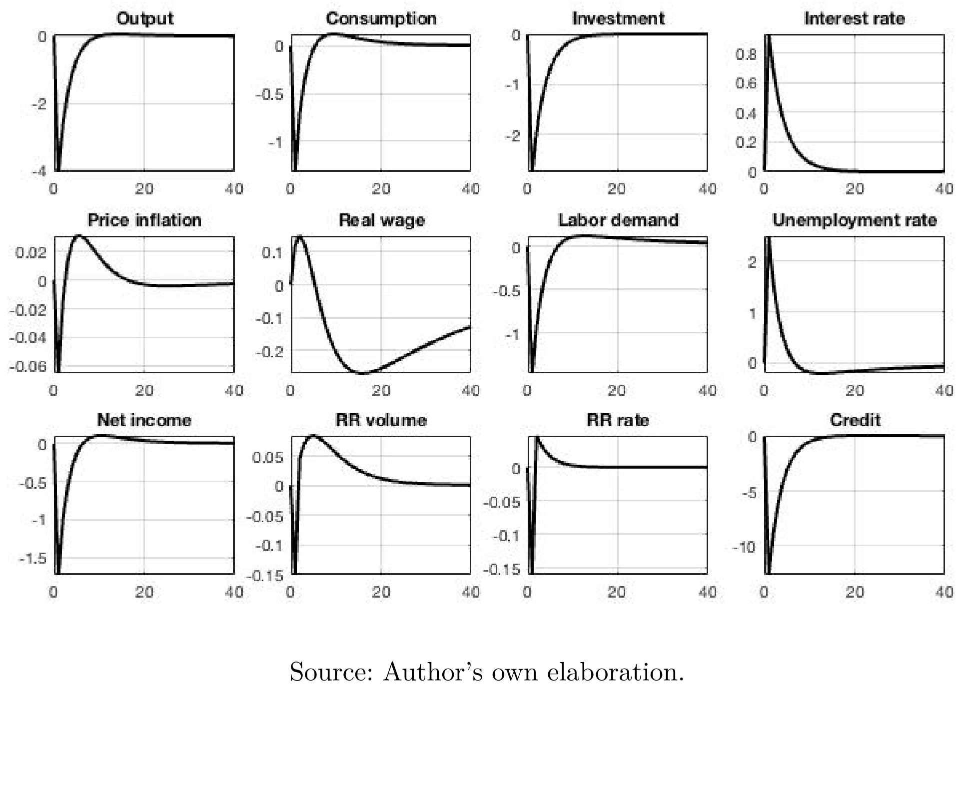
Figure 17 – Responses to a 1% persistent budget-neutral government spending shock



Source: Author's own elaboration.

to the steady-state level. The substitution effect does not work in the initial period because, given predetermined capital, a higher real wage is correlated with a decrease in the output-capital ratio (Yt/Kt-1 - equation 3.13), which in turn, reduces the initial output. A decrease in investment is associated with a rising real interest rate that reduces the desired capital stock.

Figure 18 – Responses to a 1% persistent interest rate shock



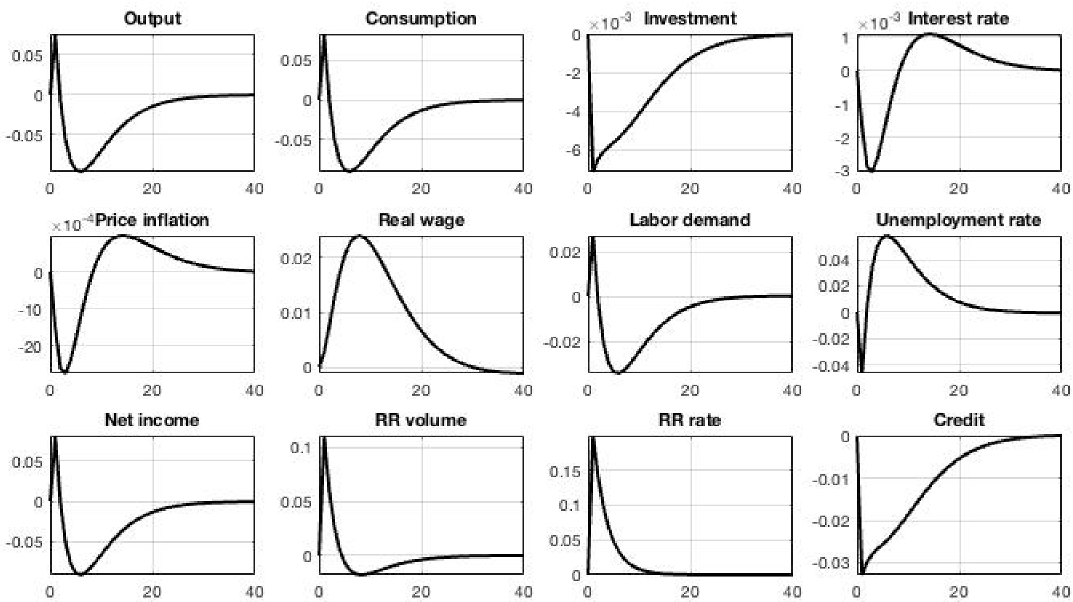
Source: Author's own elaboration.

3.3.3.3 Macroprudential policy shock

The effects of an exogenous contractionary RR shock in the DSDE model are depicted in Figure 19. The macroprudential policy shock has the opposite effects on macroeconomics variables as a government expenditure shock. A higher RR acts similarly to a lump-sum tax in the model, decreasing disposable income and, given multiplier effects, reducing output, investment and consumption. The credit volume also decreases. With an initial decrease in prices, the consequence is an increase in real wages and increase in unemployment rate. Returning to equilibrium after a macroprudential policy shock takes about as long as recovery following a fiscal policy shock.

Vinhado and Divino (2016) note that macroprudential policy could be either a substitute for or a complement to monetary policy given its effects on lower inflation in their model. The decrease in prices following a contractionary RR rate shock is reproduced in the DSDE model, which is consistent with the related literature on the effects of the economic cycle.

Figure 19 – Responses to a 1% persistent reserve requirement shock



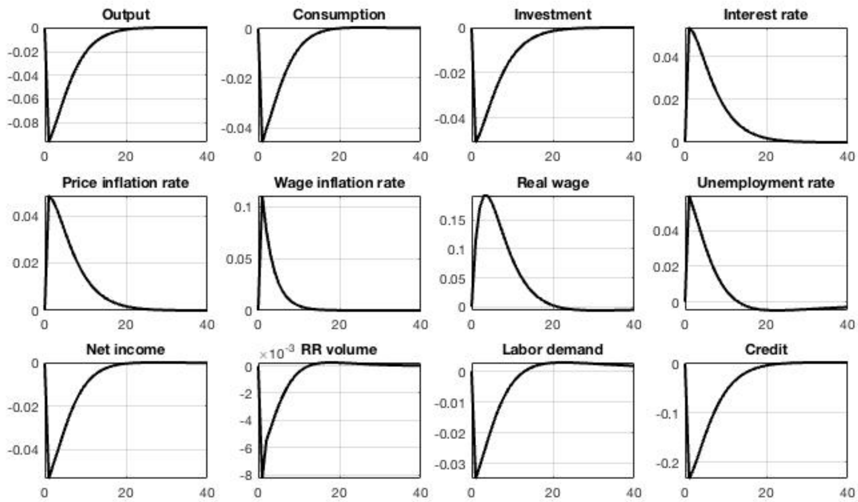
Source: Author's own elaboration.

3.3.3.4 Worker bargaining power shock

Figure 20 shows the impulse-response functions for a 1% persistent shock to worker bargaining power in the model. The increase in price inflation induces an increase in real wages and a subsequent decrease in aggregate demand and its components. Given a labor supply and a capital stock, increases in real wages and in the real interest rate are sufficient to increase real marginal costs and to reduce the expected profits of firms (evaluated as

Tobin's q), causing increases in unemployment and price inflation and decreases in income, credit volume and RR volume.

Figure 20 – Responses to a 1% persistent worker bargaining power shock



Source: Author's own elaboration.

3.4 Changing unemployment elasticity of workers' bargaining power

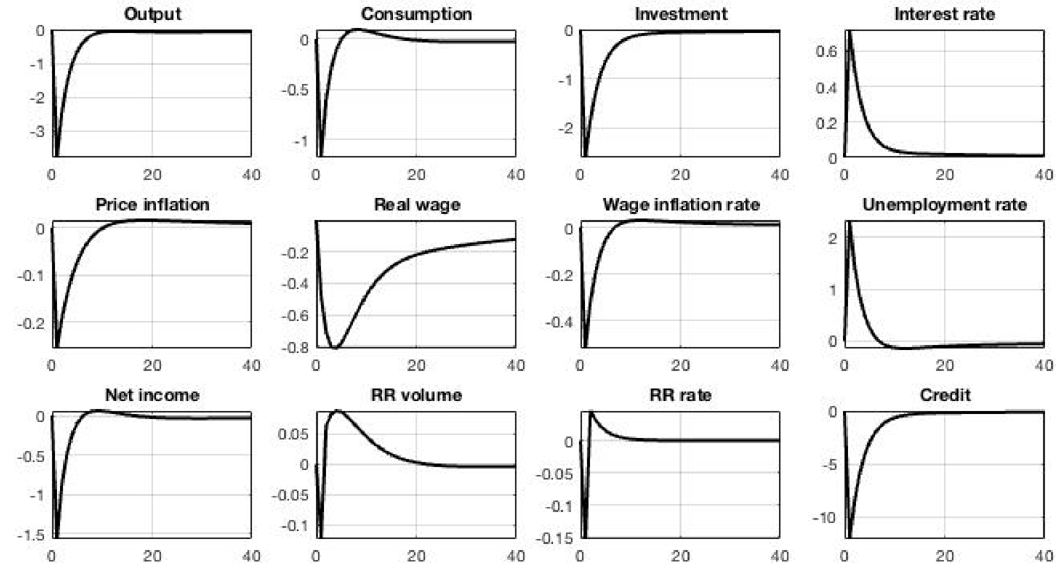
One property of the model is a fixed nominal wage given the bargaining process between worker and firm representatives. The simulation exercise in the last section examined the DSDE model with a constant wage inflation rate, that is, $\phi_{\nu,u} = 0$. Now, the model simulation process assumes feedback from the labor market to wage formation $\phi_{\nu,u} = 2$. The impulse-response analysis is depicted in figures 21 and 22. Some variables exhibit considerable changes in performance compared with the previous analysis.

A monetary policy shock has the same effect on the majority of variables (Figure 21a) as the baseline model. However, there is a disparity in prices. Price inflation fell more and reduced real wages compared with the baseline model, indicating that the decline in wage inflation was steeper than that of price inflation. Thus, the interest rate increase due to the persistence of the shock was smaller, with $\phi_{\nu,u} = 2$.

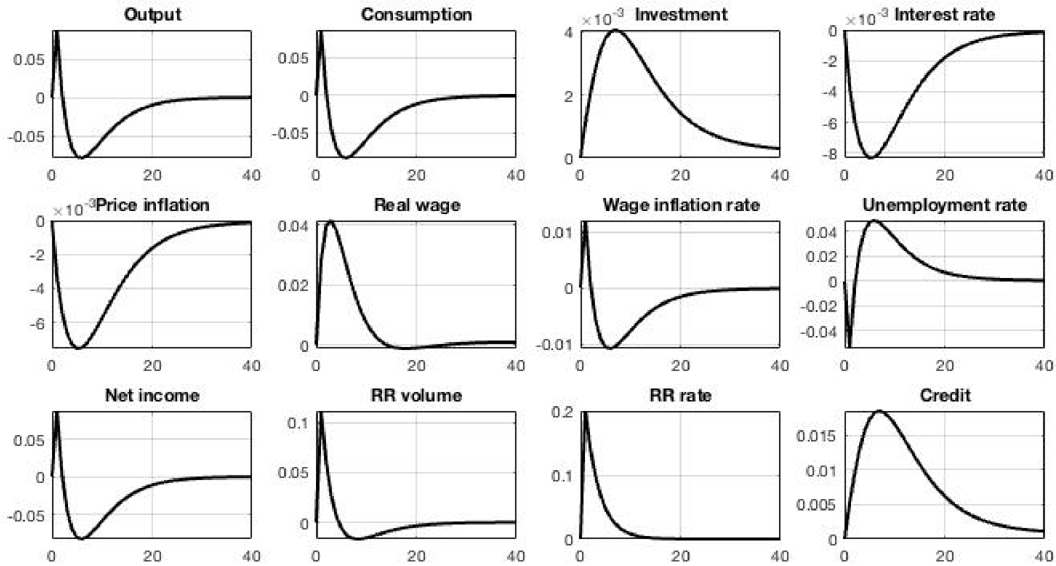
The macroprudential policy shock is displayed in Figure 21b. The responses of output, consumption, net income and RR volume to an RR shock are the same as in the baseline model. Nevertheless, the trend in investment changed to a upswing because the environment for firm investing was improved by lower interest rates. The effects of the shock reduce price inflation, which in turn, lead the central bank to lower interest rates. At first, workers ask for higher nominal wages, but when they see the decline in output and prices, they accept lower wages.

Figure 21 – Impulse-response analysis (bargaining process)

(a) Responses to a 1% persistent interest rate shock



(b) Responses to a 1% persistent reserve requirement shock

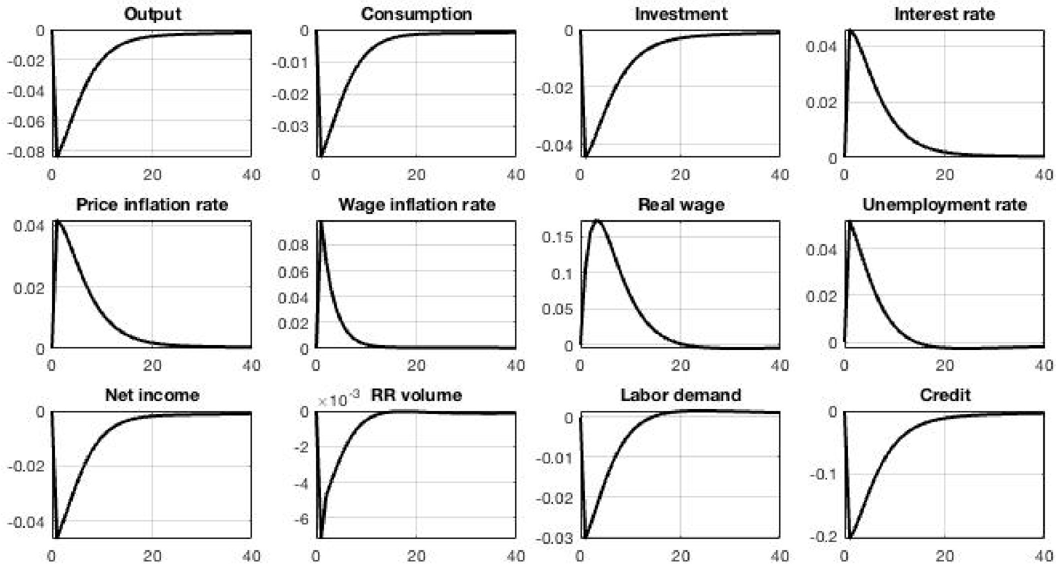


Source: Author's own elaboration.

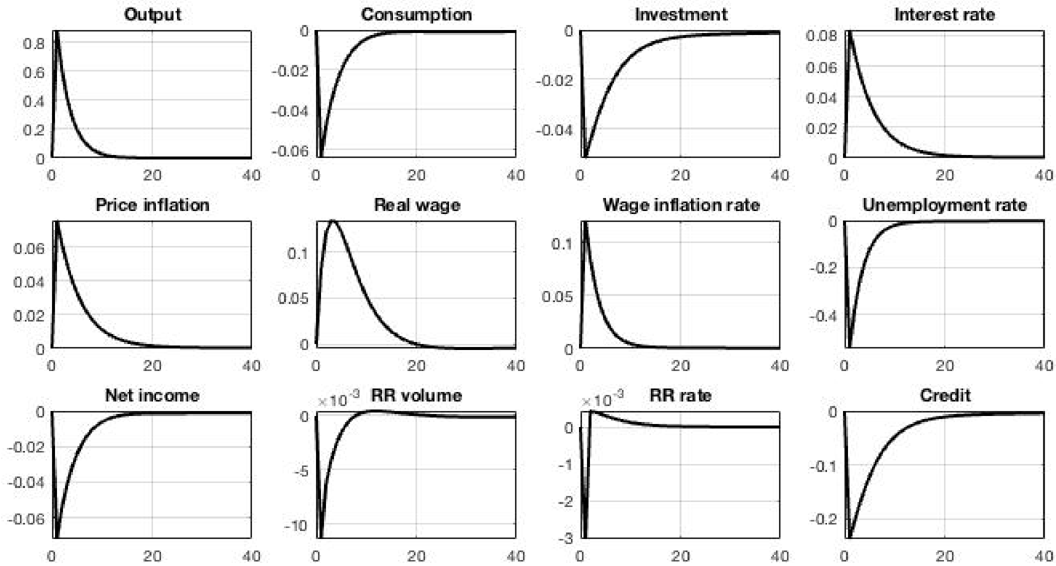
The responses of all variables to a worker bargaining power shock are almost the same as in the baseline model, with slightly higher quantities and slightly lower prices. In this simulation, the fiscal shock changed variable performance. As the wage inflation rate rise by more than price inflation, real wages increase along with an interest rate elevation that has a negative impact on consumption, investment, net income, and in turn, on the volume of credit and RR (Figure 22b).

Figure 22 – Impulse-response analysis (bargaining process)

(a) Responses to a 1% persistent worker's bargaining power shock



(b) Responses to a 1% persistent budget-neutral government spending shock



Source: Author's own elaboration.

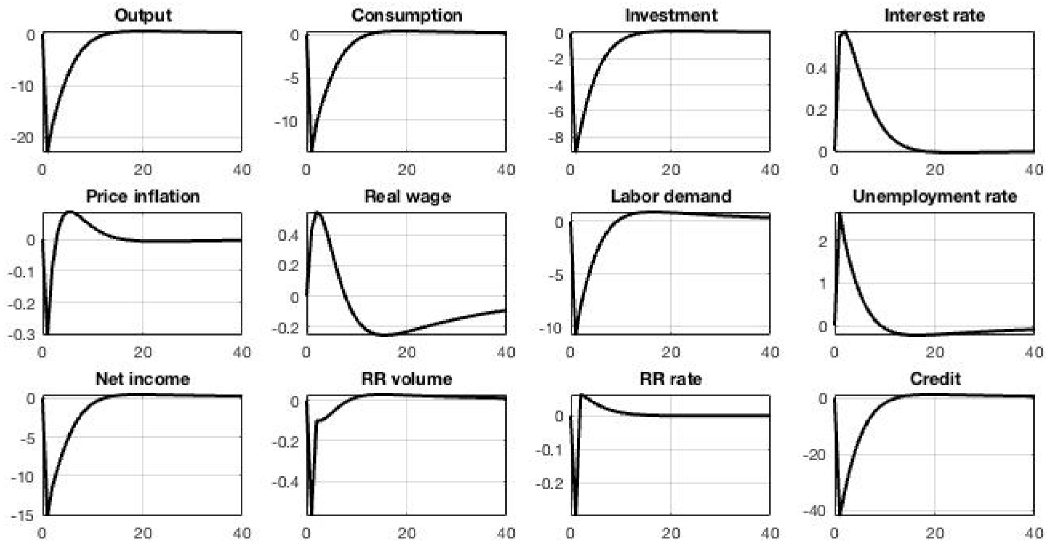
3.5 Impulse-response analysis with Brazil's parameters values

In this section, some parameters values are varied based on the Brazilian literature in order to evaluate the DSGE model predictions. This simulation exercise was conducted to observe how the model behaves with parameter variation without the formal concern of justifying the assigned values.

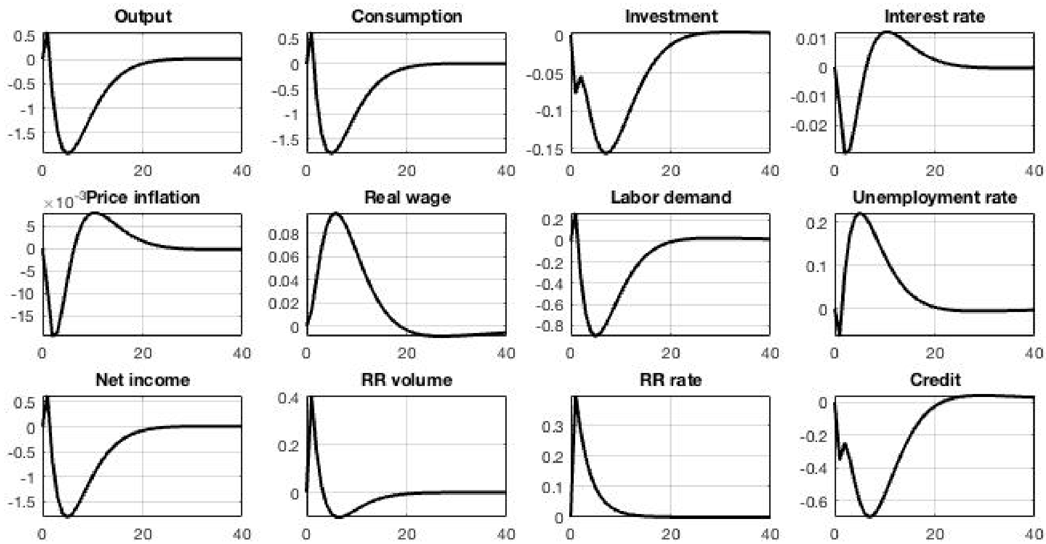
The deterministic trend (Γ) is increased by 0.005 to 1.015, as emerging countries usually grow faster than developed countries. The household discount rate is reduced to 0.995. The probability of income loss (U) is calibrated such that the old-age dependency ratio U/D is 0.15. Emerging countries usually have higher consumption patterns and fewer elderly people as a share of the population compared with developed countries. The parameter $\phi_{r,\pi}$ was set to 1.5 with respect the permissive range observed by Cavalcanti and Vereda (2011). Since the BCB sets an RR of 40% on deposits, the steady-state RR is 0.4. The remaining parameters are calibrated as in Schoder (2016).

Figure 23 – Impulse-response analysis (Brazil's parameters)

(a) Responses to a 1% persistent interest rate shock



(b) Responses to a 1% persistent reserve requirement shock

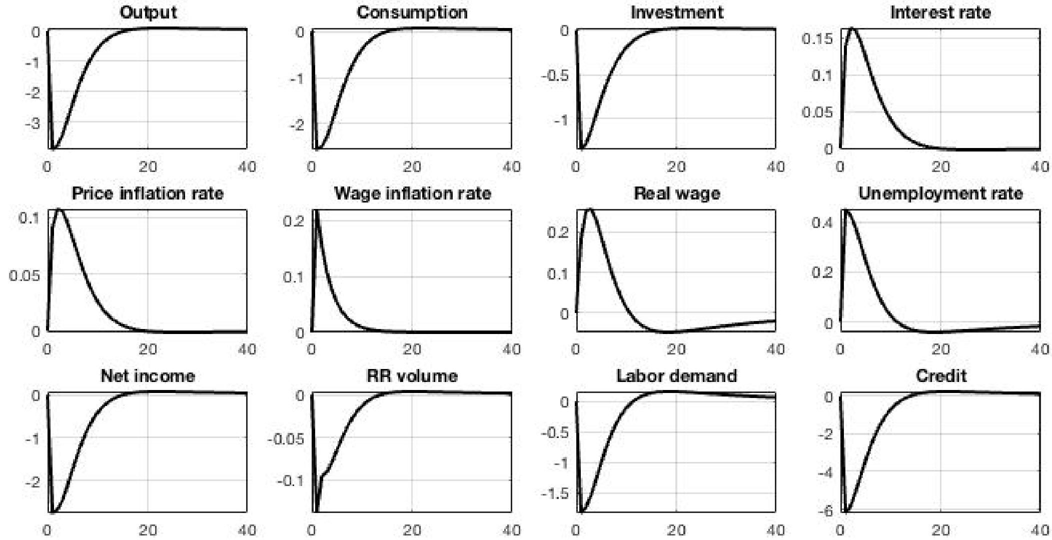


Source: Author's own elaboration.

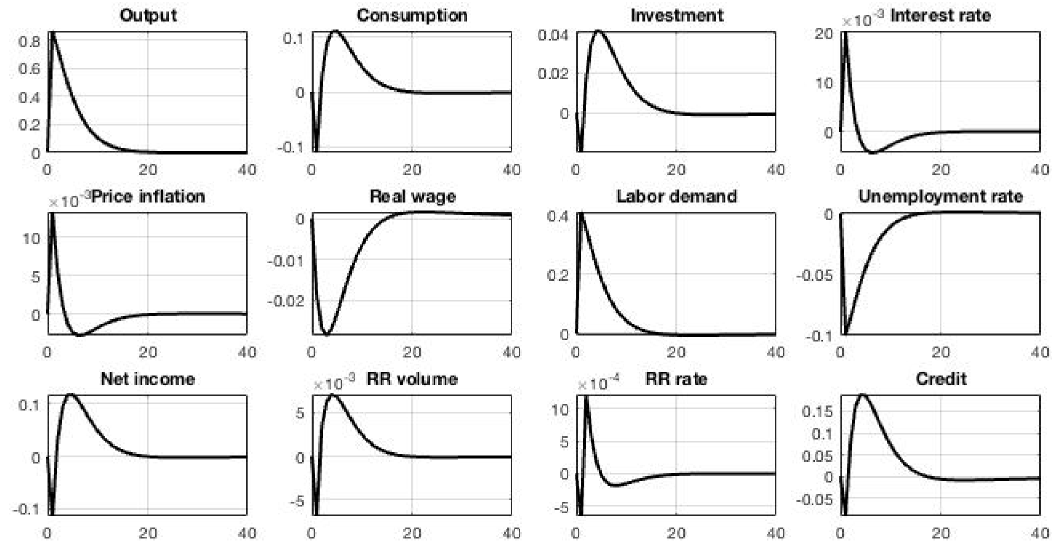
A given monetary policy shock has a stronger impact on quantities and a weaker

Figure 24 – Impulse-response analysis (Brazil's parameters)

(a) Responses to a 1% persistent worker bargaining power shock



(b) Responses to a 1% persistent budget-neutral government spending shock



Source: Author's own elaboration.

impact on prices (Figure 23a). In other words, the aggregate demand exhibits a greater decline compared with the baseline model to the tune of -23.00 units. Additionally, the weaker effects on prices, in turn, reduces the need for higher interest rates. This trend in variable performance is shared with the other shock simulations tests for the model, namely, macroprudential policy, fiscal policy and worker bargaining power shocks (Figures 23 and 24).

Conclusion

The overall proposal is to verify the model's response, through key macroeconomic variables, to changes in economic policies and to external shocks. This chapter seeks to contribute to theoretical modeling for the evaluation of macroeconomic scenarios, particularly for models of dynamic intertemporal optimization, which are widely used by policy makers to understand the Brazilian framework and to forecast economic variables. Specifically, this analysis contributes to the important function of evaluating economic policy strategies and their effects on long-term growth.

The thesis proposes the inclusion of a macroprudential instrument, an RR that acts directly on household wealth, in a Keynesian framework in which households face the probability of income loss, save in a precautionary way, are subject to unemployment and wage inflation is fixed by Nash solution to a bargaining process between worker and firm representatives. The continuum of intermediate good firms faces quadratic adjustment costs in capital and prices and is subject to some restrictions in its operating environment.

This is the first simulation of the DSDE model for Brazil, and although it is still being calibrated, the model has already demonstrated some expected results. RRs reduce price inflation, credit volume and the interest rate. Also, the RR causes a small recession in the economy, with reductions of output, consumption and investment, but the reduction in aggregate demand is smaller than that from a monetary policy shock. However, one problem was identified: the increase in variable volatility after a given shock. Fiscal and monetary policy shocks showed some outcomes predicted by Keynesian models without the crowding out private investment given an increase in government spending and a negative impact on aggregate demand given an interest rate shock. This is a peculiarity of disequilibrium models with fixed prices even in the steady state. The bargaining problem between workers and firms over the rate of wage inflation is a important assumption of the DSDE model and is another Keynesian feature.

Based on the model elaborated above, future developments of the model should estimate the parameters from the Brazilian data using Bayesian techniques in order to determine for the actual values of the structural parameters of the model in the Brazilian context and to fine-tune the model using data. Another possibility is the inclusion of financial intermediation by banks or the financial sector. It is expected that the incorporation of the financial sector into our model would highlight transmission channels from this sector to the real economy, as well as the economic policy shocks, particularly macroprudential policies, that can help smooth the business cycle.

Conclusion

What is expected of macroprudential policy? The recent academic literature seeks economic policies for monitoring and controlling the stability of the financial system. Chapter 1 attempts to summarize the recent policy debate on the supervision, regulation, and control of systemic financial market risks, as well as the instruments that can prevent financial crises, particularly transmission to the real economy. In other words, such macroprudential policies lean against the wind, acting before the materialization of risk to mitigate problems arising from the evolution of systemic risk between institutions and over the financial cycle. Ultimately, the goal is reducing macroeconomic instability. It should be noted that this result – the mitigation of systemic risk and the containment of financial crises – is expected from macroprudential policy. However, will this result appear in historical data or in the historical averages of the data series? These are questions that chapter 2 seeks to answer.

Chapters 1 and 2 summarize the performance of macroprudential policy in Brazil during the period from 2007 to 2015. The first contextualizes the Brazilian financial system with respect to the sectors responsible for containing instability and the main policies implemented during this period. Brazilian institutions have a broad scope to regulate the financial system, although this task falls mainly to the BCB. The descriptive data and the econometric analysis indicate that macroprudential policy does not change the series averages, which are proxies for systemic risk. The descriptive analysis in this thesis indicates that policies are periodic and are implemented with instruments directed to the each area of risk. Macroprudential policies were effective during this period.

Macroprudential policy, particularly through institutional instruments and arrangements, aims to mitigate the instability of the system with the objective of having positive macroeconomic effects. However, some results are not macroeconomic but sectoral. If these results do not appear in the macroeconomic data, does this mean that the policies are not efficient? Not if they are able to contain the risk in that sector. The results show some efficiency for the expected results.

Another point is of paramount importance: the role of macroprudential policy is ex ante, that is, it seeks to act before the materialization of a risk and before the risk can spread through the macroeconomy and the financial system. Theoretically, the effects will not be realized, and thus, they do not appear macroeconomically. There are few country-level empirical studies, with only panel data used to compare countries. Because of the macroprudential policy role in ex ante risk identification, the determination of institutional tools and arrangements is subjective and often dependent on discretionary determinations. That is, macroprudential policy must be analyzed on a case-by-case basis given its multiplicity of factors, institutional arrangements, relationships with other countries and available tools.

In addition, there may be other measurement problems and issues with estimation, for example, if the series chosen are not good proxies for systemic risks or the method chosen is not satisfactory for estimation. Analyzing macroeconomic data with econometrics has always been a challenge for researchers, even more so when the goal is to identify systemic risks.

The model in chapter 3 shows that macroprudential instruments have effects on the economy and can be used in conjunction with other policies. The economy was simplified and included only one macroprudential instrument, the RR, which is a monetary tool that has been used in the past. The DSDE model indicates that these policies also influence the system and are able to reduce credit, prices and output in the system.

Another question may arise: can macroprudential policies be called macroeconomic policies? Yes, they can, mainly because of the monitoring of macroeconomic instability and the evidence that the RRs affects the real economy in the DSDE model. However, the instruments are still not used in exclusively macro ways; many policies are carried out microeconomically and periodically. They effectively depend on each type of instrument and the direction of risk. In this way, the ideal is for these tools to be called prudential policies because they depend on various factors, types of financial firms, financial system structure and interconnections within the system itself, with real economy and with other countries. In sum, the essential parts of macroprudential policy are monitoring, regulation and supervision of the financial system. There are multiple policy options and the use of macroprudential tools targeted to each type of risk leads to more effective policy.

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A APPENDIX

A1 Calculation of the Household FOC

Inactive Households:

$$\begin{aligned} V_i(b_{i,t-s,t-1}) = \max_{c_i,t-s,t} \{lnc_{i,t-s,t-1} + \beta(1-D)E_tV_i(b_{i,t-s,t})\} \\ s.t. \quad c_{i,t-s,t} + b_{i,t-s,t} = \frac{R_{t-1}(1+D)}{\Pi_{p,t}} b_{i,t-s,t-1} \end{aligned}$$

Substituting out $b_{i,t-s,t}$ and solving the problem:

$$V_i(b_{i,t-s,t-1}) = \max_{c_i,t-s,t} \{lnc_{i,t-s,t-1} + \beta(1-D)E_tV_i(\frac{R_{t-1}(1+D)}{\Pi_{p,t}} b_{i,t-s,t-1} - c_{i,t-s,t})\}$$

The FOC w.r.t. $c_{i,t-s,t}$ implies the optimum consumption for a given state ($b_{i,t-s,t}$):

$$\begin{aligned} \frac{1}{c_{i,t-s,t}} &= \beta(1-D)E_tV_i'(\frac{R_{t-1}(1+D)}{\Pi_{p,t}} b_{i,t-s,t-1} - c_{i,t-s,t}) \\ &= \beta(1-D)E_tV_i'(b_{i,t-s,t-1}) \end{aligned} \tag{A.1}$$

The optimal consumption is represented by the function $c^*_{i,t-s,t-1}$ (given the state) and substituted into:

$$V_i(b_{i,t-s,t-1}) = lnc^*_{i,t-s,t-1} + \beta(1-D)E_tV_i(\frac{R_{t-1}(1+D)}{\Pi_{p,t}} b_{i,t-s,t-1} - c^*_{i,t-s,t})$$

The FOC w.r.t. $b_{i,t-s,t-1}$ and using A.1:

$$\begin{aligned} V_i'(b_{i,t-s,t-1}) &= \frac{1}{c_{i,t-s,t}} c^*_{i,t-s,t-1} + \beta(1-D)E_tV_i'(\frac{R_{t-1}(1+D)}{\Pi_{p,t}} b_{i,t-s,t-1} - c^*_{i,t-s,t}) \\ &= \beta(1-D)E_tV_i'(b_{i,t-s,t-1}) \frac{R_{t-1}(1+D)}{\Pi_{p,t}} \\ &= \frac{1}{c_{i,t-s,t}} \frac{R_{t-1}(1+D)}{\Pi_{p,t}} \end{aligned}$$

Iterating forward by one period and substituting into A.1 yields the Euler equation:

$$\frac{1}{c_{i,t-s,t}} = \beta(1-D)E_t \frac{R_{t-1}(1+D)}{\Pi_{p,t}} \frac{1}{c_{i,t-s,t+1}}$$

Iterating forward by several periods yields:

$$\frac{1}{c_{i,t-s,t}} = (\beta(1-D))^n E_t \prod_{k=1}^{n} \frac{R_{t+k-1}(1+D)}{\Pi_{p,t+k}} \frac{1}{c_{i,t-s,t+n}}$$

Considering the beginning-of-period wealth in t for newly inactive household that have not yet participated in the insurance market: $R_{t-1}/\Pi_{p,t} b_{i,t-s,t-1} = R_{t-1}/\Pi_{p,t} b_{a,t-1}$ for s = 0, and for inactive households that have been inactive before: $R_{t-1}(1+D)/\Pi_{p,t} b_{i,t-s,t-1}$ for $s = 1, 2, ..., \infty$. Taking the budget constraint and iterating forward recursively yields:[1]

$$\begin{aligned}
\frac{R_{t-1}}{\Pi_{p,t}} b_{a,t-1} &= b_{i,t,t} + c_{i,t,t} \\
&= \left(\frac{R_{t-1}(1+D)}{\Pi_{p,t+1}}\right)^{-1} b_{i,t,t+1} + \left(\frac{R_{t-1}(1+D)}{\Pi_{p,t+1}}\right)^{-1} c_{i,t,t+1} + c_{i,t-s,t} \\
&= \sum_{n=0}^{\infty} \prod_{k=1}^{n} \left(\frac{R_{t+k-1}(1+D)}{\Pi_{p,t+k}}\right)^{-1} c_{i,t,t+n} \\
&= \sum_{n=0}^{\infty} \prod_{k=1}^{n} \left(\frac{R_{t+k-1}(1+D)}{\Pi_{p,t+k}}\right)^{-1} c_{i,t,t+n} (\beta(1-D))^n E_t \prod_{k=1}^{n} \frac{R_{t+k-1}(1+D)}{\Pi_{p,t+k}} \frac{1}{c_{i,t,t+n}} c_{i,t,t} \\
&= \sum_{n=0}^{\infty} (\beta(1-D))^n c_{i,t,t} \\
&= \frac{1}{1-\beta(1-D)} c_{i,t,t} \\
c_{i,t,t} &= (1-\beta(1-D)) \frac{R_{t-1}}{\Pi_{p,t}} b_{a,t-1} \\
c_{i,t,t} &= \kappa \frac{R_{t-1}}{\Pi_{p,t}} b_{a,t-1}
\end{aligned}$$

It follows that the inactive household chooses consumption proportional to its previous wealth. We deduce the same relations of consumption and wealth for inactive household that have been inactive before ($R_{t-1}(1+D)/\Pi_{p,t} b_{i,t-s,t-1}$ for $s = 1, 2...\infty$):

$$c_{i,t-s,t} = \kappa(1+D) \frac{R_{t-1}}{\Pi_{p,t}} b_{i,t-s,t-1}$$

Active household problem:

$$\begin{aligned}
V_a(b_{a,t-1}) &= \max_{c_a,t} \{ lnc_{a,t-1} + \beta(1-U) E_t V_a(b_{a,t}) + \beta U E_t V_i(b_{a,t}) \} \\
s.t. \quad c_{a,t} + b_{a,t} &= \omega(1-u_t)n + \pi_{d,t} - t_t - \tau_t + \frac{R_{t-1}}{\Pi_{p,t}} b_{a,t-1} - \mu_t b_{a,t}
\end{aligned}$$

[1]

$$b_{i,t-s,t-1} = \left(\frac{R_{t-1}(1+D)}{\Pi_{p,t}}\right)^{-1} b_{i,t-s,t} + \left(\frac{R_{t-1}(1+D)}{\Pi_{p,t}}\right)^{-1} c_{i,t-s,t+1}$$

The FOC w.r.t. consumption is:

$$\frac{1}{c_{a,t}} = \beta(1-U)E_tV_a'(b_{a,t}) + \beta U E_t V_i'(b_{a,t})$$

Substituting the function $c_a^*(b_{a,t-1})$ back into the objective (given state, $b_{a,t-1}$):

$$V_a(b_{a,t-1}) = \max_{c_a,t}\{lnc^*_{a,t-1}(b_{a,t-1}) + \beta(1-U)E_tV_a(b_{a,t}) + \beta U E_t V_i(b_{a,t})\}$$

The FOC w.r.t. $b_{a,t-1}$, noting that $c_a^{*\prime}(b_{a,t-1}) = 0$ and using the FOC w.r.t. consumption, yields:

$$\begin{aligned}
V_a'(b_{a,t-1}) &= \frac{1}{c_a^*(b_{a,t-1})}c_a^{*\prime}(b_{a,t-1}) + \beta(1-U)E_tV_a'(b_{a,t})(\frac{R_{t-1}}{\Pi_{p,t}} * \frac{1}{1+\mu_t} - c_a^{*\prime}(b_{a,t-1}) * \frac{1}{1+\mu_t}) + \\
&\quad +\beta U E_t V_i'(b_{a,t})(\frac{R_{t-1}}{\Pi_{p,t}} * \frac{1}{1+\mu_t} - c_a^{*\prime}(b_{a,t-1}) * \frac{1}{1+\mu_t}) \\
&= \beta(1-U)E_tV_a'(b_{a,t})\frac{R_{t-1}}{\Pi_{p,t}}\frac{1}{1+\mu_t} + \beta U E_t V_i'(b_{a,t})\frac{R_{t-1}}{\Pi_{p,t}}\frac{1}{1+\mu_t} \\
&= \frac{1}{c_{a,t}}\frac{R_{t-1}}{\Pi_{p,t}}\frac{1}{1+\mu_t}
\end{aligned}$$

A2 Firm Aggregation

The law of motion of the capital stock:

$$\begin{aligned}
k_t &= i_t + (1-\delta)k_{t-1} \\
K_t &= I_t + (1-\delta)K_{t-1} \\
\frac{K_t}{\Gamma^t} &= \frac{I_t}{\Gamma^t} + (1-\delta)\frac{k_{t-1}}{\Gamma^t} \\
\tilde{K}_t &= \tilde{I}_t + (1-\delta)\frac{1}{\Gamma}\tilde{K}_{t-1}
\end{aligned} \tag{A.2}$$

Production function:

$$\begin{aligned}
y_t &= (\Gamma k_{t-1})^\alpha(\Gamma^t l_t)^{1-\alpha} \\
\left(\frac{p_t}{P_t}\right)^{-\epsilon} Y_t &= (\Gamma k_{t-1})^\alpha(\Gamma^t l_t)^{1-\alpha} \\
Y_t &= (\Gamma K_{t-1})^\alpha(\Gamma^t L_t)^{1-\alpha} \\
\frac{Y_t}{\Gamma^t} &= \left(\frac{\Gamma K_{t-1}}{\Gamma^t}\right)^\alpha (L_t)^{1-\alpha} \\
\tilde{Y}_t &= (\tilde{K}_{t-1})^\alpha(L_t)^{1-\alpha}
\end{aligned} \tag{A.3}$$

Annex

ANNEX A – ANNEX

A1 Table of Dummies

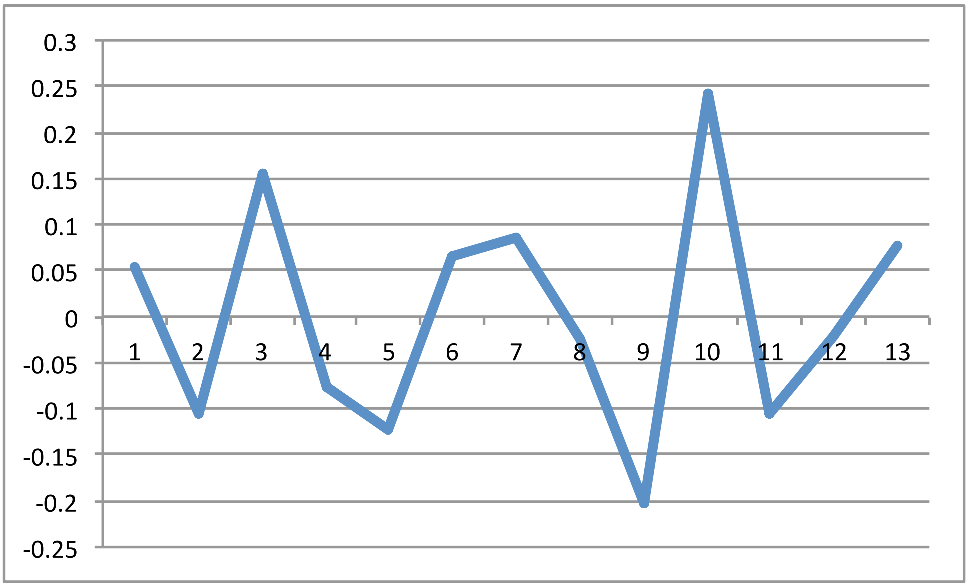
Table 13 – Dummies

Credit	
Dummies	**Data**
Reserve Requirement	October 2008 to June 2010
IOF	April 2011 to May 2012
Capital Requirement	December 2010 to March 2013
Exchange	
Dummies	**Data**
IOF on portfolio s	October 2009 to June 2013
IOF on external loans	March 2011 to June 2012
IOF on derivatives	July 2011 to June 201
Reserve requirement	January 2011 to July 2013

Source:

A2 Impact of Macroprudential Policy Shocks on Capital Flows

Figure 25 – DL model with the IOF-Derivatives dummy



Note: The DL estimation shows the β coefficients of the equation on the y-axis. In all figures, the x-axis shows the months after the shock in t=0. All coefficients are statistically significant at the 10% level, except the following lags: 3, 7, 10, 11, and 12.

A3 Table of Statistics

Table 14 – Statistics

	Leverage	Leverage BCB	Liquidity	Liquidity BCB	Capital flows	Credit 2	Credit 1
Mean	5.728199	10.19889	0.335674	1.932407	-2.039793	0.007902	-0.00012
Median	5.363426	10.345	0.33656	1.9	-2.00991	0.006528	-0.003015
Maximum	9.155398	11.53	0.469328	2.8	-1.642903	0.033458	
Minimum	4.790235	8.43	0.241593	1.4	-2.533823	-0.014795	-0.129929
Std. Dev.	0.904048	0.759288	0.057361	0.328926	0.206305	0.009146	0.049168
Skewness	1.502653	-0.455125	0.322228	0.726043	-0.390124	0.216571	0.208486
Kurtosis	4.945033	2.316096	2.217305	2.764056	2.574464	3.116694	3.609456
Jarque-Bera	57.66759	5.833257	4.625709	9.739009	3.554401	0.90553	2.453865
Probability	0	0.054116	0.098978	0.007677	0.169111	0.635867	0.293191
Sum	618.6455	1101.48	36.25285	208.7	-220.2976	0.853378	-0.013144
Sum Sq. Dev.	87.45138	61.68747	0.352056	11.57657	4.554104	0.008951	0.258668
Observations	108	108	108	108	108	108	108

A4 Macroprudential Policy Changes in Brazil

Table 15 – Policy changes

Date	Instrument
Dec 2007	IOF Loan
Jan 2008	IOF Loan
Mar 2008	IOF Port
Oct 2008	IOF Port (+1)/RR Credit (-1)
Mar 2009	RR Credit (-1)
Oct 2009	IOF Port
Feb 2010	RR Credit
Jun 2010	RR Credit
Oct 2010	IOF Port ?IOF derivatives ?
Nov 2010	Credit Cards
Dec 2010	IOF Port (-1)/RC (+1)/Letras Financeiras (+1)
Jan 2011	RR Bank (FX)
Mar 2011	IOF Loan
April 2011	IOF Loan/IOF Credit
Jul 2011	IOF Derivatives
Nov 2011	RC
Dec 2011	IOF Port/IOF Credit (-1)
Mar 2012	IOF Loan/Advanced Payment
May 2012	IOF Credit (-1)
Jun 2012	IOF Loans (-1)
Jul 2012	RR Credit (-1)
Dec 2012	IOF Loan (-1)
Mar 2013	RC (-1)
Jun 2013	IOF Derivatives (-1)
Jul 2013	RR Cambio Bank (FX)(-1)
Jun 2014	IOF Loan/RR Credit (-1)
Aug 2014	RC (-1)

A5 ADL com variaveis coeficentes de curto prazo

Table 16 – Short-run dummies by instrument

Credit - ARDL(8, 11, 11, 8)				
Dummy	Coefficient	Std. Error	t-Statistic	P-value
IOF-loans	0.003641	0.036683	0.099259	0.9213
IOF-loans (-1)	0.006703	0.034724	0.193038	0.8477
IOF-loans (-2)	0.008102	0.023696	0.341923	0.7337
IOF-loans (-3)	-0.030712	0.030088	-1.020722	0.3119
IOF-loans (-4)	0.013922	0.03183	0.43738	0.6636
IOF-loans (-5)	0.00516	0.028226	0.182793	0.8556
IOF-loans (-6)	0.035262	0.028673	1.229789	0.2241
IOF-loans (-7)	-0.075592	0.028231	-2.677642	0.0098
IOF-loans (-8)	0.047349	0.014923	3.172836	0.0025
Capital flows -ARDL(1, 0, 5, 0)				
IOF-loans	-0.046953	0.022321	-2.103517	0.0381
Capital flows - ARDL(1, 0, 5, 0)				
CR-Credit	-0.042576	0.020624	-2.064349	0.0418
Leverage - ARDL(4, 2, 6, 1)				
IOF-Deriv	0.079024	0.033949	2.327733	0.0223
IOF-Deriv(-1)	-0.173964	0.032844	-5.296738	0
Leverage - ARDL(12, 2, 7, 5)				
IOF-loans	-0.056414	0.091641	-0.615602	0.5403
IOF-loans(-1)	-0.109523	0.085928	-1.274596	0.207
IOF-loans(-2)	0.466217	0.129533	3.599199	0.0006
IOF-loans(-3)	-0.56425	0.239719	-2.353799	0.0216
IOF-loans(-4)	0.508867	0.194371	2.618013	0.011
IOF-loans(-5)	-0.315959	0.087421	-3.614209	0.0006
Leverage -ARDL(8, 3, 6, 5)				
IOF-Port	0.278234	0.053498	5.200866	0
IOF-Port(-1)	-0.136398	0.050816	-2.68413	0.009
IOF-Port(-2)	-0.034922	0.142176	-0.245625	0.8067
IOF-Port(-3)	-0.072223	0.113133	-0.63839	0.5252
IOF-Port(-4)	0.174217	0.073085	2.383779	0.0197
IOF-Port(-5)	-0.328581	0.08166	-4.023756	0.0001
Leverage -ARDL(4, 2, 7, 3)				
CR-Credit	-0.337447	0.038106	-8.855603	0
CR-Credit (-1)	0.420575	0.117333	3.584469	0.0006
CR-Credit (-2)	0.085145	0.091012	0.935537	0.3523
CR-Credit (-3)	-0.247533	0.087084	-2.842459	0.0057
Liquidity (IL-sa) - ARDL(10, 10, 12, 6)				
IOF-Credit	0.000573	0.006235	0.091912	0.9271
IOF-Credit (-1)	0.015214	0.008802	1.728474	0.0897
IOF-Credit (-2)	-0.014913	0.00852	-1.750408	0.0858
IOF-Credit (-3)	0.026232	0.006589	3.980964	0.0002
IOF-Credit (-4)	-0.029228	0.011317	-2.582609	0.0126
IOF-Credit (-5)	0.021648	0.012536	1.726891	0.09
IOF-Credit (-6)	-0.01034	0.006489	-1.593372	0.117