How Do Capital Buffers Respond to Basel? An Empirical Analysis of the Brazilian Banking System

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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.

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.

Specifically, those previous fundamentals 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. And the last one has been included in the last version of the Basel Accord following the recent 2008, and it is defined as the banks' capital management cyclical behavior.

We structure the empirical problem as a dynamic unbalanced panel with fixed effects on the basis of the capital buffer theory, and estimate the regressions through the system generalized method of moments. 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.

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.

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 explores the banking theories regarding banks' funding/investment decisions, and reviews some related empirical results in the literature. Section three 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 four describes the database, highlighting the characteristics of the local market. Section five presents the econometric approach and the robustness tests, and analyzes the empirical results. Section six concludes the study.

2. Banks' balance-sheet decision

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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.

2.1. 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.

3. <u>Capital buffer empirical model</u>

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, θ, 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, $u_{i,t}$.[1]

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

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*).

$$BUF_{i,t}^{*} = f(MNG, SUP, MKT, CYCLE) \qquad (2)$$

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.

3.1. 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. 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.[2] 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*.[3]

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, 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.

3.2. 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.

3.3. 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 deposits due to banks, *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).

3.4. 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.

3.5. 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:

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

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 good 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: $\mu_1 < 0$).*

4. 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.[4] 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.[5] 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.

The amount of uninsured funding is measured, firstly, by the ratio of subordinated debt to total liability, *SUBORD*, and, secondly, by the amount of deposits due to banks 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 I summarizes the basic statistics for the described variables.

Table I - 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

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.

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

5. Methodology and econometric analysis

The empirical problem in equation (3) has the structure of a dynamic unbalanced panel with fixed effects. We estimate the regressions through the system generalized method of moments developed by Arellano and Bover (1995) and Blundell and Bond (1998). 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.[6] 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.[7]

5.1. Empirical results

Table II presents the system GMM regression results. In the diagnostic analysis for all equations, the autocorrelation tests 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.

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.

Table II - 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. Specifications I to V are estimated by System GMM; endogenous variables are instrumented with one to five lags and the instruments are collapsed. In all models quarter and year 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. 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.

	I		II		III		IV		V	
BUF_{t-1}	0.818	***	0.809	***	0.830	***	0.811	***	0.798	***
	(23.87)		(23.34)		(25.35)		(24.33)		(17.18)	
ROE	0.306	***	0.291	***	0.297	***	0.293	***	0.197	**
	(2.87)		(2.68)		(2.83)		(2.79)		(1.99)	
VOL	0.190	***	0.190	***	0.180	***	0.184	***	0.159	**
	(2.87)		(2.82)		(2.61)		(2.80)		(2.25)	
NPL	-0.001		-0.001		-0.001		-0.001		-0.001	
	(-0.68)		(-0.67)		(-0.74)		(-0.65)		(-0.74)	
SIZE	-0.019	***	-0.020	***	-0.020	***	-0.020	***	-0.020	***
	(-3.11)		(-2.96)		(-3.23)		(-3.29)		(-3.94)	
LIQUID	0.025	***	0.022	***	0.024	***	0.026	***	0.025	***
	(3.50)		(3.12)		(3.34)		(3.59)		(3.53)	
SUBORD	0.436				0.444	*	0.413		0.504	
	(1.64)				(1.75)		(1.52)		(1.46)	
BANKDEP			-0.069							
			(-1.41)							
PEER	0.058	*	0.046		0.059	**	0.060	*	0.064	**
	(1.78)		(1.29)		(2.05)		(1.96)		(2.07)	
$SUPERV_{t-1}$	0.056	*	0.053	*			0.039		0.012	
	(1.80)		(1.70)				(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	-0.262	***	-0.265	***	-0.271	***	-0.255	***	-0.238	***
	(-6.30)		(-6.25)		(-7.65)		(-6.12)		(-6.48)	
GDPG	-0.328	**	-0.338	**	-0.305	**				
	(-2.04)		(-2.03)		(-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	***	0.525	***	0.487	***	0.510	***	0.566	***
	(3.24)		(3.05)		(3.36)		(3.51)		(4.37)	
AR(1)	**0.000**		**0.000**		**0.000**		**0.000**		**0.000**	
AR(2)	**0.670**		**0.688**		**0.700**		**0.667**		**0.812**	
Hansen	**0.347**		**0.244**		**0.516**		**0.534**		**0.273**	

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 I and II. 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 III, 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 I and it is significant at 10% level in model III. Moreover, the interbank market seems to have no disciplinary effects on banks' capital ratios, since, unexpectedly, model II shows a non-significant negative relationship between *BANKDEP* and capital buffers ($\gamma_1 = 0$).[8] 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 III and V) and 10% levels (models I and IV). 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.

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 models (models I to III). 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 in models IV and V.

In model IV, 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 V, 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. 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.

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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.

Finally, 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.

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End Notes

[1] 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: an unobserved bank-specific effect (η_i) and a white noise (ε_{it}).

[2] 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.

[3] 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).

[4] 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.

[5] 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).

[6] 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).

[7] 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.

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