The relationship between capital requirements and bank behavior:

A revision in the light of Basel II[*]

José Filipe Abreu[**]

Mohamed Azzim Gulamhussen[***]

[*] The views and opinions expressed in this paper are those of the authors and do not necessarily represent those of the institutions to which they are affiliated. Any errors are the responsibility of the authors.

[**] Banking Supervision, Central Bank of Portugal. Av. Almirante Reis no. 71, 6º, 1150-012 Lisbon Portugal. Telephone +351 213130511. E-mail jfabreu@bportugal.pt.

[***] Finance Research Center, ISCTE Business School. Av Forças Armadas, 1649-026 Lisbon Portugal. Telephone +351 217903954. E-mail magn@iscte.pt.

Abstract

We extend the literature on the efficiency of capital adequacy requirements in reducing risk taking behavior of banks using a representative dataset and new measures for the degree of regulatory pressure: a dummy variable with reduced arbitrariness and a variable that allows for a continuous shift of behavior. Our dataset comprises a pure Basel I framework period and a period where banks were already strongly involved in the adoption of the Basel II framework whilst maintaining Basel I for regulatory purposes. Our findings suggest that (i) after a period of adjustment of the banking system to capital levels above the minimum requirements set in the Basel I framework, regulatory pressure associated with low capital buffers seems to lose efficiency; and (ii) that prior to the subprime crisis there was a market perception that the Basel II framework will allow banks to reduce their risk-weighted capital ratios.

JEL classification: G21, G28

Keywords: Basel II, bank regulation, risk taking, bank capital

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1. INTRODUCTION

Prudential regulation often imposes regulatory capital requirements1 in order to create the necessary cushion to protect banks against unexpected losses and ultimately failure (Dewatripont and Tirole, 1994; Goodhart et al., 2003; Pennacchi, 2005; Goodhart, 2008; amongst others). One of the principles in the design of capital requirements is to make them risk sensitive, obliging banks to put aside more capital when they enter into more risky positions. Therefore the efficiency of regulatory capital requirements is intrinsically linked to their capacity to make "low" capital buffers banks rebuilt their buffers by simultaneously raising capital and lowering risk.

However, capital requirements may not contribute to reduce banks' risk-taking behavior and can even create perverse effects on bank safety (see for example Koehn and Santomero, 1980; Kim and Santomero, 1988; Clare, 1995; Blum, 1999). Therefore, in a time where the successful implementation of Basel II poses new and complex challenges both to regulators and banks, researchers still have not answered to the question if the Basel I framework was efficient in reducing banks' risk-taking behavior.

We ask a similar question but in the context of the approval of the Basel II framework. Our research question is defined as follows: Does the regulatory pressure imposed by minimum capital requirements is efficient in reducing banks' risk-taking behavior? In order to analyse empirically one of the major criticisms to the Basel II framework in the context of the subprime crisis – the inadequacy of the level of capital required – we focus our analysis in the period from the approval of the Basel II Accord to the

[1] A bank's regulatory capital is divided into three tiers: tier 1 capital, also referred to as 'core capital'; tier 2 capital, or 'supplementary capital'; and tier 3 capital, eligible only to meet part of the capital requirements for market risks. The minimum total capital (Tier I + Tier II + Tier III) and core capital (Tier1) ratios set by the Basel Committee are 8 % and 4% of the risk-weighted assets, respectively.

subprime crisis. Additionally and since previous studies on the impact of capital requirements on banks' behavior analysed the firsts years after the implementation of the Basel I framework we further extend our sample back to 2001[2] in order to analyse a pure "Basel I" period.

Following the literature, we first introduce a regulatory dummy and arbitrarily define the regime shift at a certain threshold. Since the attributed relevance of capital levels should vary according to the size of the buffer/insufficiency of capital our second approach avoids the definition of thresholds: we normalize capital ratios and reduce the restrictions on the impact of regulatory pressure allowing banks' behavior to continuously shift as a function of their capital buffers.

Building on previous research, we use a two-stage least squares (2SLS) simultaneous equation model with partial adjustment to analyze the impact of capital requirements[3]. Our sample comprises contemporaneous data on 4,176 USA commercial banks (with a total of 24,834 observations from 2002 to 2007). Contrary to previous studies on the efficiency of regulatory capital requirements in reducing banks' risk taking behavior we find only partial evidence to support the efficiency hypothesis. Moreover, our results signalize that prior to the subprime crisis there was a market perception that the Basel II framework will allow banks to relax their capital ratios.

The remainder of the paper is organized six sections. We formulate our hypotheses in Section 2. The model is described in section 3 and the data in section 4. Our main findings are discussed in Section 5. Section 6 summarizes the study and our main conclusions.

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[2] The starting point was selected due to data availability in Bankscope.

[3] The empirical literature linked to our framework begins with Shrieves and Dahl (1992), Jacques and Nigro (1997), Aggarwal and Jacques (1998, 2001), Ediz *et al*. (1998), Rime (2001), Stolz (2007), Van Roy (2008) that in general uses the simultaneous equations approach to investigate the impact of capital requirements on bank behavior defining the degree of regulatory pressure as a dummy variable (or a set of dummy variables) depending on the size of capital buffers. This practice assumes a discrete regime shift in reaction to regulatory pressure and introduces a high level of arbitrariness in the analysis since the threshold for the shift is intuitively defined (rather than on the basis of empirical evidence).

2. THE HYPOTHESES

We first analyze whether Basel I minimum capital requirements significantly affected capital and risk levels. It is important to note prior relevant studies in this context.

Jacques and Nigro (1997) studied the impact during the first year after the implementation of the Basel I framework and found that the capital requirements increased capital levels and reduced risk levels for US commercial banks. Stolz (2007) examined the impact of capital requirements on capital and risk levels of German savings banks. She found evidence that banks response to regulatory requirements depended on their excess of capital over regulatory minima: "low" capital buffers banks rebuilt their buffers by simultaneously raising capital and lowering risk; while "high" capital buffers banks tend to keep their buffers by simultaneously raising both variables. Both studies conform to the efficiency of regulatory capital requirements.

Ediz *et al.* (1998), Aggarwal and Jacques (1998, 2001), Rime (2001) and Van Roy (2008) found that banks reacted to the regulatory pressure by adjusting their capital ratios primarily through capital rather than through risk. These findings only partially support the efficiency hypothesis. Ediz *et al.* (1998) applied a random effects panel regression model on confidential supervisory data on British banks during the period 1989-1995. Aggarwal and Jacques (1998, 2001) focused on the introduction of the Federal Deposit Insurance Corporation Improvement Act (FDICIA), where capital ratio buckets were established that mandate prompt corrective action (PCA) rules and early intervention in banks with shortages of capital and/or excess of leverage. Rime (2001) studied a Swiss banks sample, during the period 1989-1995. Van Roy (2008) used a simultaneous equations model to examine the behavior of banks from six G-10 countries between 1988 and 1995, but the evidence partially supporting the efficiency hypothesis holds only for US.

We focus our analysis on the efficiency of regulatory capital requirements during a pure Basel I framework period, starting in 2002[4]. We do not intend to test the Basel I framework itself but to analyze whether the regulatory pressure associated with the size of capital buffers was efficient in reducing the risk-taking behavior of banks with reduced capital buffers.

Stolz (2007) considered three different impacts of regulatory pressure on banks' behavior: an impact on the need to rebuild capital buffers, either directly or after changes in capital or risk levels; and an impact on the adjustment speeds to their optimal levels of capital and risk. Therefore, we test the following hypotheses:

H.i.1: An increase in regulatory pressure will positively (negatively) impact the level of capital (risk).

H.i.2: An increase in regulatory pressure will positively impact the speed at which banks adjust to their optimal levels of capital and risk.

H.i.3: Banks with increased regulatory pressure (after an adjustment on capital or risk) will rebuild their buffers by increasing capital or decreasing risk.

The second dimension of our analysis refers directly to the period after the approval of the new Basel II framework. The Accord was approved in 2006 and is structured in the so-called three pillars (BCBS, 2006a; Decamps *et al.*, 2004): Pillar 1 defines the minimum capital requirements; Pillar 2 is related with the supervisory review process; and Pillar 3 establishes the disclosure requirements on the financial condition and solvency of institutions. The Basel Committee intended the new framework to be implemented in 2007 for the standard approaches[5] and in 2008 for the most advanced approaches.[6]

[4] Our data collection starts from 2001 but due to the use of lagged and difference variables our observations start in 2002.
[5] The Standard and the Foundation Internal Ratings Based (FIRB) approaches for credit risk and the Basic Indicator and the Standardised approaches for operational risk.
[6] The Advanced Internal Ratings Based (AIRB) approach for credit risk and the Advanced Measurement (AMA) approach for operational risk.

However, the Basel II framework has been subject to a number of criticisms (Benink and Kaufman, 2008; Blundell-Wignall *et al.*, 2008; Caprio *et al.*, 2008; Goodhart and Persaud, 2008; Kashyap *et al.*, 2008) after the financial crisis originated in the US subprime mortgage market, the most preeminent being the inadequacy of the average level of capital required by the framework. Blundell-Wignall *et al.* (2008) argue that the Basel II framework provided an arbitrage opportunity that allowed banks to relax their capital levels by accelerating off-balance-sheet activity of mortgages.[7] Caprio *et al.* (2008) argue that the new framework should have established stricter eligibility criteria for capital. Benink and Kaufman (2008) recall the last Quantitative Impact Study (QIS) conducted by the Basel Committee (BCBS, 2006b) that shows that minimum required capital would decrease for many banks with the implementation of the new framework. However, we need to consider also that the last QIS results were obtained using internal models before supervisory validation; not considering the effect of Pillar 2 requirements; and in a good economic scenario. We add to the literature by testing the implications in a distressed economic scenario. For this purpose, we test the following hypotheses according to the three expected impacts of regulatory pressure:

H.ii.1: The approval of the Basel II framework has contributed to diminish the regulatory pressure associated to reduced capital buffers.

H.ii.2: The approval of the Basel II framework has relaxed the adjustment to appropriate levels of capital and risk.

H.ii.3: The approval of the Basel II framework has reduced the need to rebuild buffers of banks with increased regulatory pressure (after an adjustment on capital or risk).

[7] According to Blundell-Wignall *et al.* (2008), the arbitrage opportunity resides in the lower risk weight associated with mortgages in the Basel II framework: accelerating mortgage securitization they could transfer on-balance sheet mortgages (with a 50 per cent risk weight) to off-balance sheet mortgages (with a zero capital weight), banks could raise the return on capital right away without waiting for the new framework (where risk weights would apply regardless of whether assets are on or off the balance sheet).

Since our purpose is to analyze banks' reaction to the new Basel II framework in terms of capital and risk decisions prior to the subprime crisis our sample has to cover a period after the announcement of the new rules but previous to the effective implementation of the framework. Therefore, a prior question for testing hypotheses H.ii.1 to H.ii.3 is to define the threshold to distinguish between a pure Basel I framework period and a period were banks are already strongly involved in the adoption of the Basel II framework whilst maintaining Basel I for regulatory purposes. We chose to select the year 2006 as threshold taking into consideration: (i) the importance of examining the impact of the new regulatory framework during the period after the new rules were announced but previously to their effective implementation (Jacques and Nigro, 1997) and (ii) the publication in mid-2006 of both the final rules of the new framework by the Basel Committee and the US inter-agency[8] proposal rulemaking to implement the framework for large and international banks. Our hypothesis tests are described in Appendix 1.

3. METHODOLOGY

3.1. The empirical model

Regulatory capital ratios are defined as a risk weighted capital ratio with the banks' capital in the numerator and the risk-weighted assets in the denominator:

$$Capital\ ratio\ (CR) = \frac{Capital\ (C)}{Risk\ weighted\ assets\ (RWA)} = \frac{\frac{C}{Total\ Assets\ (A)}}{\frac{RWA}{A}} \equiv \frac{level\ of\ capital\ or\ leverage}{level\ of\ risk} \qquad (1)$$

In determining their level of regulatory capital ratio banks can both influence their level of capital (act over the numerator) or risk (act over the denominator). For that reason we use a simultaneous equation methodology to analyze banks' reaction to regulatory changes. The empirical specification of the model

[8] Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, Federal Deposit Insurance Corporation and Office of Thrift Supervision.

resulted in the following equations while more detail on the modeling framework is available in Appendix 2:

Capital equation:

(2)

Risk equation:

(3)

where $\varepsilon_{i,t}$ and are error terms.

3.2. The variables

In the sequence of equation (1) we approach the capital level through the ratio of tier 1 capital[9] to total assets and the risk level through the ratio of risk-weighted assets to total assets ( )[10].

Following previous research, we proxy the target capital (*) and risk ( ) levels with measures of liquidity, asset quality and profitability. As a measure of liquidity ( ), we use the ratio of net loans to total assets[11], with increases on this ratio meaning reductions on banks' liquidity. A deterioration of asset quality ( ) may put banks under pressure if they do not build up sufficient capital buffers to cope

[9] We produced estimates using Total Capital as definition of capital and the results were quite similar to obtained with Tier 1 Capital suggesting that our conclusions are not particularly sensitive to the concept of capital used.

[10] The association of the ratio of risk-weighted assets to total assets to the level of risk was followed in previous studies (*e.g.* Shrieves and Dahl, 1992; Berger, 1995; Jacques and Nigro, 1997) with Shrieves and Dahl (1992) arguing that "*a bank's portfolio risk is primarily determined by its allocation of assets across risk categories and the quality of its assets*"

[11] This is a Bankscope standard ratio for liquidity measuring the percentage of banks' assets that are tied up in loans.

with credit losses. The ratio of impaired loans to total loans is used as a proxy for asset quality, with increases on this ratio meaning deteriorations of asset quality. As a proxy for profitability ($PROF$) we use the return on assets, expecting a positive effect of this variable on capital.

In order to evaluate the interaction between capital and risk decisions we additionally include the variations in the risk ($\Delta RISK$) and capital (ΔCAR) ratios, respectively in the capital and risk equations.

According to Rime (2001:797), "*macroeconomic shocks such as a change in the volume or in the structure of loans demand can also affect banks' capital ratios and risk*". To capture this effect we use the annual growth rate of real US GDP (ΔGDP).

Moreover we control for size and efficiency in both capital and risk equations and for capital structure in the capital equation. For banks' dimension ($SIZE$) we use the natural log of assets. We control for different levels of efficiency (EFF) using the cost-to-income ratio, with increases on this ratio meaning reductions on banks' efficiency. We expect inefficient banks to hold more capital and bear more risk. Banks with a higher component of Tier 1 capital are also expected to require smaller buffers due to the characteristics of Tier 2 capital[12]. Therefore, we control for capital structure ($CAPST$) using the percentage of tier 1 capital in total capital.

Additionally we control for the shareholders dividend policy (DIV) in the capital equation, due to the asymmetric information in capital markets that may lead banks to use retained earnings to increase capital rather than issuing new equity (Focarelli *et al.*, 2008; La Porta *et al.*, 2000). This impact is captured through the dividend payout ratio and we expect a negative effect of this variable on capital.

Finally we define the threshold distinguishing a pure Basel I framework period from a period were banks were already strongly involved in the adoption of the Basel II framework (whilst maintaining Basel I for regulatory purposes) as a dummy variable ($B2$) taking the value one after the conclusion of the Basel II

[12] Tier 2 capital is considered to be cheaper and easier to raise but is limited to 100 % of Tier I capital.

Accord (i.e., for the years 2006 and 2007) and zero otherwise. We control for these sub-periods either in the regulatory pressure and the macroeconomic shocks variables.

3.3. The degree of regulatory pressure (REG)

With the degree of regulatory pressure (REG) we intend to test differences in banks' behavior according to their degree of capitalization. The rationale behind this variable is based on the assumption that capital adequacy ratios below or close to the minimum requirements will be subject to a closer supervisory monitoring.

As previously referred we consider three different effects of the degree of regulatory pressure between "low" and "high" capital buffers banks' (Stolz, 2007): (i) we use the variable $REG_{i,t}$ in both equations to allow for different magnitudes of adjustments; (ii) we use the interaction of the variable $REG_{i,t}$ with the lagged level of capital (variable $REG_{i,t} * CAP_{i,t-1}$) in the capital equation and with the lagged level of risk (variable $REG_{i,t} * RISK_{i,t-1}$) in the risk equation to allow for different adjustment speeds in capital and risk adjustments; (iii) finally, we use the interaction of the variable $REG_{i,t}$ with the variation in risk (variable $REG_{i,t} * \Delta RISK_{i,t}$) and in capital (variable $REG_{i,t} * \Delta CAP_{i,t}$) in the capital and risk equations, respectively, allowing different interactions between both adjustments.

In order to analyse banks' reaction to the Basel II framework we additionally interact the variable $REG_{i,t}$ (and the variables associated) with the dummy variable for the period after the approval of the new framework ($B2_t$). Therefore we include in the capital equation the variables $REG_{i,t} * B2_t$, $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ and $REG_{i,t} * CAP_{i,t-1} * B2_t$ and in the risk equation the variables $REG_{i,t} * B2_t$, $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ and $REG_{i,t} * RISK_{i,t-1} * B2_t$.

The degree of regulatory pressure is commonly defined as a dummy variable (or a set of dummy variables) which depends on banks' capital buffers. Table 1 presents the concepts of regulatory pressure used in previous studies. This practice assumes a discrete regime shift in reaction to regulatory pressure and introduces a high level of arbitrariness in the analysis since the threshold for the shift is intuitively defined (rather than on the basis of empirical evidence).

[Please insert Table 1 about here].

We first tested a dummy definition for the degree of regulatory pressure where the dummy variable assumes the value one when the bank is not "well capitalized" according to the Prompt Corrective Action Standards of FDICIA[13,14] and zero otherwise. However, this approach has revealed not to be viable given the expressive number of well capitalized banks in our sample[15]. We can understand this evidence as if Prompt Corrective Action Standards have fixed new minimum capital cushions for US banks.

We use two innovative approaches to measure the degree of regulatory pressure.

3.3.1. Dummy approach for the variable REG

Using the literature standard approach, we first introduce a regulatory dummy and arbitrarily define the regime shift at a certain threshold. The arbitrariness in the definition of the threshold was reduced by transforming and normalizing capital ratios, since the supervisory attributed relevance of capital levels will vary according to the size of the buffer/insufficiency. We start by fitting an S shaped function, given by equation 4, to the distribution of capital ratios, such that the upper (U) and lower (L) deviation point (the point where the slope begins and ends) will represent two percentiles of the capital ratios distribution.

$$T_{CR}(x) = \frac{1}{1+e^{slope*(center-x)}} \quad (4)$$

[13] Prompt corrective action (PCA) standards are a provision of the Federal Deposit Insurance Corporation Improvement Act (FDICIA). According to Section 131 of FDICIA, banks are classified into one of five capital categories – "well capitalized", "adequately capitalized", "undercapitalized", "substantially undercapitalized" and "critically undercapitalized" – depending on their Total Capital, Tier 1 and Tier 1 Leverage ratios.
[14] In order to be classified as "well capitalized", a bank must have simultaneously a Total Capital ratio equal or higher than 10 percent, a Tier 1 capital ratio equal or higher than 6 percent and a Tier 1 leverage ratio higher than 5 percent.
[15] Only 307 yearly observations (in a total of 24.834) do not fulfill the three thresholds simultaneously.

where $center = mean(L, U)$ and $slope = 2 * \frac{2{,}95}{(U-L)}$ and $T_{CR}(x)$ denotes the transformed value of capital ratios.

For low levels of capital we assume that the reaction of supervisors will be very different according to the size of capital insufficiency. Therefore the lower deviation point L – the point from where smaller capital buffers will result in similar supervisory reaction – is set to a small percentile of the distribution (0.01%) in order to capture different realities. For high levels of buffers we assume that supervisors will not differ in their reaction *ceteris paribus*.[16] We define high levels as buffers above the sample median[17] and set the upper deviation point U to a time varying percentile of the distribution[18].

After transformation, the capital ratios are normalized according to the following formula:

$$N_{T_{CR}}(x) = \frac{T_{CR}(x) - \mu_{CR}}{\sigma_{CR}} \tag{5}$$

where $N_{T_{CR}}(x)$ denotes the normalization of the transformed value of capital ratios andμ_{CR} and σ_{CR} represents the yearly mean and standard deviation of the transformed values of F, respectively.

We assume that banks are more prone to regulatory pressure due to (relatively) reduced buffers for negative values of capital ratios after transformation and normalization. Therefore the dummy variable for the degree of regulatory pressure takes the value of unity when $N_{T_{CR}}(x) < 0$ and zero otherwise.

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[16] Obviously, the reaction of supervisors will be different according to the specific characteristics of each bank.
[17] We tested for other percentages and the results did not significantly alter.
[18] This percentile varies between 78,45% and 82,78%.

3.3.2. Continuous approach for the variable REG

Secondly, we reduce the restrictions on the impact of regulatory pressure allowing banks' behavior to continuously shift as a function of their capital buffers.[19]

For this purpose, we use the inverse of the risk-based capital ratio to measure the degree of regulatory pressure. Our definition is conceptually close to Jacques and Nigro (1997) who measure regulatory pressure using the differences between the inverse of both capital and regulatory minimum capital ratios. Although not incorporating directly the buffer our definition recognizes the nonlinear relationship between it and the pressure exerted by supervisors to raise risk-weighted capital ratios, since the minimum requirement is common to all banks. Figure 1 highlight the expected exponentially increase in regulatory pressure with the decrease in capital ratios.

[Please insert Figure 1 about here].

Our definition has the drawback of not considering the volatility of capital ratios since our number of yearly observations is relatively small to adequately calculate standard deviations. However, it has the advantage of reducing the arbitrariness in the definition of the threshold between "well" and "bad" capitalized banks. Moreover, the regulatory pressure on the level of risk adjusted capital ratios should be a progressive process when the bank is reducing its levels of capital close to the regulatory minima and should became much stronger when those minima are not attained. This behavior is reflected in the continuous approach and not in the dummy approach.

[19] Although with a different technique (based on a rolling window approach), the same principle was followed by Stolz (2007).

4. DATA DESCRIPTION

US commercial banks' data were obtained from Bankscope, a database containing information on banks. Our sample criteria were banks with minimum total assets of 100 thousand USD and with available figures for capital ratios between 2003 and 2006. The resulting number of banks selected was 4,213. We excluded banks with incomplete observations (7 banks) and with abnormal high levels of capital or risk[20] (30 banks). This leaved us with 4,176 banks and a total of 24,834 yearly observations, representing more than 87% of the US commercial banks system.[21] We collected data on US GDP from the US Department of Commerce.

The sample is described in tables 2a to 2c. From the analysis of the data we can infer decreasing Total Capital and Tier I Capital ratios since 2004 and higher levels of risk-to-assets ratios while capital-to-assets ratios remain relatively stable throughout the sample period.

[Please insert Tables 2a – 2c about here].

Sample descriptive statistics are provided in table 3. From the data we can see that low buffers apparently result from both lower capital levels and higher risk levels. Additionally, "low" capital buffers are characterized for being bigger, less liquid and with lower proportion of Tier I Capital relatively to "high" capital buffers banks. Although the size effects were expected, the lower liquidity and proportion of Tier I capital were expected to justify higher capital buffers. Table 4 presents the correlation matrix.

[Please insert Table 3 about here].

[Please insert Table 4 about here].

[20] Specifically, we excluded banks with total capital to assets ratio of over 75%, Tier I capital to assets ratio over 50%, risk ratio over 200% or with no loans.
[21] Total assets from banks in the sample represent 87.8% of the US Commercial Banks system (average figures between 2002 and 2007).

5. FINDINGS

5.1. Dummy approach for regulatory pressure

First, we estimate the simultaneous system of equations (2) and (3) with the dummy approach for regulatory pressure. We produce estimates using both fixed and random effects. Tables 5a and 5b present the results that are according to our expectations for almost all the variables.

[Please insert Tables 5a & 5b about here].

Control variables

Size (SIZE) has the expected negative effect on capital, reflecting the easier access of larger US commercial banks to capital markets in order to raise capital, and positive effect on risk, meaning that larger US commercial banks are more prone to risk-taking. As expected, the effect of both profitability (PROF) and shareholders remuneration policy (DIV) on capital is respectively positive and negative, indicating that US commercial banks regard retained earnings as an important mean to increase capital. Efficiency (EFF), measured trough the cost-to-income ratio, has the expected positive[22] effect on capital and risk, meaning inefficient banks hold more capital and a deterioration of cost-to-income ratios (higher ratios, lower efficiency) increases banks' risk.

The variable QUAL shows the expected positive[23] effect on capital, meaning deteriorations of asset quality increase banks' capital needs. However, the evidence on the effect of this variable on risk is mixed. The positive effect of capital structure (CAPST) on capital is contrary to our expectations that a higher proportion of Tier 1 capital on Total capital will require lowers levels of capital. The variable LIQ

[22] Please note that we define EFF as the cost-to-income ratio which has an inverse relation with the level of efficiency.
[23] Please note that we define QUAL as the ratio of impaired loans to total loans which has an inverse relation with the level of asset quality.

shows the expected positive[24] effect on both equations, meaning liquidity deteriorations increase both the bank risk and the needs of capital.

Hypothesis

The results for the regulatory dummy variable suggest that "low" capital buffers banks are less intense in rebuilding their buffers relatively to "high" capital buffers banks, either through lower adjustments in capital and risk. This counterintuitive evidence may result from the measurement of regulatory pressure by a single dummy variable (Stolz, 2007). Therefore we do not find evidence to support H.i.1. The results for the lagged variables ($CAP_{i,t-1}$ and $RISK_{i,t-1}$) are significant and represent the adjustment speeds to capital and risk targets. Our estimates are relatively high meaning that banks take less than two years[25] to adjust for shocks to capital and risk. The coefficients of the interaction of the lagged variables with the regulatory dummy ($REG_{i,t} * CAP_{i,t-1}$ and $REG_{i,t} * RISK_{i,t-1}$) are significant with the expected negative sign in both equations. The results support H.i.2 and suggest that "low" capital buffers banks are faster in adjusting capital and risk. For the interaction of the regulatory dummy with the crossed adjustment terms ($REG_{i,t} * \Delta RISK_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t}$), the estimation results are mixed. As expected the estimated coefficient of $\Delta RISK_{i,t}$ is simultaneously positive and absolutely smaller than the coefficient of $REG_{i,t} * \Delta RISK_{i,t}$. However, the evidence is not consistent in what refers to risk level adjustments when capital changes. The estimated coefficients of $\Delta CAP_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t}$ are statistically not significant using fixed effects and significant but contrary to our expectations using random effects. These findings support only partially H.i.3.

For the interaction of the degree of regulatory pressure with the Basel II dummy variable we expected a significant and positive effect on risk which is found only when using fixed effects. Therefore the

[24] Please note that we define LIQ as the ratio of net loans to total assets which has an inverse relation with the level of liquidity.
[25] With the exception of the estimate for the adjustment speed of risk when using random effects (shocks halved after almost three years).

evidence for H.ii.1 is not conclusive. Regarding the interaction of the lagged capital and risk variables with the dummies for regulatory pressure and Basel II, the variable on the capital equation ($REG_{i,t} * CAP_{i,t-1} * B2_t$) has the expected positive sign but is not significant and the variable on the risk equation ($REG_{i,t} * RISK_{i,t-1} * B2_t$) is significant with the expected positive sign using random effects but is significant with the opposite sign using fixed effects. Therefore the evidence for H.ii.2 is not conclusive. Regarding the interaction of the crossed adjustment terms with the dummies for regulatory pressure and Basel II, both variables – $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ (capital equation) and $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ (risk equation) – have statistically significant and positive coefficients. This evidence supports H.ii.3 and suggests that banks with capital closer to regulatory minima have reduced the need to build up capital buffers after the approval of the Basel II framework.

5.2 Continuous approach for regulatory pressure

Second, we estimate the simultaneous system of equations (2) and (3) with the continuous approach for regulatory pressure. We produce estimates using both fixed and random effects. Results are presented in tables 6a and 6b and are very similar to the dummy approach' results. Therefore we focus our analysis on the differences for control variables and on the full evidence for our hypotheses.

[Please insert Tables 6a & 6b about here].

Control variables

Only two variables have different parameter estimates from the dummy approach for regulatory pressure. The evidence for the expected significant and positive effect of the variable SIZE on risk is only verified when using random effects (the parameter estimate is not significant when using fixed effects). Also, the evidence that inefficient banks hold more capital and a deterioration of cost-to-income ratios (higher ratios, lower efficiency) increases banks' risk is not verified when using random effects.

Hypotheses

Similarly to the case when using the regulatory dummy variable, the parameter estimates for the regulatory pressure variable suggest that “low” capital buffers banks increase (decrease) capital (risk) less than “high” capital buffers banks. Therefore, even allowing for a continuous shift of behavior from banks to regulatory pressure our evidence does not support H.i.1 that capital and risk will be inversely impacted by an increase in regulatory pressure. The parameter estimates of the lagged variables and of their interaction with the continuous regulatory variable are very similar to the previous approach. Therefore we find evidence to support H.i.2 meaning that an increased regulatory pressure push banks to adjust faster to their optimal levels of capital and risk. The estimation results are mixed for the interaction of the regulatory dummy with the crossed adjustment terms. The cumulative effect on capital of the variables $\Delta RISK_{i,t}$ and $REG_{i,t} * \Delta RISK_{i,t}$, using the average value for $REG_{i,t}$[26], is negative. This evidence is consistent with the dummy approach and suggests that “low” (“high”) buffers banks tend to rebuild (maintain) their capital buffers following changes in risk. However, the cumulative effect on risk of the variables $\Delta CAP_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t}$ is contrary to our expectations, suggesting that “low” (“high”) capital buffers banks tend to maintain (increase) their buffers following changes in capital. Therefore our findings indicate that the crossed adjustments on capital and risk following changes in the other variable only run according to our expectations (supporting partially H.i.3) from risk to capital.

Regarding the interaction of the degree of regulatory pressure with the dummy variable for Basel II, the evidence for H.ii.1 is more conclusive than using the regulatory dummy variable and presents the expected results both for capital and risk equation. Therefore, the approval of the Basel II framework appears to have restrained the regulatory pressure associated to reduced capital buffers in the period prior to the subprime crisis. Relatively to the interaction of the lagged variables with both the continuous variable for regulatory pressure and the dummy for Basel II, the results are different from the ones

[26] The average values for REG (7.243 and 7.9729 using Total Capital and Tier 1 Capital as definition of capital, respectively) serve as thresholds between banks with low and high capital buffers.

obtained using the regulatory dummy variable. The parameter estimate of the variable $REG_{i,t} * CAP_{i,t-1} * B2_t$ is significant and positive as expected, strengthening the evidence from the previous approach. However the results for the variable $REG_{i,t} * RISK_{i,t-1} * B2_t$ are contrary both to our expectations and to the results from the dummy approach turning the evidence inconclusive. Summing up the results of both approaches we find partial evidence to support H.ii.2 meaning that banks relaxed their adjustment speed to optimal levels of capital after the approval of the Basel II framework. As in the in the dummy approach for regulatory pressure, the parameter estimates for the interaction of the crossed adjustment terms with the continuous regulatory variable and the dummy for Basel II ($REG_{i,t} * \Delta RISK_{i,t} * B2_t$ and $REG_{i,t} * \Delta CAP_{i,t} * B2_t$) are positive and statistically significant as expected in H.ii.3. Therefore, the approval of the Basel II framework appears to have reduced the need to build up capital buffers of banks with capital closer to regulatory minima.

6. CONCLUSIONS

In this paper we examined the reactions of US commercial banks to regulatory pressure in terms of capital and risk decisions. In order to analyse empirically one of the major criticisms to the Basel II framework in the context of the subprime crisis – the inadequacy of the level of capital required – we focus our analysis in the period from the approval of the Basel II Accord to the subprime crisis. We further extend our sample back to 2002 in order to analyze a pure "Basel I" period.

We define the efficiency of regulatory capital requirements as their capacity to make "low" capital buffers banks rebuilt their buffers by simultaneously raising capital and lowering risk. We extended the Shrieves and Dahl (1992) simultaneous equations model using two innovative approaches to measure regulatory pressure: the dummy approach commonly used in the literature, but with a reduced level of arbitrary in the definition of the threshold; and a variable that allows banks' behavior to continuously shift as a function of their capital buffers. With this second definition the impact of regulatory pressure is modeled with fewer restrictions.

Contrary to previous studies on the efficiency of regulatory capital requirements in reducing banks' risk taking behavior we find only partial evidence to support the efficiency hypothesis. When we analyze banks behavior during a "pure" Basel I framework our results do not support the hypothesis that an increase in regulatory pressure will impact positively the level of capital and negatively the level of risk. These results hold even when we allow for a continuous shift of behavior from banks to regulatory pressure. In line with the literature, one of the effects of regulatory pressure seems to be the increase of the speed at which banks adjust to their optimal levels of capital and risk. Contrary to previous studies we find that "low" capital buffers banks rebuild their buffers after risk adjustments but not after capital adjustments.

Moreover, our findings suggest that the approval of the Basel II framework appears to have restrained the regulatory pressure associated to reduced capital buffers, either by reducing the pressure associated with low capital buffers, by relaxing the adjustment speed to optimal levels of capital and by reducing the need to build up capital buffers of banks with capital closer to regulatory minima.

Our results suggest that (i) after a fast adjustment of the banking system to capital levels above the new minimum capital requirements set by the Basel I framework as shown by previous works (*e.g.* Jacques and Nigro, 1997), regulatory pressure associated with smaller capital buffers seems to lose efficiency; and (ii) there seems to exist a market perception that the Basel II framework will allow banks to relax their capital ratios.

In terms of the implications for policy and research, finding (i) suggests that regulatory pressure associated with low capital buffers is effective essentially when new minimums are set. This finding is important for the ongoing discussions on literature and international *fora* about how to deal with the procyclicality presumably associated with the Basel II framework (*e.g.* Ayuso *et al.*, 2003; Gordy and Howells, 2006), namely through the introduction of countercyclical target capital levels (*e.g.* BCBS, 2009b; CEBS, 2009). Critical for the success of this measure will be the enforcement level associated with the targets: a strong enforcement can be perceived by the market as the imposition of new minimum capital requirements (and leading banks to rapidly adjust to the new level of capital), canceling the countercyclical purpose of the measure; and a merely recommendation of the new target should not be fully effective as perceived by our results.

Finding (ii) suggests that regulators should take extra care when assessing the adequacy of banks' Internal Capital Adequacy Assessment Process (ICAAP) under Pillar 2. Recognizing the insufficient level and quality of capital of the banking sector prior to the subprime crisis the Basel Committee has already issue a package of measures to strengthen the Basel II framework (BCBS, 2009a), which includes the strength of the treatment of securitization exposures and the rules governing trading book capital. European regulators (e.g. FSA, 2008) have also recommended increases in Tier 1 capital ratios as part of the plans to support banking systems after the subprime crisis.

The Basel Committee has also issued for consultation a package of proposals to enhance capital and liquidity regulations (BCBS, 2009b). These proposals include elements that respond to both our findings: the proposed framework for capital conservation based on capital distribution constraints will increase the regulatory pressure associated with reduced capital buffers and, therefore, the efficiency of regulatory capital requirements; and finding (ii) is directly addressed by the proposals to increase the quality of capital and the risk coverage of the framework.

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TABLES

Table 1. Regulatory pressure definition used on previous studies

Author(s) (Year of publication)	Regulatory pressure definition
Shrieves and Dahl (1992)	Dummy variable which takes the value of unity if the capital adequacy ratio falls below 7% and zero otherwise.
Aggarwal and Jacques (1998)	Two dummy variables. One takes the value of unity if the bank is adequately capitalized according to the PCA standards and zero otherwise. The other takes the value of unity if the bank is undercapitalized, substantially undercapitalized, or critically undercapitalized, according to the PCA standards and zero otherwise.
Jacques and Nigro (1997)	Two variables. One equals the difference between the inverse of bank's total capital ratio and the inverse of the regulatory minimum for all banks with a total capital ratio of less than 7.25%, and zero otherwise. The other equals the difference between the inverse of the regulatory minimum and the inverse of bank's total capital ratio for all banks with a total capital ratio greater than or equal to 7.25%, and zero otherwise.
Ediz *et al.* (1998)	Two dummy variables. One takes the value of unity if the bank has experienced an upward adjustment in its regulatory trigger ratio in the previous three quarters and zero otherwise. The other takes the value of unity if the bank capital ratio is less than one bank-specific standard deviation above the bank's trigger and zero otherwise.
Rime (2001)	Two approaches. (1) Dummy variable which takes the value of unity if the bank's capital ratio is within one standard deviation of the minimum capital requirement and zero otherwise. (2) Two dummy variables, one which takes the value of unity for banks with capital ratio of less than 8% and zero otherwise and a second which takes the value of unity for banks with capital ratio of between 8% and 10% and zero otherwise.
Stolz (2007)	Three approaches: (1) Dummy variable which takes the value of unity if a bank has a standardized capital buffer equal or less than the median standardized capital buffer over all observations, and zero otherwise. (2) Sample split according to the threshold defined in (1) and estimation of both subsamples separately. (3) Rolling window approach, allowing for a continuous shift of behavior depending on the size of the capital buffer.
Van Roy (2008)	Dummy variable which takes the value of unity if the Total Capital ratio falls below 10 percent or if the Tier 1 Capital ratio falls below 6 percent.

Table 2a – Sample characterization

Year	# of obs	Sum Total Assets (milUSD)	Avg Total Assets (milUSD)	StdDev Total Assets
2002	4,056	5,293,029	1,305	17,151
2003	4,107	5,832,892	1,420	18,610
2004	4,176	7,041,900	1,686	24,167
2005	4,176	8,007,944	1,918	27,926
2006	4,176	9,215,416	2,207	32,884
2007	4,143	10,205,056	2,463	37,857
All	24,835	45,596,236	1,836	27,488

Table 2b – Sample characterization

Year	Total Capital (TC) as definition of capital					
	Avg TC ratio	StdDev TC ratio	Avg CAR	StdDev CAR	Avg RISK	StdDev RISK
2002	0.156	0.097	0.101	0.032	0.684	0.128
2003	0.157	0.096	0.103	0.032	0.691	0.133
2004	0.155	0.097	0.105	0.035	0.708	0.136
2005	0.152	0.094	0.104	0.031	0.721	0.133
2006	0.151	0.094	0.105	0.031	0.731	0.131
2007	0.147	0.092	0.105	0.032	0.744	0.130
All	0.153	0.095	0.104	0.032	0.713	0.134

Table 2c – Sample characterization

Year	Tier 1 Capital (T1) as definition of capital					
	Avg T1 ratio	StdDev T1 ratio	Avg CAR	StdDev CAR	Avg RISK	StdDev RISK
2002	0.144	0.097	0.093	0.032	0.684	0.128
2003	0.145	0.096	0.095	0.032	0.691	0.133
2004	0.144	0.097	0.096	0.035	0.708	0.136
2005	0.141	0.094	0.096	0.031	0.721	0.133
2006	0.139	0.094	0.097	0.031	0.730	0.131
2007	0.136	0.093	0.096	0.032	0.744	0.130
All	0.141	0.095	0.096	0.032	0.713	0.134

Table 3 – Descriptive statistics

Variable	Obs	Mean	StdDev	Min	Max	Mean for banks with "low" capital buffers (1)	Mean for banks with "high" capital buffers (1)
$CAR_{i,t}$	24.834	0,096	0,032	-0,012	0,963	0,080	0,111
$CAR_{i,t-1}$	24.834	0,097	0,044	-0,012	1,000	0,082	0,112
$\Delta CAR_{i,t}$	24.834	-0,002	0,029	-0,840	0,290	-0,002	-0,001
$RISK_{i,t}$	24.834	0,713	0,134	0,062	2,118	0,780	0,646
$RISK_{i,t-1}$	24.834	0,702	0,134	0,000	2,995	0,767	0,638
$\Delta RISK_{i,t}$	24.834	0,011	0,055	-1,667	0,727	0,013	0,009
$SIZE_{i,t}$	24.834	5,558	1,109	1,541	14,092	5,779	5,338
$LIQ_{i,t}$	24.834	0,661	0,145	0,002	0,997	0,726	0,596
$QUAL_{i,t}$	24.834	0,007	0,011	0,000	0,343	0,007	0,007
$PROF_{i,t}$	24.834	0,011	0,009	-0,146	0,251	0,011	0,012
$EFF_{i,t}$	24.834	0,645	0,190	0,010	9,949	0,641	0,648
$CAPST_{i,t}$	24.834	0,916	0,043	0,087	1,318	0,898	0,934
$DIV_{i,t}$	24.834	0,438	0,588	-9,810	9,923	0,431	0,445
ΔGDP_t	24.834	0,043	0,011	0,024	0,057	0,043	0,043

(1) For this purpose, capital buffers are classified acording to the value of the dummy regulatory pressure variable (REG=1 for "low" capital buffers and REG=0 for "high" capital buffers).

Table 4 – Correlation matrix

	$CAR_{i,t}$	$CAR_{i,t-1}$	$\Delta CAR_{i,t}$	$RISK_{i,t}$	$RISK_{i,t-1}$	$\Delta RISK_{i,t}$	$SIZE_{i,t}$	$LIQ_{i,t}$	$QUAL_{i,t}$	$PROF_{i,t}$	$EFF_{i,t}$	$CAPST_{i,t}$	$DIV_{i,t}$	ΔGDP_t
$CAR_{i,t}$	1.000													
$CAR_{i,t-1}$	0.739	1.000												
$\Delta CAR_{i,t}$	-0.004	-0.677	1.000											
$RISK_{i,t}$	-0.065	-0.043	-0.007	1.000										
$RISK_{i,t-1}$	-0.099	-0.106	0.050	0.917	1.000									
$\Delta RISK_{i,t}$	0.084	0.155	-0.138	0.198	-0.210	1.000								
$SIZE_{i,t}$	-0.149	-0.164	0.081	0.146	0.155	-0.023	1.000							
$LIQ_{i,t}$	-0.117	-0.090	0.006	0.779	0.712	0.161	0.014	1.000						
$QUAL_{i,t}$	0.013	-0.023	0.049	0.021	0.056	-0.088	0.002	-0.009	1.000					
$PROF_{i,t}$	0.197	-0.014	0.236	-0.227	-0.180	-0.113	0.051	-0.216	-0.153	1.000				
$EFF_{i,t}$	-0.025	0.204	-0.331	-0.082	-0.125	0.106	-0.177	-0.080	0.080	-0.581	1.000			
$CAPST_{i,t}$	0.377	0.280	-0.003	-0.404	-0.407	0.011	-0.380	-0.329	-0.054	0.118	0.053	1.000		
$DIV_{i,t}$	-0.066	-0.029	-0.029	-0.069	-0.060	-0.020	0.052	-0.098	0.031	0.186	-0.114	-0.026	1.000	
ΔGDP_t	0.031	-0.008	0.045	0.072	0.041	0.077	0.069	0.059	-0.095	0.009	-0.017	0.010	0.000	1.000

Table 5a. Dummy approach for regulatory pressure – Estimation using 2sls with fixed effects

Ordinary least squares (OLS) are not appropriate for estimating simultaneous equation systems since equations' error terms are generally correlated with the endogenous variables included in each equation as explanatory variables. The endogeneity of capital and risk adjustments is recognized by the two-stage least squares (2SLS) methodology which provides consistent parameter estimates. As endogenous variables we considered the variables $\Delta RISK_{i,t}$, $REG_{i,t} * \Delta RISK_{i,t}$ and $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ in the capital equation and the variables $\Delta CAP_{i,t}$, $REG_{i,t} * \Delta CAP_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ in the risk equation. Endogeneity was verified using the Hausman test.

	Coef.	*t*-value	
Capital equation			
$\Delta RISK_{i,t}$	0,058	18,4	***
$CAR_{i,t-1}$	-0,897	-275,9	***
$REG_{i,t}$	-0,005	-7,6	***
$REG_{i,t}*CAR_{i,t-1}$	-0,090	-12,0	***
$REG_{i,t}*\Delta RISK_{i,t}$	-0,069	-13,1	***
$REG_{i,t}*B2_t$	0,000	0,3	
$REG_{i,t}*CAR_{i,t-1}*B2_t$	0,010	0,6	
$REG_{i,t}*\Delta RISK_{i,t}*B2_t$	0,112	12,4	***
ΔGDP_t	0,108	16,0	***
ΔGDP_t*B2_t	0,043	8,6	***
$SIZE_{i,t}$	-0,009	-23,3	***
$LIQ_{i,t}$	0,023	13,8	***
$QUAL_{i,t}$	0,073	8,1	***
$PROF_{i,t}$	0,252	20,5	***
$EFF_{i,t}$	0,008	10,3	***
$CAPST_{i,t}$	0,174	40,4	***
$DIV_{i,t}$	-0,002	-10,5	***
_constant	-0,049	-10,2	***
# of observations	24.834		
# of banks	4.176		
avg. obs. per bank	5,9		
R^2	0,493		
Risk equation			
$\Delta CAR_{i,t}$	0,005	0,5	
$RISK_{i,t-1}$	-0,812	-155,3	***
$REG_{i,t}$	0,025	5,5	***
$REG_{i,t}*RISK_{i,t-1}$	-0,022	-3,7	***
$REG_{i,t}*\Delta CAR_{i,t}$	-0,012	-0,5	
$REG_{i,t}*B2_t$	0,017	3,3	***
$REG_{i,t}*RISK_{i,t-1}*B2_t$	-0,014	-2,2	**
$REG_{i,t}*\Delta CAR_{i,t}*B2_t$	1,212	14,7	***
ΔGDP_t	0,233	12,4	***
ΔGDP_t*B2_t	0,121	8,5	***
$SIZE_{i,t}$	0,002	2,4	**
$LIQ_{i,t}$	0,621	142,6	***
$QUAL_{i,t}$	0,051	2,1	**
$EFF_{i,t}$	0,024	13,4	***
_constant	0,125	18,9	***
# of observations	24.834		
# of banks	4.176		
obs. per bank	5,9		
R^2	0,248		

***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 5b. Dummy approach for regulatory pressure – Estimation using 2sls with random effects

Ordinary least squares (OLS) are not appropriate for estimating simultaneous equation systems since equations' error terms are generally correlated with the endogenous variables included in each equation as explanatory variables. The endogeneity of capital and risk adjustments is recognized by the two-stage least squares (2SLS) methodology which provides consistent parameter estimates. As endogenous variables we considered the variables $\Delta RISK_{i,t}$, $REG_{i,t} * \Delta RISK_{i,t}$ and $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ in the capital equation and the variables $\Delta CAP_{i,t}$, $REG_{i,t} * \Delta CAP_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ in the risk equation. Endogeneity was verified using the Hausman test.

	Coef.	*t*-value	
Capital equation			
$\Delta RISK_{i,t}$	0,059	18,9	***
$CAR_{i,t-1}$	-0,865	-281,1	***
$REG_{i,t}$	-0,005	-7,2	***
$REG_{i,t}*CAR_{i,t-1}$	-0,099	-13,7	***
$REG_{i,t}*\Delta RISK_{i,t}$	-0,066	-12,8	***
$REG_{i,t}*B2_t$	0,000	-0,4	
$REG_{i,t}*CAR_{i,t-1}*B2_t$	0,009	0,6	
$REG_{i,t}*\Delta RISK_{i,t}*B2_t$	0,111	12,7	***
ΔGDP_t	0,085	13,3	***
ΔGDP_t*B2_t	0,032	6,7	***
$SIZE_{i,t}$	-0,004	-16,2	***
$LIQ_{i,t}$	0,021	14,1	***
$QUAL_{i,t}$	0,080	9,3	***
$PROF_{i,t}$	0,281	24,1	***
$EFF_{i,t}$	0,006	8,6	***
$CAPST_{i,t}$	0,166	41,6	***
$DIV_{i,t}$	-0,002	-11,8	***
_constant	-0,065	-14,7	***
# of observations	24.834		
# of banks	4.176		
avg. obs. per bank	5,9		
R^2	0,530		
Risk equation			
$\Delta CAR_{i,t}$	-0,311	-21,6	***
$RISK_{i,t-1}$	-0,356	-79,8	***
$REG_{i,t}$	0,065	13,9	***
$REG_{i,t}*RISK_{i,t-1}$	-0,074	-11,6	***
$REG_{i,t}*\Delta CAR_{i,t}$	0,293	9,3	***
$REG_{i,t}*B2_t$	-0,013	-2,0	**
$REG_{i,t}*RISK_{i,t-1}*B2_t$	0,021	2,5	**
$REG_{i,t}*\Delta CAR_{i,t}*B2_t$	1,598	15,1	***
ΔGDP_t	0,296	12,3	***
ΔGDP_t*B2_t	0,056	3,1	***
$SIZE_{i,t}$	0,004	12,7	***
$LIQ_{i,t}$	0,306	88,8	***
$QUAL_{i,t}$	-0,122	-4,3	***
$EFF_{i,t}$	0,011	5,9	***
_constant	0,009	2,6	***
# of observations	24.834		
# of banks	4.176		
obs. per bank	5,9		
R^2	0,278		

***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 6a. Continuous approach for regulatory pressure – Estimation using 2sls with fixed effects

Ordinary least squares (OLS) are not appropriate for estimating simultaneous equation systems since equations' error terms are generally correlated with the endogenous variables included in each equation as explanatory variables. The endogeneity of capital and risk adjustments is recognized by the two-stage least squares (2SLS) methodology which provides consistent parameter estimates. As endogenous variables we considered the variables $\Delta RISK_{i,t}$, $REG_{i,t} * \Delta RISK_{i,t}$ and $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ in the capital equation and the variables $\Delta CAP_{i,t}$, $REG_{i,t} * \Delta CAP_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ in the risk equation. Endogeneity was verified using the Hausman test.

	Coef.	*t*-value	
Capital equation			
$\Delta RISK_{i,t}$	0,242	21,0	***
$CAR_{i,t-1}$	-0,733	-114,5	***
$REG_{i,t}$	-0,005	-41,8	***
$REG_{i,t}*CAR_{i,t-1}$	-0,041	-43,0	***
$REG_{i,t}*\Delta RISK_{i,t}$	-0,032	-21,4	***
$REG_{i,t}*B2_t$	0,000	-1,8	*
$REG_{i,t}*CAR_{i,t-1}*B2_t$	0,006	6,0	***
$REG_{i,t}*\Delta RISK_{i,t}*B2_t$	0,016	20,9	***
ΔGDP_t	0,106	17,2	***
ΔGDP_t*B2_t	-0,021	-2,0	**
$SIZE_{i,t}$	-0,006	-17,5	***
$LIQ_{i,t}$	0,049	33,5	***
$QUAL_{i,t}$	0,051	6,5	***
$PROF_{i,t}$	0,157	10,0	***
$EFF_{i,t}$	0,002	3,1	***
$CAPST_{i,t}$	0,045	11,2	***
$DIV_{i,t}$	-0,001	-4,4	***
_constant	0,090	19,9	***
# of observations	24.834		
# of banks	4.176		
avg. obs. per bank	5,9		
R^2	0,646		
Risk equation			
$\Delta CAR_{i,t}$	-0,112	-4,0	***
$RISK_{i,t-1}$	-0,792	-73,2	***
$REG_{i,t}$	0,012	12,8	***
$REG_{i,t}*RISK_{i,t-1}$	-0,004	-3,1	***
$REG_{i,t}*\Delta CAR_{i,t}$	0,012	2,8	***
$REG_{i,t}*B2_t$	0,005	11,5	***
$REG_{i,t}*RISK_{i,t-1}*B2_t$	-0,002	-5,1	***
$REG_{i,t}*\Delta CAR_{i,t}*B2_t$	0,209	31,4	***
ΔGDP_t	0,352	18,3	***
ΔGDP_t*B2_t	-0,400	-12,0	***
$SIZE_{i,t}$	-0,005	-4,8	***
$LIQ_{i,t}$	0,564	123,9	***
$QUAL_{i,t}$	-0,031	-1,3	
$EFF_{i,t}$	0,022	11,9	***
_constant	0,117	12,7	***
# of observations	24.834		
# of banks	4.176		
obs. per bank	5,9		
R^2	0,262		

***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 6b. Continuous approach for regulatory pressure – Estimation using 2sls with random effects

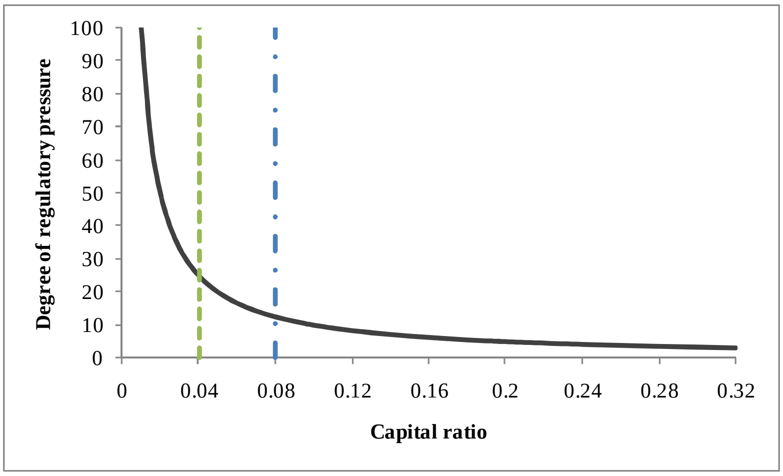
Ordinary least squares (OLS) are not appropriate for estimating simultaneous equation systems since equations' error terms are generally correlated with the endogenous variables included in each equation as explanatory variables. The endogeneity of capital and risk adjustments is recognized by the two-stage least squares (2SLS) methodology which provides consistent parameter estimates. As endogenous variables we considered the variables $\Delta RISK_{i,t}$, $REG_{i,t} * \Delta RISK_{i,t}$ and $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ in the capital equation and the variables $\Delta CAP_{i,t}$, $REG_{i,t} * \Delta CAP_{i,t}$ and $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ in the risk equation. Endogeneity was verified using the Hausman test.

	Coef.	*t*-value	
Capital equation			
$\Delta RISK_{i,t}$	0,186	15,6	***
$CAR_{i,t-1}$	-0,657	-110,9	***
$REG_{i,t}$	-0,004	-41,5	***
$REG_{i,t}*CAR_{i,t-1}$	-0,049	-55,3	***
$REG_{i,t}*\Delta RISK_{i,t}$	-0,025	-16,2	***
$REG_{i,t}*B2_t$	0,000	-7,1	***
$REG_{i,t}*CAR_{i,t-1}*B2_t$	0,006	7,4	***
$REG_{i,t}*\Delta RISK_{i,t}*B2_t$	0,017	22,6	***
ΔGDP_t	0,081	14,5	***
ΔGDP_t*B2_t	0,005	0,5	
$SIZE_{i,t}$	-0,002	-8,1	***
$LIQ_{i,t}$	0,054	44,1	***
$QUAL_{i,t}$	0,059	8,2	***
$PROF_{i,t}$	0,119	11,7	***
$EFF_{i,t}$	0,000	-0,5	
$CAPST_{i,t}$	0,033	9,3	***
$DIV_{i,t}$	-0,001	-5,1	***
_constant	0,072	17,7	***
# of observations	24.834		
# of banks	4.176		
avg. obs. per bank	5,9		
R^2	0,700		
Risk equation			
$\Delta CAR_{i,t}$	-1,015	-21,6	***
$RISK_{i,t-1}$	-0,380	-42,0	***
$REG_{i,t}$	0,012	15,4	***
$REG_{i,t}*RISK_{i,t-1}$	-0,008	-7,3	***
$REG_{i,t}*\Delta CAR_{i,t}$	0,122	16,9	***
$REG_{i,t}*B2_t$	0,002	3,8	***
$REG_{i,t}*RISK_{i,t-1}*B2_t$	-0,001	-1,3	
$REG_{i,t}*\Delta CAR_{i,t}*B2_t$	0,216	26,1	***
ΔGDP_t	0,340	14,2	***
ΔGDP_t*B2_t	-0,207	-4,7	***
$SIZE_{i,t}$	0,002	6,3	***
$LIQ_{i,t}$	0,305	80,7	***
$QUAL_{i,t}$	-0,104	-3,6	***
$EFF_{i,t}$	0,001	0,7	
_constant	-0,007	-1,1	
# of observations	24.834		
# of banks	4.176		
obs. per bank	5,9		
R^2	0,281		

***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

FIGURES

Figure 1 – Degree of regulatory pressure by capital ratio



APPENDIX 1 – HYPOTHESES TESTS

Test of H.i.1: An increase in regulatory pressure will positively (negatively) impact the level of capital (risk) if the parameter associated with the variable $REG_{i,t}$ is significant and positive (negative) on the capital (risk) equation.

Test of H.i.2: An increase in regulatory pressure will positively impact the speed at which banks adjust to their optimal levels of capital and risk if the parameters associated with the variables $REG_{i,t} * CAP_{i,t-1}$ and $REG_{i,t} * RISK_{i,t-1}$ are significant with negative sign.

Test of H.i.3: Banks with increased regulatory pressure (lower capital buffers) will try to rebuild their buffer if (i) the parameter associated with the variable $REG_{i,t} * \Delta RISK_{i,t}$ (capital equation) is significant, negative and compensates the effect of the parameter associated with the variable $\Delta RISK_{i,t}$ (we expect the parameter associated with this variable to be significant and positive given that well capitalized banks have incentives to maintain their capital ratios levels) and/or (ii) the parameter associated with variable $REG_{i,t} * \Delta CAP_{i,t}$ (risk equation) is significant, negative and compensates the effect of the parameter associated with the variable $\Delta CAP_{i,t}$ (we expect the parameter associated with this variable to be significant and positive given that well capitalized banks have incentives to maintain their capital ratios levels).

Test of H.ii.1: The approval of the Basel II framework has contributed to diminish the regulatory pressure associated to reduced capital buffers if the parameters associated with the variable $REG_{i,t} * B2_t$ are significant with positive sign in the capital equation and with negative sign in the risk equation.

Test of H.ii.2: The approval of the Basel II framework has contributed to relax the adjustment to appropriate levels of capital (risk) if the parameter associated with the variable $REG_{i,t} * CAP_{i,t-1} * B2_t$ ($REG_{i,t} * RISK_{i,t-1} * B2_t$) is statistically significant and positive.

Test of H.ii.3: The approval of the Basel II framework has reduced the need to increase buffers of banks with capital closer to regulatory minima if variables $REG_{i,t} * \Delta RISK_{i,t} * B2_t$ (capital equation) and/or $REG_{i,t} * \Delta CAP_{i,t} * B2_t$ (risk equation) have significant and positive coefficients on capital and risk, respectively.

APPENDIX 2 – SHRIEVES AND DAHL FRAMEWORK

According to Shrieves and Dahl (1992) the observed changes in capital and risk levels ($\Delta CAR_{i,t}$ and $\Delta RISK_{i,t}$) are separated into two components – a discretionary adjustment term (represented by the variables $\Delta^d CAR_{i,t}$ and $\Delta^d RISK_{i,t}$) and an exogenously determined factor (represented by the variables $E_{i,t}$ and $S_{i,t}$) – such that:

$$\Delta CAR_{i,t} = \Delta^d CAR_{i,t} + E_{i,t} \tag{1}$$

$$\Delta RISK_{i,t} = \Delta^d RISK_{i,t} + S_{i,t} \tag{2}$$

Due to rigidities and adjustment costs, Shrieves and Dahl (1992) used a partial adjustment framework, where the discretionary changes in capital and risk are proportional to the distance to the target levels of capital and risk ($CAR^*_{i,t}$ and $RISK^*_{i,t}$):

$$\Delta^d CAR_{i,t} = \alpha(CAR^*_{i,t} - CAR_{i,t}) \tag{3}$$

$$\Delta^d RISK_{i,t} = \beta(RISK^*_{i,t} - RISK_{i,t}) \tag{4}$$

where α and β are capital and risk adjustment factors, respectively.

Replacing equations (3) and (4) into equations (1) and (2), we have:

$$\Delta CAR_{i,t} = \alpha\left(CAR^*_{i,t} - CAR_{i,t-1}\right) + E_{i,t} \tag{5}$$

$$\Delta RISK_{i,t} = \beta\left(RISK^*_{i,t} - RISK_{i,t-1}\right) + S_{i,t} \tag{6}$$

Therefore, the observed adjustments in capital and risk depend both on the distance to the target levels and on exogenous factors.