FUNDAÇÃO GETULIO VARGAS
ESCOLA DE ADMINISTRAÇÃO DE EMPRESAS DE SÃO PAULO

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# REGULATION ISSUES IN THE BANKING INDUSTRY

SÃO PAULO
2011

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Tese apresentada à Escola de Administração de Empresas da Fundação Getulio Vargas, como requisito para obtenção do título de Doutor em Administração de Empresas

Campo de Conhecimento:
Mercados Financeiros e Finanças Corporativas

Orientador: Prof. Dr. Richard Saito

SÃO PAULO

2011

Pereira, João André Calviño Marques.
Regulation Issues in the Banking Industry / João André Calviño Marques Pereira. - 2011.
106 f.

Orientador: Prof. Dr. Richard Saito
Tese (doutorado) - Escola de Administração de Empresas de São Paulo.

1. Capital bancário – Administração. 2. Bancos – Regulamentação. 3. Investimentos bancários. 4. Modelos econométricos. I. Saito, Richard. II. Tese (doutorado) - Escola de Administração de Empresas de São Paulo. III. Título.

CDU 336.71

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**Data de aprovação:**
_15_/_04_/_2011_

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*Aos meus pais, Enio e Flora, que sempre me incentivaram.*

## AGRADECIMENTOS

Agradeço a minha querida esposa, Manuela, por todo o amor, carinho e companheirismo durante essa jornada; e ao nosso amado filho, João Gabriel, que nos abençoou com sua recente chegada. Sem eles eu não conseguiria.

Aos meus pais, Enio e Flora, e meus irmãos, Fabiana e Luis Otavio, pelo apoio e incentivo.

Ao professor Doutor Richard Saito pela orientação, ajuda e confiança.

Aos professores da banca pelas observações que muito contribuíram à forma final do trabalho.

Ao amigo e professor Gilneu Francisco Astolfi Vivan pelo importante auxílio no trabalho.

Aos gabinetes do Departamento de Normas (Denor) e do Departamento de Monitoramento do Sistema Financeiro e de Gestão da Informação (Desig) do Banco Central do Brasil, que viabilizaram a execução deste projeto.

Aos amigos do Banco Central do Brasil pelas críticas e sugestões ao trabalho. Entre eles, não poderia deixar de citar alguns nomes (em ordem alfabética): Caio Fonseca Ferreira; Guilherme Matsumura Yanaka; Jaildo Lima de Oliveira; Mario Rubem do Coutto Bastos; e Pedro Calhman de Miranda.

## ESCLARECIMENTO INSTITUCIONAL

As opiniões expressas pelo autor são exclusivamente de sua responsabilidade e não necessariamente refletem a posição do Banco Central do Brasil.

## RESUMO

Esta tese tem por objetivo examinar os fatores que direcionam o processo decisório de estrutura de capital/investimento do banco e avaliar a efetividade da intervenção regulatória no Brasil. O trabalho está divido em três capítulos. No primeiro capítulo, apresenta-se, de forma sistematizada, arcabouço teórico e evidências empíricas na literatura para explicar o comportamento da firma bancária, fortemente regulada, em suas decisões de financiamento e investimento. Além disso, descreve-se a evolução dos padrões internacionais de regulação prudencial de capital, desde a publicação do primeiro Acordo de Basiléia até as medidas iniciais de Basiléia III, apresentando também o contexto normativo no Brasil. No segundo capítulo, por meio de modelo dinâmico da teoria de *trade-off*, analisam-se os determinantes do *buffer* de capital dos bancos brasileiros entre 2001 e 2009. Os resultados sugerem que: (i) o requerimento regulatório de capital e os custos de ajustes de capital influenciam nas decisões dos bancos; (ii) as avaliações da autoridade de supervisão bancária impacta os colchões de capital; (iii) a disciplina de mercado pode não ser efetiva em aumentar a solvência dos bancos; e (iv) existe uma relação negativa entre o colchão de capital e o ciclo de negócios que pode representar uma gestão procíclica de capital dos bancos. Por fim, no terceiro capítulo, utiliza-se metodologia proprietária dos escores das instituições conferidos pela autoridade supervisora (CAMEL), para apresentar evidências de que as pressões regulatória e de supervisão no Brasil induzem os bancos a realizarem ajustes de curto prazo relativamente menores na alavancagem e, principalmente, no risco do portfólio.



Palavras-chave: microeconomia bancária, regulação prudencial, capital regulatório, risco dos ativos.

## ABSTRACT

This dissertation aims to examine the factors that drive the bank decision process of capital/investment structure and to evaluate the effectiveness of regulatory intervention in Brazil. This study is divided into three chapters. The first chapter presents, in a systematic fashion, the theoretical and empirical literature to explain the financing and investment decisions of a heavily regulated banking firm. It also describes the evolution of international standards of prudential capital regulation, since the publication of the first Basel Accord until the initial steps of Basel III, and the regulatory scenario in Brazil. The second chapter, through a dynamic model of the trade-off theory, analyzes the determinants of Brazilian banks' capital buffer between 2001 and 2009, suggesting that: (i) regulatory capital requirements and adjustment costs may influence banks decisions; (ii) supervisory authority evaluations may impact capital buffers; (iii) market discipline may not being effective in improving bank solvency; and (iv) there is a negative relationship between the buffer and business cycle, which may represent a pro-cyclical bank's capital management. Finally, the third chapter uses supervisory authority ratings (CAMEL) to provide evidences that the supervisory and regulatory pressures induce banks in Brazil to undertake downwards short-term adjustments in leverage and also in portfolio risks.



Key-words: microeconomics of banking, prudential regulation, regulatory capital, asset risk.

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**SUMMARY**

# INTRODUCTION

The financial system stability is essential to the effectiveness of business activities and government policies focused on economic growth. Overall, a robust and efficient financial system must be capable to provide an efficient capital allocation in the economy and to maintain the smooth functioning of the payments system and the transmission mechanisms of monetary policy.

Due to the nature of the financial intermediation activity, in which illiquid long-term assets (loans) are generally funded by short-term demand deposits, banks end up incorporating a very peculiar financial fragility. Therefore, the stability of deposits becomes a key issue for the solvency of the institution and, consequently, for the system soundness.

From this perspective, financial regulation is justified, among other reasons, by the need for establishing a safety net capable of protecting the depositors from a possible insolvency of their depository institutions. Ultimately, the objective is to prevent the failure of a single institution promotes the widespread loss of confidence by depositors, which probably would set off a bank run and a major proportion financial market liquidity crisis. A classical instrument developed for this purpose, adopted in almost all international financial systems, is the deposit insurance. The benefit of avoiding banking panics, however, is not without the potential social cost of banks opportunistic behaviors, since the deposit insurance scheme shields the banking system from the market discipline. The resulting moral hazard is reflected in the banking industry by extremely risky investment profiles and highly leveraged balance-sheets. So, prudential regulation, especially the minimum risk-adjusted capital requirement, aims to eliminate externalities associated with banks moral hazard, imposing the social costs of possible bankruptcies on the institutions themselves. Complementing the capital rules, the banking supervision and the market discipline incorporate other elements to ensure the soundness in the financial system.

Recently, the structure of prudential regulation proved to be quite vulnerable to systemic shocks. The 2008 global economic crisis has shown a strong interaction between the financial and real sectors of the economy that amplifies the macroeconomic shocks via banks' balance-sheet channels. At the same time, those amplified macroeconomic shocks increase the fragility of banks, depressing their balance-sheets. Therefore, new proposals for macro-prudential regulation have been discussed with two main objectives: firstly, to adjust the

leverage of banks to the business cycles; and secondly, to reduce the systemic importance of certain financial institutions.

This dissertation introduces three chapters to examine the factors driving the decision process of banks capital/investment structure and also to evaluate the effectiveness of the regulatory intervention in Brazil.

In the first chapter, we present, in a systematic fashion, the theoretical and empirical evidence in the literature to explain the behavior of the heavily regulated banking firm regarding its financing and investment decisions. We also describe the evolution of international standards of prudential capital regulation since the publication of the first Basel Accord until the initial steps of Basel III, and its implications for the Brazilian banking system.

In the second chapter, we empirically examine the main determinants of the capital buffer management (capital exceeding the minimum required by regulation) for the Brazilian banking industry, in order to test whether banks respond to the previous and new fundamentals of capital regulation. We find evidence that regulatory capital requirements may influence banks behavior, since those with more volatile earnings and higher adjustments costs may decide to hold higher capital buffers. We also find that banks may follow a pecking order when deciding their capital levels, and larger banks present lower levels of capital ratios, which may be related to too-big-to-fail issues. Moreover, we provide evidence that: (i) Central Bank supervision exerts positive pressure on bank's decision; (ii) market discipline may play a minor role in driving capital ratios; and (iii) the business cycle has a negative impact on bank's capital cushion, suggesting a pro-cyclical behavior of capital management. The results contribute to the discussion of the implementation in Brazil of the macro-prudential regulatory policies discussed in the Basel Committee.

Finally, in the third chapter, we investigate how Brazilian banks react to capital constraints and monitoring assessments placed by the financial authority. In order to do that, we use empirical models that incorporate the endogenous decision making process on the bank capital structure and risk taking. Our results suggest that the regulatory and supervisory pressures increase the institutions risk aversion by inducing banks to take greater positive adjustments in capital levels and smaller in portfolio risk levels. Moreover our findings show positive coordination between these variables, which is most pronounced in less capitalized banks, indicating a more active capital management by those close to the regulatory capital limit. The overall results support the capital buffer theory.

# CHAPTER 1: CAPITAL STRUCTURE AND REGULATION: THEORY AND PRACTICE OF BRAZILIAN BANKS

## 1. Introduction

The purpose of this chapter is to introduce, in a systematic fashion, the theoretical and empirical evidence in the literature to explain the financing and investment decisions of the heavily regulated banking industry. In addition it describes the evolution of international standards of prudential capital regulation since the inception of the first Basel Accord until the initial steps of Basel III, and its implications to Brazilian banks.

Section two provides a literature review, initiating with the classical theories of corporate finance derived by relaxing the assumptions of the Modigliani and Miller (1958) irrelevance proposition: (i) the trade-off theory; (ii) the agency theories; and (iii) the pecking order theory. This section covers structural differences between non-financial firms and banks to explain the concepts of bank fragility, safety net, and the resulting moral hazard. Finally, this section presents the rationale of the capital regulation and its effects on banks' behavior including the theory of capital buffer which allows a comprehensive analysis about the determinants of capital and risk structures of banking firms.

Section three shows the widely adopted standards of the risk-weighted capital regulation as per the Basel Committee. This Section introduces the historical evolution and the main features of the regulatory regime in its third revision. The first Basel Accord dates back to 1988 and focuses on the micro-prudential models to calculate capital requirements. The second agreement in 2004, or Basel II, extended the rules scope by allowing the use of more sophisticated models for risk-weighting the assets and by proposing expansions to the structures of supervision and market discipline. Finally, since the end of 2010, the Basel III proposes capital standards enhancements and focuses on macro-prudential measures to address systemic risks.

Section four discusses the implementation of the Accord in Brazil, which has been proved to be more conservative due to economic and financial crises experiences. This section also presents some empirical results regarding the effects of the capital rules in the local

banking system and compares actual capital requirements rules with those coming from the new Basel III Accord.

The fifth and final section briefly presents final considerations and points out some proposals for future works.

## 2. The capital role in the banking firm

The capital structure debate of both financial and non-financial institutions must have a starting point in the irrelevance proposition of Modigliani and Miller (1958). The firm's investment decisions and value should be influenced by its financing structure when market frictions are included in the model. In what comes to banks, Santos (2001) notes two additional factors: first, banks have as main financing source debts originated from small uninformed investors, and second, banks have access to a safety net, especially deposit insurance, in order to prevent bank runs and panics. Both features, jointly with banker's limited liability, boost banking management moral hazard in the form of increases in either leverage or asset risk that may raise the likelihood of insolvencies and systemic instability. From this perspective, the typical financial intermediation externalities justify capital regulation.

For the sake of clarity, the main incentives surrounding the banks' financing and investment decisions can be separated into three groups.

The first source of influence on banks' behavior comes from the interaction between banks and market agents. According to Berger *et al*. (1995), markets may encourage banks to hold certain capital ratios in the absence of regulatory capital requirements. Therefore, the bank will rationally maximize its value based on market frictions that are common to all kind of firms, while still considering the incentives provided by the bank-specific safety net that shields the banking system from market discipline. Subsection 2.1 deals with the classical corporate finance theories and subsection 2.2 explores the banking safety net effects.

The second stimulus refers to capital regulation. The regulatory capital requirement is motivated by negative externalities not accounted by the market requirement and adjusts the proportion of capital held by banks to cover risks they incur. The effect of capital regulation on banks' behavior is detailed in subsection 2.3.

Finally, the third motivation for bank behavior, evidenced by the 2008 global economic crisis, is the business cycle. Indeed, it was observed a strong interaction between

the financial and the real sectors of the economy that amplified vulnerabilities of banking systems to macroeconomic shocks. During periods of economic expansion, investment opportunities increase and the risk assessments of these projects become less stringent, leading banks to reduce their capital ratios. Such conduct may be harmful, because in times of recession banks may need capital cushion to absorb potential losses. This issue is explored in subsection 2.4.

### 2.1. Corporate finance theories

The determinants concerning of the proportion for any firm should be primarily driven by the imperfections to the frictionless environment of Modigliani and Miller (1958), which include: (i) the tax benefits of debt; (ii) the bankruptcy costs; (iii) the informational asymmetries; and (iv) the agency problems.[1]

Tax benefits of debt and bankruptcy costs (trade-off theories)

In their following article, Modigliani and Miller (1963) relax the assumption on the absence of taxes and conclude that firms should choose a funding structure concentrated in debt because the interest paid is tax deductible, while dividends are not. On the other hand, the increased leverage also increases the risk of bankruptcy costs. Therefore, DeAngelo and Masulis (1980) demonstrate that the trade-off between the cost of bankruptcy and the fiscal benefits defines an optimal capital structure. That is, firms with lower bankruptcy costs, such as those with more tangible assets and less volatile cash flows, tend to target more leveraged capital structures. In the financial intermediaries perspective, Orgler and Taggart (1983) argue that the interaction between the tax system and the production function of financial services increases the optimal proportion of debt relative to equity, given that depositors are attracted by the lower cost non-taxable services embedded in deposits (liquidity, safety, and bookkeeping). The authors also point out that bankruptcy costs for financial firms are reduced by the regulatory safety net. Thus, the resulting bank's optimal capital structure should be more leveraged than the structure of non-financial firms.

Recent empirical methodology derived from the trade-off theory considers the potential dynamic nature of firm's capital structure (target-adjustment models). Flannery and

[1] Interestingly, Fama (1980) and Miller (1995) defend the validity of the M&M irrelevance proposition for the banks' capital structure. The controversial discussion have been gaining importance in the post-2008 financial crisis agenda, and it is addressed in the work of Admati *et al.* (2010), which seeks to deconstruct the banks paradigms regarding the higher cost of equity and the higher structural leverage. The article has as signatories many of the leading academics in finance.

Rangan (2006) show that firms adjust their capital levels over time toward an optimal target leverage. In what comes to banking firms, the methodology has intuitive an appeal as the regulation explicitly establishes a capital level reference that may direct the banks behavior. This argument has been developed in the capital buffer theory, which is explored hereinafter.

Informational asymmetries

This theoretical line assumes that managers have proprietary information about company's characteristics of cash flows and investment opportunities. Under this rationale, the firm's decisions on its capital structure may signal this information to the market. Leland and Pyle (1977) show that entrepreneurs willingness to invest in their own project can serve as a signal of project quality.

On the other hand, the issuance of new shares could represent negative signaling since the firm controller, which has informational advantage regarding its own projects, sells equity when he thinks the market may overestimate the share price. Therefore the asymmetric information could increase public offering costs in a phenomenon called underpricing (Rock, 1986; and Benveniste and Spindt, 1989). Based on this consideration, Myers (1984) and Myers and Majluf (1984) propose the pecking order theory, in which firms follow a hierarchy to choose the financing source for new projects rather than seeking an optimal proportion of capital. Initially, it should be used retained earnings because they have no issuance costs, including the informational ones. Then, if external resources are necessary, the firm would prefer to issue debt, since it is usually less costly than equity and it also reduces verification costs (Townsend, 1979; and Dowd, 1996).

It is noteworthy that the difference among the costs of funding sources is quite peculiar for banks when compared to non-financial firms. The direct costs of debt issuance are significantly lower as demand deposits generally pay no interest and banks are, by nature, further opaque and susceptible to greater information asymmetries, which mean higher informational costs. Diamond and Rajan (2000) add that equity financing increases recurring costs related to reductions in the banks capacity to create both liquidity and credit.

Agency problems

Jensen and Meckling (1976) identify conflicts of interest in the relationship between agent and principal, which are caused by imbalances in the parties' rights and obligations and by the difficulty for the principal in observing and verifying process of the actions of the agents. The capital structure should then be used to mitigate the problem. In case of conflict

between shareholder and manager, the increase in debt reduces free cash flows and also increases the likelihood of firm's bankruptcy, providing incentives for managers to expend more effort, to use less of firm's resources for their own benefit, and to make better investment decisions. Saunders *et al*. (1990) observe that the problem also occurs in the banking environment. The manager, who is more risk averse than the shareholder, seeks to reduce the portfolio risk exposure in response to increases in leverage, defining higher levels for the bank's solvency ratio.

In case of conflict between shareholder and debtholder, the increase in equity bears incentives for shareholders to make suboptimal investment decisions, and, thus, to appropriate wealth from debtholders. This inefficiency, in turn, is twofold. On the one hand, the banker may invest in excessively risky projects (asset substitution). On the other hand, he may not invest in positive net present value projects even if the project fits on the institution risk profile (underinvestment).[2] The shareholder-debtholder conflict is quite particular for banking institutions, because the bank, as an intermediary, acts both as a shareholder (bank versus entrepreneur) and as a creditor (bank versus depositor), and both relationships are intensely permeated by issues of informational asymmetries. The bank should monitor the entrepreneur (borrower) and should be monitored or "disciplined" by the depositor (investor). Those interactions are outlined in the next subsection.

### 2.2. Financial intermediation and moral hazard

Due to bank specificities, the market imperfections described above may magnify some fundamental risks of financial institutions, such as excessive leverage and the moral hazard asset substitution. Typically, banks are funded by liquid low-cost resources originated from dispersed groups of investors (depositors). The funds are then used to finance long-term projects from specialized entrepreneurs. This balance-sheet structure, while permeated by informational asymmetries and maturity transformations, may have harmful consequences which are widely explored by the microeconomic banking theories.

On the asset side, the seminal model of Diamond (1984) is based on the investor-entrepreneur agency problem and shows that the intermediation function is Pareto optimal, because the bank has economies of scale on its information technology. That way, it is possible to minimize opportunistic behaviors by monitoring the entrepreneurs on behalf of the

[2] The seminal article by Myers (1977) addresses the underinvestment problem in which, in certain states of the nature (for instance, if the firm is getting closer to bankruptcy), stockholders would not contribute with new capital even to positive net present value investments since the funds may be used to pay the creditors.

investors. The bank's incentive to monitor depends on its diversification on assets, since the consequent reduction in the portfolio risk also reduces the need for the costly equity signaling described by Leland and Pyle (1977). The model yields in intermediaries financed primarily by debt contracts.

On the liability side, Diamond and Dybvig (1983) also point out to a rigid structure fully leveraged. The model shows that intermediaries are efficient in competitive markets as deposit agreements permit the diversification of risk among investors with different liquidity needs. In contrast, the liquidity insurance exposes banks to sequential withdrawals by depositors, which can turn in bank runs and panics with high social costs.[3]

A comprehensive approach is proposed by Diamond and Rajan (2000), in which the various agents – creditors, depositors and stockholders – negotiate with the bank the pay-offs of their respective financial contracts. In environments of asymmetric information and incomplete contracts, the authors show that the fragility of a structure financed by deposits permits an efficient flow of resources between investors and entrepreneurs, because the possibility of bank runs disciplines the bank in its task as a monitor.[4] The capital is necessary to protect the bank from negative shocks in the prices of their risky assets, which, in the case of a rigid structure, could cause bank runs. The bank's optimal capital structure is, therefore, defined in terms of the costs of reductions in both the credit flow and the liquidity creation versus the benefit of a greater stability of the institution. The clear implication of this model is that the leverage ratio of a bank is high and should increase when the underlying projects liquidity increases.

Buttler (1999) also extends the liquidity insurance model of Diamond and Dybvig (1983) by considering both the bank's decisions on investment and financing, and the *ex post* depositors' reactions. The depositor withdraws his funds when he believes the bank is exposed to solvency problems. The bank, in turn, maximizes its expected pay-off, considering: (i) the potential reactions of depositors; (ii) the probable changes in its asset value; and (iii) the four possible states of the nature at the end of the period (solvent-liquid,

[3] The literature identifies two main theoretical perspectives explaining bank panics. The first one articulates that the bank runs and panics are random events, as in the line followed by Diamonds and Dybvig (1983). The second one argues that panics are systematically related to events that changes the risk perception of the depositors, such as failures of major banks, economic recessions, and seasonal restrictions. Although there is no consensus in empirical literature, the results of Gorton (1988) point out to the second type, indicating that bank panics are systematic events linked to the business cycle.

[4] Calomiris and Kahn (1991) are the first ones to model the disciplining effect of the deposit on bank management. According to the authors, uninsured debt contracts subject to the sequential service and intended for qualified investors reduce the financial intermediation moral hazard. Under this rationale, bank runs would be a result of market discipline and, therefore, they would be socially efficient.

solvent-illiquid, insolvent-liquid, and insolvent-illiquid) with their respective cost structures. The authors show that, if the bank imposes a constraint on its decision process that the expected return on equity must be greater than the risk free rate, then the optimal capital structure is overly leveraged and the bank becomes more susceptible to insolvency and illiquidity.

Two major theoretical implications are as follows: firstly, banks are leveraged and this balance-sheet fragility can be socially inefficient; secondly, the mechanisms that discipline bankers' moral hazard behaviors may lose efficiency the lower the informational sophistication of depositors and the higher the complexity of banking business are.

Banking safety net

The banking safety net consists of government actions that aim to protect depositors and prevent failures due to the fragility of financial intermediaries. In addition to the regular action of bank supervision, the protection schemes include other typical central banking activities, such as loans of last resort (discount window) and deposit insurance, which may also be established on a private basis.[5] However, as side effects, the safety net may suppress incentives to market discipline and inflate perverse incentives to banks opportunistic behavior, since, with reduced monitoring, the banker rationally maximizes the bank's value on the basis of the safety net subsidy. The result is an increasing risk-taking.[6]

Merton (1977) argues that this behavior happens if deposit insurance is inappropriately priced. The author shows the insurance is equivalent to a put option on the bank's asset value with strike equal to the promised payment to depositor. As the option premium is an increasing function of volatility (positive vega), a riskier management would maximize the value of the bank. By using a state-preference approach to bank behavior under uncertainty, Dothan and Williams (1980) demonstrate that, even adjusting deposit insurance premiums for risks, banks tend to choose excessively risky portfolios. Marcus (1984) proves the potential loss of charter value due to the proximity to insolvency may restrict the moral hazard arising from risk insensitive deposit insurance.

Moral hazard also stems from the financial authority acting as lender of last resort. Rochet and Tirole (1996) show the discount window should be made available to solvent

[5] In Brazil, the protection structure was augmented with the banking system restructuring process after the economic reform named "Plano Real" in the 90's. Lundberg (1999) presents a detailed review of the Brazilian banking safety net adopted at that time.

[6] In a historical analysis of the implementation of deposit insurance systems in U.S. states, Calomiris (1990) argues that depositors protected by these schemes had less incentive to carefully choose their financial services providers and supposedly tolerated higher leverage and increasing risk taking.

institutions suffering liquidity shocks, in order to mitigate the systemic risk arising from the interbank market. When rescuing insolvent banks, the monetary authority negatively influences the behavior of those perceived as too-big-to-fail. Stern and Feldman (2004) stress the severity of the too-big-to-fail moral hazard issue and propose several policy measures to treat it. The problem was in evidence in the international financial crisis of 2008, when a number of governments have launched several social costly measures to bailout insolvent systemic important banks.[7]

Market discipline

As argued above, a major drawback of deposit insurance is that it undermines the market monitoring. The challenge for policy makers is, therefore, to design a safety net scheme which, at the same time, protects banking system from bank runs and provides incentives for the market to discipline riskier banks. Bliss and Flannery (2000) argue that market discipline might incorporate two distinct components: (i) the private investors' ability to understand (monitor) a financial firm's true condition, and (ii) their ability to influence managerial actions in appropriate ways. Indeed, it starts from the existence of stakeholders who have something to lose with the bank failure; then, it goes through the availability of information about the bank's conditions; and finally, it ends up with some costly consequence which may positively influence the bank behavior.

The theoretical literature has mainly focused on the role of subordinated debtholders in disciplining banks' risk-taking. Calomiris and Kahn (1991) demonstrate that uninsured demandable debt intended for qualified investors disciplines banks by the threat of bank runs. Taking an ex ante perspective, Blum (2002) models the potential disciplining effect of subordinated debt through the level of interest rates charged by the debtholders, so the riskier the bank, the higher is the interest they would have to pay. The author shows that those instruments should be effective in reducing banking risks only if banks are able to credibly commit to a given level of risk. Therefore, an optimal scheme should be one that combines market monitoring and regulatory enforcement.

Substantial empirical literature, mostly in US, has intended to identify market discipline by analyzing the relationship between bank risk and debt spread, but it has found ambiguous results. Some authors also have tested market discipline taking the banks' balance-

[7] Congleton (2009) has reviewed the measures taken by the U.S. government in the 2008 financial crisis, which resulted in the transfer of more than 700 billion dollars in public funds to troubled financial institutions, in so-called TARP (Troubled Asset Relief Program).

sheet reactions to the quantity of uninsured debt, instead of its price. A comprehensive review of theoretical issues and empirical evidences on market discipline around the banking systems around the world is presented by Borio *et al.* (2004).

### 2.3. Regulatory capital requirement

The main instrument widely adopted to address the safety net moral hazard issue is the prudential regulation. Thus, the government intervention arises with two objectives. The first objective is to protect uninformed depositors by replacing them in the task of auditing the bank. The second one is to strengthen the solvency and stability of the banking industry, forcing banks to maintain appropriate capital levels and a sound management of risks.[8]

From the theoretical perspective, a number of models analyze the efficiency of capital regulation in reducing banks opportunistic behavior. Based on the options theory, Sharpe (1978) finds that the capital requirement adjusted to risks incurred by the bank may dampen the problem of moral hazard caused by risk-insensitive deposit insurance premiums. Using efficient frontier models, Kahane (1977) and Koehn and Santomero (1980) conclude that when the level of regulatory capital exceeds the economic capital, the manager compensates the reduction in the expected return by allocating the bank's assets to an optimal point at greater risk. Kim and Santomero (1988) extend the model and point out a minimum capital requirement defined proportionally to the bank's portfolio risk as a solution to the risk-shifting problem. Finally, in order to account for the deposit insurance effect, Furlong and Keeley (1989) and Keeley and Furlong (1990) combine the options approach with the state-preference model to demonstrate that, even in case of risk-insensitive capital constraints, the mechanism should curb excessive risk taking.

Capital buffer theory

It is to be noticed that the models based on moral hazard usually assume capital as exogenously defined by regulation and focus their conclusions in the bank's decision on its portfolio risk. However, the capital structure of banks in different countries reveals that most

[8] Dewatripont and Tirole (1994) show the capital ratio plays a key part in the regulatory mechanism of transferring control between the bank shareholders and the government. The shareholders, which have a convex return structure in firm's profit, is more compliant with managers and must assume the control when the bank's performance is good. That is, when net debt is low and hence the rate of capitalization is high. Similarly, the government, representing the unsophisticated depositors (Representation Hypothesis), which have concave pay-off function, is more rigorous and takes over when performance is poor and the capital ratio is low.

institutions maintain capital levels well above the limits required by regulations (Flannery and Rangan, 2008; and Berger *et al.*, 2008).[9]

As an explanation for this phenomenon, Berger *et al.* (1995) suggest that banks may opt for a substantial capital cushion, in order to hedge against unexpected shocks which could make them violate the minimum regulatory capital, since rapid adjustments in the capital level and the penalties for noncompliance with regulation are costly. In this sense, the frictions common to financial firms should continue influencing banks behavior; however, capital regulation imposes additional timely costs on banks which should also be considered in their decision model. On the one hand, there is the cost of not having capital in excess, which is related to potential regulatory penalties and reputational distress. And, on the other hand, there is the cost of having such excess, since capital is as an expensive source of financing.

Based on this concept, the so-called capital buffer theories formalize the optimal capital structure problem for banking firms by including the time perspective and taking capital as an endogenous response to risks constraints. In the model of Froot and Stein (1998) the level of capital and the investment and hedging policies are interdependent and endogenously defined. The decision is taken as a result of the trade-off between the costs of raising new capital and the costs of maintaining capital surplus. The authors conclude that the degree of bank's risk aversion is a decreasing function of the total capital held; in other words, the greater the capital cushion, the more aggressive is the bank investment profile.

Milne and Whalley (2001) and Milne (2004) model the dynamics in bank's capital decision as a continuous time inventory problem. The manager must decide in what level he must issue new capital or wait until supervisory authority forces him to do so. Besides balancing costs and benefits of capital surplus, the key point of the model is that banks with high charter values would have more to lose if they breach the regulation, and for that reason they have greater incentive to maintain extra capital. The models have important implications for the impact of capital regulation on banks risk-taking. According to the authors, in the short term, the incentive to take risks is reduced by the decrease in the capital buffer, which is in line with Froot and Stein (1998). However, if the level falls below the minimum capital, the incentive is reversed to an extremely risky behavior described in the literature as a "gamble of resurrection".

[9] In the Brazilian banking system, the average risk-adjusted capital ratio (CAR) has always been well above the local regulatory requirement of 11%. As of December 2009, commercial banks presented a weighted average capital ratio exceeding 17%.

Peura and Keppo (2006) extend those continuous time models taking into account timing constraints to raise capital. Due to the presence of these delays, banks face the threat of intervention that might lead to recapitalizations in situations of positive levels of capital buffers.

Estrella (2004) includes in his optimization model cyclical shocks on banks losses and compares the minimum capital requirement, defined on a value-at-risk (VaR) model basis, with the optimal economic capital level modeled as a function of three costs: (i) the cost of maintaining capital; (ii) the cost of failure or insolvency; and (iii) the cost of capital adjustments. Due to the backwards-looking nature of VaR and to the adjustment costs, the author demonstrates that, over the cycle, the levels of the optimal and the regulatory capital are negatively correlated, thus the difference between them – the optimal capital buffer – presents a cyclical behavior. The results suggest that the regulatory capital requirement would be loose following phases of gains and binding on banks' capital structures during the loss periods, increasing the likelihood of reductions in credit supply.

Empirical results regarding bank's capital structures

Gropp and Heider (2010) find evidence for publicly traded banks in the US and Europe that variables commonly used as capital structure determinants for non-financial companies, such as size, profitability, market-to-book ratio, and tangibility, are also determining factors in explaining banks leverage. Çağlayan and Şak (2010) show similar results for the Turkish banking system, distinguishing the pecking order theory as the primary driver of bank behavior.

The construction of the capital buffer theory adds new elements to the choice of the appropriate empirical method to test banks behaviors. Accordingly, the dynamic version of the trade-off theory (Flannery and Rangan, 2006), which suggests partial adjustments toward target capital level, has strong intuitive appeal because: (i) banking regulation explicitly define costly constraints to leverage and portfolio risks; and (ii) the capital adjustment costs are supposedly higher for banks. Ayuso *et al*. (2004), Alfon *et al*. (2004), Wong *et al*. (2005), Stolz (2007), Jokipii and Milne (2008), and Francis and Osborne (2009a) find that adjustment costs, profitability, risk, size, and economic growth are significant in the bank's capital adequacy ratio decision.

The methodology also allows testing the effectiveness of prudential regulation, assessing short-run reactions of banks under regulatory pressure. Shrieves and Dahl (1992) propose an approach in which banks simultaneously adjust their capital and risk. They verify

in the non-risk-weighted capital regulation that banks closer to the capital limit may offset capital increases by increasing risk. Conversely, Jacques and Nigro (1997), Aggarwal and Jacques (1998), and Rime (2001) observe increases in levels of capital and reductions in bank risk, suggesting that risk-sensitive capital rules should be important to refrain risky behaviors.

### 2.4. Business cycle

One major criticism of the current regulatory framework is that it is based on a micro-prudential model, which aims to ensure systemic stability by preventing failures of individual financial institutions (Hanson *et al*., 2010). The global financial crisis of 2008, however, has been characterized by strong interaction between the financial and real sectors of the economy, and such interactions are likely to amplify the fluctuations of the business cycle and to increase financial instability. Brunnermeier (2009) explains how the borrowers' balance-sheet transmission channel may cause liquidity spirals, pushing down prices in fire sales, and also how the lenders' balance-sheet transmission channel may result in credit crunches, due to institutions hoarding funds when they are concerned about future access to capital markets.

Borio (2003) argues that risk is endogenous to the financial system and systemic vulnerabilities are built up over time during asset booms. According to the author, this pro-cyclicality has two fundamental sources. The first is the limitation on the risk assessment, which may boost the bank's capital channel, since risk estimation models, as well as their underlying assumptions, tend to be slightly forward-looking and usually ignore possible systemic effects.[10] The second source of pro-cyclicality is distortions in incentives, which is basically related to informational asymmetries and conflicts of interests between lenders and borrowers. Coordination issues and herd behavior may create gaps between individual rationality and desirable aggregate outcomes. In this sense, individual retrenchment in times of stress can be self-defeating, by inducing fire sales or a credit crunch.

Allen and Saunders (2003) review several academics' and practitioners' credit risk models and verify the need for methodological developments to incorporate systemic risk factors. Estrella (2004) demonstrate that a VaR-based capital management may be misaligned to the optimal capital decision over the cycle. Repullo *et al*. (2009) empirically show that the

[10] The cyclicality in risk measures such as VaR is somehow intuitive. Economic downturns are generally accompanied by increasing default rates and high volatility in financial and economic variables, which, therefore, are reflected in the statistics of risk models. For banks that use VaR-based risk management systems, when a negative shock reduces the bank's asset prices, consequently, reducing the total equity, the tightening in the risk constraint may force the bank to reduce leverage to a higher extent. Therefore this leverage mechanism, which also works in the other direction, may amplify booms and busts in the market. This rationale is theoretically explored by Danielsson *et al.* (2009).

probability of default (PD) of a loan portfolio, which is the main input in the Basel II credit risk model for capital requirements, increases following recessions. Repullo and Suarez (2008) point out that the higher risk-sensitiveness of Basel II style models may exacerbate the pro-cyclical effect of capital regulation and might lead to a reduction of bank loan supply in recessions.

Many authors identify bank's balance-sheet channels and provide evidences that bank's capital affect its supply of loans and may consequently impact the real sector. Francis and Osborne (2009b) find that UK banks with surpluses (deficits) of capital relative to this target tend to have higher (lower) credit growth, and lower (higher) capital growth. Blum and Nakane (2005) find similar results in Brazil. Also, there is a quite extensive empirical literature on the hypothesis that the early 1990's US credit crunch is related to the introduction of Basel I capital constraints (e.g. Bernanke and Lown, 1991; and Furfine, 2001). Some other researchers show that banks' balance-sheet have negative relationship with the economic environment and, therefore, may amplify economic cycles. Adrian and Shin (2008) observe that US banks excessively expand balance-sheets following asset prices booms and dangerously shrink the assets in subsequent recession periods. Ayuso *et al.* (2004) find a negative relationship between Spanish banks' capital buffers and economic growth, indicating that banks are not forward-looking optimizers and may follow a pro-cyclical capital behavior.

### 2.5. Summary on bank's capital/risk determinants

As presented in the subsections above, the main drivers on bank's behavior can be separated according to three fundamental frictions sources: (i) the market imperfections that include the bank's safety net subsidy; (ii) the capital regulation; and (iii) the macroeconomic shocks. Table I summarizes these frictions and presents their expected effects on banks' capital and risk structures along with the related literature.

**Table I – Determinants in the banking risk-taking and capital management**

The table separates the main theoretical lines that explain banking firms' behavior regarding their financing and investment decisions.

| Source | Theory | Friction | Explanation | Effect on Capital | Effect on Risk |
|---|---|---|---|---|---|
| **Market Capital Requirement** | *Corporate Finance Theories* | Taxes and bankruptcy costs | - Tax benefit of debt **(Modigliani and Miller, 1963)**. | ↓ | - |
| | | | - Bankruptcy costs **(DeAngelo and Masulis, 1980)**. | ↑ | - |
| | | Asymmetric information and agency conflicts | - Signaling (**Leland and Pyle, 1977**). | ↑ | - |
| | | | - Pecking order (**Myers and Majluf, 1984**). | ↓↑ | - |
| | | | - Agency problems between shareholders and debtholders **(Myers, 1977)**. | ↑ | ↓ |
| | | | - Agency problems between shareholders and managers **(Jensen and Meckling, 1976)**. | ↓ | - |
| | *Banking Theories* | Moral hazard | Perverse incentives due to safety net **(Merton, 1977)**. | ↓ | ↑ |
| **Regulatory Capital Requirement** | *Capital Regulation* | Asset substitution | Compensation between leverage and asset risk **(Koehn and Santomero, 1980)**. | ↑ | ↓↑ |
| | | Regulatory costs | Regulatory penalties **(Milne, 2004)**. - Well-capitalized | ↑ | ↑ |
| | | | Regulatory penalties **(Milne, 2004)**. - Low-capitalized | ↑ | ↓ |
| **Business Cycle** | *Risk Models* | Micro-founded models | Pro-cyclical regulatory risk models **(Repullo *et al.*, 2009)**. | - | ↓* |
| | *Capital Buffer Theory* | Shortsighted management | Pro-cyclical capital buffers **(Estrella, 2004)**. | ↓* | - |

* The effects refer to economic expansion periods.

## 3. International standards of capital regulation: the Basel Accord

Based on the theoretical conclusion that the optimal regulation would be one in which capital is adjusted by the bank's risk, the Basel Committee in 1988 defined a set of principles concerning the regulation and supervision of banks' capital (BCBS, 1988).[11] The agreement aimed at ensuring the stability of the international financial system and also to level the playing field among internationally active banks. The document has become known as the Basel Accord and, despite being restricted to the G10 countries which at the time formed the Committee, it has been adopted at least partially by more than one hundred countries.

[11] The Basel Committee on Banking Supervision, which Secretariat is provided by the Bank for International Settlements in Basel - Switzerland, serves as a central banking forum in order to improve the processes of banking supervision and cooperation among different national authorities. Initially formed by the G10 countries, today it comprises 27 members, including Brazil.

The Basel Accord stipulates that international banks must maintain capital equal to at least 8% of their total risk weighted assets (RWA). The risk weights, in turn, are function of the types of assets composing the bank's credit portfolio. The methodology for calculating the risk level of each asset operation is a simple multiplication of its nominal value by one of the five predefined type-related credit weights (0, 10, 20, 50 and 100%), with the sum of all the weighted assets defining the total RWA. It should be noted that this approach is low risk-sensitive and does not consider portfolio diversification effects.

In 1996, it followed an amendment to the Accord to incorporate the market risk charge in the capital requirements. The new criterion has reflected changes in the banking systems' operational profiles due to expansion in trading book activities. Interestingly, it has allowed the migration of risk management practices into the regulatory process. Value-at-risk models already were widely used by financial institutions and have become also a regulatory standard to define capital requirements related to interest rate risk exposures.

The work of Jackson *et al*. (1999), in the context of the Basel Committee, summarizes the impact of the Accord on banks' behavior based on empirical results from more than 130 articles. The main findings suggest that less capitalized banks rebuilt faster their capital levels after the regulation. Nevertheless the results are ambiguous regarding the risk profile, with some studies indicating that the capital requirement may have not succeeded in limiting the bank risk-taking despite the capital increasing. Some results also show that banks have reduced the effectiveness of regulation by engaging in off-balance-sheet regulatory arbitrages.[12]

Regulatory capital definition

The regulatory capital is intended to absorb losses due to negative shocks in the bank's asset values, so it is important to define the types of financial contracts that fit this objective. Berger *et al.* (1995) emphasize that a regulatory-eligible capital instrument must present three characteristics. Firstly, the instrument must be subordinated to deposits, so it serves as a cushion to absorb losses before the government. Secondly, the instrument must be "patient money", i.e. it should not be redeemed without refunding, in order to ensure a stable source of funds in case of bank panics. Finally, it should reduce moral hazard incentives of exploiting the safety net subsidy, in other words, it must effectively expose the creditors or shareholders

[12] Jones (2000) details the main techniques used by banks under Basel I capital framework to undertake capital arbitrage, reducing substantially their regulatory capital requirements with little or no corresponding reduction in their overall economic risks. Most of those methods are based on securitization, credit derivatives, and other financial innovations, which allow some "cosmetic capital adjustments" by hiding risks out of the balance-sheet.

to the risks taken by the bank. Besides the described essential features, the Accord classifies capital instruments into two levels according to its loss absorbency capacity: tier 1 capital formed by equity and cash reserves accounted in the balance-sheet, which must be at minimum 50% of total regulatory capital; and tier 2 composed by the remaining reserves, provisions, convertible debt, and subordinated debt.

### 3.1. The Basel II

By the late 1990's, in response to the Asian and Russian crises, the Committee initiated the drafting of a new document to replace the 1988 version. The new Basel Accord, or Basel II, was published in 2004 and brings significant changes to capital regulation (BCBS, 2004). The new principles of prudential regulation were based on three pillars: Pillar 1, which deals with the calculation of minimum regulatory capital requirement; the Pillar 2, which defines the supervisory review process; and Pillar 3, which describes measures of disclosure and market discipline.

Regarding the minimum capital requirement, Pillar 1, the major novelties of Basel II were the introduction of operational risk charge and the possibility of using internal models and advanced approaches to risk-weight the assets. In this sense, the regulation seeks to encompass most of the risks faced by the institution and to become adapted to the rapid technological innovations in financial markets, moving the capital required by regulation closer to the economic capital estimated by the institution. In relation to Pillar 2, supervisory actions are formalized in order to correct perceived distortions between regulatory and economic capital. Therefore, financial institutions are required to demonstrate to the regulator that they efficiently assess their economic capital (ICAAP - Internal Capital Adequacy Assessment Process). Finally, with respect to Pillar 3, the document presents a series of recommendations on transparency of the institutions' risk-taking profile and risk management processes. The central objective is to facilitate and promote market discipline.

### 3.2. The international financial crisis of 2008 and the Basel III

The recent financial turmoil has been characterized for fire-sale externalities and network effects, which suggest that, under the actual financial architecture, institutions have incentives to take on too much leverage, to have excessive mismatch in asset-liability maturities, and to be too interconnected (Brunnermeier, 2009). To deal with these negative externalities, a third Accord, or Basel III, was formatted at the end of 2010 with a schedule for full implementation by 2019 (BCBS, 2010d).

The micro-prudential models incorporate more stringent capital and liquidity requirements rules in order to individually improve the soundness of financial institutions. In addition, the structure is complemented with elements that consider systemic risk factors, defining the new macro-prudential regulation. That way, the objective of the new framework is to enhance wider banking sector stability by: (i) constructing defenses to deal with and mitigate the financial imbalances build up in economic expansions as well as the speed of the subsequent economic downturns; and (ii) identifying and treating common exposures, concentration risks, and interdependencies that may be sources of financial contagious. Under this line of reasoning, the main instruments of macro-prudential regulation are defined in two dimensions. To address the temporal dimension, measures are drawn to reduce the pro-cyclicality of the banking system. And to address the longitudinal dimension, there are policies primarily targeted to systemically important and interconnected institutions.

New micro-prudential and liquidity standards

The fast financial innovations combined to markets globalization recently proved that banks need to hold higher levels of capital and liquidity. In this sense, the Basel III micro-prudential framework has enhanced the standards for both capital and liquidity requirements. Some important improvements include: (i) considerable raising in the quality and quantity of capital with greater focus in common equity as to ensure the bank's viability in a going concern (tier 1 to RWA ratio must be higher than 6% and the common equity ratio must be higher than 4.5%); (ii) more conservative models for dealing with credit exposures in the trading book; (iii) higher capital charges for trading book exposures through the aggregation of risk measures that accounts for stressed periods (stressed value-at-risk); (iv) a new tier 1 risk-insensitive leverage requirement on the basis of total on- and off-balance-sheet assets (although it is not yet defined, the Committee is considering a ratio of 3% for the initial tests); and (v) a novel liquidity framework which comprises formal short and long-term liquidity requirements.[13]

Some of those measures have also a macro-prudential nature. The new stressed VaR aggregates to the capital requirement a "through-the-cycle" component that may help to stabilize the typical risk models cyclical sensitiveness. Also, a simple leverage ratio may curb

[13] The new capital requirements standards were calibrated based on an historical simulation on banks losses. Specifically, it was used the distribution of bank's return on RWA (RORWA) to estimate the potential loss and hence capital needs for a bank. The leverage ratio was calibrated based on historical trends in the banking systems. The results are presented in BCBS (2010c).

excessive balance-sheet growth not captured by risk-sensitive measures and may contribute to refrain risks built up in asset prices booms.

Pro-cyclicality

To reduce the potential cyclical effect of the banking system, which may harmfully amplify economic shocks, the new macro-prudential regulatory framework states that two extra layers of capital must be formed above the new minimum capital requirement. The first, which corresponds to the conservation buffer, has value fixed at 2.5% of total risk-weighted assets and aims to increase the financial system resilience, regardless of the stage of the business cycle. The second layer, the counter-cyclical buffer, has value between 0% and 2.5% of total risk-weighted assets and aims to smooth the banks' pro-cyclical behavior over the business cycle, protecting the banking system from systemic risks due to excessive aggregate credit growth. The buffer is gradually triggered in each jurisdiction as the ratio between total credit and gross domestic product moves away from its long-term trend.[14] An important feature of these buffers is that, unlike the capital requirements, they can be drawn in bad states of the nature with no penalties, safe for the freezing of earnings distributions until the bank recomposes its buffer levels.

Much research is being done on this theme, especially on countercyclical capital rules (Hanson *et al.*, 2010; Goodhart, 2010; and CGFS, 2010). Borio *et al.* (2001) provide previous discussion on supervisory instruments to explicitly treat the time-varying systemic risk. Borio and Drehmann (2009a) advocate using capital rules based on automatic stabilizers rather than discretion to address the pro-cyclicality of the financial system. Borio and Drehmann (2009b) test some early warning indicators of system-wide financial distress and suggest that relatively simple indicators based on credit and asset price can help informing assessments of the build-up of risks of future banking distress.

Systemic risk and interconnectedness

On the macro-prudential cross-sectional dimension, it is agreed that the bank identified as a systemically important financial institution (SIFI) must have higher loss absorbency capacity in order to mitigate moral hazard and to counteract its funding competitive advantage over those institutions not perceived as too-big-to-fail. Indeed, the approach for identification

[14] The buffers calibration was carried out through historical analysis on banking losses during stress periods and also through the analysis on projected decreases in capital from stress tests conducted by eight Committee member countries during the recent financial crisis. The results are presented in BCBS (2010c).

of systemic importance should not be restricted to the balance-sheet size, but should also consider how complex and interconnected the institution is. It has been discussed explicit additional capital requirements to SIFIs; however, the methodology to assess the magnitude of the surcharges has not yet been defined.

In practice, quantifying systemic risk can be a challenge, but recent studies have advanced on this front, presenting some statistical measures and further extending them to evaluate the contribution to the systemic risk from one financial institution. Adrian and Brunnermeier (2008) propose a method to estimate the marginal contribution of a particular institution to the overall systemic risk based on the "CoVaR", which is the value-at-risk of the financial system conditional on that institution being under distress. Acharya *et al*. (2010) propose another method based on the "SES" (Systemic Expected Shortfall), which is the institution's propensity to be undercapitalized when the system as a whole is undercapitalized. The authors also show that an optimal tax scheme should combine a tax on the bank's expected capital shortfall with a tax on its systemic expected shortfall, in order to address respectively the bank's deposit insurance subsidy and its systemic externality.

Costs and benefits of the new capital regulation framework

According to the Basel Committee, the benefits of a more capitalized banking industry may exceed its costs. The Committee has estimated, through a long-term cost-benefit analysis, that raising the ratio of tangible common equity to risk-weighted assets by 1 percentage point and meeting the Basel Committee's new liquidity standard should reduce the probability of crises from 4.6% to 2.3%, what means a gain of 1.4% of global GDP (BCBS, 2010a). Another Committee's working group has estimated that, taking a transition phase of four years, the level of GDP relative to the baseline path declines by a maximum of about 0.19% (BCBS, 2010b).

## 4. Implementation of Basel Accords in Brazil

Following the international standards, risk-adjusted capital rules were introduced in Brazil by the Resolution number 2,099 of August 17, 1994. It has been established that institutions should maintain an amount of regulatory capital (*Patrimônio Líquido Ajustado* - PLA) consistent with the risk exposure of their asset structure. The minimum capital requirement, formalized as the *Patrimonio Líquido Exigido* (PLE), is obtained by applying a factor of 8%

to the risk weighted assets. The risk weights, in turn, correspond to the five buckets of credit risk recommended by Basel I. In the same year, a new economic plan – Plano Real – initiated the process of local economic stabilization which successfully brought Brazilian annual inflation down from three to one-digit figures in less than three years (Bogdanski *et al.*, 2000).

The subsequent period was characterized by severe banking problems and the threat of a systemic crisis, when the banking industry lost its inflationary revenues, and three major institutions and several other small and midsize banks declared bankruptcy. As a result, the following is a comprehensive restructuring and strengthening on both the institutional aspects and the legal basis of the national financial system (Alves and Alves, 2010). From a prudential perspective, Franco and Rosman (2010) interestingly argue the Brazilian experience allows many comparisons with the procedures and solutions recently conjectured in the context of international financial crisis of 2008. For example, the reformed Brazilian banking legislation has two important differences from the American legal framework that may significantly contribute to reduce moral hazard incentives and social costs of bank failures in Brazil: (i) the unlimited liability of the manager of the institution under intervention or liquidation; and (ii) the powers of the intervenor or liquidator of selling and trading assets to resolve the troubled institution.

In this context, the harmonization process toward international standards of capital requirement finds solid basis for its development. The adaptations of the Basel Accord to local experiences and market conditions prove to be relatively more conservative. In 1997, as banking problems were materializing in Asia, the Brazilian capital regulation became stronger by increasing the minimum capital (to RWA) ratio requirement from 8% to 11%. In 1999, with the change from an exchange anchor regime to a floating exchange regime, the country suffered a currency crisis, resulting in the implementation of capital rules to cover market risk due to foreign currency exposures. As argued by Gruben and Welch (2001), the strengthened banking system was an important factor that allowed a fast economic recovery from that crisis.

Recently, the Resolution number 3,444 of February 28, 2007 amended the regulatory capital definition (*Patrimônio de Referência* - PR). In parallel, the Resolution number 3,490 of August 29, 2007, effective from June 2008 on, provided new methodologies for calculating the minimum capital requirement (*Patrimônio de Referência Exigido* - PRE). The rule introduced the capital to cover operational risk and has changed the form of calculation for market risk and credit risk. Regarding the credit risk capital, it has established new risk-weighting buckets, making capital less risk-insensitive. It is also important to mention that

these risk-weights are set by the regulator rather than by rating agencies. As for market risk capital, there is a strong emphasis to cover the risks of FX variability, aimed at reducing vulnerabilities arising from imbalances in exchange rates, as the international flow of capital is free in Brazil (Miranda, 2006). All models are based on simplified or standardized methodologies proposed by the Basel Accord.

Besides more conservative capital requirements standards, Brazilian banking system also presents higher capital buffer levels, since the local financial reform. Figure 1 depicts the banks' capital ratios evolution and shows that, in aggregate terms, the Brazilian banking sector has been well capitalized.

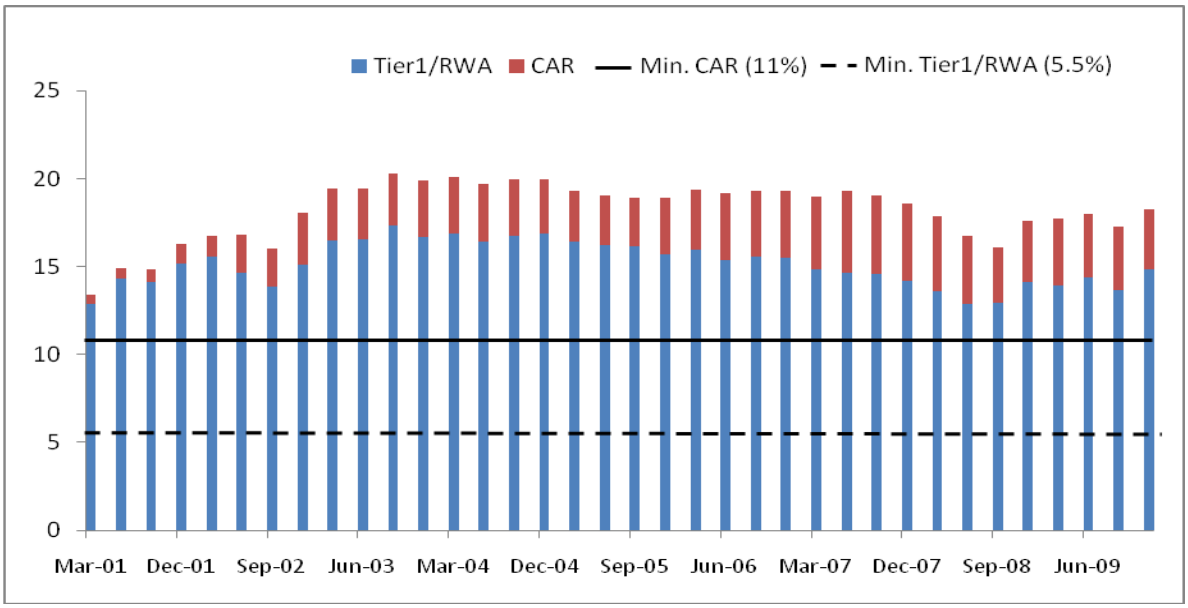


**Figure 1. The capital adequacy ratio in the Brazilian banking system.** The graph shows the quarterly evolution of capital adequacy ratio (CAR) and tier 1 ratio (Tier1/RWA) of commercial-type banking firms in Brazil between 2001 and 2009. The capital ratios are calculated as the total regulatory capital and the tier 1 capital over the total risk weighted assets in a specific quarter.

Risk-sensitive Basel II capital requirement models are also in the Brazilian prudential regulation agenda. The Communiqué number 19,028 of October 29, 2009 set forth the following revised implementation schedule for Basel II: (i) mid-year 2010, authorizations for the use of market risk internal VaR models; (ii) end-year 2012, authorizations for the use of credit risk internal rating-based approaches; and (iii) end-year 2013, authorizations for the use of operational risk internal measurement approaches. The timeline may change due to the new Basel III proposals.

### 4.1. Basel III in Brazil

As a member of the Basel Committee, Brazil has participated of the debate on the regulatory reform and, therefore, it moves toward deploying the new Basel III prudential rules. Accordingly, it follows a brief analysis on probable effects and practical issues for the Brazilian banking system regarding some major proposed capital requirements changes.

Differently from those jurisdictions most affected by the last financial crisis, Brazilian banks seem better prepared to cope with stronger capital rules. Figure 2 compares Brazilian and international actual capital requirements with the new proposed framework and shows that Brazilian regulation is much closer to the Basel III settings. The current local regulation already imposes stricter capital requirements to the banking system: Brazilian implicit core capital requirement is equal to 4.7% of RWA, against the 4.5% of the new regulation. Moreover, local banks (on average) have large capital surpluses, mostly composed by tier 1 capital, and their off-balance-sheet activities are not substantial *vis-a-vis* major banks from abroad.[15]

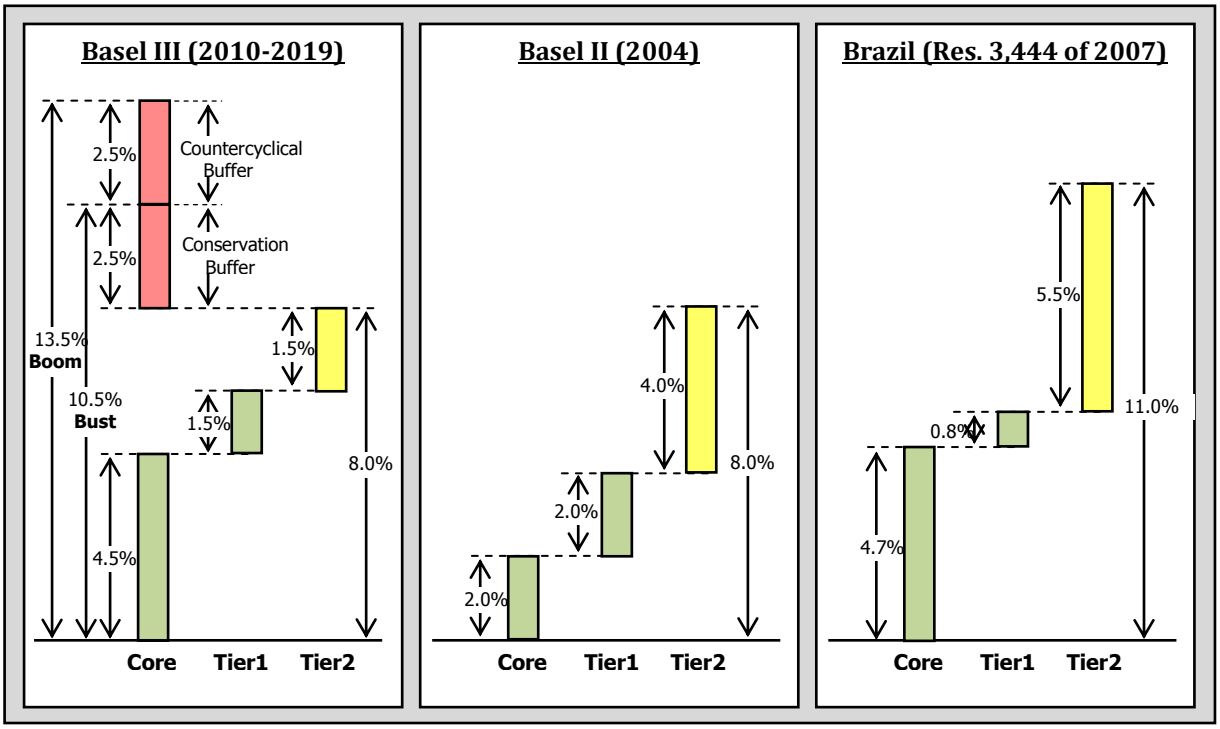


**Figure 2. Capital requirement frameworks comparison.** The picture shows the differences among regulatory frameworks regarding requirements on core capital, other tier 1 instruments, tier 2, and the conservation and countercyclical buffers: (i) the new Basel III, which will be fully implemented by 2019; (ii) the Basel II, which maintained the same requirements of the old version; and (iii) the current Brazilian capital regulation.

[15] The last quantitative impact study provided by the Basel Committee (BCBS, 2010f), which comprises 263 banks from 23 Committee member jurisdictions, presented that the aggregated average capital ratios (CAR and Tier 1/RWA), in December 2009, were equal to: (i) 14.0% and 10.5% for those internationally active banks with Tier 1 capital in excess of €3 billion; and (ii) 12.8% and 9.8% for the remaining banks. For the same date, Brazilian commercial banks' capital ratios were above 14% (see Figure 1).

On the other hand, some adjustments on tier 1 capital might be needed to account for proposed capital deductions aimed at improving the institutions' going-concern loss absorbance capacity. As this regard, a major concern for local banks may be the deferred tax assets and liabilities (DTA and DTL) related to temporary differences. Although local regulation establishes some accounting-based deductions on deferred tax assets (Resolution number 3,355 of March 31, 2006), some banks have significant amounts of those assets impacting on their tier 1 capital. From 2007 to 2009, the amount of deferred tax assets doubled in banks' balance-sheets, from 49.8 to 97.7 R$ billion (BCB, 2010).

In addition to the stronger capital definitions, the new tier 1 leverage ratio may force capital increases as it may be binding for some banks, especially those investment banks focused on treasury operations. The computation of RWA has also been strengthened and might contribute to elevate minimum capital requirements. Particular focus is given to the trading book exposures, once complex traded securities were responsible for most of the losses in the crises. The possible consequences of the two major trading book rules changes for the Brazilian banks are as follows.

The first important regulation change is the enhancement of regulatory risk models to properly deal with the counterparty credit risk; however, this has a minor impact on local banks, because they have lower exposure to resecuritizations and credit derivatives, and also because the local regulatory capital requirement for credit risk has always encompassed both portfolios: banking book and trading book. The second major change regards the addition of a stressed value-at-risk term in the models for market risk capital charges. In Brazil it has already been incorporated in the standardized capital models to cover market risk and by 2012, it will probably have a major impact on banks' capital requirements, since the typical emerging markets high historical volatilities may substantially increase the market risk capital charge.

Taking those considerations together and adding up the new buffers requirements, we can infer that Brazilian banks are likely to be required to raise quality capital during regulatory regime transition, although in lower levels if compared to banks in developed economies. Apart from the greater resilience and social benefit of a more capitalized financial system, some expected responses to the new capital standards in Brazil may be derived from the latest local banking empirical literature.

Firstly, banks may set their capital levels above the new regulatory constraint, as argues the capital buffer theory. Even those banks already compliant with the new regulation

may increase their capital ratios according to their revised capital buffer targets. Pereira and Saito (2010b) show that banks in Brazil feel pressured to undertake downwards short-term adjustments in both leverage and portfolio risks, as they get closer to the regulatory capital requirement. Hence, they will probably retain earnings and, alternatively, some of them may go to capital markets, since the local market has become more receptive to more efficient banks. Pereira and Saito (2010a) find evidence that the Brazilian banks follow the pecking order, using mainly retained earnings as a financing source. Oliveira *et al.* (2009) analyze the recent Brazilians banks IPO wave and show that those banks presented better performance, but higher capital constraints before the public offering, what may indicate that they were not just exploiting market timing, but rather were taking better financing opportunities.

Also, higher capital requirements may result in reductions in loans supply. Blum and Nakane (2005) test whether credit supply contractions in Brazil result from the regulatory costs of maintaining capital levels above the minimum. The authors observe a positive relationship between capital ratio and loan supply, particularly for non-compliant banks, and alert to the potential credit crunch effect of regulation as the capital requirement becomes more binding.

Finally, a time-varying capital requirement should be an efficient instrument to deal with the balance-sheet pro-cyclicality and, especially, with the financial imbalances built-up in economic expansions, which lately in Brazil has been characterized by a strong credit growth (see Figure 3). Pereira and Saito (2010a) show that the banks' capital buffers are negative related to the business cycle, so banks shrink balance-sheets in good times and enlarge them in bad times.

A practical issue is the definition of indicators to function as triggers in the buffer mechanism. According to Basel III definition, authorities are expected to follow a common reference guide, based on the aggregate private sector credit-to-GDP gap (BCBS, 2010e), but they may also apply judgment based on the best information available to assess the build-up of systemic risk. Particularly for Brazil, the discretionary component should have significant weight in the final setting of the buffer, due to data problems and points of structural breaks that make it difficult to follow the credit long-term trend. As further analyses are needed, Capelletto and Corrar (2008) test several accounting and economic variables and show that indicators related to the volatility of non-performing loans, profitability, interest rate, and credit risk may be useful in evaluating the banking sector's vulnerability to a systemic crisis.

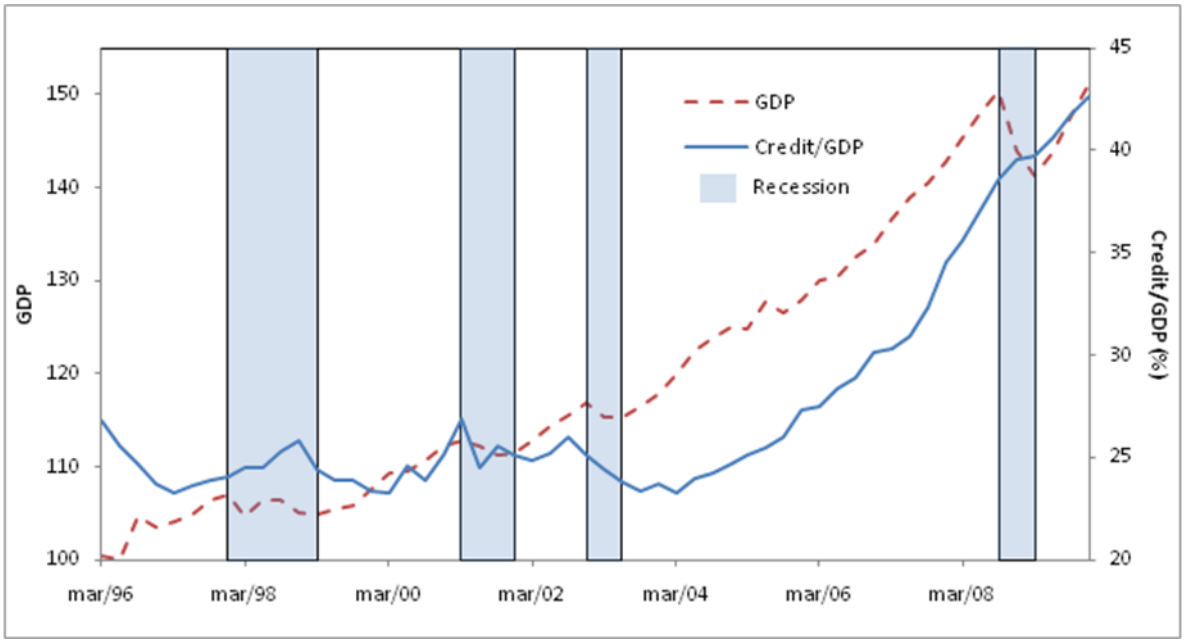


**Figure 3. Credit and GDP in Brazil from 1996 to 2009.** The credit to GDP series encompasses the total private loans and the total output at market prices. The GDP series is the seasonally adjusted quarterly GDP at market prices (average 1996 = 100). Both series are available on the Central Bank of Brazil website. The quarterly chronology of the Brazilian business cycles is defined by the Economic Cycle Dating Brazilian Committee of the *Instituto Brasileiro de Economia* (IBRE).

## 5. Final remarks

The first part of this study reviews the main determinants on banks' capital structure, separating the main drivers on banks' behavior into three groups. Firstly, it covers the common factors to financial and non-financial firms and the structural differences between them, also approaching the need for a safety net to protect banks and depositors from costly bank runs. Secondly, it explores the prudential regulation, which is theoretically justified by the need to restrain perverse incentives generated by risk-insensitive deposit insurance schemes. Finally, it presents some effects of the business cycle.

The second part reviews the international standards of capital regulation – the Basel Accord –, starting from its first version by 1988 until the first steps of the Basel III, as a response to the 2008 global financial crisis. The new regulatory approach stemming from the Basel III seeks to address the negative externalities in the financial system in a macro-prudential framework. The effects of this new policy, however, are not yet clear. There are several issues that require theoretical and empirical developments. Two important examples are the countercyclical buffer calibration and the capital surplus methodology for too-important-to-fail institutions.

It has also been commented some potential effects of the new regulation on the Brazilian banking system and some implementation practical issues. We argue that the new strengthened capital standards may impact loans supply and that the new time-varying capital buffer may effectively smooth the Brazilian banks behavior.

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# CHAPTER 2: HOW DO CAPITAL BUFFERS RESPOND TO BASEL? AN EMPIRICAL ANALYSIS OF THE BRAZILIAN BANKING SYSTEM

## 1. Introduction

Despite banks' key role in allowing an efficient resources allocation in the economy, they also inherently carry a fragility and opacity that may cause instability to the financial system with high costs to society. For those reasons, the banking industry is heavily regulated. Particularly, the capital regulation requires from the banker a minimum participation in the business which is proportional to the risk of the firm's investments, in order to minimize opportunistic behavior and make the bank safer against shocks on the value of its assets. The banker, in turn, generally chooses his stake so as to maintain a safety margin over the regulatory capital limit and, at the same time, meeting the expectations and pressures from the market. Thus, beyond the regulatory constraint, some other factors may influence the combination between the banking structures of capital and investments.

The international regulatory standards, dictated by the Basel Accord (BCBS, 1988, 2004), to some degree address each of those factors ultimately aiming for financial system soundness. Besides the minimum risk-adjusted capital requirement, the financial authority also monitors banks and requires from them an appropriate risk management, in accordance to the business complexity, as well as appropriate disclosure allowing the market monitoring. Specifically, those factors are defined in the Basel II structure as the three pillars of regulation: Pillar 1, which deals with capital requirement models and banks capital/risk management; Pillar 2, approaching the supervisory monitoring; and Pillar 3, which deals with the market discipline.

Nevertheless, the recent 2008 global financial crisis has revealed that, even following prudential regulation requirements, banks are exposed to potentially costly systemic impacts. Among the various causes of recent financial instability, we can mention two that evidenced important flaws in the actual regulatory framework. The first one is the strong interaction between the real and financial sectors of the economy, which may increase financial vulnerabilities in times of expansion and amplify the phases of recession. The second one is related to the high complexity and opacity derived from the originate-to-distribute business model, which may hide banks' excessive risk-taking from the monitoring of market and

supervision. Thus, the Basel Committee has worked to redesign the regulatory model by strengthening capital requirements, increasing standardization in financial transactions, and adding a macro-prudential scope to regulation, which includes the imposition of capital surcharges sensitive to economic cycles (BCBS, 2010).

In the light of the aforesaid discussion, the present paper seeks to investigate the drivers of banks' capital buffers in Brazil, and particularly to test whether they respond to the previous and new fundamentals of capital regulation, as defined by the Basel Accord. Using a dynamic empirical model on a bank-level panel data, we provide evidences that: (i) capital requirement influences banks' capital management; (ii) supervision monitoring has a positive effect on solvency ratios, especially for less capitalized banks; (iii) uninsured depositors may play a minor role in disciplining banks; and (iv) capital management practices are likely to be pro-cyclical.

The paper has the following structure. Section two provides some historical aspects on the implementation of the Basel Accord in Brazil and the trends in capital ratios in the local banking industry. Section three explores the banking theories regarding banks' funding/investment decisions, and reviews some related empirical results in the literature. Section four presents, based on capital buffer theories, the empirical construction for the determinants on the banks' solvency cushions, and defines the variables and their expected signs in the testing hypotheses. Section five describes the database, highlighting the characteristics of the local market. Section six presents the econometric approach and the robustness tests, and analyzes the empirical results. Section seven concludes the study.

## 2. Prudential regulation in Brazil

Following the international regulatory standards, Basel I risk-adjusted capital rules were introduced in Brazil by the Resolution number 2,099 of August 17, 1994. Accordingly, the document stipulated that banks must maintain a solvency ratio, calculated as the ratio of capital to risk weighted assets, of at least 8%.

In the same year, the new economic plan – Plano Real – initiated the process of local economic stabilization which successfully controlled Brazilian hyperinflation in less than three years. The subsequent period was characterized by severe banking problems and the threat of a systemic crisis when the banking industry lost inflationary revenues, and three major institutions and several other small and midsize banks declared bankruptcy. As a result,

it followed a comprehensive restructuring and strengthening on both the institutional aspects and the legal basis of the national financial system (Alves and Alves, 2010). The new laws also improved supervisor's power to enforce the regulations, permitting the Central Bank to resolve a bank with solvency problems through merger or closure, or even by selling the bank's equity.

In this context, the harmonization process to international standards of capital regulation found a solid basis for its development. The adaptations of the Basel Accord to the local experiences and market conditions proved to be relatively more conservative. In 1997, as banking problems were materializing in Asia, the Brazilian capital requirement became more rigid by elevating the factor on the risk-weighted assets from 8% to 11%. In 1999, with the switch from an exchange anchor regime to a floating one, the country suffered a currency crisis, resulting in the implementation of capital rules to cover market risk due to foreign currency exposures.

Interestingly, Gruben and Welch (2001) argue that an important reason that permitted Brazil to get out this crisis faster than other countries in similar situations was the post-restructuring banking system stability. The strong prudential regulation, the historical macroeconomic volatility, and a tight monetary policy, which encouraged banks to expand holdings of high-yield government securities, made Brazil's commercial banks to work with high levels of capitalization ratios and liquidity. On the other hand, that banking system stability may have also contributed to curb banks' loan supply and, consequently, economic growth.

The conservative behavior remains, as Brazilian banks, in general, have very large capital buffers. As shown in Figure 1, since 2003, the aggregated capital adequacy ratio of the commercial banks (total regulatory capital over the total risk weighted assets in the system for a determined point in time) has varied between 16% and 19%, well above the limit of 11% required by regulation.

Figure 1 also shows the Brazilian annual GDP growth adjusted by inflation between 2000 and 2009. It should be noted that after the economic stabilization, the movements of GDP and banks risk-adjusted capital ratios (CAR), in aggregate terms, suggest some degree of negative coordination.

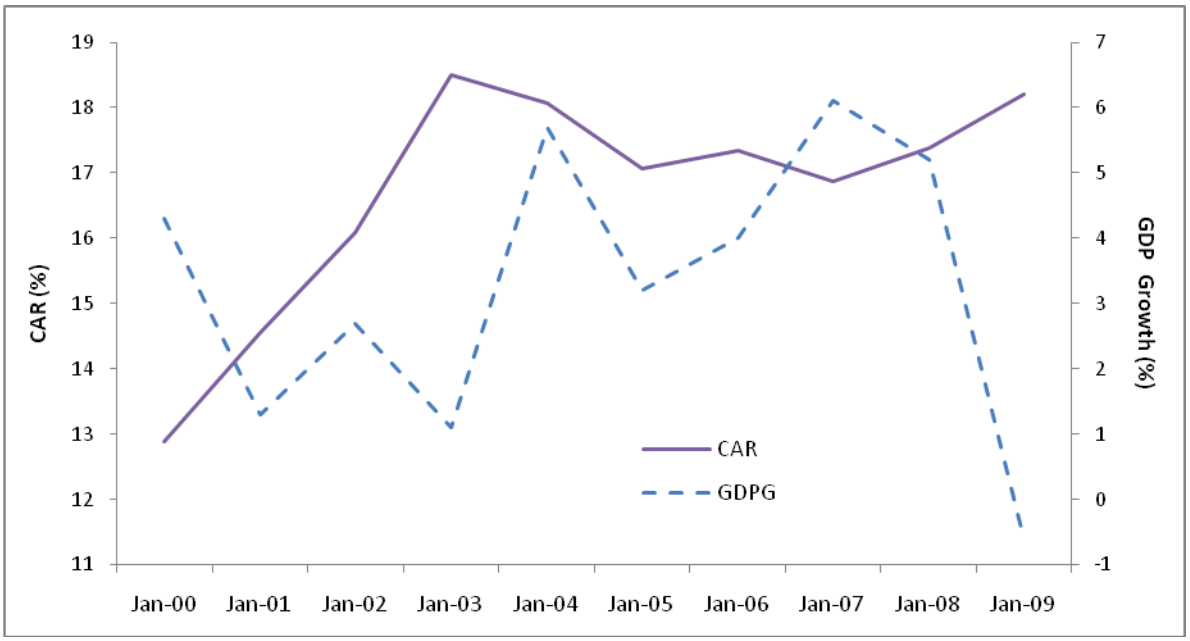


**Figure 1. Banks' capital adequacy ratios and the economic cycle in Brazil.** The graph shows the evolution of both the capital adequacy ratios (CAR) of commercial-type banking firms in Brazil, and the local annual GDP growth. The aggregated capital adequacy ratio is calculated as the total regulatory capital over the total risk weighted assets in the banking system for a determined quarter. The real GDP growth series is calculated by the Economic Department of the Central Bank of Brazil.

## 3. Banks' balance-sheet decision

Since the classical proposition of Modigliani and Miller (1958) that, in perfect markets, the capital structure choice is irrelevant to both firm value and its investment strategy, substantial research has been carried out to identify the nature of market imperfections which are likely to influence firm's decisions. Besides the traditional well known corporate factors, Santos (2001) points out two additional bank-specific frictions that should influence financial firms' behavior: (i) the structural fragility due to deposit financing; and (ii) the safety net protection. Under such differences some authors concerned on explaining the banks' capital structure decision.

Merton (1977) explores the safety net influence on banks opportunistic behavior, which may directly impact banks' balance-sheet. He shows that the deposit insurance can be seen as the equivalent of an European put option held by the bank and written by the deposit insurance agency, with a premium which is decreasing in bank's equity capital and increasing in bank's asset risk.

Using a static trade-off framework, Orgler and Taggart (1983) argue that, because of depositors' tax benefits, which include non-taxable services embedded in deposits (liquidity,

safety, and bookkeeping), and the reduction of failure costs due to safety net subsidy, the bank optimal proportion of debt relative to equity is high. Diamond and Rajan (2000) show that the optimal capital structure for banking firms is defined in terms of the costs of reductions in the credit flow and in the liquidity creation versus the benefit of greater stability of the institution. They conclude that the bank's leverage ratio is high and should increase when the underlying projects liquidity increases.

Flannery (1994) argues that leveraged capital structures may reduce agency costs, imposing desirable limits on management and reducing the need for shareholder monitoring; however, it may also provide incentives for the manager to undertake riskier projects, which should be counteracted by the disciplinary power of short-term debtholders. Indeed, depositors may discipline poor management performance or excessive risk-taking by either withdrawing deposits or demanding a risk premium. Calomiris and Kahn (1991) demonstrate that uninsured demandable debt intended for qualified investors disciplines banks by the threat of bank runs. Blum (2002) models the potential disciplining effect of subordinated debt through the level of interest rates charged by the debtholders, but demonstrates that the efficiency of the market discipline is conditional on the bank being able to credibly commit to certain level of risk, otherwise the subordinated debt may even increase bank risk-taking.

Nevertheless, the main adopted instrument to refrain banks' moral hazard is the capital regulation. Dewatripont and Tirole (1994) explicitly address the role of the bank's capital structure in a prudential regulation scheme, where financial authority intervention, based on minimum capital requirements, may adjust banks' perverse incentives. Some other theoretical studies focus on banks' responses to capital regulation. In general, those are static models which take capital as exogenous and derive their conclusions in the light of the bank risk-taking optimal choice under capital constraint. A comprehensive analysis is presented by Rochet (1992), who shows that capital requirements effects on portfolio risk decision may be ambiguous. On the one hand, considering profit-maximizing banks, capital regulations cannot prevent banks from choosing very risky assets. On the other hand, for utility-maximizing banks, risk-based regulations can be effective, in line with previous mean-variance models (e.g. Furlong and Keeley, 1989; and Keeley and Furlong, 1990).

A recent theory line has explored the empirical fact that banks present capital ratios above the regulatory requirements. The capital buffer theory states that banks balance costs and benefits across the entire balance sheet when subjected to capital regulation. Basically, the capital level should be set as an endogenous response to: (i) penalties and other kinds of

distress related to the breach of the regulatory minimum; (ii) the cost of capital surpluses; and (iii) the costs and time constraints for adjusting capital levels.

Milne and Whalley (2001) and Milne (2004) model the dynamics in bank's capital decision as a continuous-time inventory problem. The manager must decide in what level he must issue new capital or wait until the supervisory authority forces him to do so. Besides balancing the costs and benefits of the capital surplus, the key point of the model is that banks with high charter values would have more to lose if they breach the regulation and, for that reason, they have greater incentive to maintain extra capital. The models have important implications for the impact of capital regulation on banks' risk-taking. According to the authors, in the short term, banks' incentive to take risks decrease as their capital levels approach the regulatory minimum.

Estrella (2004) develops a dynamic model in which forward-looking banks choose their capital levels subject to adjustment costs and to capital requirements on the basis of value-at-risk (VaR) models. He shows that, over the cycle, the optimum capital level is negatively related to the period-dependent VaR capital constraint, so the difference between them – the optimal capital buffer – assumes a cyclical pattern. The results suggest that the regulatory capital requirement would be loose following phases of gains and binding on banks' capital structures during the loss periods, increasing the likelihood of reductions in credit supply. The model also provides some useful insights regarding possible banks' conducts and their further implications to financial stability. In business cycle upturns, the gap between optimal and regulatory capital may be so large that the bank may follow the temptation of opportunistically burning its buffer to increase short-run profits, ignoring possible future needs for capital. Ayuso *et al.* (2004) define such shortsighted behavior as a pro-cyclical capital management.

### 3.1. Empirical evidences in the literature

Gropp and Heider (2010), through a static panel model, find evidences that the variables commonly used as capital structure determinants for non-financial companies, such as size, profitability, market-to-book ratio, and tangibility, are also determining factors to explain the leverage of publicly traded banks in US and Europe. Çağlayan and Şak (2010) show similar results for the Turkish banking system, distinguishing the pecking order theory as the primary driver of banks behavior.

The majority of the empirical literature, however, has focused on dynamic models, on the basis of the capital buffer theories construction. Ayuso *et al.* (2004) test banks' behavior

in Spain; Alfon *et al.* (2004) and Francis and Osborne (2009) assess the determinants on bank capital in UK; Wong *et al.* (2005) test the banking industry from Hong Kong; and Lindquist (2004), Stolz (2007), and Jokipii and Milne (2008) undertake similar studies in Norway, Germany and Europe, respectively. These studies show persistent series of capital ratios in the various jurisdictions, indicating that capital adjustment costs significantly influence the bank's choice for holding capital in excess. In general, the authors note the prevalence of a capital management based on the trade-off between costs of capital and the cost of failures, with the exception of Alfon *et al.* (2004), who verify the predominance of a pecking order in the banks' capital decision.

Regarding the impact of supervision on capital ratios, Furfine (2001) provides evidence that a tighter supervisory monitoring may influence the bank's balance-sheet decision. Lindquist (2004) finds a positive relationship between capital ratios and supervisory efforts, but his results are not significant.

Wong *et al.* (2005) and Francis and Osborne (2009) test the role of market discipline in the determination of capital holdings, and, respectively, find that the wholesale funding market and the subordinated debtholders have positive impacts on capital ratios. Interesting cross-country market discipline evidences are provided by Nier and Baumann (2006), who show that uninsured deposits due to banks bring about decreases in banks' leverage.

Finally, all authors (Ayuso *et al.*, 2004; Alfon *et al.*, 2004; Francis and Osborne, 2009; Wong *et al.*, 2005; Lindquist, 2004; Stolz, 2007; and Jokipii and Milne, 2008) test the influence of business cycle on bank's behavior, and provide evidence that capital buffers may be pro-cyclical, as banks shrink balance-sheets in bad times and enlarge them in good times. Conversely, Jokipii and Milne (2008) find a positive relationship between capital buffer and business cycle for banks from countries which have recently joined the European Union, and Francis and Osborne (2009) also find a positive sign in UK when testing for an alternative former period, shortly after the implementation of Basel I capital regulation. These results suggest that legal and regulatory pressures can induce increases in banks' capital levels despite the countervailing influence of the business cycle.

## 4. Capital buffer empirical model

We test the determinants on banks' capital buffer behavior through a dynamic empirical model, taking into account the costs of adjusting capital and the costs of regulation, as argues

the capital buffer theory. Under this rationale, the equation (1) considers that the capital adjustments, $\Delta BUF_{i,t}$, are not instantaneous. Hence, the bank *i* only partially reaches its optimal buffer, $BUF^{*}_{i,t}$, during the period between *t-1* and *t*. The proportion or speed of adjustment, $\theta$, will be greater the lower the adjustment costs. In case of zero adjustment cost, capital is fully adjusted ($\theta$ = 1) and the observed buffer, $BUF_{i,t}$, shall be equivalent to the optimum one plus an exogenous error component, $u_{i,t}$.[16]

$$\Delta BUF_{i,t} = \theta(BUF^{*}_{i,t} - BUF_{i,t-1}) + u_{i,t} \quad (1)$$

The theoretical optimum buffer, in turn, is modeled as a function of four fundamental sources of influence on banks' decisions, as noted in the above literature discussion and presented in equation (2): firstly, the influence of capital requirements on bank's management model (*MNG*); secondly, the pressure of supervision (*SUP*); thirdly, the market discipline (*MKT*); and finally, the economic environment (*CYCLE*).

$$BUF^{*}_{i,t} = f(MNG, SUP, MKT, CYCLE) \quad (2)$$

Note that the first three sources of incentives to the optimal solvency cushion correspond to the three regulation pillars of Basel II, and the fourth one is the base of the new macro-prudential requirement of the new Basel Accord. The variables capturing each of those stimuli are then defined in the following subsections.

### 4.1. Capital requirements and internal capital management

A profit-maximizing bank may balance the costs of holding capital surplus in the extent of the likelihood of facing costs associated with failure. On the one hand, the banker may maintain a lower capital ratio when the opportunity cost of capital is high. On the other hand, the banker may decide on a higher capital standard as the higher is the probability of breaching the regulation, which should increase the probability of bankruptcy; thus, as intended by regulators, banks with riskier portfolios should hold larger capital buffers.

[16] We assume that the exogenous shocks to buffer adjustments, i.e. the error term $u_{it}$, consists of two orthogonal components, independent and identically distributed: a bank-specific effect ($\eta_i$) and a white noise ($\varepsilon_{it}$). Non-directly observable effects (e.g. managerial attitudes, corporate strategy, and instability of deposits) that remain stable over time for a given bank, but change from firm to firm, justify the fixed effects assumption. Additionally, Hausman tests reject the use of random effects.

Therefore, under the trade-off perspective, the return on equity, *ROE*, may be used as a proxy of the cost of remunerating the equity, with a negative expected sign.[17] Regarding the cost of failure, as measuring bank's riskiness is a complex task, we combine two variables commonly adopted by the banking and the corporate finance empirical literatures, which are expected to have positive signs: the nonperforming loans, *NPL*; and the volatility of return on equity, *VOL*.[18]

In contrast, the expected sign for the variable *ROE* should also be positive, especially in markets where asymmetric information can significantly increase the costs of external capital, making retained earnings the main source of recapitalizations, which is in line with the pecking order theory (Myers and Majluf, 1984). Indeed, Berger (1995) distinguishes three main reasons for a positive relationship between banks' profits and their capital ratios. First, considering a multi-period framework, a higher profitability leads to increases in capital, provided that the marginal profits are not fully distributed as dividends. Second, if investors are risk averse and markets are incomplete, increases in capital reduce bankruptcy costs and may lower market's expected rate of return, therefore, leading to increases in expected earnings. Finally, given information asymmetries, banks that expect better performances may signal that information through higher capital ratios (Leland and Pyle, 1977).

Other firm-specific variables may influence the banks' capital choice. The bank size, *SIZE*, may impact the bank's behavior in several ways. Larger banks usually have a broader access to capital markets and, in consequence, lower financing costs. In general, large banks also have more diversified portfolios, whose effect of reducing the aggregate risk of default should minimize the need for capital; if the diversification effect is not fully captured by the regulatory risk models, the final effect should be a reduction in the capital ratio. Finally, the big ones can take advantage of the depositors' perception on the safety net involving banks too-big-to-fail by maintaining lower levels of capital ratios. Therefore, the expected sign for this variable is negative, as commonly verified by the empirical literature.

It is also expected a negative effect for the variable that accounts for the bank's liquidity cushion, *LIQUID*, as bankruptcy costs, specifically the cost of liquidating the bank,

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[17] The definition of the equity profitability as a proxy for the cost of equity is based on the comparable accounting earnings model (Green *et al.*, 2003), widely used due to its practicality. Roughly speaking, the methodology starts from the principle that shareholders may expect returns based on past earnings, thus each dollar invested as capital must perform according to this target.

[18] Some related empirical studies (e.g. Ayuso *et al.*, 2004) have argued that non-performing loans are an *ex post* measurement of the risks assumed by the institution and, therefore, they should have a negative expected sign; however, the Brazilian regulation demands that the credit classification must be initially carried out under prospective criteria, and later, such classification should be reviewed based on the credit past-due status (Resolution number 2,682 of December 19, 1999).

may decrease because of its assets liquidity (Diamond and Rajan, 2000). So the optimal size of capital cushions may decrease if the amount of liquid assets is large.

### 4.2. Supervisory pressure

Banking supervision can influence banks' decisions even for those apparently compliant with the capital regulation. Each bank is periodically evaluated in accordance with quantitative and qualitative criteria that cover broad definitions of bank economic and financial conditions, risk profile, and efficiency. A poorly rated institution, captured by the variable *SUPERV*, is more likely to suffer direct actions from supervision. In this case, the bank may compensate its deficiencies by increasing its solvency ratio in the short-run (Alfon *et al.*, 2004). It is also expected a more intense indirect effect of supervision for banks closer to the regulatory capital limit. As the worse the supervisory evaluation, the higher the score, the expected sign of the variable is positive.

### 4.3. Market discipline

The effect of market discipline might be stronger, the larger the amount of uninsured funding. For a given increase in bank risk, the market will demand higher yields which in turn reduce the bank profitability; thus the greater the amount of uninsured debt, the stronger is the effect of market discipline. Following Francis and Osborne (2009), we measure the amount of uninsured funding of a bank by the total subordinated debt, *SUBORD*. Alternatively, as some banks may not have access to the subordinated debt market, we also test the amount of interbank deposits, *BANKDEP*, following Wong *et al.* (2005) and Nier and Baumann (2006). Both variables are expected to present positive signs.

The behavior of competition should also put pressure on banks' capital buffers. The variable *PEER* is defined by the average capital buffer of similar institutions. Banks with smaller capital buffers than their peer groups may provide negative signals to the market, so it is expected a certain positive coordination among similar banks. A positive sign is observed in different countries by Lindquist (2004), Alfon *et al.* (2004), and Wong *et al.* (2005).

### 4.4. Economic environment influence

Negative co-movements between the banks' capital buffers and variables of economic growth in several banking systems suggest that business cycle may significantly impact banks' behavior. Therefore, we add the variable of gross domestic product growth, *GDPG*, whose negative sign may indicate shortsighted management.

Ayuso *et al.* (2004) suggest controlling for the loan growth through the variable *LOANG*, as a proxy for the variations of bank-specific credit demand. The authors argue that, as the credit supply is rarely constrained by the capital requirement, the credit growth may be mainly demand-driven.

### 4.5. Final empirical equation and testing hypotheses

Considering the described variables, the capital buffer empirical model composed by equations (1) and (2) has its full specification as follows:

$$\begin{aligned} BUF_{i,t} = {} & (1-\theta)BUF_{i,t-1} + \alpha_1 ROE_{i,t} + \alpha_2 NPL_{i,t} + \alpha_3 VOL_{i,t} + \alpha_4 SIZE_{i,t} + \alpha_5 LIQUID_{i,t} \\ & + \beta_1 SUPERV_{i,t-1} + \gamma_1 SUBORD_{i,t} + \gamma_2 PEER_{i,t} + \mu_1 GDPG_t + \mu_2 LOANG_{i,t} \\ & + DModel + TimeDummies + K + \eta_i + \varepsilon_{i,t} \end{aligned} \quad (3)$$

It should be noted that it is included the dummy *DModel* to control for the mid 2008 changes in the regulatory models of capital requirement, and time dummies to capture possible quarterly seasonality and specificities of each year in the sample.

From equation (3) we can also derive our empirical testing hypotheses for the banks' capital ratio decision on the basis of the four presented Basel-based stimuli. The null hypothesis is that none of them influences banks' behavior.

Regarding the capital management strategy and the influence of capital requirements (Basel Pillar 1), three main hypotheses address, respectively, the adjustment costs, capital profitability, and banks' risk-taking.

> ***Hypothesis H1.*** *Adjustment costs may influence banks to maintain capital surpluses, as argue the capital buffer theory (*$0 < \theta < 1$*).*

> ***Hypothesis H2.*** *Value-maximizing banks may reduce capital levels, the higher the cost of capital (H2A:* $\alpha_1 < 0$*). Alternatively, banks may follow a pecking order, using retained earnings to improve capital ratios and to provide solvency signals to the market (H2B:* $\alpha_1 > 0$*).*

***Hypothesis H3.*** *Riskier banks should have higher capital ratios in order to avoid violating capital requirements, as argue the capital buffer theory ($\alpha_2 > 0$ and $\alpha_3 > 0$).*

As for the financial authority monitoring (Basel Pillar 2), we test the impact of supervisory solvency evaluations on banks' capital choice.

***Hypothesis H4.*** *Banks, when perceived to be riskier by supervision, may feel pressured to improve capital ratios ($\beta_1 > 0$).*

Regarding market discipline (Basel Pillar 3), as depositors may monitor banks' behavior, we test whether institutional debtholders force banks to reduce their probability of default. Additionally, we test whether banks consider their peer groups when setting their capital ratios.

***Hypothesis H5.*** *Uninsured depositors may discipline banks, inducing them to strengthen their solvency ratios ($\gamma_1 > 0$). In addition, their peer group may put pressure on banks behavior ($\gamma_2 > 0$).*

Finally, regarding capital buffers responses to the business cycle, we define two alternative hypotheses to test whether banks' capital management behave counter- or pro-cyclically.

***Hypothesis H6.*** *Forward-looking banks may raise capital during economic expansions, when capital is less costly (H6A: $\mu_1 > 0$). Conversely, a negative co-movement between banks' capital buffers and economic growth indicates a pro-cyclical capital management (H6B: $\mu_1 < 0$).*

Table I summarizes the explanatory variables included in the final empirical model and their expected signs.

**Table I – Explanatory variables and expected signs**

Explanatory variables and their expected signs in the presented capital buffer econometric model. The time dummies and the variable *DModel* are not included in the table.

| Stimulus | Variable | Definition | Rationale | Expected sign |
|---|---|---|---|---|
| ***Capital Requirement and Capital Management*** | $BUF_{t-1}$ | Lagged capital buffer. | Proxy for the adjustment costs. The higher the capitalization costs, the lower is the adjustment speed. | + |
| | *ROE* | Return on equity. | - Higher costs of capital (trade-off theory).<br>- Retained earnings as an important source of capitalization (pecking order). | -<br>+ |
| | *VOL* | Return on equity volatility. | Proxy for the firm's risk profile. Higher costs of failure (bankruptcy or violation of the capital minimum requirement). | + |
| | *NPL* | Nonperforming loans. | Proxy for the firm's risk exposure. | - |
| | *SIZE* | Total assets. | - Broader access to capital markets.<br>- Higher diversification and better investments opportunities.<br>- Opportunistic behavior of those perceived as too-big-to-fail. | - |
| | *LIQUID* | Liquid assets. | Lower liquidation costs. | - |
| ***Supervisory Pressure*** | $SUPERV_{t-1}$ | Supervisory CAMEL ratings. | Supervisory monitoring effect. | + |
| ***Market Discipline*** | *SUBORD* | Subordinated debt. | Market discipline effect. | + |
| | *BANKDEP* | Uninsured banks' deposits. | Market discipline effect. | + |
| | *PEER* | Buffer average of the peer group. | Peer group pressure. | + |
| ***Economic Environment*** | *GDPG* | GDP growth. | - Prudent capital management.<br>- Shortsighted capital management. | +<br>- |
| | *LOANG* | Loan growth. | Control individual credit demand changes. | - |

## 5. Data base

The data base consists of quarterly information from banks solo and banking holding companies with commercial portfolios, operating in Brazil in the period between the first quarter of 2001 and the fourth quarter of 2009. Development banks, as well as those whose main activities are investment banking or treasury operations, were excluded from the sample. Institutions subject to government intervention or liquidation processes and those with less than five observations in the period were also excluded.

After cleaning the data, some banks presented regulatory capital more than eighty times greater than the required, as the case of some small foreign subsidiaries whose main function is to prove credit lines and export-import foreign exchange contracts to companies of

their nationality doing business in Brazil. As their banking activity varies according to the business activity of their related firms, in some downturn periods the loan portfolio is replaced by government securities, making their solvency ratio extremely high and defining an accentuated cyclical pattern. We, therefore, removed those extreme outliers by eliminating observations with capital ratios above the sample's ninety-ninth percentile.[19] The final data set composes an unbalanced panel with 3,806 observations of 112 banks distributed in 36 quarters.

The firm-specific data include descriptive information of the institutions, accounting information from balance sheets and financial statements, and operational limits which are periodically sent to the Central Bank.

The bank's capital buffer, *BUF*, is calculated in percentage as the excess regulatory capital over the risk-weighted assets.[20] The value can also be calculated in terms of the capital adequacy ratio (CAR), as the actual CAR minus the minimum required CAR. As shown in Figure 1, the Brazilian banks' capital ratios are well above the limit of 11% required by regulation, as the sample mean capital buffer is about 17%.

The return on equity, *ROE*, is calculated by the quarterly net income over the average net book value. The volatility of this variable in the last four quarters, measured by standard deviation, defines the risk variable, *VOL*. The average equity profitability in the sample is 3.8% per quarter and the average variability for this variable is 4.4%. Complementing the bank risk profile, *NPL* is defined by the nonperforming loans over the total loans. A loan is considered nonperforming when payments of interest and principal are past due by 90 days or more.

The bank size, *SIZE*, is defined by the total assets net of amounts related to financial intermediation. The six largest banks account for over 70% of the sample total assets in the last quarter of 2009. Banco do Brasil alone totaled about 565 billion Reais in assets on the same date.

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[19] To deal with those kinds of extreme events in the regressions, it has been taken three alternative treatments in the data set. Firstly, the estimations were carried out with the whole sample. Secondly, it was excluded the observations with capital buffers higher than the ninety-ninth percentile in the sample, equivalent to a CAR value of 211 %. Thirdly, it was limited the maximum buffer value to the ninety-ninth percentile, so any observation with a higher buffer had its value changed to the defined ceiling. In all three cases the results and diagnostic tests of the models showed no significant change.

[20] The Resolution number 3,444 of February 28, 2007 amended the regulatory capital definition (*Patrimônio de Referência* – PR). In parallel, the Resolution number 3,490 of August 29, 2007, with effect from June 2008, provided new models for calculating the minimum capital requirement (*Patrimônio de Referência Exigido* – PRE).

The amount of uninsured funding is measured, firstly, by the ratio of subordinated debt to total liability, *SUBORD*, and, secondly, by the amount of interbank deposits to total deposits, *BANKDEP*.

The peer group capital buffer, *PEER*, is calculated by the weighted average of the buffers of institutions with close business strategies and similar sizes. With regard to strategies, banks are divided into four groups according to cluster analysis methodology adopted by the Central Bank of Brazil (Capelletto, 2006): (i) companies specialized in retail loans; (ii) banks of corporate credit; (iii) complex institutions with multiple strategies; and (iv) banks related to the automotive industry. In the sample, approximately 37% of banks are aimed at retail transactions, 41% are focused on corporations, 10% are multi-strategies banks, and the remaining are banks of automobile industry. As for size, each strategy group is ordained as the individual total assets and then segmented into three subgroups of equal number of banks.

The liquidity cushion, *LIQUID*, is defined by the ratio of liquid assets to total assets. It has been opted for a strict definition for liquid assets, including only cash and government bonds held in portfolio. Brazilian banks commonly invest considerable portion of their assets in government bonds. This can be explained by the low liquidity in the secondary credit market in addition to the historically high macroeconomic volatility and high interest rates.

It has also been considered the bank individual total loans growth, *LOANG*. The growth of individual credit portfolios is significant; in the sample the loan volume increased, on average, 7.7% per quarter.

Table II summarizes the basic statistics for the described variables, and Table III presents the correlations among those variables.

**Table II - Descriptive statistics**

Summary statistics of the variables that represent specific characteristics of the banks in the sample, on a quarterly basis.

| Variable | Unit | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| *BUF* | (%) | 17.4 | 23.4 | -8.1 | 195.2 |
| *ROE* | (%) | 3.8 | 10.1 | -77.2 | 309.9 |
| *VOL* | (%) | 4.4 | 7.7 | 0.1 | 167.7 |
| *NPL* | (% Total credit) | 5.4 | 7.1 | 0.0 | 84.0 |
| *SIZE* | (Millions R$) | 14,500 | 50,300 | 18 | 565,000 |
| *LIQUID* | (%) | 17.7 | 16.0 | 0.0 | 95.5 |
| *SUBORD* | (% Total liability) | 0.6 | 1.8 | 0.0 | 25.4 |
| *BANKDEP* | (% Total deposit) | 13.9 | 26.2 | 0.0 | 100.0 |
| *PEER* | (%) | 12.8 | 8.9 | -2.0 | 46.1 |
| *LOANG* | (%) | 7.6 | 29.8 | -98.8 | 554.4 |

**Table III - Correlation matrix**

Correlations among the variables in the sample on a quarterly basis. The index * represents a significance level of at least 5%.

| | *BUF* | $BUF_{t-1}$ | *ROE* | *VOL* | *NPL* | *SIZE* | *LIQUID* | *SUBORD* | *BANKDEP* | *PEER* | *LOANG* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *BUF* | 1 | | | | | | | | | | |
| $BUF_{t-1}$ | 0.78* | 1 | | | | | | | | | |
| *ROE* | -0.09* | -0.10* | 1 | | | | | | | | |
| *VOL* | -0.03 | -0.04* | 0.30* | 1 | | | | | | | |
| *NPL* | 0.14* | 0.09* | -0.12* | 0.15* | 1 | | | | | | |
| *SIZE* | -0.14* | -0.12* | 0.05* | -0.05* | 0.00 | 1 | | | | | |
| *LIQUID* | 0.44* | 0.37* | -0.04* | 0.04* | 0.23* | -0.03 | 1 | | | | |
| *SUBORD* | -0.11* | -0.10* | 0.00 | -0.03 | 0.00 | 0.29* | -0.09* | 1 | | | |
| *BANKDEP* | -0.19* | -0.16* | -0.04* | -0.05* | -0.07* | -0.11* | -0.03* | 0.08* | 1 | | |
| *PEER* | 0.40* | 0.33* | -0.07* | 0.03 | 0.13* | -0.23* | 0.10* | -0.17* | -0.23* | 1 | |
| *LOANG* | -0.01 | 0.12* | 0.01 | -0.03* | -0.14* | -0.01 | -0.05* | -0.04* | 0.02 | -0.01 | 1 |

The data set also contains data on bank-specific supervisory ratings regarding the banks' overall solvency conditions. The variable *SUPERV* is constructed from the average of the scores given to the institution by the supervisory authority on a quarterly basis. We use the local supervisor's proprietary assessment criteria, which involve evaluations on capital adequacy, asset quality, management, earnings, and liquidity, in a CAMEL style. The worse the supervisory evaluation, the higher is the score.

Regarding the macroeconomic data, the variable *GDPG* is formed by the real GDP growth, quarter versus the same quarter a year earlier. This variable represents the Brazilian business cycle, which, during the period of analysis, was marked by continuing expansion phases, as highlighted by the CODACE (2009) business cycles dating reproduced in Figure 2.

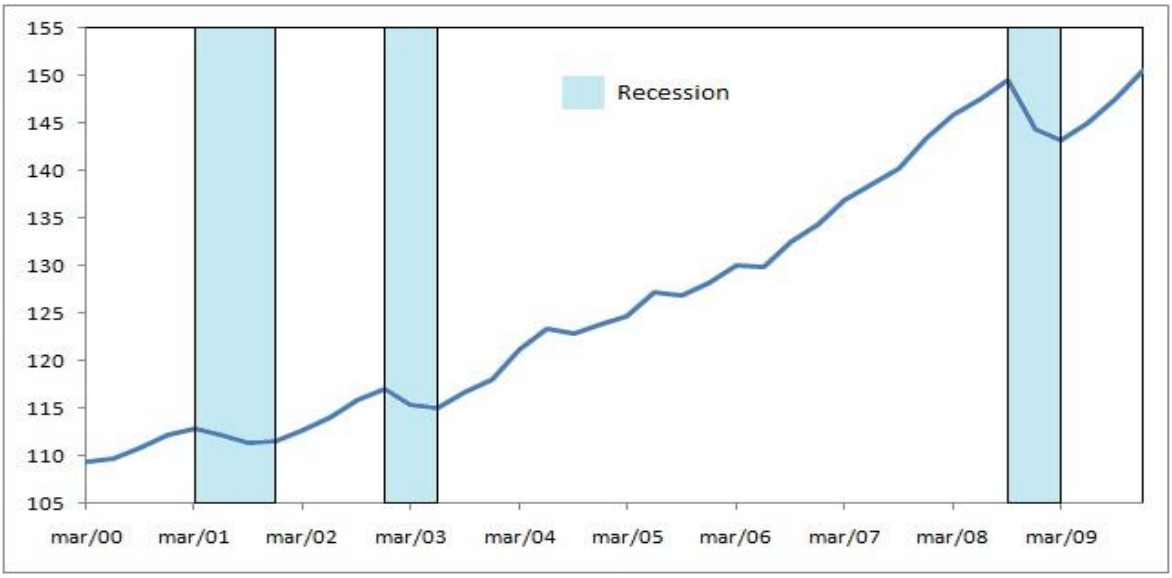


**Figure 2. Business cycle in Brazil from 2000 to 2009.** The chart shows the quarterly chronology of the Brazilian business cycles defined by the Economic Cycle Dating Brazilian Committee (CODACE, 2009) of the *Instituto Brasileiro de Economia* (IBRE). The reference series is the seasonally adjusted quarterly GDP at market prices (average 1996 = 100).

Finally, as commonly operated in econometric analysis to address asymmetry issues in the data, we transformed the variables into their logarithmic forms.

## 6. Methodology and econometric analysis

The empirical problem in equation (3) has the structure of a dynamic unbalanced panel with fixed effects. Given the high amount of temporal information concerning the amount of cross sectional data (N=112 and T=36), the panel is at the borderline between classical macro and micro panel data; therefore, we aim to explicitly care for the asymptotic properties of the series involved, in order to avoid the problem of spurious regression among non-stationary variables that are not cointegrated. We thus employ the Fisher-type statistic proposed by Maddala and Wu (1999) to test for unbalanced panel unit roots.

Table IV shows that the null hypothesis of non-stationarity can be rejected at the 5% level for all variables but *SUBORD*. Nevertheless we kept the variable, since it has a strong theoretical appeal and we are less likely to get spurious results given that (i) the explained variable is stationary; (ii) excluding or even switching the variable for other related proxy do not change both the results and the model's performance; and (iii) we additionally performed a residual based unit root test for cointegration on our final model specifications (Kao, 1999).

**Table IV - Panel unit roots test**

$\chi^2$ -statistics of Fisher-type (Phillips-Perron) panel unit roots tests for variables in levels. Indexes *,**,*** represent significance levels of 10%, 5% and 1% respectively, based on MacKinnon approximations p-values. $H_0$: Series non-stationary.

| Variable | Constant without trend | | Constant and time trend | |
|---|---|---|---|---|
| *BUF* | 579.5 | *** | 481.8 | *** |
| *ROE* | 2,493.1 | *** | 2,350.9 | *** |
| *VOL* | 499.8 | *** | 359.9 | *** |
| *NPL* | 585.5 | *** | 449.7 | *** |
| *SIZE* | 271.6 | ** | 382.5 | *** |
| *LIQUID* | 897.3 | *** | 915.2 | *** |
| *SUPERV* | 408.3 | *** | 303.3 | *** |
| *SUBORD* | 159.6 | | 154.3 | |
| *BANKDEP* | 727.2 | *** | 733.2 | *** |
| *PEER* | 598.9 | *** | 472.4 | *** |
| *LOANG* | 3,275.9 | *** | 3,012.8 | *** |

Since we do not reject that our panel is stationary, we proceed with the econometric exercise estimating the regressions through the two-step system generalized method of moments developed by Arellano and Bover (1995) and Blundell and Bond (1998). The robustness are then verified by the bounding procedure proposed by Bond (2002), which compares the performance of the system GMM estimator with alternative estimators with known properties in dynamic panels applications. The results are presented in Table V, and some complementary specifications are presented in Table VI.

The first bounding procedure estimation (model I in Table V) is performed by pooled ordinary least squares (POLS), in which the dependent and explanatory variables are defined in level. The main problem is that the predetermined variable (lagged dependent) is endogenous to the omitted fixed effect term, violating a necessary condition for the OLS consistency. Consequently, the coefficient estimate appropriates predictive power from the firm's fixed effects embedded in the error term. As the estimate is positively biased, it sets the upper boundary for this coefficient.

The second bounding procedure estimation (model II in Table V) addresses the endogeneity problem by removing the fixed effects through the least square dummy variables estimator (LSDV). However, the within group transformation is still biased because it ignores the correlation between the lagged dependent variable and the error term. The estimated coefficient of the pre-determined variable becomes downwards biased and thus defines its lower boundary.

Although the estimation bias decreases when increasing the panel temporal dimension (Nickell, 1981), the problem may persist even for samples longer than thirty time units, as

tested by Judson and Owen (1999). One way to fix this short panel issue should be through the use of instrumental variables (IV), but reliable instruments for applications in micro-finance panels are rare and weak instruments can also result in biased estimates.

Arellano and Bond (1991) apply a generalized method of moments to construct efficient instruments. After taking first differences to remove the time-invariant heterogeneity effect, they demonstrate that the lagged variables are valid instruments for the predetermined variable in first difference, provided that the residuals do not have second-order serial correlation. The weakness in the "difference GMM" methodology is the low correlation between first differences and lagged levels of these variables, especially if the series is time-persistent. To address the potential problem, Arellano and Bover (1995) and Blundell and Bond (1998) propose a methodology called system GMM that combines a system of regressions in differences with the regression in level and considerably increases the statistical efficiency of the estimator.

Therefore, the remaining estimations (models III and IV in Table V, and models V to VII in Table VI) are carried out through the system GMM. With the aim of removing the unobserved idiosyncratic effects, we apply orthogonal deviations rather than first differences, since the first differences transformation may increase the gaps in unbalanced panels. We also use the two-step process that is asymptotically more efficient than the estimator of the first stage. As it may produce inconsistently smaller standard errors, especially in cases of short samples and large number of instruments, we take two corrective measures. Firstly, we apply the Windmeijer (2005) method for finite samples to correct the variances and co-variance matrix. Secondly, we control the number of instruments by initially reducing the number of lags and then combining (collapsing) those instruments into smaller sets.[21] The optimal number of instruments is defined by the downward testing procedure for dynamic panels, proposed by Andrews and Lu (2001), which consists in progressively testing combinations of moments, reducing the over-identification restrictions until the significance of the Hansen test increases. As a result, the endogenous variables considered are instrumented with one to five lags.[22]

[21] Roughly speaking, the procedure reduces the moment conditions, creating, for each variable, one instrument for each lag distance, rather than one for each period and lag distance. It is noteworthy that in addition to the standard error bias, the excess of instruments may overfit endogenous variables and undermines identification tests, especially the J test of Hansen (Roodman, 2009).

[22] As a robustness check, all models were reestimated considering only those banks with complete observations during the period of analysis (90 institutions) in a balanced panel. The results remained robust, with no significant differences from those presented.

## Table V - Capital buffer model specifications

The dependent variable is the bank's capital buffer calculated as the natural logarithm of capital over the minimum required by regulation. The explanatory variables include, besides the lagged dependent variables, firm-specific and macroeconomic factors. The specification I is estimated by Pooled OLS. The specification II is a fixed effects panel model (FE) estimated by LSDV. Specifications III to V are estimated by System GMM; its endogenous variables are instrumented with one to five lags and the instruments are collapsed. In all models (I to IV) time dummies are included, but the coefficients were suppressed. Indexes *,**,*** represent significance levels of 10%, 5% and 1% respectively, and z-statistics (Specification I) and t-statistics (Specifications II to V) are reported in parentheses. The Hansen test refers to the test for over-identification restrictions, and tests AR (1) and AR (2) refer to tests of the first and second order autocorrelation. For those tests, p-values are reported.

| | **POLS** | | **FE-DVLS** | | **Sys.GMM** | | **Sys.GMM** | |
|---|---|---|---|---|---|---|---|---|
| | **I** | | **II** | | **III** | | **IV** | |
| $BUF_{t-1}$ | 0.901 | *** | 0.756 | *** | 0.818 | *** | 0.809 | *** |
| | (137.35) | | (74.46) | | (23.87) | | (23.34) | |
| *ROE* | 0.282 | *** | 0.294 | *** | 0.306 | *** | 0.291 | *** |
| | (8.24) | | (8.44) | | (2.87) | | (2.68) | |
| *VOL* | 0.157 | *** | 0.166 | *** | 0.190 | *** | 0.190 | *** |
| | (3.71) | | (3.54) | | (2.87) | | (2.82) | |
| *NPL* | 0.000 | | 0.001 | | -0.001 | | -0.001 | |
| | (0.18) | | (1.18) | | (-0.68) | | (-0.67) | |
| *SIZE* | -0.009 | *** | -0.041 | *** | -0.019 | *** | -0.020 | *** |
| | (-3.50) | | (-5.28) | | (-3.11) | | (-2.96) | |
| *LIQUID* | 0.009 | *** | 0.024 | *** | 0.025 | *** | 0.022 | *** |
| | (3.91) | | (5.68) | | (3.50) | | (3.12) | |
| *SUBORD* | 0.376 | ** | 0.618 | *** | 0.436 | | | |
| | (2.03) | | (2.66) | | (1.64) | | | |
| *BANKDEP* | | | | | | | -0.069 | |
| | | | | | | | (-1.41) | |
| *PEER* | 0.031 | ** | 0.076 | *** | 0.058 | * | 0.046 | |
| | (2.12) | | (3.72) | | (1.78) | | (1.29) | |
| $SUPERV_{t-1}$ | 0.016 | | 0.044 | *** | 0.056 | * | 0.053 | * |
| | (1.09) | | (2.60) | | (1.80) | | (1.70) | |
| *LOANG* | -0.307 | *** | -0.268 | *** | -0.262 | *** | -0.265 | *** |
| | (-23.41) | | (-20.51) | | (-6.30) | | (-6.25) | |
| *GDPG* | -0.311 | ** | -0.218 | | -0.328 | ** | -0.338 | ** |
| | (-1.98) | | (-1.43) | | (-2.04) | | (-2.03) | |
| *K* | 0.228 | *** | 0.971 | *** | 0.487 | *** | 0.525 | *** |
| | (3.69) | | (5.87) | | (3.24) | | (3.05) | |
| **$R^2$** | **0.895** | | **0.879** | | | | | |
| **AR(1)** | | | | | **0.000** | | **0.000** | |
| **AR(2)** | | | | | **0.670** | | **0.688** | |
| **Hansen** | | | | | **0.347** | | **0.244** | |

## Table VI - Complementary specifications

The dependent variable is the bank's capital buffer calculated as the natural logarithm of capital over the minimum required by regulation. Specifications are estimated by System GMM; its endogenous variables are instrumented with one to five lags and the instruments are collapsed. In all models time dummies are included, but the coefficients were suppressed. Indexes *,**,*** represent significance levels of 10%, 5% and 1% respectively, and t-statistics are reported in parentheses. The Hansen test refers to the test for over-identification restrictions, and tests AR (1) and AR (2) refer to tests of the first and second order autocorrelation. For those tests, p-values are reported.

| | **Sys.GMM V** | | **Sys.GMM VI** | | **Sys.GMM VII** | |
|---|---|---|---|---|---|---|
| $BUF_{t-1}$ | 0.830 | *** | 0.811 | *** | 0.798 | *** |
| | (25.35) | | (24.33) | | (17.18) | |
| *ROE* | 0.297 | *** | 0.293 | *** | 0.197 | ** |
| | (2.83) | | (2.79) | | (1.99) | |
| *VOL* | 0.180 | *** | 0.184 | *** | 0.159 | ** |
| | (2.61) | | (2.80) | | (2.25) | |
| *NPL* | -0.001 | | -0.001 | | -0.001 | |
| | (-0.74) | | (-0.65) | | (-0.74) | |
| *SIZE* | -0.020 | *** | -0.020 | *** | -0.020 | *** |
| | (-3.23) | | (-3.29) | | (-3.94) | |
| *LIQUID* | 0.024 | *** | 0.026 | *** | 0.025 | *** |
| | (3.34) | | (3.59) | | (3.53) | |
| *SUBORD* | 0.444 | * | 0.413 | | 0.504 | |
| | (1.75) | | (1.52) | | (1.46) | |
| *PEER* | 0.059 | ** | 0.060 | * | 0.064 | ** |
| | (2.05) | | (1.96) | | (2.07) | |
| $SUPERV_{t-1}$ | | | 0.039 | | 0.012 | |
| | | | (1.21) | | (0.32) | |
| $DBuf_L$ .$SUPERV_{t-1}$ | 0.070 | ** | | | | |
| | (2.12) | | | | | |
| *DBuf* .$SUPERV_{t-1}$ | 0.049 | * | | | | |
| | (1.71) | | | | | |
| $DBuf_H$ .$SUPERV_{t-1}$ | 0.016 | | | | | |
| | (0.33) | | | | | |
| *LOANG* | -0.271 | *** | -0.255 | *** | -0.238 | *** |
| | (-7.65) | | (-6.12) | | (-6.48) | |
| *GDPG* | -0.305 | ** | | | | |
| | (-2.03) | | | | | |
| *DUp* .*GDPG* | | | -0.341 | ** | | |
| | | | (-2.23) | | | |
| *DDown* .*GDPG* | | | 0.599 | * | | |
| | | | (1.66) | | | |
| $DBuf_L$ .*DUp* .*GDPG* | | | | | -2.223 | *** |
| | | | | | (-5.51) | |
| *DBuf* .*DUp* .*GDPG* | | | | | -0.367 | ** |
| | | | | | (-2.17) | |
| $DBuf_H$ .*DUp* .*GDPG* | | | | | 3.594 | *** |
| | | | | | (5.23) | |
| $DBuf_L$ .*DDown* .*GDPG* | | | | | 0.105 | |
| | | | | | (0.08) | |
| *DBuf* .*DDown* .*GDPG* | | | | | 0.787 | ** |
| | | | | | (2.27) | |
| $DBuf_H$ .*DDown* .*GDPG* | | | | | 2.010 | |
| | | | | | (1.06) | |
| *K* | 0.487 | *** | 0.510 | *** | 0.566 | *** |
| | (3.36) | | (3.51) | | (4.37) | |
| **AR(1)** | **0.000** | | **0.000** | | **0.000** | |
| **AR(2)** | **0.700** | | **0.667** | | **0.812** | |
| **Hansen** | **0.516** | | **0.534** | | **0.273** | |

### 6.1. Empirical results

Table V shows that GMM estimation results are robust to the bounding procedure. As expected, the model I estimated by POLS presents the highest coefficient estimate on the lagged dependent variable (positive bias); the fixed effects model II has the lowest estimate (negative bias); and models III and IV, based on GMM instrumentation, encompass intermediate values. It is also noticeable that the coefficient estimates on the other explanatory variables do not change signs and, in general, their values and significance levels have remained similar, regardless of the adopted method. Moreover, the autocorrelation tests in the instrumented models suggest that the condition of absence of second order serial correlation is fulfilled, and the Hansen tests do not indicate over-identification restrictions on the estimated equations. The consistency of both tests is also observed in models V and VI of Table VI.

Results on firm's capital management strategy

The estimated coefficient of the lagged dependent variable, $BUF_{t-1}$, has positive signs at 1% level in all models. The positive values close to one (about 0.83) indicate that the variable is persistent, i.e. the adjustment of the buffers is fairly slow ($0 < \theta < 1$). Comparatively, the estimated adjustment speeds are close to those of other jurisdictions, such as England (Francis and Osborne, 2009) and Hong Kong (Wong *et al.*, 2005). The results support the Hypothesis H1 of the buffer capital theories about the influence of adjustment costs in the decision of banks.

Unlike what is usually found in the literature, the coefficient of the variable *ROE*, although significant at the 1% level, has a positive sign in all models ($\alpha_1 > 0$), supporting the hypothesis on earnings as a source of recapitalization and as a bank solvency signal for the market. In fact, it has been observed in the Brazilian banking industry a high rate of earnings retention, which on average exceeds 50%. Retained earnings may be the main source of capital increases, in line with the Myers and Majluf (1984) pecking order theory, and corroborating Hypothesis H2B. This result may be related to some combined characteristics of the Brazilian banking industry, such as the highly concentrated ownership structure, the limited access to external capital sources for the majority of banks, and the high profitability that may also increase the bank's charter value.

The coefficient of the variable *VOL* is positive and significant ($\alpha_2 > 0$) at the 1% level in all models. It shows that institutions with greater earnings instability may have higher

levels of capital ratios to avoid eventual breaches of the capital limits, as states Hypothesis H3. However, nonperforming loans, *NPL*, which also composes the firm's risk profile, is not significant in all specifications and its signal is undefined ($\alpha_3 = 0$).

The bank's size, *SIZE*, presents a significant coefficient at 1% level with negative sign in all models. As expected, larger banks seem to hold less capital. Economies of scale, higher diversification, and especially the public perceptions of safety net for the large ones may permeate this result. This evidence contributes to the discussion of different prudential rules for systemically important institutions.

Conversely, the coefficient of the variable *LIQUID* is positive and significant at the 1% in all models, indicating that banks with larger liquid asset cushions also have higher capital buffers. It seems that the most prominent effect of this variable is the reduction in the value of risk-weighted assets, since most of the assets compounding the variable have zero risk weight. One reason for such unexpected result is that the variable, as it was built, has not fully captured the underlying liquidity of the bank's portfolio; however, we reestimated the model including in the liquidity proxy other riskier liquid assets (stocks, quotes of investment funds, and other securities), but the signal remained significantly positive. Another explanation may be related to strategies for longer-term investments. Since the profitability of government bonds is high due to the high interest rates, some banks may decide to hold capital and liquidity in excess to remain flexible in order to take advantage of growth opportunities.

Results on supervisory pressure

The variable $SUPERV_{t-1}$ is positive and becomes significant ($\beta_1 > 0$) at the 10% level when it is taken as endogenous in the instrumented models III and IV. After controlling for the level of capitalization ($BUF_{t-1}$), a bad rating may cause subsequent positive adjustments in the capital ratio. One possible interpretation is that less efficient institutions and, consequently, poorly evaluated banks use capital as a way of compensating for their deficiencies and avoiding increase in supervision monitoring. The result indicates a beneficial influence of the supervisory evaluation over the firms' management and solvency, which would respond by either increasing the capital proportion or reducing risk exposures.

As expected, the marginal effect of supervisory assessments is more pronounced for banks closer to the regulatory limit. In model V of Table VI, the variable $SUPERV_{t-1}$ is interacted with dummies that separate three levels of capitalization in each quarter of the

sample: (i) $DBuf_L$, considering the 10% lowest capital buffers; (ii) *DBuf*, for banks with buffers between the tenth and ninetieth percentiles of the sample; and (iii) $DBuf_H$ for the 10% highest capital buffers. For the group of less capitalized banks, the coefficient is positive and significant at the 5% level. To a lesser extent, supervision evaluation effect is also positive for the intermediate group, since the coefficient is significant at the 10% level. For the third group, the coefficient is not significant, suggesting that the scores do not affect the capital structure of over capitalized banks. Hence, the monitoring carried out by the supervisory authority seems to contribute to curb risky behaviors of less solvent banks, in line with Hypothesis H4.

Results on market discipline

Regarding subordinated debtholders influence on capital buffers, the coefficient of the variable *SUBORD* is positive, but, when instrumented, it loses significance. This coefficient is not significant in model III and it is significant at 10% level in model V. Moreover, the interbank market seems to have no disciplinary effects on banks' capital ratios, since, unexpectedly, model IV shows a non-significant negative relationship between *BANKDEP* and capital buffers ($\gamma_1 = 0$).[23] Those results indicate that uninsured debtholders may play a minor role in disciplining banks, in line with the recent tests performed by Mendonça and Loures (2009), who found no empirical evidence that reveals market discipline through subordinated debt spreads in Brazil. One reason for those findings may be the lack of a developed and transparent financial system.

On the other hand, competition among banks appears as a significant factor in defining banks' behavior. As expected, the signal of variable *PEER* is positive and significant in four out of five models ($\gamma_2 > 0$) at the 5% (models V and VII) and 10% levels (models III and VI). As in other jurisdictions, there is evidence that banks are influenced by their peer group behavior.

Overall, the evidences indicate that market discipline may arise from the competitors rather than from the debtholders. Therefore, Hypothesis H5 is only partially supported. Nevertheless, peer group pressure may also have negative consequences for financial stability, if banks begin decreasing capital ratios. Hence, disclosure rules and market discipline should be an important part of the regulation agenda, as the recent accelerated growth in credit and capital markets in Brazil may provide incentives for banks to migrate to riskier investments.

[23] The variable *BANKDEP* was tested within other specifications; however, in all of them, it remained negative and non-significant.

Results on business cycle effects

Economic growth has a negative effect on capital buffer adjustments. Even controlling for individual loan portfolio growth (*LOANG*), the variable *GDPG* has a negative coefficient ($\mu_1 < 0$) and shows significance level of 5% in all instrumented models (models III to V). The results provide evidence that banks act following economic cycles.

We also analyze two asymmetries in banks' reaction to business cycle fluctuations. First, we test whether capital buffers react differently in periods of boom and bust of the economic cycle. Second, we test whether less capitalized banks have different behaviors depending on the phase of the cycle. Therefore, to differentiate upturns from downturns, we use the dummy variables *DUp* and *DDown*, built as CODACE (2009) quarterly dating for the phases of economic expansion and recession, respectively. To differentiate levels of capitalization, we use the previously defined dummy variables, $DBuf_L$, *DBuf*, and $DBuf_H$, which consider, respectively, low-, regular-, and high-capitalized banks on the basis of the tenth and ninetieth buffer percentiles for each quarter. The results are presented by Table VI, in models VI and VII.

In model VI, the dummy variables *DUp* and *DDown* are interacted with the variable of real GDP growth. The coefficient of the variable *DUp.GDPG* is negative and significant at the 5% level, and the coefficient of the variable *DDown.GDPG* is positive and significant at the 10% level. The latter estimate coefficient is statistically higher than the former, in absolute terms, suggesting that banks increase their buffers during downturns more intensely than they reduce capital in upturns. This stronger reaction when economy deteriorates may indicate a more defensive stance adopted by Brazilian banks.

In model VII, GDP growth is interacted with the cycle phase dummies, *DUp* and *DDown*, and also with the capitalization level dummies, $DBuf_L$, *DBuf*, and $DBuf_H$. As expected, mid-capitalized banks follow the cyclical pattern described above, increasing buffers in downturns by higher amounts than decreasing them in upturns. The variables *DBuf.DUp.GDPG* and *DBuf.DDown.GDPG* present negative and positive signs, respectively, and they both are significant at the level of 5%. Interestingly, the results for the extremes of capitalization levels indicate not only asymmetrical, but opposite behaviors between these groups, especially following upturns. We observe that highly-capitalized banks are likely to counter-cyclically manage their capital buffers, as in upturns they significantly increase capital ratios: $DBuf_H$*.DUp.GDPG* is positive and significant at the level of 1%. On the other

hand, low-capitalized banks seem to take the opposite behavior, significantly decreasing capital ratios, which may characterize a pro-cyclical management: $DBuf_L.DUp.GDPG$ is negative and significant at the level of 1%. As financial imbalances are likely to be built up in upturns, the observed result suggests that those with low capital buffers may become even more fragile following economic growth.

Overall, the evidences suggest a pro-cyclical capital management, corroborating Hypothesis H6B. Those results are important for the new macro-prudential regulation debate, since the observed behavior may, at first instance, destabilize the banking system following loss periods and, at second, accentuate downturns in the real economy. Some macro-prudential measures have been discussed, such as additional time-varying capital requirements and dynamic credit loss provisions as the one adopted in Spain.

### 6.2. Some policy implications

In the light of a clear trend of Brazilian economic and credit growth, some policy implications can be derived from our results. First, we provide evidences that the supervisory monitoring may positively influence banks' decisions, while the market seems to have less disciplinary effects on banks' capital behavior. Certainly, an advantage of the Brazilian financial system is that it is less exposed to complex over the counter credit derivatives, thereby contributing to the efficiency of authority supervision. However, it is important to keep in sight the innovative movements within the market, especially because the local financial market is growing at an impressive pace. In this situation, market discipline should play a key role in restraining banking moral hazard; hence, it should be also important to improve transparency as the extent of market development.

Secondly, we show that the banks' capital buffers are negative related to the business cycle, so banks shrink balance-sheets in good times and enlarge them in bad times. Therefore, a time-varying capital requirement should be an efficient instrument to deal with the balance-sheet pro-cyclicality and, especially, with the financial imbalances built-up in economic expansions, which lately in Brazil has been characterized by a strong credit growth (the total private credit in relation to GDP expanded from around 20% to almost 50% in the last thirteen years).

# 7. Conclusion

Banks integrating the Brazilian banking system maintain capital ratios above the level required by regulation. A banking theory line explains that capital buffers aim to ensure the institution against unexpected negative shocks in its capital that may lead to a breach of the regulatory minimum. The bank decision is permeated by costs and time constraints of recapitalizations. In addition, financial intermediaries are exposed to a sort of external pressures from the market and the economy which may also influence their behavior.

In this study, we use a dynamic empirical model derived from the mentioned capital buffer theory to comprehensively analyze the determining factors in banks' capital ratios decisions. We focus on testing whether banks respond to the previous and new fundamentals of capital regulation, as defined by the Basel Accord.

The first set of capital determinants is related to banks' capital management and their reactions to the regulatory capital requirements, which Basel defines as the Pillar 1 of prudential regulation. Our results suggest that: (i) the costs of recapitalization are significant in banks' decision; (ii) profitability positively impacts banks' capital buffers, providing evidences that the banks may follow a pecking order, in contrast with most literature results on other jurisdictions; and (iii) banks with higher earnings volatility may decide to maintain higher levels of capital, supporting the capital buffer theories hypothesis on the cost of breach of regulatory minimum requirement driving increases in capital buffers. Other bank-specific results include, first, that larger banks present lower levels of capital ratios, which may represent an opportunistic attitude of those who are too big to fail; and, second, that banks with higher liquidity cushions have larger capital buffers.

Regarding supervisory pressure, the Pillar 2 of Basel framework, we observe that the ratings that guide the work of supervision have positive influence on banks' solvency. Financial firms, especially those closer to the regulatory limit, positively respond to authority evaluations by raising their capital buffers.

Conversely, we find that the Basel Pillar 3, which concerns to the disciplinary power of the market, may have a minor role in the local banking industry, as the main uninsured debtholders in banks' balance-sheet do not seem to influence banks' solvency. As a source of market influence on banks' behavior, we identify that the peer group, represented by banks of similar size and operational activities, exert pressure on the institutions' capitalization, since banks seem likely to adjust their ratios accordingly.

Regarding what we should call the "fourth" Pillar of Basel, we find a negative co-movement between the economic cycle and capital cushions, which may represent a pro-cyclical capital management by the banking industry. We also provide evidences that low-capitalized banks are likely to behave in a more pro-cyclical way, especially during upturns.

Finally, we present some policy implications in the sense that improving market discipline and dealing with banks pro-cyclicality can increase the resilience of the Brazilian banking system.

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# CHAPTER 3: BANKING REGULATION AND SUPERVISION: EVIDENCE ON DECISION MAKING REGARDING CAPITAL REQUIREMENTS

## 1. Introduction

In the later decades, the minimum capital requirement has gained central importance in the banking regulation debate. Theoretically built on the basis of asymmetric information between bankers and depositors, the capital rules became an international practice since the inception of the Basel Accord in 1988 (BCBS, 1988) with the purpose of mitigating the moral hazard stemmed from deposit insurance subsidies.[24]

Nevertheless, the industry practice has been to have capital adequacy ratios well above the limits stipulated by financial authorities, suggesting the regulatory constraint may not be determinant on the risk-taking and capital structure of banks. Rather, the banks' optimal decision may have been influenced by market discipline mechanisms, by the agents' investment strategies, or even by indirect schemes of regulatory pressure regarding other risk profile aspects captured by off-site and on-site supervisory measures.

In the task of understanding and evaluating the effect of regulatory intervention on banks solvency, a recent micro-founded theoretical line named capital buffer theory demonstrates that the typical bank capital cushion may be driven by the explicit and implicit costs of prudential regulation. In this sense, the theory has helped to clarify several behaviors observed in the market.

Supported by predictions of the mentioned theory, the contribution of the present paper is to test the influence of prudential regulation in the short term simultaneous decisions about capital and risk in the Brazilian banking system. One major novelty is the analysis of the indirect effect of the supervisory solvency evaluations on those banks decisions. This way, it is possible to separate in a certain degree the effect of the direct regulatory capital restriction from the supervisory pressure. Our results show the particularity of the Brazilian banking system in which institutions closer to the regulatory minimum seems to be relatively more risk-averse by taking greater positive adjustments in capital levels and smaller in

[24] Santos (2001) reviews the literature on bank regulation, giving special attention to the capital requirements rules.

portfolio risk levels. Low-capitalized banks also demonstrate to manage more actively their solvency ratios, coordinating capital and risk adjustments in the same direction. The supervisory monitoring effect also appears likely to support the capital restriction, increasing the risk-aversion as worse the authority evaluation result is.

The rest of the paper is divided as follows: Section two brings a brief literature review on the role of prudential regulation in the banking firm behavior regarding the adjustments in leverage and in portfolio risk. The section also presents the main results of related empirical studies. Section three details the simultaneous partial adjustment model used as a reference on the empirical analysis and presents the testing hypothesis. Section four describes the data base. Section five presents the estimation methods and interprets the results. Section six concludes the paper.

## 2. The regulation and the capital-risk dynamics in the banking literature

The theoretical literature on minimum capital requirements begins in the late 1970's, assigning to capital rules the function of correcting perverse incentives generated by the traditional risk-insensitive structure of deposit insurance (Sharpe, 1978). Generally, "moral hazard authors" assume that capital is set at the minimum regulatory limit and focus their analysis on the bank's possible portfolio risk decisions. Kahane (1977) and Koehn and Santomero (1980) use efficient frontier models in which banks maximize asset returns subject to portfolio risk constraints. They demonstrate that imposed limits on leverage can increase the risks of the institution, because banks would tend to reallocate the portfolio among riskier assets looking for higher expected returns (asset substitution moral hazard). Kim and Santomero (1988) show that such perverse incentive may be mitigated by risk-based capital requirements, unless the defined risk-weights do not correctly reflect the potential losses of the portfolios. Furlong and Keeley (1989) and Keeley and Furlong (1990) incorporate in the model the value of the deposit insurance option and show that, regardless risk-weighing, leverage restrictions create incentives for institutions to maintain indeed proper levels of risk-taking.

Other theoretical lines also indicate certain articulation between the bank's financing and investment decisions, but they take the regulatory limit as an exogenous restriction which, in case it is not reached, it should not influence bank's behavior. Orgler and Taggart (1983) argument that the bankruptcy costs related to higher levels of asset risks can induce reductions

on leverage. Saunders *et al.* (1990) show that agency conflicts can motivate changes in the company's risk profile, as the manager, more risk-averse than the shareholder, would seek to reduce the portfolio's risk exposures in response to increases in leverage, thereby defining levels of solvency above the ones preferred by the shareholder.

A chain that specifically analyses the regulatory influence as determinant on the banks' behavior is based on the theory of capital buffer, which supports the hypothesis that banks maintain a capital surplus (buffer) in order to reduce interferences of the supervisory authority and to mitigate eventual regulatory costs associated to the violation of the minimum capital limit. Unlike the traditional moral hazard lines, the models of the capital buffer theory (Milne and Whalley, 2001; Furfine, 2001; and Peura and Keppo, 2006) take capital as an endogenous response to regulation and add an intertemporal perspective to the recapitalization process of the banking firm. As they approach the minimum, banks would tend to increase their capital and to reduce the risk exposures, in order to restore their solvency ratios and to avoid those regulatory costs. Subsequently, they would coordinate again their behavior toward their combined capital and risk targets.

Milne and Whalley (2001) extend the buffer behavioral model adding the supervisor agent audit function to the capital regulation restrictions. The authors demonstrate that, in this construction, the bank's risk aversion is a positive function of the supervisory monitoring. Therefore, banks would tend to enlarge capital cushions and decide for less risky portfolios in reaction to the higher activity of bank supervision.

### 2.1. Empirical results in literature

Unlike moral-hazard-based theories, capital buffer constructions have been more consistent in explaining banks' capital ratios behaviors. Indeed, most of the empirical studies have shown that banks behave differently according to how far they are from the regulatory constraints, suggesting that risk-taking and capital levels may be endogenous responses to regulation pressures.

The seminal empirical work of Shrieves and Dahl (1992) analyses the relationship between capital and risk on banking sector considering that they are simultaneously determined by the bank. The tests are run for the US market in the 1980's, a period when capital requirement was not risk-adjusted, and they suggest that banks under regulatory pressure (below the minimum capital requirement) offset increases in capital by increasing risks. After the deployment of risk-based capital rules in the United States, in 1991, Jacques and Nigro (1997) replicate the methodology and observe increases in capital levels and

reductions in risk levels, suggesting that the Basel Accord has played an important role in changing banks' opportunistic behaviors.

Also in the United States, Aggarwal and Jacques (2001) examine the effect of the 1991 FDICIA legislation, which has stipulated specific supervisory corrective actions for banks not properly capitalized (Prompt Corrective Action), according to five pre-established ranges of capital levels. Their results indicate the policy efficiency, once the institutions achieved by the regulation, especially those classified as "low-capitalized", presented increases in capital levels and reductions in risk levels.

Among studies performed out of the US financial market, Rime (2001) observes that Swiss banks' behavior is influenced by the proximity to the minimum capital required by regulation. He finds that less capitalized banks set up higher capital levels without promoting corresponding adjustments in risk levels. Stolz (2007) performs a similar study for German savings banks, arguing they comprise the more extensive and homogeneous group of institutions in the country. She finds evidences that banks adjust capital faster than risk and that banks with smaller buffers promote faster adjustments than well-capitalized ones. Regarding to the coordination between the decisions of capital and risk adjustments, she observes that they are negatively correlated for banks with smaller buffers, but positively correlated for banks with larger buffers. The author interprets the results as indications that the regulatory pressure increases the banks risk-aversion.

One criticism of the empirical studies is that they may not properly identify and separate the direct effects of the regulatory restriction from those indirectly originated by the pressure of supervision or by disciplining market forces. Furfine (2001) distinguishes the greater strictness on the monitoring criteria of the supervisory authority as one of the major factors leading to the United States credit crunch in the 1990's. The author points out that the tighter supervisory rules have had greater influence in the bank's balance-sheet decisions than the imposition of minimum capital limits.

Berger *et al.* (2001) analyze the solvency ratings marked by the supervisors of US commercial banks (CAMEL – Capital Adequacy; Asset Quality; Management; Earnings; Liquidity) and identify that the rigor of the supervision impacts the credit supply, but with moderate effect. De Young *et al.* (2001) explore the informational value in the supervisory CAMEL ratings and find evidences that the scores reflect the risks taken by financial institutions and may generate incentives to more efficient risk management.

## 3. Model of simultaneous partial adjustments

In order to test the decisions of capital and risk adjustments of Brazilian banks, we follow the partial adjustments model proposed by Shrieves and Dahl (1992). Hence, it is assumed that the changes in capital and risk levels of institution *i* in the period between *t-1* and *t* ($\Delta CAP_{i,t}$ and $\Delta RISK_{i,t}$) are simultaneously defined and may be decomposed into a discretionary portion ($\Delta^d CAP_{i,t}$ and $\Delta^d RISK_{i,t}$), endogenously determined, and another part composed by exogenous shocks ($u_{i,t}$ and $w_{i,t}$):

$$\Delta CAP_{i,t} = \Delta^d CAP_{i,t} + u_{i,t} \quad (1)$$

$$\Delta RISK_{i,t} = \Delta^d RISK_{i,t} + w_{i,t} \quad (2)$$

As a premise, the exogenous shocks are formed by two orthogonal components, independent and identically distributed: a firm-specific effect and a white noise. The discretionary variations, in turn, are modeled by a partial adjustment approach, assuming the institutions cannot perform immediate adjustments due to some kind of rigidity and transaction costs. Thus, the optimum levels of capital and risk ($CAP_{i,t}^*$ and $RISK_{i,t}^*$) are followed based on the adjustment speeds $\alpha$ and $\beta$, respectively. Considering also the simultaneity in capital and risk decisions, the model becomes described as:

$$\Delta CAP_{i,t} = \alpha.(CAP_{i,t}^* - CAP_{i,t-1}) + \mu.\Delta RISK_{i,t} + u_{i,t} \quad (3)$$

$$\Delta RISK_{i,t} = \beta.(RISK_{i,t}^* - RISK_{i,t-1}) + \gamma.\Delta CAP_{i,t} + w_{i,t} \quad (4)$$

Although the partial adjustments present in the equations (3) and (4) suggest that banks optimally set their ideal capital and risk levels, these variables are not directly observable. However, the empirical literature indicates that these targets may be estimated from firm-specific variables and economic environment factors, which are represented by the

vectors *Y* and *Z*.[25] The capital and risk targets should also be influenced by the regulatory constraint and by the financial authority monitoring. Thus, in order to capture the effects of regulatory and supervisory pressures, respectively, the binary variable *DREG* indicates the less capitalized banks, and the continuous variable *SUPERV* denotes the bank assessments conducted by the supervision authority, in which, the higher the score, the worse the perceived condition of solvency. Including these new variables, the simultaneous equations model (Specification I) is defined as following:

$$\Delta CAP_{i,t} = \delta.DREG_{i,t-1} + \tau.SUPERV_{i,t-1} + \sum_{n=1}^{N} a_n.Y_{n\ i,t} - \alpha.CAP_{i,t-1} + \mu.\Delta RISK_{i,t} + u_{i,t} \quad (5)$$

$$\Delta RISK_{i,t} = \pi.DREG_{i,t-1} + \psi.SUPERV_{i,t-1} + \sum_{n=1}^{N} b_n.Z_{n\ i,t} - \beta.RISK_{i,t-1} + \gamma.\Delta CAP_{i,t} + w_{i,t} \quad (6)$$

Besides allowing different intercepts for banks under different levels of regulatory pressure through the explanatory dummy *DREG*, Stolz (2007) suggests the inclusion of variables constructed by interacting the variable *DREG* with the variables Δ*CAP* and Δ*RISK*. It helps, then, to verify whether the pattern of coordination between capital and risk is maintained along the capitalization levels. Additionally, in order to test if the banks under greater regulatory pressure adjust capital and risk at a faster pace than the others, she suggests including the interaction of the variable *DREG* with the variables $CAP_{t-1}$ and $RISK_{t-1.}$ The system defined this way assumes the form of the Specialization II in equations (7) and (8).

$$\begin{aligned}\Delta CAP_{i,t} = {} & \delta.DREG_{i,t-1} + \tau.SUPERV_{i,t-1} + \sum_{n=1}^{N} a_n.Y_{n\ i,t} - \alpha_0.CAP_{i,t-1} - \alpha_1.DREG_{i,t-1}.CAP_{i,t-1} \\ & + \mu_0.\Delta RISK_{i,t} + \mu_1.DREG_{i,t-1}.\Delta RISK_{i,t} + u_{i,t}\end{aligned} \quad (7)$$

$$\begin{aligned}\Delta RISK_{i,t} = {} & \pi.DREG_{i,t-1} + \psi.SUPERV_{i,t-1} + \sum_{n=1}^{N} b_n.Z_{n\ i,t} - \beta_0.RISK_{i,t-1} - \beta_1.DREG_{i,t-1}.RISK_{i,t-1} \\ & + \gamma_0.\Delta CAP_{i,t} + \gamma_1.DREG_{i,t-1}.\Delta CAP_{i,t} + w_{i,t}\end{aligned} \quad (8)$$

[25] Gropp and Heider (2010) find evidences for publicly traded banks in US and Europe that the variables commonly used as capital structure determinants for non-financial companies, such as size, profitability, market-to-book ratio, and tangibility, are also determining factors in explaining banks leverage. Çağlayan and Şak (2010) show similar results for the Turkish banking system, distinguishing the pecking order theory as the primary driver of bank behavior.

Finally, in Specification III, the interaction between the supervision variable *SUPERV* and the regulation variable *DREG* is incorporated in both capital and risk adjustment equations, with the aim of testing the influence of the supervision criteria on the capital rules.

$$\begin{aligned}\Delta CAP_{i,t} &= \delta.DREG_{i,t-1} + \tau_0.SUPERV_{i,t-1} + \tau_1.DREG_{i,t-1}.SUPERV_{i,t-1} + \sum_{n=1}^{N} a_n.Y_{n\ i,t} \\ &- \alpha_0.CAP_{i,t-1} - \alpha_1.DREG_{i,t-1}.CAP_{i,t-1} + \mu_0.\Delta RISK_{i,t} + \mu_1.DREG_{i,t-1}.\Delta RISK_{i,t} + u_{i,t}\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta RISK_{i,t} &= \pi.DREG_{i,t-1} + \psi_0.SUPERV_{i,t-1} + \psi_1.DREG_{i,t-1}.SUPERV_{i,t-1} + \sum_{n=1}^{N} b_n.Z_{n\ i,t} \\ &- \beta_0.RISK_{i,t-1} - \beta_1.DREG_{i,t-1}.RISK_{i,t-1} + \gamma_0.\Delta CAP_{i,t} + \gamma_1.DREG_{i,t-1}.\Delta CAP_{i,t} + w_{i,t}\end{aligned} \tag{10}$$

### 3.1. Testing hypothesis

Under the null hypothesis of no effects of capital and monitoring rules on banks' behavior, the simultaneous equations model presented in Specifications I to III allows confronting theoretical and observed banks management in three different aspects. Hence, the hypotheses are defined to test: firstly, the direct impact of the regulation and supervision on capital and risk targets; secondly, the coordination between adjustments in capital and risk; and thirdly, the speeds of those adjustments.

As for the direct impacts of the prudential regulation and supervision, Hypotheses H1 and H2 consider the influence of the minimum capital requirement and the supervisory evaluation on changes in the banks' optimum levels of capital and risk. As intended by financial authorities and in line with capital buffer theories, it is expected, in the short term, banks under greater regulatory pressure to adjust upwards their capital level and to take less risk in their portfolios (Hypothesis H1 tested by Specifications I, II and III). It is also expected that the perceptions of supervision are likely to influence the banks' decision in the same direction, as shown in Hypothesis H2 tested by Specifications I, II and III. Moreover, the joint effect of regulation and monitoring described in Hypothesis H2 is tested exclusively by Specification III.

> ***Hypothesis H1.*** *Capital regulation influence on capital and risk adjustments: banks closer to the minimum regulatory capital requirement are likely to feel increasing regulatory pressure; therefore, the impact of this regulatory pressure on banks'*

*decision might be positive for the capital adjustments ($\delta > 0$) and negative for the portfolio risk adjustments ($\pi < 0$).*

***Hypothesis H2.*** *Banking supervision influence on capital and risk adjustments: banks negatively evaluated by the supervisory authority might react by increasing capital ($\tau > 0$) and reducing portfolio risks ($\psi < 0$). Additionally, the effect of those evaluations should be stronger for less capitalized banks ($\tau_1 > 0$ and $\psi_1 < 0$).*

Regarding to the short-run interdependence between capital and risk decisions, the expected effect of regulation may also depend on the banks capitalization level. The prudential regulation should exert a minor influence on well-capitalized banks; nevertheless, a positive relationship between the adjustment of capital and risk should be justified by agency conflicts or by internal solvency targets set by the banks administration. For the case of low-capitalized banks, the cost associated with regulatory penalties should make them even more sensitive to changes in either capital or risk; therefore, it should be expected a stronger coordinated behavior between capital and risk adjustments in order to avoid a violation of regulation, as stated in Hypothesis H3 tested by Specifications II and III.

***Hypothesis H3.*** *Capital-risk coordination: the costs associated with the violation of capital regulation should enhance incentives for low-capitalized banks to positively coordinate capital and risk adjustments. Thus, an increase (decrease) in risk may lead to a compensatory increase (decrease) in capital, as well as a reduction (increase) in capital may be compensated by a reduction (increase) in risk ($\mu_1 > 0$ and $\gamma_1 > 0$).*

Finally, it is expected that the banks under pressure from regulation and supervision seek to replenish their capital and risk targets faster than the well-capitalized institutions (Hypothesis 4 tested by Specifications II and III).

***Hypothesis H4.*** *Capital and risk adjustments velocities: banks closer to the minimum regulatory capital requirement might be faster in the adjustments of their capital and risk levels to escape from the regulatory costs ($\alpha_1 < 0$ and $\beta_1 < 0$).*

### 3.2. Capital and risk definitions

The capital and risk measures used to compose respectively the variables *CAP* and *RISK* follow the provision of local prudential regulation which, in turn, follows the proposals of the Basel Accord.[26] The total capital in the variable *CAP* is defined in two different levels depending on the instrument loss absorbance capacity. The Tier 1 capital is composed mainly by equity capital and disclosed reserves. The Tier 2 capital, which has less capacity to absorb losses, is composed mainly of subordinated debt instruments and hybrid instruments of capital and debt.

The institution's risk exposure contained in the variable *RISK* is determined by its risk-weighted assets (RWA). The risk weights are based on methods adapted from standardized models of the Basel Accords and encompass three main risk sources: credit risk, market risk, and operational risk. The RWA, in turn, is obtained by multiplying the sum of the capital requirement portions to cover market and operational risks by 9.09 and adding the portion of risk-weighted exposures related to credit risk.

The bank's capital adequacy ratio (CAR) is then calculated by dividing the regulatory capital by the RWA. It is worth noting that the formula, as described, reflects, in terms of CAR, a minimum capital required by Brazilian regulation of 11%, therefore, more conservative than the 8% proposed by the Accord.

### 3.3. Measurement of the regulatory and supervisory pressures

The regulatory pressure can be measured either by the evaluation of specific changing in regulation or through variables that capture this pressure over time. In the econometric models, that attribute is usually represented by a dichotomous variable, *DREG*, identifying the less capitalized banks which are also the most susceptible to regulatory actions. The main issue in this construction, however, lies in the definition of the capital level that characterizes a bank under regulatory pressure. An obvious choice would be the regulatory capital limit; however, few banks fall below that level. What happens in practice is that the regulation interference is triggered still within positive levels of capital buffers, despite these levels are

[26] The prudential risk-based capital regulation was implemented in Brazil by the Resolution number 2.099 of August 17, 1994. In 1997, the Brazilian capital regulation became more rigid by elevating the factor on the risk-weighted assets from 8% to 11%. In 1999, it began the implementation of capital rules to cover market risk due to foreign currencies exposures. Recently, the Resolution number 3.444 of February 28, 2007 amended the regulatory capital definition (*Patrimônio de Referência* - PR). In parallel, the Resolution number 3.490 of August 29, 2007, effective from June 2008 on, provided new models for calculating the minimum capital requirement (*Patrimônio de Referência Exigido* - PRE). The normative introduced the capital to cover operational risk and changed the form of calculation for market risk and credit risk. All models are based on the simplified or standardized methodologies proposed by the Basel Accord.

not formally defined. Accordingly, researchers have tried to capture this feature in different ways. Part of the literature uses fixed capital buffer thresholds. Rime (2001), for instance, fixes a limit of two percentage points above the minimum capital adequacy ratio. As an alternative proposal, Stolz (2007) uses a statistical criterion, in which the threshold for regulatory pressure is defined by the tenth percentile of the set of standardized capital buffers (capital buffer over its standard deviation) in a specific time period.

In this study, we tested three different methods based on different parameters on the banks capital buffers (actual CAR minus 11%) to define the regulatory pressure threshold: (i) absolute approaches, in which the fixed absolute capital buffer thresholds are 1% and 2%; (ii) a statistical criterion, in which the threshold is the tenth percentile of the standardized capital buffers; and (iii) relative approaches, in which the thresholds are the fifth, tenth, and fifteenth percentiles of the set of absolute capital buffers in each quarter. Due to better results in the estimated regressions, we adopted the third option, using the tenth percentile of absolute buffers as a cutoff for the variable *DREG*. Figure 1 shows the evolution of some capital buffers percentiles over the sample period.

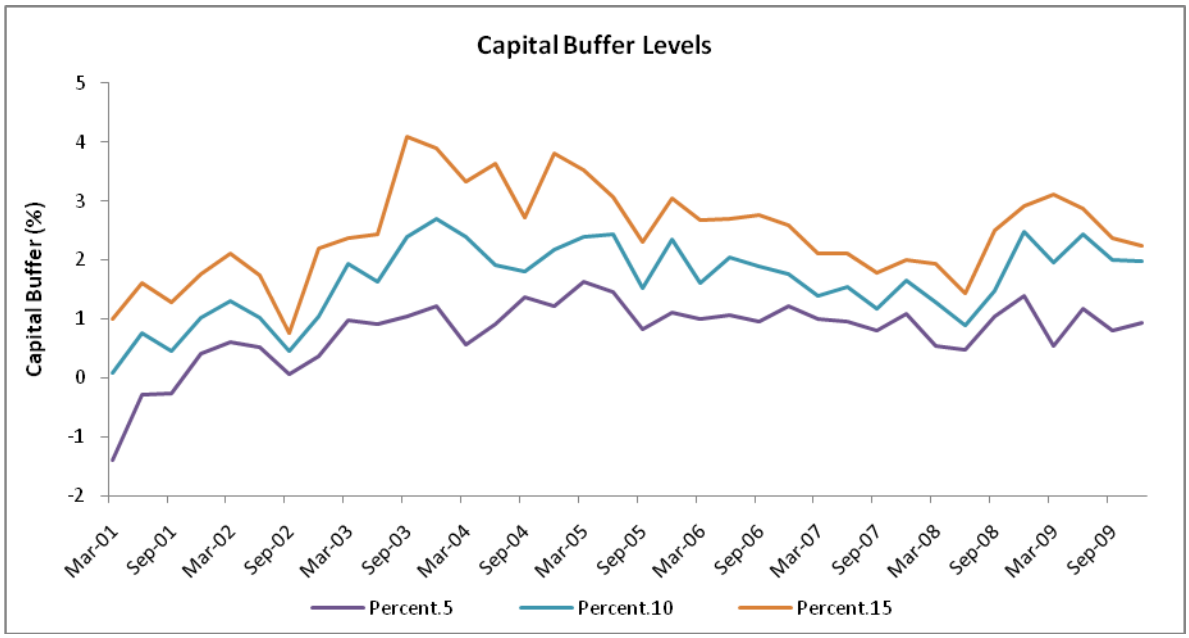


**Figure 1. Percentiles of absolute capital buffers.** The graph shows the evolution over time of the fifth, tenth, and fifteenth percentiles of banks capital buffers in the sample. The buffers are calculated in percentage points as the excess of the current capital adequacy ratio (CAR) over the minimum regulatory capital adequacy ratio in Brazil (11%).

The effects of regulatory pressure are intrinsically linked to the supervisors' performance. The authority should ensure that institutions are compliant with the limits established by regulation and, accordingly, effective actions of supervision will bring

credibility to the regulatory constraints. Moreover, the supervisor has tools and information not available to the market, which may result in perceptions about the solvency conditions of an institution that go beyond its capital ratio. That way, the indirect pressure of supervision may deviate from the direct regulation pressure.

As to control the influence of supervision in the model, the variable *SUPERV* consists of the scores given to the institution by the banking supervisory authority. We use the local supervisor's proprietary assessment criteria, which involve management features as well as accounting and prudential information, in a CAMEL style. The final score represents, therefore, the supervisor's perspective on the institution's economic and financial conditions, risk profile, and efficiency, and it is an important tool, among others, in the decision of whether to intensify the focus on a specific firm. Thus, a poorly rated institution, even if does not present problems in its solvency ratio, is more likely to suffer direct actions of supervision.

It is important to highlight that not always the score is informed to the institution. Even in this case, the argument of the supervisory pressure should remain valid, because if the perception of risk relating to that institution is high, the supervisor might increase preventive actions that, consequently, may push the bank's behavior.

### 3.4. Variables affecting the target levels of capital and risk

Following the empirical literature on bank's capital structure, the optimum levels of capital and risk depend directly on firm-specific and economic environment factors. These variables are represented by the vectors *Y* and *Z* in the simultaneous equation models presented.

As the retained earnings correspond to a significant source of financing for Brazilian banks, the return on assets (*ROA*) is used in the capital equations with positive expected sign. Expenses with loan losses (*LLOSS*), in turn, reduce the value of exposures subject to risk-weighting and, as a result, also reduce the defined risk measure. For this reason, it is included as an explanatory variable in the risk equations with negative expected sign.

The size (*SIZE*) as an indicator for external capital access may have negative effect on capital level. It also may present a negative impact on risk level, reflecting better investment opportunities and higher portfolio diversification of the larger banking firms (Acharya *et al.*, 2006). However, bigger banks, as perceived as too-big-to-fail, can take advantage of the safety net by increasing both leverage and portfolio risk. Thus, the expected sign of the variable in the capital equation remains negative, but becomes ambiguous in the risk equation.

The capital buffer theory suggests that banks with more liquid assets (*LIQUID*) need less insurance against breaches of capital requirements. The buffer can be rapidly replenished by changing liquid assets with higher risk weights (for example, stocks) for others low risk-weighted assets. Accordingly, the expected impacts of the assets liquidity should be negative on the capital target and positive on the risk target.

In order to capture the effect of the economic fluctuations on banks' decisions, the variable of GDP growth (*GDPG*) is included in both equations. A current regulation concern refers to risks and financial imbalances being built up during upturns in the business cycle. In a period of economic expansion, increases in leverage and decreases in portfolio risk may evidence a harmful pro-cyclical behavior of the banking system.[27] In this case, the observed signs would be negative in both equations.

Table I presents a summary description of the variables considered in the models of capital and risk targets and their expected signs. Time dummies are also included to capture possible seasonality and specificities of each year in the sample, as well as a dummy *DModel* is introduced for controlling changes in the regulatory standardized capital requirement models, in July 2008.

**Table I - Explanatory variables of the capital and risk targets**

Descriptions and expected signs of the variables explaining the optimal levels of capital and risk in the proposed model of partial adjustment simultaneous equations.

| Variable | Definition | Rationale | Effect on capital | Effect on risk |
|---|---|---|---|---|
| *DREG* | Dummy for low-capitalized banks | Proxy for regulatory pressure. | + | - |
| *SUPERV* | CAMEL ratings | Proxy for supervisory pressure. | + | - |
| *ROA* | Return on assets. | Retained earnings representing a significant source of recapitalization. | + | |
| *LLOSS* | Provision losses. | Expenses with loan provisions directly affect the RWA by reducing the risk-assets base. | | - |
| *SIZE* | Bank size. | - Access to financial markets.<br>- Investments opportunities and portfolio diversification.<br>- The too-big-to-fail problem. | - | +/- |
| *LIQUID* | Liquid assets. | Liquidity as an insurance against violations of capital requirement. | - | + |
| *GDPG* | Real GDP growth. | Business cycle influence. Shortsighted capital management with pro-cyclical effects. | - | - |

[27] Risk measures are pro-cyclical as they may underestimate the risk in booms and overestimate in recessions. For a theoretical discussion see Danielsson *et al.* (2009).

## 4. Data base

The data set consists of quarterly information of 112 commercial banks and banking holding companies with credit portfolios which compose the Brazilian banking system.[28] The period of analysis covers 36 quarters, from the first of 2001 until the fourth of 2009. Institutions subject to government intervention or liquidation processes and those with less than five observations within the period were removed from the sample. Development banks as well as those whose main activities are investment banking or treasury operations were also excluded.[29] Therefore, the final unbalanced panel totalizes 3,846 bank-quarter observations.

Due to mergers and acquisitions, the number of institutions oscillates around 100 in all quarters. Table II shows the total banks in December of each year. At the end of 2009, the sample comprises more than 70% of the total number of institutions in the Brazilian banking system and represents about 97% of the system's total assets. Along with the high concentration of banking industry, the ten largest banks in the sample hold approximately 88% of the sample's total assets for the same date.

**Table II - Number of banks**

Number of institutions in the sample at the end of each year.

| Year | # Banks | Year | # Banks |
|---|---|---|---|
| 2001 | **106** | 2006 | **104** |
| 2002 | **107** | 2007 | **103** |
| 2003 | **107** | 2008 | **98** |
| 2004 | **105** | 2009 | **96** |
| 2005 | **106** | | |

The variable *CAP* represents the ratio between the institution's regulatory capital and its total assets. Analogously, the assets risk of the institution, *RISK*, is determined by dividing the firm's risk-weighted assets (RWA) by its total assets. The ratio between the two variables represents the bank's capital adequacy ratio (CAR), and its capital buffer (*BUF*), in turn, is calculated by subtracting 11% from the CAR. The dummy *DREG*, which indicates institutions under greater regulatory pressure, assumes a unit value if the institution presents a buffer below the sample tenth percentile for a specific quarter, as discussed in the previous section.

[28] The banking system is defined as the set of institutions that form the Banking Consolidated of types I and II, according to classification of the Central Bank of Brazil. The referred group includes commercial banks, universal banks, saving banks, investment banks, and financial conglomerates composed by at least one of these institutions.

[29] The methodology applied to separate the financial institutions according to their operational profiles is described by Capelletto (2006). The procedure is used by the Central Bank of Brazil for supervisory purposes.

The supervisory evaluation variable, *SUPERV*, is constructed from the average of the CAMEL scores given to the institution. The lower the score, the better is the evaluation.

The profitability defined by the variable *ROA* represents the quarterly net profit in relation to the mean of bank's total assets. The provision expenses are computed in the variable *LLOSS* as a proportion of the outstanding credit operations. And the variable *SIZE* is calculated by the natural logarithm of the institution's total assets. Importantly, the total assets values do not include the financial intermediation account.

The liquidity cushion, *LIQUID*, is defined by the ratio of liquid assets to total assets. The liquid assets are comprised by cash, interbank operations, government bonds, other liquid bonds, stocks, quotes of investment funds and reserves at the Central Bank. Finally, the component of the economic cycle (*GDPG*) is set based on seasonally adjusted quarterly change in GDP, deflated by the Brazilian inflation index, IPCA.

The descriptive statistics for the main variables in the sample are presented in Table III. It is observed that the levels of capital and risk present wide variations, both in terms of standard deviation as the minimum and maximum values.

**Table III - Descriptive statistics**

Summary of basic statistics for the variables in the sample on a quarterly basis.

| Variable | Unit | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| $\Delta CAP$ | (% Total asset) | -0.16 | 4.95 | -56.54 | 83.96 |
| $CAP_{t-1}$ | (% Total asset) | 23.31 | 19.11 | 0.98 | 100.87 |
| $TIER1_{t-1}$ | (% Total asset) | 21.98 | 18.93 | 0.92 | 100.87 |
| $\Delta RISK$ | (% Total asset) | 0.08 | 18.51 | -225.13 | 187.22 |
| $RISK_{t-1}$ | (% Total asset) | 84.78 | 43.32 | 5.63 | 479.67 |
| *ROA* | (%) | 0.56 | 2.02 | -39.48 | 24.37 |
| *LLOSS* | (% Total credit) | 0.97 | 2.47 | -30.67 | 40.18 |
| *SIZE* | (Millions R$) | 14,500 | 50,300 | 18 | 565,000 |
| *LIQUID* | (% Total asset) | 25.61 | 18.71 | 0.01 | 97.76 |
| $BUF_{t-1}$ | (%) | 18.21 | 29.74 | -8.70 | 195.22 |

Table IV shows the means and standard deviations for the variables, separating the sample into banks with lower levels of capital (*DREG* = 1) and those with higher capital ratios (*DREG* = 0). It is noted that, on average, less capitalized banks have positive capital adjustments (0.59%) and negative risk adjustments (-2.19%), while for the other banks, the average adjustments have opposite directions (capital reductions of 0.26% and risk increases of 0.38%). The differences in profitability and liquidity between the two groups are also

evident. The better capitalized banks have higher average returns on assets (0.58% versus 0.36%) and larger liquid asset cushions (26.9% versus 15.7%).

**Table IV - Descriptive statistics by level of capitalization**

Means and standard deviations of the variables in the sample on a quarterly basis and separated into the group of less capitalized banks (*DREG* = 1) and the others (*DREG* = 0).

| | | ***DREG* = 1** | | ***DREG* = 0** | |
|---|---|---|---|---|---|
| **Variable** | **Unit** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| $\Delta CAP$ | (% Total asset) | 0.59 | 2.28 | -0.26 | 5.20 |
| $CAP_{t-1}$ | (% Total asset) | 12.75 | 8.38 | 24.73 | 19.69 |
| $TIER1_{t-1}$ | (% Total asset) | 12.06 | 8.68 | 23.32 | 19.53 |
| $\Delta RISK$ | (% Total asset) | -2.19 | 12.86 | 0.38 | 19.13 |
| $RISK_{t-1}$ | (% Total asset) | 110.12 | 71.37 | 81.37 | 36.72 |
| *ROA* | (%) | 0.36 | 1.62 | 0.58 | 2.07 |
| *LLOSS* | (% Total credit) | 0.95 | 2.15 | 0.97 | 2.51 |
| *SIZE* | (Millions R$) | 12,200 | 32,300 | 14,600 | 52,100 |
| *LIQUID* | (% Total asset) | 15.74 | 13.44 | 26.94 | 18.92 |
| $BUF_{t-1}$ | (%) | 0.59 | 1.41 | 25.42 | 64.35 |

Table V presents the correlation matrix for the main variables of the sample. There is a high positive correlation between the Tier 1 capital (*TIER1*) and total regulatory capital (*CAP*), and also the means and standard deviations of the variables in Table III are very similar, indicating that, on average, the higher quality capital is the main form of capitalization for the institutions. Correlations between measures of risk and capital are also positive, both in levels and in first differences, setting alert for coordinated action on the banks decisions over capital and risk adjustments.

**Table V - Correlation matrix**

Correlations among the variables in the sample on a quarterly basis. The index * represents a significance level of at least 5%.

| | $\Delta CAP$ | $CAP_{t-1}$ | $TIER1_{t-1}$ | $\Delta RISK$ | $RISK_{t-1}$ | *ROA* | *LLOSS* | *SIZE* | *LIQUID* | $BUF_{t-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta CAP$ | 1 | | | | | | | | | |
| $CAP_{t-1}$ | -0.16* | 1 | | | | | | | | |
| $TIER1_{t-1}$ | -0.16* | 0.99* | 1 | | | | | | | |
| $\Delta RISK$ | 0.22* | -0.03 | -0.03 | 1 | | | | | | |
| $RISK_{t-1}$ | -0.06* | 0.30* | 0.29* | -0.22* | 1 | | | | | |
| *ROA* | 0.10* | 0.07* | 0.08* | 0.03* | 0.08* | 1 | | | | |
| *LLOSS* | 0.03* | 0.12* | 0.11* | -0.04* | 0.07* | -0.17* | 1 | | | |
| *SIZE* | 0.01 | -0.63* | -0.63* | -0.01 | -0.29* | -0.05* | -0.08* | 1 | | |
| *LIQUID* | 0.04* | 0.38* | 0.39* | -0.02 | -0.22* | 0.01 | 0.08* | -0.11* | 1 | |
| $BUF_{t-1}$ | -0.12* | 0.53* | 0.53* | 0.07* | -0.19* | -0.02 | 0.08* | -0.30* | 0.40* | 1 |

In order to explore whether the relationship between capital and risk adjustments varies with the level of banks capitalization, Table VI shows the correlations between *ΔCAP* and *ΔRISK* for ten subsets of banks with similar capital buffers. Those groups are separated based on the deciles of the capital buffers in each quarter. Thus, group 1 encompasses ten percent of the sample and comprises the banks with the lowest buffers; the second group comprises the next ten percent less capitalized banks and so on, until the tenth group, which captures the ten percent better capitalized ones.

**Table VI - Correlations between capital and risk adjustments**

Correlations between the variables *ΔCAP* and *ΔRISK* for different levels of capitalization. Group 1 is formed by the banks with the lowest levels of capital, and group 10 is formed by the most capitalized banks. The index * represents a significance level of 5%.

| Capitalization level | Correlation (*ΔCAP*,*ΔRISK*) | Capitalization level | Correlation (*ΔCAP*,*ΔRISK*) |
|---|---|---|---|
| Group 1 | 0.55* | Group 6 | 0.19* |
| Group 2 | 0.29* | Group 7 | 0.18* |
| Group 3 | 0.21* | Group 8 | 0.33* |
| Group 4 | 0.44* | Group 9 | 0.33* |
| Group 5 | 0.34* | Group 10 | 0.10 |

It is noticeable that the correlation between adjustments of capital and risk is positive and significant for the whole sample, but the estimate is high in the case of less capitalized banks (group 1). The results may indicate that, in the short term, banks closer to the limits of regulation act in a more coordinated fashion than the others.

## 5. Empirical analyses

In general, the related empirical literature uses pooled data approaches to estimate the simultaneous equations model (Shrieves and Dahl, 1992; Jacques and Nigro, 1997; Aggarwal and Jacques, 2001; and Rime, 2001). Given the endogeneity between the variables *CAP* and *RISK*, the ordinary least squares (OLS) estimator should be dismissed for providing biased and inconsistent coefficient estimates. A fairly common strategy in these cases is the least square estimators in two or three stages (2SLS/3SLS). These approaches use the exogenous and predetermined variables as instruments for the endogenous variables. Thus, by structuring the combination of all available exogenous variables, both estimators provide consistent and efficient estimates.[30]

[30] As the 3SLS estimator incorporates the cross-correlations among the equations, it presents coefficient estimates asymptotically more efficient than the 2SLS estimator.

The gap in the methodology, however, lies in the omission of eventual unobserved banks heterogeneity (fixed effects), which can lead to biased estimations. Indeed, even approaches that specifically address the fixed effect issue should be sources of biases in the case of dynamic panels, since the within group transformation ignores the correlation between the lagged dependent variable and the regression error term (Nickell, 1981).

Arellano and Bond (1991) propose an estimator based on the generalized method of moment (GMM) to correct the bias in dynamic panels. Known as difference GMM, the estimation procedure initially eliminates the unobserved heterogeneity effect, usually by differentiation, and subsequently applies the GMM using the lagged variables in level as instruments for the transformed explanatory variables. The problem with this method is that, in the case of highly persistent series, the lagged variables are just weak instruments in the transformed equation, generating a bias in finite samples, as demonstrated by Blundell and Bond (1998).

Under additional hypotheses, Arellano and Bover (1995) and Blundell and Bond (1998) incorporate the equation in level into the difference GMM method. The new method generates a system of two equations, the original (in level) and the transformed (in differences), and is, therefore, called system GMM. The equation in level is instrumented by lags of the explanatory variables first differences and, analogously, the equation in differences is instrumented by lags of the variables in level. Besides reducing the difference GMM bias for finite samples, the system GMM approach allows wider use of instruments and can substantially increase the statistical efficiency of the coefficient estimator.

Considering the characteristics of the empirical construction presented, we carry out the estimations in this study using the described generalized method of moments with corrected standard errors (system GMM) and with some adjustments in order to account for the simultaneity between the dependent variables. We apply the two-step procedure that is asymptotically more efficient than the first stage estimator. As the second stage estimator may produce inconsistently smaller standard errors, especially in cases of small samples and large number of instruments, we take the Windmeijer (2005) method to correct the variances and covariance matrix. Regarding the number of instruments, it is controlled initially by reducing to eight the maximum number of lags of the variables and then by combining (collapsing) the instruments into smaller sets.[31]

[31] The proliferation of instruments may generate over-identification of the endogenous variables, hindering the proper treatment of endogeneity and thereby resulting in biased estimates (Roodman, 2009).

We also decide to use orthogonal deviations rather than first differences in order to remove the unobserved idiosyncratic effects, since the first differences transformation may increase the gaps in unbalanced panels.

Finally, with the purpose of incorporating the simultaneity in the decisions of capital and risk, we adopt the adjustment proposed by Stolz (2007) and Jokipii and Milne (2010), in which $\Delta RISK$ is modeled as an endogenous variable in the capital equation, including lags of the variable *RISK* in the related set of instrumental variables, and, analogously, $\Delta CAP$ is modeled as endogenous in the risk equation, including lags of *CAP* as its instruments.

### 5.1. Empirical results

Table VII presents the system GMM regression results for the system of simultaneous equations, according to Specifications I, II and III. In the diagnostic analysis for all equations, the autocorrelation tests of first and second order proposed by Arellano and Bond (1991) indicate the validity of the hypothesis of GMM identification, as well as the J tests of Hansen suggest the correct model specification.

## Table VII - Estimations of the simultaneous equations model of capital and risk adjustments

Panel A presents the specifications I to III, regarding to the equations that explain the capital adjustments, *ΔCAP*. Panel B presents the specifications I to III, relating to the equations of risk adjustments, *ΔRISK*. The coefficients are estimated through the system generalized method of moments (System GMM). It was included time dummies, but the coefficients were omitted. Indexes *, **, *** represent significance levels of 10%, 5% and 1%, respectively, and the t-statistics are reported in parentheses. The Hansen test refers to the test of over-identification restrictions and tests AR (1) and AR (2) refer to tests of the first and second order autocorrelation. For those tests, p-values are reported.

**Panel A – Equations of capital adjustments *ΔCAP***

| | Espec. I Eq. (5) | | Espec. II Eq. (7) | | Espec. III Eq. (9) | |
|---|---|---|---|---|---|---|
| $DREG_{t-1}$ | 0.015 | * | 0.001 | | 0.007 | |
| | (1.80) | | (0.01) | | (0.36) | |
| $SUPERV_{t-1}$ | 0.009 | * | 0.009 | * | 0.011 | * |
| | (1.80) | | (1.67) | | (1.68) | |
| $DREG_{t-1}.\ SUPERV_{t-1}$ | | | | | -0.007 | |
| | | | | | (-1.06) | |
| *ROA* | 0.396 | ** | 0.380 | ** | 0.374 | ** |
| | (2.37) | | (2.11) | | (2.04) | |
| *SIZE* | -0.006 | ** | -0.006 | ** | -0.007 | *** |
| | (-2.23) | | (-2.29) | | (-3.06) | |
| *LIQUID* | 0.117 | *** | 0.126 | *** | 0.131 | *** |
| | (3.09) | | (3.61) | | (3.67) | |
| *GDPG* | -0.090 | *** | -0.090 | ** | -0.081 | ** |
| | (-2.58) | | (-2.44) | | (-2.21) | |
| *ΔRISK* | 0.062 | *** | 0.053 | *** | 0.053 | *** |
| | (4.44) | | (3.46) | | (3.69) | |
| $DREG_{t-1}.\ \Delta RISK$ | | | 0.103 | ** | 0.096 | * |
| | | | (2.00) | | (1.78) | |
| $CAP_{t-1}$ | -0.156 | *** | -0.159 | *** | -0.178 | *** |
| | (-2.96) | | (-3.39) | | (-4.21) | |
| $DREG_{t-1}.\ CAP_{t-1}$ | | | 0.119 | | 0.143 | |
| | | | (1.29) | | (1.56) | |
| *DModel* | 0.009 | *** | 0.012 | *** | 0.010 | *** |
| | (3.11) | | (3.59) | | (3.27) | |
| *K* | 0.109 | * | 0.099 | * | 0.114 | ** |
| | (1.68) | | (1.65) | | (2.21) | |
| **AR(1)** | **0.000** | | **0.000** | | **0.000** | |
| **AR(2)** | **0.903** | | **0.880** | | **0.888** | |
| **Hansen** | **0.238** | | **0.266** | | **0.277** | |

**Panel B – Equations of risk adjustments *ΔRISK***

| | Espec. I Eq. (6) | | Espec. II Eq. (8) | | Espec. III Eq. (10) | |
|---|---|---|---|---|---|---|
| $DREG_{t-1}$ | -0.040 | ** | -0.181 | *** | -0.068 | |
| | (-2.02) | | (-4.24) | | (-1.02) | |
| $SUPERV_{t-1}$ | -0.030 | ** | -0.030 | ** | -0.021 | |
| | (-2.34) | | (-2.21) | | (-1.25) | |
| $DREG_{t-1}.\ SUPERV_{t-1}$ | | | | | -0.049 | * |
| | | | | | (-1.79) | |
| *LLOSS* | -1.131 | * | -0.447 | | -0.478 | |
| | (-1.66) | | (-0.74) | | (-0.80) | |
| *SIZE* | -0.013 | *** | -0.013 | *** | -0.014 | *** |
| | (-3.21) | | (-3.90) | | (-4.36) | |
| *LIQUID* | -0.245 | *** | -0.282 | *** | -0.275 | *** |
| | (-4.37) | | (-4.73) | | (-4.54) | |
| *GDPG* | -0.078 | | -0.059 | | -0.061 | |
| | (-0.50) | | (-0.36) | | (-0.35) | |
| *ΔCAP* | 0.811 | *** | 0.741 | *** | 0.748 | *** |
| | (5.24) | | (5.21) | | (5.22) | |
| $DREG_{t-1}.\ \Delta CAP$ | | | 2.548 | *** | 2.601 | *** |
| | | | (5.37) | | (5.17) | |
| $RISK_{t-1}$ | -0.187 | *** | -0.222 | *** | -0.224 | *** |
| | (-3.42) | | (-4.15) | | (-4.14) | |
| $DREG_{t-1}.\ RISK_{t-1}$ | | | 0.128 | *** | 0.125 | *** |
| | | | (2.82) | | (3.11) | |
| *DModel* | -0.027 | * | -0.019 | | -0.020 | |
| | (-1.72) | | (-1.26) | | (-1.27) | |
| *K* | 0.583 | *** | 0.614 | *** | 0.612 | *** |
| | (4.26) | | (4.95) | | (4.96) | |
| **AR(1)** | **0.000** | | **0.000** | | **0.000** | |
| **AR(2)** | **0.586** | | **0.616** | | **0.596** | |
| **Hansen** | **0.154** | | **0.268** | | **0.332** | |

Results on the impact of regulation and supervision on capital and risk targets

The coefficients of the variable *DREG* in the capital adjustments equations are positive ($\delta > 0$), but in only one of three equations it is significant at the 10% level (equation 5). In the risk adjustments equations, *DREG* shows negative coefficients which are significant in two of three specifications at the 5% and 1% levels (equations 6 and 8). There is, thus, evidence that banks with lower capital surpluses increase capital at higher amounts and, especially, increase risk by lower amounts, in comparison to other banks. The result is in line with the expected effect described in Hypothesis H1 about the influences of regulatory pressure.

Similarly, the coefficients of the variable *SUPERV*, which represents the ratings of the supervisory authority on banks' economic and financial conditions, are positive and significant in the capital equations ($\tau > 0$) at the 10% level, and negative and significant in the risk equations ($\psi < 0$) at the 5% level. That is, poorly evaluated banks tend to pursue short-term adjustments to improve their solvency ratios by both increasing capital and decreasing risk. Moreover, the interaction between the variables *SUPERV* and *DREG* in the Specification III shows that the effect of the scores may be higher for banks close to the capital limits, particularly regarding the risk adjustments. In equation (10), the coefficient of the interacted variable is negative and significant ($\psi_1 < 0$) at the 10% level, showing that the intensity in the risk adjustments is higher for lower rated banks when they are near the regulatory capital limit. However, the observed result is not maintained for the capital adjustments. The coefficient of the combined variable *DREG.SUPERV* in equation (9) is not significant ($\tau_1 = 0$), suggesting that, regarding the capital behavior, there are no differences between low-capitalized banks and the others that may be explained by the scores received. Overall, the results are also aligned with the expected effects in the Hypothesis H2 about the influence of supervisory pressure and its joint effect with prudential rules.

Results on the coordination between capital and risk adjustments

With regard to the coordinated decision on capital and risk, the coefficients of the variables of capital and risk adjustments in equations (5) and (6) are both positive and significant at the 1% level, indicating that banks increase capital when risk increases and vice versa. The result suggests that banks may have an optimal level of solvency (CAR), and may coordinate the levels of risk and capital in order to achieve this target ($\mu > 0$ and $\gamma > 0$).

Including the interaction of the variable *DREG* with the variable *ΔCAP* (equations 8 and 10), and with the variable *ΔRISK* (equations 7 and 9), the coefficients of the interacted variables remain positive and significant ($\mu_1 > 0$ and $\gamma_1 > 0$), indicating that banks under regulatory pressure are more sensitive to changes in their levels of capital and risk. The results support the Hypothesis H3 and suggest that less capitalized Brazilian banks actively manage their capital ratios, with the probable intention of avoiding the regulatory costs of a minimum capital requirements breach.

Results on the velocities of capital and risk adjustments

The estimated adjustment speeds of capital ($\alpha$) and risk ($\beta$) are relatively similar and suggest that the capital and risk targets are fully reached after six and five quarters, respectively. Comparing to related works, Brazilian banks seem to adjust both capital and risk levels much faster than the banks abroad. For instance, Rime (2001) shows that Swiss banks may take about ten and twenty years to adjust capital and risk levels. Stolz (2007) estimates that Germany savings banks may spend more than thirty years to reach their targets. The differences should be justified by higher capital ratio levels in the Brazilian banking system, so the banks may be closer to their optimal levels.

Regarding to the differences in speed adjustments between the low-capitalized banks and the others, only the coefficient of lagged risk is positive and significant ($\beta_1 > 0$) at 1% level, as shown in equations (8) and (10). It indicates that the better capitalized banks may adjust risk faster than the banks under regulatory pressure. The result is at odds with the predictions of the buffer capital theory, and therefore does not support Hypothesis H4. One explanation may be related to the effect of capital increases and risk reductions captured by the dummy *DREG*. In this rationale, less capitalized banks take longer to reach their targets, because they set, in the short run, higher capital targets and lower risk targets.

Additional results

As expected, the estimated coefficient of the return on assets (*ROA*) is positive and significant at the 5% level in all capital equations, indicating that institutions may count on retained earnings as an important source of capital increases. The loan loss provisions (*LLOSS*), in turn, have coefficients with negative signs due to the expected negative impact of provisions on the outstanding risk exposures; however, the estimated values are not quite

significant, with only the equation (6) presenting significance level of 10%. The results suggest a minor influence of this variable on the risk-weighted assets (RWA).

The size of bank assets (*SIZE*) has a negative influence on the changes in capital, as the coefficients of the variable are negative and show significance levels of 5% in equations (5) and (7) and 1% in equation (9). The result is in line with other empirical works, suggesting that larger banks promote lower adjustments in their capital structures than smaller banks. The reason may be related to big banks' wider access to different sources of financing or to greater economies of scale in their credit management activities. The result may also evidence the presence of moral hazard in the institutions noticed as too-big-to-fail.

On the other hand, it is observed a negative effect of size on the level of risk, what is in contradiction with the results usually found in the literature. The negative coefficients, which are significant at 1% level in all risk equations, show that large banks may lower their risks in greater proportions than the small ones. The result contributes to undermine the hypothesis of the asset substitution moral hazard related to the implicit safety net for large banks, thus supporting the argument of a greater portfolio diversification of those banks.

The effects of the liquidity cushion (*LIQUID*) in capital and risk adjustments also show intriguing results. The estimated coefficients for the variable are all significant at 1% level, but they have opposite signs from those expected. Interestingly, it is observed a positive impact in the capital adjustments and a negative impact in risk adjustments. The results go against the capital buffer theory propositions in which the liquidity cushion could replace capital as insurance against violations in the minimum capital requirement. One explanation for the fact that capital and liquidity reserves go in the same direction may be related with the long-term investment strategies, in which banks may hold capital and liquid assets as waiting for better investment opportunities.

Another important outcome concerns the effect of the economic cycle (*GDPG*) on the dependent variables. The negative and significant (at 1% and 5% levels) coefficients in the capital equations may be interpreted as a pro-cyclical behavior of banks, which tend to increase their leverage in periods of economic expansion. Moreover, it is observed that the effect of this variable on the risk-weighted assets is not significant, which can be explained by the fact that the new operations may belong to the same risk-type buckets of the current credit portfolios, and because of standardized weights for credit risk in the regulatory models that are invariant over the economic cycle. Despite not having the reference of risk-sensitive Basel II models in the local market, the results suggest that standardized models of capital may be less pro-cyclical.

## 6. Conclusion

The capital requirements rules have become predominant instruments in the context of prudential banking regulation. In the present study we examined the effects of regulatory restrictions on the short-term dynamics of capital and risk in the Brazilian financial system, comprising the period between 2001 and 2009. A novelty is the analysis of the influence of the supervisory authority monitoring in this process. Using banks CAMEL ratings proprietary methodology, we assessed the indirect contribution of supervisory perception in the banks' solvency decisions.

Our results indicate that regulation-related costs may put pressure on banks to maintain capital cushions, a conclusion which is in line with the capital buffer theory. We observed higher adjustments in capital and lower in risk, when the bank is close to the regulatory constraint. The supervisory evaluation is likely to influence the banks' decisions in the same direction, inducing banks to recompose their capital ratios when receiving poor ratings.

Additionally, we provide evidence of a positive relationship between the levels of capital and risk. Accordingly, risk levels are defined in terms of adjustments in the level of capital and, simultaneously, capital levels are adjusted based on changes in risk levels, all in the same direction. This coordinated behavior seems to be even more intense for the less capitalized banks, suggesting that institutions under regulatory pressure may actively manage their regulatory capital ratios in order to avoid the regulatory costs of a breach of minimum capital requirements.

Among the additional results, it is worth emphasizing the influence of the economic cycle on banks' capital formation. In periods of economic expansion, Brazilian banks show significant increases in leverage, which may evidence a sort of pro-cyclical behavior.

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