Coordination of capital buffer and risk profile under supervision of Central Bank

(Coordenação entre capital buffer e perfil de risco sob supervisão do Banco Central)

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Abstract

This work investigates how banks react to the capital constraints imposed by the Central Bank. Using models that incorporate the simultaneity of capital decisions and risk decisions, our findings confirm the capital buffer theory, which predicts that adjustments to capital and adjustments to risk are positively related. Moreover, we find that regulatory pressures induce banks to increase their risk levels in response to capital adjustments but not vice versa.

***Keywords**:* regulatory capital, asset risk, prudential regulation.

***JEL Classification**:* G21, G28.

Resumo

Este artigo investiga como bancos reagem a restrições de capital impostas pelo Banco Central. Usando modelos que incorporam simultaneidade entre decisões de capital e decisões de risco, nossos resultados confirmam a teoria de capital buffer que preconiza que os ajustes a capital e os ajustes ao risco são positivamente relacionados. Além disso, encontramos que a pressão regulatória exercida pelo Banco Central induz bancos a aumentar o nível de risco em resposta ao ajuste de capital, mas não vice-versa.

***Palavras-chave**:* capital regulatório, risco dos ativos e regulação prudencial

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1. Introduction

The Basel Accord of 1988 (BCBS, 1988) sets a new standard for minimum capital requirements which was adopted by Brazil central bank in 1994. The Accord sets a minimum capital adequacy ratio (CAR) of 8% which was increased by Brazil central bank to 11% in 1999.

Since the adoption of the minimum capital requirements, banks have adopted a higher standard than that set by the financial authorities. This can be partly explained by the cost of adjustment for the optimal level of the CAR for the bank. For instance, banks' optimal decisions may be influenced by market discipline mechanisms, by agents' investment strategies, or even by indirect schemes of regulatory pressure related to other aspects of risk profiles captured by both on- and off-site supervisory measures.

In attempting to understand and evaluate the effect of regulatory interventions on bank solvency, a new line of research on capital buffer theory has shown that a typical bank's capital cushion may be driven by the explicit and implicit costs of prudential regulation.

This paper contributes to the prudential regulation on short-term, simultaneous decisions about capital and risk in the Brazilian banking system. To our knowledge, this is the first work to address how prudential regulation has been conducted in Brazil. The results show that banks closer to the regulatory minimum seem relatively more risk-averse in that they make larger positive adjustments to their capital levels and smaller adjustments to their portfolio risk levels. Low-capitalized banks also manage their solvency ratios more actively, coordinating their capital and risk adjustments in the same direction. The supervisory monitoring effect also appears likely to support capital restriction, increasing risk aversion as the evaluation authority strengthens.

The rest of the paper is divided as follows. Section two provides a brief theoretical review of the role of prudential regulation in banks' behavior related to adjustments in leverage and portfolio risk followed by some empirical evidence. Section three details the simultaneous partial adjustment model used as a reference in the empirical analysis and presents the testing hypothesis. Section four describes the database. Section five presents the estimation methods and interprets the results. Section six concludes.

2. Regulation and capital-risk dynamics in the banking literature

The literature on minimum capital requirements was first approached in the late 1970s to look at how capital rules may correct perverse incentives generated by the traditional risk-insensitive structure of deposit insurance (Sharpe, 1978). Generally, "moral hazard authors" assume that capital is defined at the minimum regulatory limit and focus on analyzing banks' 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 an institution's risk as banks tend to reallocate their portfolios among riskier assets, looking for higher expected returns (asset substitution moral hazard). Kim and Santomero (1988) show that the perverse incentive may be mitigated by risk-based capital requirements unless the defined risk-weights do not correctly reflect the portfolios' potential losses. Furlong and Keeley (1989) and Keeley and Furlong (1990) incorporate the value of the deposit insurance option into the model and show that regardless of risk weighing, leverage restrictions create incentives for institutions to maintain proper risk levels.

The theory of capital buffering supports the hypothesis that banks maintain a capital surplus (buffer) to reduce interference by supervisory authorities and to mitigate the eventual regulatory costs associated with violating the minimum capital rule. Unlike traditional moral hazard lines, the models of the capital buffer theory (Furfine, 2001; Milne & Whalley, 2001; Peura & Keppo, 2006) take capital as an endogenous response to regulation and add an intertemporal perspective to the bank's recapitalization process. As they approach the minimum, banks tend to increase their capital and/or reduce their risk exposure to restore their solvency ratios and avoid regulatory costs. Subsequently, they again coordinate their behavior to meet their combined capital and risk targets.

Milne and Whalley (2001) extend the behavioral model of the buffer theory, adding to the capital regulation restrictions the audit function of the supervisor agent. Those authors find that bank's risk aversion is a positive function of supervisory monitoring. Therefore, banks tend to enlarge capital cushions and to choose less risky portfolios in reaction to higher levels of bank supervision.

The recently formalized capital buffer theory, however, proposes relationships among capital, risk, and regulation that seem more aligned to the evidence in the empirical literature. In general, it is observed that less capitalized banks engage in major positive short-term adjustments for capital and lower adjustments for risk.

The precursory work of Shrieves and Dahl (1992) analyzes the simulatenous relationship between capital and risk in the banking sector. These authors run tests on the US market in the 1980s, a period when the capital requirement was not risk-adjusted, and 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) replicated 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.

Following the enactment of Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA), Aggarwal and Jacques (1998) investigated how FDICIA may have helped in supervisory corrective actions for banks that are not properly capitalized (*Prompt Corrective Action*). Their results indicate that "low-capitalized," banks have shown increases in capital levels and reductions in risk levels.

Rime (2001) observes that Swiss banks' c that less-capitalized banks establish higher capital levels without promoting corresponding adjustments to their risk levels. Stolz (2007) performs a similar study of German savings banks, arguing that these banks comprise the most extensive and homogeneous group of institutions in the country. She finds evidence that banks adjust capital faster than risk and banks with smaller buffers promote faster adjustments than do well-capitalized banks. With respect to the coordination between capital decisions and risk adjustments, she observes that the two are negatively correlated for banks with smaller buffers but positively correlated for banks with larger buffers. The author interprets the results as indicative that regulatory pressure increases banks' risk aversion.

One criticism of the empirical research is that it may not properly identify and separate the direct effects of regulatory restrictions from those indirectly caused by either the pressure of supervision or disciplinary forces in the market. Furfine (2001) distinguishes greater strictness in the monitoring criteria of supervisory authorities as one of the major factors that led to the credit crunch in the United States during the 1990s. The author notes that tighter supervisory rules have had a greater influence on banks' balance sheet decisions than have the imposition of minimum capital limits.

Berger *et al.* (2001) analyze the solvency ratings given by the supervisors of US commercial banks (CAMEL—Capital Adequacy; Asset Quality; Management; Earnings; Liquidity) and note that supervisory rigor has an impact on the credit supply, but only to a moderate degree. De Young *et al.* (2001) explore the informational value of the supervisory CAMEL ratings and find evidence that CAMEL scores reflect the risks taken by financial institutions and may generate incentives to engage in risk management that is more efficient.

Our work hopes to fill the gap by including proprietary central bank as a proxy for supervisory pressure and its impact on the coordination between capital and risk.

3. Model of simultaneous partial adjustments

To test the decisions of Brazilian banks' capital and risk adjustments, we follow the partial adjustments approach proposed by Shrieves and Dahl (1992). TObserved change in the capital and risk levels of the institution *i* in the period between *t-1* and *t* ($\Delta CAP_{i,t}$ e $\Delta RISK_{i,t}$) are simultaneously defined and may be decomposed into a discretionary portion ($\Delta^d CAP_{i,t}$ e $\Delta^d RISK_{i,t}$) that is endogenously determined and another part composed of exogenous shocks ($u_{i,t}$ e $w_{i,t}$):

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

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

Our assumption is that the exogenous shocks are formed by two orthogonal components, which are independent and identically distributed: a firm-specific effect and white noise. In turn, the discretionary variations are modeled on a partial adjustment approach, assuming that institutions cannot perform immediate adjustments due to some type 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 α and β, respectively. Considering the simultaneity in capital and risk decisions, the model is described as follows:

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

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

The partial adjustment in equations (3) and (4) suggests that banks set their capital and risk targets. Although these variables are not directly observable, the empirical literature indicates that they depend on variables related to both the specific characteristics of the institution and the economic environment, which are represented by the vectors *Y* and *Z*.[1] The capital and risk targets should also be influenced by regulatory constraints and monitoring by financial authorities. Thus, to capture the respective effects of regulatory and supervisory pressures, the binary variable *DREG* indicates less-capitalized banks, and the continuous variable *SUPERV* denotes the assessments of the bank conducted by the supervisory authority, according to which the higher the score is, the worse the perceived condition of solvency is. By including these new variables, the simultaneous equations model (Specification I) is defined as follows:

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

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

By allowing different intercepts for banks under different levels of regulatory pressure through the explanatory dummy *DREG*, Stolz (2007) suggests including variables constructed by interacting the variable *DREG* with the variables ΔCAP and $\Delta RISK$, which helps verify whether the pattern of coordination between capital and risk is maintained along capitalization levels. Additionally, to test whether banks under greater regulatory pressure adjust their capital and risk more quickly than do

[1] Gropp and Heider (2008) find evidence for publicly traded banks in the U.S. and Europe that the variables commonly used as capital structure determinants for non-financial companies, such as size, profitability, the 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.

other banks, she suggests including the interaction of the variable *DREG* with the variables CAP_{t-1} and $RISK_{t-1.}$ Defined this way, the system assumes the form of Specialization II in equations (7) and (8).

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

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

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

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

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

$$\begin{aligned}\Delta CAP_{i,t} &= \delta.DREG_{i,t-1} + \tau_0.SUPERV_{i,t-1} + \tau_1.DREG_{i,t-1}.SUPERV_{i,t-1} + a.Y_{i,t} \\ &- \alpha_0.CAP_{i,t-1} - \alpha_1.DREG_{i,t-1}.CAP_{i,t-1} + \mu_0.\Delta RISK_{i,t} + \mu_1.DREG_{i,t-1}.\Delta RISK_{i,t} + u_{i,t}\end{aligned} \qquad (9)$$

$$\begin{aligned}\Delta RISK_{i,t} &= \pi.DREG_{i,t-1} + \psi_0.SUPERV_{i,t-1} + \psi_1.DREG_{i,t-1}.SUPERV_{i,t-1} + b.Z_{i,t} \\ &- \beta_0.RISK_{i,t-1} - \beta_1.DREG_{i,t-1}.RISK_{i,t-1} + \gamma_0.\Delta CAP_{i,t} + \gamma_1.DREG_{i,t-1}.\Delta CAP_{i,t} + w_{i,t}\end{aligned} \qquad (10)$$

3.1. Testing hypotheses

Under the null hypothesis of no effects of capital and monitoring rules on banks' behavior, the simultaneous equations model presented in Specification I allows us to confront three aspects of banks' theoretical and observed management conduct. Thus, the hypotheses are defined to conduct the following tests: first, the direct impact of regulation and supervision on capital and risk targets; second, the coordination between adjustments in capital and risk; and third, the speeds of those adjustments.

With respect to the direct impacts of prudential regulation and supervision, Hypotheses H1 and H2 consider the influence of minimum capital requirements and supervisory evaluations on changes in banks' optimum levels of capital and risk. As intended by financial authorities and consistent with the capital buffer theory, banks are expected in the short term to experience greater regulatory pressure to adjust their capital levels upwards and to take less risk in their portfolios (Hypothesis H1, tested by Specifications II). It is also expected that perceptions of supervision are likely to influence banks' decisions in the same direction, as shown in Hypothesis H2 (tested by Specification I). Moreover, the joint effect of regulation and monitoring, described in Hypothesis H2,.

Hypothesis H1. *<u>Capital regulation on capital and risk adjustments</u>: Banks closer to the minimum regulatory capital requirement are likely feel increasing regulatory pressure; therefore, the impact of this regulatory pressure on banks' decisions might be positive for capital adjustments ($\delta > 0$) and negative for portfolio riskadjustments ($\pi < 0$).*

Hypothesis H2. *<u>Banking supervision on capital and risk adjustments</u>: Banks negatively evaluated by a 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 $\psi_1 < 0$).*

With respect to the short-run interdependence between capital and risk decisions, the expected effect of regulation may also depend on a bank's capitalization level. 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 a bank's administration. In the case of low-capitalized banks, the cost associated with regulatory penalties should make banks even more sensitive to changes in either capital or risk; therefore, more strongly coordinated behavior between capital and risk adjustments should be expected to avoid the violation of a regulation, as stated in Hypothesis H3.

> ***Hypothesis H3.*** *Capital-risk coordination: The cost associated with the violation of capital regulation should enhance the 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, and 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 banks under regulatory and supervisory pressures will seek to replenish their capital and risk targets faster than well-capitalized institutions

> ***Hypothesis H4.*** *Velocity of capital and risk adjustments: Banks closer to the minimum regulatory capital requirement might adjust their capital and risk levels more quickly to escape regulatory costs (* $\alpha_1 < 0$ *and* $\beta_1 < 0$ *).*

3.2. Definitions of capital and risk

The capital and risk measures used to compose the variables *CAP* and *RISK*, respectively, follow the provisions of local prudential regulation, which in turn follows the proposals of the Basel Accord.[2] The total capital in the variable *CAP* is defined at two different levels depending on its instrument loss-absorption capacity. Tier I capital is primarily composed of equity capital and disclosed reserves. Tier II capital, which has a lower capacity to absorb losses, is primarily composed of subordinated debt instruments and hybrid instruments of capital and debt.

[2] Prudential risk-based capital regulation was implemented in Brazil by Resolution 2.099 of August 17, 1994. In 1997, Brazilian capital regulation became more rigid by elevating the factor of RWA from 8% to 11%. In 1999, Brazil began to implement capital rules to cover the market risk caused by exposure to foreign currencies. Recently, Resolution 3.444 of February 28, 2007, amended the definition of regulatory capital (*Patrimônio de Referência* - PR). In parallel, Resolution 3.490 of August 29, 2007, which took effect in June 2008, has provided new models for calculating the minimum capital requirement (*Patrimônio de Referência Exigido*—PRE). This norm introduces capital to cover operational risk and changes 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.

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

A bank's CAR is then calculated by dividing the regulatory capital by RWA. It is worth noting that the formula as described reflects, in terms of the CAR, the minimum capital required by Brazilian regulation, which is 11% and therefore more conservative than the 8% proposed by the Basel Accord.

3.3. Measurement of regulatory and supervisory pressures

Regulatory pressure can be measured either by an evaluation of specific changes in regulation or through variables that capture that pressure over time. In econometric models, that attribute is usually represented by a dichotomous variable, *DREG*, which identifies the less-capitalized banks that are also the most susceptible to regulatory action. 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, a few banks fall below that threshold. What happens in practice is that regulatory interference is triggered, while a bank's capital remains within positive levels of capital buffers despite the fact that these levels are not formally defined. Accordingly, researchers have attempted 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 CAR. Stolz (2007) alternatively proposes a statistical criterion in which the threshold for regulatory pressure is defined by the tenth percentile of the set of standardized capital buffers (i.e., a capital buffer over its standard deviation) of a specific period.

In this study, three different methods based on different parameters for banks' capital buffers (actual CAR minus 11%) have been tested 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.

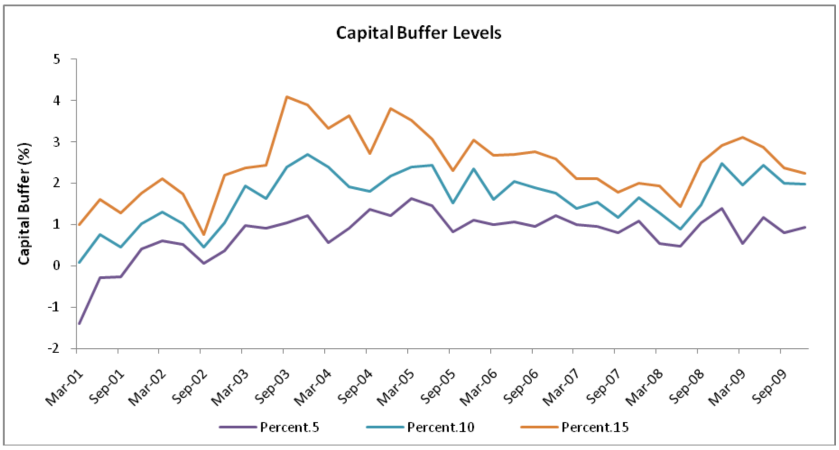

Figure 1
Percentiles of absolute capital buffers. The graph shows the evolution over time of the fifth, tenth, and fifteenth percentiles of the capital buffers of the banks in the sample. The buffers are calculated in percentage points as the excess of the current capital adequacy ratio (CAR) over the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

The effects of regulatory pressure are intrinsically linked to the performance of supervisors. The Central Bank should ensure that institutions are compliant with the limits established by the regulations; accordingly, effective supervisory actions bring credibility to the regulatory constraints. Moreover, supervisors have tools and information not available to the market that may result in perceptions about an institution's solvency conditions that go beyond its capital ratio. Therefore, the indirect pressure of supervision may deviate from the direct pressure of regulation.

To control for the influence of supervision in the model, the variable *SUPERV* consists of the scores given to the institution by the Central Bank. The assessment criteria are confidential but involve not only management features but also information about accounting and prudential controls in the CAMEL style. Therefore, the final score represents the supervisor's perspective on economic and financial conditions, risk profile, and institutional efficiency and is an important tool, among others, with which to decide whether to intensify focus on a specific firm. Thus, a poorly rated institution, even if its solvency ratio does not present problems, is more likely to suffer from direct supervisory actions.

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

3.4. Variables that affect the target levels of capital and risk

Following the empirical literature on bank capital structure decisions, the optimum levels of capital and risk depend directly on firm-specific and economic environment factors.

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

Size (*SIZE*) as an indicator of external capital access may have a negative effect on the level of capital. It may also have a negative impact on risk level, reflecting larger banks' greater investment opportunities and better portfolio diversification (Acharya *et al.*, 2006). However, larger banks that are perceived as too big to fail can take advantage of their safety net by increasing both their leverage and their portfolio risk. Thus, the expected sign of the variable in the capital equation remains negative, but it 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' lower RWA. Accordingly, the expected impacts of the assets' liquidity should be negative on the capital target and positive on the risk target.

To capture the effect of economic fluctuations on banks' decisions, both equations include the variable of GDP growth (*GPDG*). One of the regulation's current concerns refers to the amplification effect on the business cycle that originated in the prudential rules and in the management conduct of some banks. In an economic expansion phase, increases in leverage and portfolio risk may present evidence of harmful pro-cyclical behavior by the banking system. In this case, the signs observed would be negative in the capital equation and positive in the risk equation.

Table I presents a summary description of the variables considered in the models of capital and risk targets and their expected signs. Indeed, time dummies are also included to capture possible seasonality and specificities for each year in the sample, along with a dummy for controlling changes in the regulatory standardized models for calculating capital requirements in July 2008.

Table I
Explanatory variables of the capital and risk targets. Descriptions and the expected signs of the variables that explain the optimal levels of capital and risk in the proposed model of the partial adjustment of simultaneous equations.

Variable	Definition	Hypothesis	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 RWA by reducing the risk-asset base.		-
SIZE	Bank size	- Access to financial markets. - Investment opportunities and portfolio diversification. - The *too-big-to-fail* problem.	-	-/+
LIQUID	Liquid assets	- Liquidity as insurance against violations of capital requirements.	-	+
GDPG	Real GDP growth	Business cycle influence. Shortsighted capital management with pro-cyclical effects.	-	+

4. Database

The dataset consists of quarterly information for the 112 commercial banks and banking holding companies with credit portfolios that comprise the Brazilian banking system.[4] The period of analysis covers 36 quarters from the first quarter of 2001 until the fourth quarter of 2009. Institutions subject to government intervention or liquidation processes and those with less than five observations in 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. Therefore, the final unbalanced panel includes 3,846 bank-quarter observations.[5]

Due to mergers and acquisitions, the number of institutions oscillates by approximately 100 during all quarters. Table II shows the number of banks in December of each year. At the end of 2009, the sample comprised more than 70% of the total number of institutions in the Brazilian banking system and represented approximately 97% of the system's total assets. Along with the high concentration in the banking industry, the ten largest banks in the sample hold approximately 88% of the total assets in the sample 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 an institution, *RISK*, is determined by dividing its RWA by its total assets. The ratio between the two variables represents its CAR. In turn, its

[4] The banking system is defined as the set of institutions that form Banking Consolidated I and II, according to the Central Bank of Brazil. That group includes commercial banks, universal banks, saving banks, investment banks and financial conglomerates composed of at least one of these institutions.
[5] The methodology applied to separate the financial institutions according to their operational profiles is described by Capelletto (2006). This procedure is used by the Central Bank of Brazil for supervisory purposes.

capital buffer (*BUF*) 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's tenth percentile for a specific quarter, as discussed in the previous section. The supervisory evaluation variable, *SUPERV*, is constructed from the average of the CAMEL scores given to the institution. The lower the score is, the better the evaluation is.

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

The liquidity cushion, *LIQUID*, is defined by the ratio of liquid assets to total assets. Liquid assets are composed of cash, interbank operations, government bonds, other liquid bonds, stocks, quotes from investment funds, and Central Bank reserves. Finally, the economic cycle component (*GDPG*) is set based on the 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, except for the variable *SUPERV*, which has been suppressed for confidentiality reasons. It is observed that the levels of capital and risk both present wide variations 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.
ΔCAP	(%)	-0.16	4.95	-56.54	83.96
CAP_{t-1}	(%)	23.31	19.11	0.98	100.87
$TIER1_{t-1}$	(%)	21.98	18.93	0.92	100.87
$\Delta RISK$	(%)	0.08	18.51	-225.13	187.22
$RISK_{t-1}$	(%)	84.78	43.32	5.63	479.67
ROA	(%)	0.56	2.02	-39.48	24.37
LLOSS	(%)	0.97	2.47	-30.67	40.18
SIZE	(Millions R$)	14,300	50,200	17	566,000
LIQUID	(%)	25.61	18.71	0.01	97.76
GDPG	(%)	4.20	3.42	-2.85	10.45
BUF_{t-1}	(%)	22.48	60.95	-8.70	1,232.06

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%), whereas for other banks, the average adjustments are made in the 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 ROA (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 a group of less capitalized banks (*DREG* = 1) and others (*DREG* = 0).

		***DREG* = 1**		***DREG* = 0**	
Variable	**Unit**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
ΔCAP	(%)	0.59	2.28	-0.26	5.20
CAP_{t-1}	(%)	12.75	8.38	24.73	19.69
$TIER1_{t-1}$	(%)	12.06	8.68	23.32	19.53
$\Delta RISK$	(%)	-2.19	12.86	0.38	19.13
$RISK_{t-1}$	(%)	110.12	71.37	81.37	36.72
ROA	(%)	0.36	1.62	0.58	2.07
LLOSS	(%)	0.95	2.15	0.97	2.51
SIZE	(Millions R$)	12,200	32,300	14,600	52,100
LIQUID	(%)	15.74	13.44	26.94	18.92
GDPG	(%)	4.30	3.41	4.47	3.42
BUF_{t-1}	(%)	0.59	1.41	25.42	64.35

Table V presents the correlation matrix for the main variables in the sample. There is a high positive correlation between Tier 1 capital (*TIER1*) and total regulatory capital (*CAP*); moreover, the means and standard deviations of the variables in Table III are very similar, indicating that on average, higher-quality capital is the primary form of the institutions' capitalization. The correlations between measures of risk and capital are also positive both in levels and in first differences, alerting us to coordinated action by the banks in their decisions related to 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 5%.

	ΔCAP	CAP_{t-1}	$TIER1_{t-1}$	$\Delta RISK$	$RISK_{t-1}$	*ROA*	*LLOSS*	*SIZE*	*LIQUID*	*GDPG*	BUF_{t-1}
ΔCAP	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		
GDPG	-0.05*	0.00	0.00	0.00	-0.02	0.06*	-0.04*	0.03	-0.01	1	
BUF_{t-1}	-0.12*	0.53*	0.53*	0.07*	-0.19*	-0.02	0.08*	-0.30*	0.40*	0.01	1

5. Empirical analyses

In general, the related empirical literature uses pooled data approaches to estimate the simultaneous equations model (Shrieves & Dahl, 1992; Jacques & Nigro, 1997; Aggarwal & Jacques, 2001; Rime, 2001). Given the endogeneity between the *CAP* and *RISK* variables, the ordinary least squares (OLS) estimator should be dismissed because it provides biased and inconsistent coefficient estimates. A common strategy in these cases is the least squares estimators in two or three stages (2SLS/3SLS). In sum, those 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.[6]

The gap in the methodology, however, lies in its omission of the 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 bias in the case of dynamic panels because the within-group transformation ignores the correlation between the lagged dependent variable and the regression error term (Nickell, 1981).

[6] Because the 3SLS estimator incorporates the cross-correlations among the equations, it presents coefficient estimates asymptotically efficientr.

Arellano and Bond (1991) propose a generalized method of moments estimator (GMM) to correct the bias in the 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 form 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 merely weak instruments in the transformed equation, generating a bias in finite samples, as demonstrated by Blundell and Bond (1998).

Formulating additional hypotheses, Arellano and Bover (1995) and Blundell and Bond (1998) incorporate the first differences of the instrumental variables used in the difference GMM method as instruments for the original equation. This method generates a system of two equations, the original (in level) and the transformed (in differences) equations, and is therefore called system GMM. The equation in level form 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 form. In addition to reducing the difference GMM bias for finite samples, the system GMM approach allows a wider use of instruments and can substantially increase the statistical efficiency of the coefficient estimator.

Considering the characteristics of the empirical construction presented, the estimations in this study have been performed using the described GMM with corrected standard errors (system GMM) and with some adjustments to account for the simultaneity between the dependent variables. Because the second-stage estimator may produce inconsistently smaller standard errors, especially in cases of small samples and large numbers of instruments, the Windmeijer (2005) method has been used to correct variances and the covariance matrix. The number of instruments has been controlled initially by reducing to eight the maximum number of lags of the variables and then by combining (collapsing) the instruments into smaller sets.[7]

In addition, orthogonal deviations have been used rather than first differences to remove the unobserved idiosyncratic effects because the

[7] The proliferation of instruments may generate the overidentification of the endogenous variables, hindering the proper treatment of endogeneity and thus resulting in biased estimates (Roodman, 2009).

first differences transformation may increase the gaps in unbalanced panels.

Finally, with the purpose of incorporating simultaneity into capital and risk decisions, we have adopted the adjustment proposed by Stolz (2007) and Jokipii and Milne (2010) in which Δ*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 in turn, Δ*CAP* is modeled as endogenous in the risk equation, using lags of *CAP* as its instruments.

5.1. Empirical results

Table VI presents the system GMM regression results for the system of simultaneous equations of Specifications I, II and III. In the diagnostic analysis of all equations, the autocorrelation tests of the first and second orders proposed by Arellano and Bond (1991) indicate the validity of the hypothesis of GMM identification, and Hansen's J tests suggest the correct model specification.[7]

[7] Further, the autocorrelation does not imply a bias, but this underestimate the standard errors. One way is to cluster at the bank level. However, clustering at bank level will increase the standard erros as you decrease the degree of freedom from N x T to N. As we use dynamic GMM panel data, we have tested and we have not found any major changes on the results.

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

Panel A presents Specifications I to III regarding the equations that explain the capital adjustments, *ΔCAP*. Panel B presents Specifications I to III regarding the equations of risk adjustments, *ΔRISK*. The coefficients are estimated through the system-generalized method of moments (System GMM). K is the intercept and DModel is a dummy for the 2008 crisis. The model includes time dummies, whose 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 overidentification restrictions, and tests AR (1) and AR (2) refer to first- and second-order autocorrelation tests. The p-values are reported for those tests.

Panel A – Equations of capital adjustments *ΔCAP*

	Spec. I Eq. (5)	**Spec. II Eq. (7)**	**Spec. 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*

	Spec. I Eq. (6)	**Spec. II Eq. (8)**	**Spec. 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 regarding the impact of regulation and supervision on the targets of capital and risk

The coefficients of the variable *DREG* in the capital adjustments equations are positive ($\delta > 0$), but they are significant at the 10% level in only one of three equations (equation 5). In the risk adjustment equations, *DREG* shows negative coefficients that are significant in two of three specifications at the 5% and 1% levels (equations 6 and 8). Accordingly, there is evidence that banks with lower capital surpluses increase their capital at higher amounts and particularly increase their risk by lower amounts compared to other banks. This 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 supervisory author's ratings of 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 ($\psi < 0$). That is, poorly evaluated banks tend to pursue short-term adjustments to improve their solvency ratios by either increasing capital or decreasing risk. Moreover, the interaction between the variables *SUPERV* and *DREG* in Specification III shows that the effect of the scores may be higher for banks close to the capital limits, particularly with respect to risk adjustments. In equation (10), the coefficient of the interacted variable is negative and significant ($\psi_1 < 0$) at the 10% level, showing that intensity in the risk adjustments is higher for lower-rated banks 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 with respect to capital behavior, none of the differences between low-capitalized banks and others can be explained by the scores received. Overall, the results are also aligned with the expected effects of Hypothesis H2 related to the influence of supervisory pressure and its joint effect with prudential rules.

Results regarding the coordination between capital and risk adjustments

With regard to coordinated decisions about 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 their levels of risk and capital to achieve that 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 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 breach of minimum capital requirements.

<u>Results regarding the velocities of capital and risk adjustments</u>

The estimated adjustment speeds of capital (α *, about -016*) and risk (β *of about - -0.19*) are relatively similar and suggest that capital and risk targets are fully achieved after six (as six times α equals one) and five quarters (β *of about -0.20 time five equals one)* respectively. Compared to the results of related works, the results of this analysis imply that Brazilian banks seem to adjust both capital and risk levels much more quickly than banks abroad. For instance, Rime (2001) shows that Swiss banks may take approximately ten and twenty years to adjust capital and risk levels, respectively. Stolz (2007) estimates that German savings banks may require more than thirty years to reach their targets. The differences can be justified by the higher capital ratio levels in the Brazilian banking system, so the banks may be closer to their optimal levels.

Regarding the differences in speed adjustments between the low-capitalized banks and others, only the coefficient of lagged risk is significant and positive ($\beta_1 > 0$) at the 1% level, as shown in equations (8) and (10). This result indicates that the better-capitalized banks may adjust risk faster than banks under regulatory pressure. This 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 higher capital targets and lower risk targets in the short run.

Additional results

As expected, the estimated coefficient of ROA is positive and significant at the 5% level in all of the capital equations, indicating that institutions may rely on retained earnings as an important source of capital increases. In turn, the loan loss provisions (*LLOSS*) have coefficients with negative signs due to the expected negative impact of provisions on outstanding risk exposures; however, the estimated values are not quite significant, with only equation (6) presenting a significance level of 10%. The results suggest a minor influence of this variable on RWA.

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

However, a negative effect of size on the level of risk is observed, which contradicts the results usually found in the literature. The negative coefficients, which are significant at the 1% level in all risk equations, show that large banks may lower their risks in greater proportions than do small banks. This result contributes to undermining the hypothesis of the asset substitution moral hazard related to large banks' implicit safety net, thus supporting the argument that those banks have greater portfolio diversification.

The effects of the liquidity cushion (*LIQUID*) in capital and risk adjustments also show intriguing results. The estimated coefficients for the variable are significant at the 1% level but have opposite signs from those expected. Interestingly, a positive impact on the capital adjustments and a negative impact on risk adjustments are observed. These results contradict the propositions of the capital buffer theory in which the liquidity cushion can replace capital as insurance against violations of the minimum capital requirement. One explanation for the fact that capital and liquidity reserves go in the same direction may be related to long-term investment strategies, pursuant to which banks may hold capital and liquid assets while 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 pro-cyclical behavior by banks, which tend to increase their leverage during periods of economic expansion. Moreover, it is observed that the effect of this variable on RWA is not significant, which can be explained by the fact that new operations may belong to the same risk-type buckets as current credit portfolios and that standardized weights for credit risk in the regulatory models are invariant over the economic cycle. Despite not having the reference of the risk-sensitive Basel II models, the results suggest that standardized models of capital may be less pro-cyclical than it would be expected.

6. Conclusion

The capital requirement rules have become predominant instruments in the context of prudential banking regulation. This study examines the effects of regulatory restrictions on the short-term dynamics of capital and risk in the Brazilian financial system between 2001 and 2009. One novelty is our analysis of the influence of the supervisory authority that monitors this process. Using the confidential information of banks' CAMEL ratings, the empirical model allows an assessment of the indirect contribution of supervisory perception in banks' solvency decisions.

In line with the capital buffer theory, our results indicate that regulatory costs may pressure banks to maintain capital cushions. It is observed that when a bank approaches regulatory constraints, it makes higher adjustments to capital and lower adjustments to risk. The supervisory evaluation seems to influence these banks' decisions in the same direction, inducing banks to recompose their capital ratios upon receiving poor ratings.

Additionally, there is evidence of a positive relationship between the levels of capital and risk. Accordingly, risk levels are defined in terms of adjustments to the level of capital, and simultaneously, capital levels are adjusted based on changes in risk levels; all are in the same direction. This coordinated behavior is shown to be even more intense for less-capitalized banks, suggesting that institutions under regulatory pressure may actively manage their regulatory capital ratios 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 phases of economic expansion, Brazilian banks show significant increases in leverage, which may evidence of pro-cyclical behavior.

References

Acharya, Viral, Hasan, Iftekhar, & Saunders, Anthony (2006). Should banks be diversified? Evidence from individual bank loan portfolios. *Journal of Business*, 79:1355-1412.

Aggarwal, Raj, & Jacques, Kevin (2001). The impact of FDICIA and prompt corrective action on bank capital and risk: Estimates using a simultaneous equations model. *Journal of Banking and Finance*, 25:1139-1160.

Arellano, Manual, & Bond, Stephen (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58:277-297.

Arellano, Manuel, & Bover, Olympia (1995). Another look at the instrumental variables estimation of error components models. *Journal of Econometrics*, 68:29-51.

Basel Committee on Banking Supervision (BCBS) (1988). *Basel Committee International Convergence of Capital Measurement and Capital Standards*. BCBS, Basel, Switzerland.

Berger, Allen, Kyle, Margaret, & Scalise, Joseph (2001). Did U.S. bank supervision get tougher during the credit crunch? Did they get easier during the banking boom? Did it matter to bank lending? In Mishkin, Frederic, editor, *Prudential Supervision: What Works and What Doesn't?*, University of Chicago Press, Chicago, 1st edition, pp. 301-356.

Blundell, Richard, & Bond Stephen (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87:115-143.

Çağlayan, Ebru, & Şak, Nazan (2010). The determinants of capital structure: evidence from the Turkish banks. *Journal of Money, Investment and Banking*, 15:57-65.

Capelletto, Lucio (2006). Classificação das instituições financeiras pela atividade operacional. *UnB Contábil*, 9:161-188.

DeYoung, Robert, Hughes, Joseph, & Moon Choon-Geol (2001). Efficient risk-taking and regulatory covenant enforcement in a deregulated banking industry. *Journal of Economics and Business*, 53:255-282.

Furfine, Craig (2001). Bank portfolio allocation: The impact of capital requirements, regulatory monitoring and economic conditions. *Journal of Financial Services Research*, 20:33-56.

Furlong, Frederick, & Keeley, Michael (1989). Capital regulation and bank risk–taking: A note. *Journal of Banking and Finance*, 13:883-891.

Gropp, Reint, & Heider, Florian (2009). The determinants of bank capital structure. Working paper Series, n. 1096, European Central Bank.

Jacques, Kevin, & Nigro, Peter (1997). Risk-based capital, portfolio risk, and bank capital: A simultaneous equations approach. *Journal of Economics and Business*, 49:533-547.

Jokipii, Terhi, & Milne, Alistair (2011). Bank capital buffer and risk adjustment decisions. *Journal of Financial Stability*, 7:165-178.

Kahane, Yehuda (1977). Capital adequacy and the regulation of financial intermediaries: A portfolio approach. *Journal of Banking and Finance*, 4:207-218.

Keeley, Michael, & Furlong, Frederick (1990). A re-examination of the mean-variance analysis of bank capital regulation. *Journal of Banking and Finance*, 14:69-84.

Kim, Daesik, & Santomero, Anthony (1988). Risk in banking and capital regulation. *Journal of Finance*, 43:1219-1233.

Koehn, Michael, & Santomero, Anthony (1980). Regulation of bank capital and portfolio risk. *Journal of Finance*, 35:1235-1244.

Milne, Alistair, & Whalley, A. Elizabeth (2001). Bank capital and incentives for risk-taking. Available at http://ssrn.com/abstract=303176. Accessed on

Nickell, Stephen (1981). Biases in dynamic models with fixed effects. *Econometrica*, 49:1417-1426.

Orgler, Yair, & Taggart, Robert (1983). Implications of corporate capital structure theory for banking institutions: Note. *Journal of Money, Credit and Banking*, 15:212-221.

Peura, Samu, & Keppo Jussi (2006). Optimal bank capital with costly recapitalization. *Journal of Business*, 79:2162-2201.

Rime, Bertrand (2001). Capital requirements and bank behaviour: Empirical evidence for Switzerland. *Journal of Banking and Finance*, 25:1137-1178.

Roodman, David (2009). A note on the theme of too many instruments. *Oxford Bulletin of Economics and Statistics*, 71:135-158.

Santos, Joao (2001). Bank capital regulation in contemporary banking theory: A review of the literature. *Financial Markets, Institutions & Instruments*, 10:41-84.

Saunders, Anthony, Strock, Elizabeth, & Travlos, Nicholaos (1990). Ownership structure, deregulation, and bank risk taking. *Journal of Finance*, 45:643-654.

Sharpe, William (1978). Bank capital adequacy, deposit insurance and security values. *Journal of Financial and Quantitative Analysis*, 13:701-718.

Shrieves, Ronald, & Dahl, Drew (1992). The relationship between risk and capital in commercial banks. *Journal of Banking and Finance*, 16:439-457.

Stolz, Stephanie (2007). Capital and risk adjustments after an increase in capital requirements. In Stolz, Stephanie, editor, *Bank Capital and Risk-Taking*: *The Impact of Capital Regulation*, *Charter Value*, *and the Business Cycle,* Springer, New York, 1st edition, pp. 30-77.

Windmeijer, Frank (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, 126:25-51.