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▶ **To cite this version:**

Boubacar Camara, Laetitia Lepetit, Amine Tarazi. Ex Ante Capital Position, Changes in the Different Components of Regulatory Capital and Bank Risk. Applied Economics, 2013, 45 (34), pp.4831-4856. 10.1080/00036846.2013.804166 . hal-00918521

HAL Id: hal-00918521

https://unilim.hal.science/hal-00918521

Submitted on 17 Apr 2014

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Ex ante capital position, changes in the different components of regulatory capital and bank risk*

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Abstract: We investigate the impact of changes in capital of European banks on their risk-taking behavior from 1992 to 2006, a time period covering the Basel I capital requirements. We specifically focus on the initial level and type of regulatory capital banks hold. First, we assume that risk changes depend on banks' ex ante regulatory capital position. Second, we consider the impact of an increase in each component of regulatory capital on banks' risk changes. We find that, for highly capitalized and strongly undercapitalized banks, an increase in equity positively affects risk; but an increase in subordinated debt has the opposite effect namely for undercapitalized banks. Moderately undercapitalized banks tend to invest in less risky assets when their equity ratio increases but not when they improve their capital position by extending hybrid capital. Hybrid capital and equity have the same impact for banks with low capital buffers. On the whole, our conclusions support the need to implement more explicit thresholds to classify European banks according to their capital ratios but also to clearly distinguish pure equity from hybrid and subordinated instruments.

JEL Classification: G21, G28

Keywords: Bank Risk, Bank Capital, Capital regulation, European banks

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* An earlier version of this paper was circulated under the title "Changes in capital and risk : an empirical study of European banks".

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Electronic copy available at: http://ssrn.com/abstract=1496818

1. Introduction

Bank capital regulation throughout the world is expected to play a major role to ensure financial stability. Capital ratios have exhibited an upward trend since the beginning of the 1990s and banks have been holding higher capital levels than imposed by the Basel I requirements implemented in 1993. The more recent regulatory frameworks known as Basel II, implemented in Europe in 2008, and Basel III which will be progressively enforced by 2019[1], are based on 3 pillars in which capital adequacy rules have been further tightened. The global financial crisis that started in 2007 challenges the effectiveness of these mandatory capital requirements. It has lead banking regulators to reshape the entire prudential regulatory framework. Under Basel III, banks have to comply with higher capital requirements based on a narrower definition of regulatory capital restricted to common equity also called core Tier 1 capital. The aim is to emphasize both the quantity and the quality of capital that banks hold. Ordinary (common) shares and retained earnings are also becoming the predominant form of Tier 1 capital and hybrid capital instruments qualifying for prudential purposes will be progressively restricted.

The theoretical literature on the impact of capital requirements on banks' risk-taking behavior has revealed mixed results. Furlong and Keeley 1989, Keeley and Furlong 1990 and Jeitschko and Jeung 2005 find that capital requirements can reduce the total volume of risky assets and thereby contribute to the stability of the banking system. However, capital regulation is likely to encourage banks to select riskier assets to offset its negative effect on leverage and on profitability (see Koehn and Santomero 1980, Kim and Santomero 1988, Rochet 1992, Blum 1999) or introduce indirect incentive effects affecting the effort to screen and monitor projects and lending behavior (see Gennote and Pyle 1991, Boot and Greenbaum 1993, Gianmarino et al. 1993, Besanko and Kanatas 1996). A more stringent capital rule could therefore, under some conditions, lead to an increase in banks' default risk. Calem and Rob (1999) also show that because the bank's portfolio choice depends on its ex ante regulatory capital position, it may either decrease or increase its portfolio risk as it moves towards compliance with a minimum capital requirement. Several empirical papers have analyzed whether banks take higher or lower risk when they are forced to hold more capital and also find contradictory results (Shrieves and Dahl 1992, Berger 1995, Jacques and Nigro

[1] For details on Basel II and Basel III, see Basel Committee on Banking Supervision: "International Convergence of Capital Standard, a Revised Framework, Comprehensive Version", Bank for International Settlements, June 2006, and Basel Committee on Banking Supervision: "Basel III: A global regulatory framework for more resilient banks and banking systems", Bank for International Settlement, June 2011.

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1997, Aggarwal and Jacques 2001, Rime 2001, Heid et al. 2004, Van Roy 2005, Altunbas et al. 2007).

While these papers have investigated the effect of capital regulation on bank risk taking, other papers have shown that banks hold buffers of capital indicating that capital standards are in general not binding (see Allen and Rai, 1996, Peura and Jokivuolle 2004, Barth et al. 2006, Berger and al. 2008). Rather than strictly complying with capital regulation, banks are shown to have their own target levels of capital and risk. Depending on the extent of their capital buffer, banks will adjust their capital and risk taking to reach their target levels (Milne and Whalley 2001, Ayuso et al. 2004, Lindquist 2004, VanHoose 2007, Jokipii and Milne 2008, Jokipii and Milne 2011, Stolz and Wedow 2011).

These two strands of the literature either focus on the risk impact of an increase in capital or on the relationship between capital buffers, i.e. the amount of capital held in excess of regulatory requirements, and risk. As a whole, the question of how changes in capital impact risk-taking incentives for banks that do not initially comply with regulatory capital standards remains unresolved. Furthermore, banks can use various instruments such as equity, hybrid capital, and subordinated debt to adjust their regulatory capital levels. Whether or not changes in different forms of regulatory capital will affect risk-taking incentives differently remains an open question. In this paper we jointly consider these two dimensions in an empirical setting.

We first investigate if changes in capital will lead to the same risk-taking behavior for banks with different ex ante regulatory capital ratios. Our aim is to specifically focus on initially undercapitalized banks but for comprehensiveness we also consider the case of banks that hold capital buffers. We therefore differentiate five sub-samples of banks on the basis of their capital ratios: (i) highly capitalized when their regulatory risk-based capital ratio (*TCR*) is above 10%; (ii) adequately capitalized when their *TCR* is between 8 and 10%; (ii) undercapitalized when their *TCR* is strictly below the regulatory threshold of 8%; (iv) moderately undercapitalized when they do not meet the total capital requirement but comply with the minimum 4% capital requirement on the *TIER1* risk-based capital ratio; (v) strongly undercapitalized when they comply with neither of these two requirements. In their theoretical work, Calem and Rob (1999) show that strongly undercapitalized banks have little to lose in the event of insolvency and might take very high risk to meet capital requirements. But they also show that highly capitalized banks have incentives to invest in risky assets associated with higher expected returns. In between, adequately and moderately undercapitalized banks take lower risk. While previous empirical work has already looked at the relationship between

capital ratios and risk for banks with different levels of capital ratios and /or capital buffers, our aim is to further investigate the case of undercapitalized banks.

We also examine, within each of our five capitalization categories, if bank risk taking is influenced by adjustments in the different components of capital defined by regulators. We therefore disaggregate bank capital into equity capital, subordinated debt and hybrid capital, i.e. the different components of regulatory capital. Subordinated debt holders are expected to be very sensitive to individual bank risk exposure since they are the first to bear any loss in excess of the bank's equity. However, when banks face distress, subordinated debt holders might prefer riskier strategies with the expectation that such strategies will allow them to recover their investment. Finally, hybrid capital presents the characteristics of both equity and debt. Their holders might also behave differently. From this perspective, our approach is expected to help supervisors to better monitor banks with different regulatory capital structures.

We work on a panel of commercial, cooperative & mutual and savings banks from 17 European countries over the 1992-2006 period. We find that banks' risk-taking behavior depends on the amount of regulatory capital they initially hold and also on the type of capital they choose to increase. We find that, for highly capitalized and strongly undercapitalized banks, an increase in equity positively affects risk; but an increase in subordinated debt has the opposite effect with a stronger impact for undercapitalized banks. Moderately undercapitalized banks tend to invest in less risky assets when their equity ratio increases but not when they improve their capital position by extending hybrid capital. Hybrid capital and equity have the same impact for banks with low capital buffers.

The paper is organized as follows. Section 2 discusses the hypotheses tested and presents the econometric framework. Section 3 describes the data and provides some preliminary statistics. Section 4 presents our estimation results. Section 5 discusses further issues and reports robustness checks. Section 6 concludes the paper.

2. Empirical framework

2.1 Hypotheses

Departing from the ambiguous results provided by existing theoretical and empirical papers our aim in this paper is to jointly analyze two dimensions of regulatory capital ratios. First, we investigate whether the sign of the relationship between changes in capital and changes in risk is conditional on the ex ante regulatory capital positions of banks. Second, we examine if the type of capital they use to adjust their capitalization influences their risk-taking

behavior. These two dimensions are important because the current regulatory reform (Basel III) emphasizes the need not only to increase capital ratios but also to consider a narrower definition of regulatory capital, the so-called Core Tier 1 capital in addition to Tier 1 and Tier 2 capital. The first issue we investigate is whether the relationship between changes in capital and changes in risk varies for banks with different ex ante regulatory capital positions. Previous papers have considered the impact of capital positions on risk taking but not the effect of capital positions on the slope of the relationship between capital changes and risk. We therefore investigate if changes in capital will affect risk-taking differently for highly capitalized, adequately capitalized and undercapitalized banks; the latter we further split into moderately undercapitalized and strongly undercapitalized banks. Severely undercapitalized banks may take much higher risk to meet capital requirements. Such a behavior might increase their probability of default as stressed by the theoretical work of Calem and Rob (1999). Because of limited liability, as shown by Rochet (1992), such banks can shift from risk aversion to risk-loving behavior. Moderately undercapitalized and adequately capitalized banks are expected to adopt a prudent behavior because they can either easily reach the standards and avoid regulatory pressure (moderately undercapitalized banks) or become inadequately capitalized (adequately capitalized banks). Such a behavior is consistent with the findings of both theoretical and empirical papers (Calem and Rob 1999, Shrieves and Dahl 1992, Jacques and Nigro 1997, Aggarwal and Jacques 2001, Rime 2001). For highly capitalized banks that hold large buffers, the expected relationship between changes in capital and changes in risk is undetermined. Banks holding large capital buffers might be targeting prudent investment strategies but they also might favor riskier investments (secured by important buffers), consistent with the U-shaped relationship between capital and risk taking found by Calem and Rob (1999). This leads us to

> ***Hypothesis 1 (H1)****: A change in capital is associated with different risk-taking behavior according to the ex ante regulatory capital positions of the bank (highly capitalized, adequately capitalized, undercapitalized, moderately undercapitalized or strongly undercapitalized).*

Furthermore, we account for the possibility that bank risk taking could depend not only on the amount of capital held ex ante but also on the type of capital (equity capital, subordinated debt and hybrid capital) used by banks to adjust their capital position. Subordinated debt holders are expected to be very sensitive to individual bank risk exposure since they are the first to bear losses after shareholders without benefitting from upside risk.

Moreover, such investors have incentives to require higher rates of return from banks that were providing misleading estimates of their risk exposure (Evanoff and Wall 2002). If market discipline is effective, higher rates required by such investors are expected to curb bank incentives to take on higher risk (Flannery 2001). When banks are adequately or well capitalized, subordinated debt holders prefer less risky assets. However, when banks face severe distress, the incentives of subordinated debt holders are aligned with those of shareholders (Gorton and Santomero 1990) and they will prefer riskier strategies to increase the probability of recovering their funds. Under such circumstances, in the absence of regulatory prompt corrective action, troubled banks may 'gamble for resurrection' (Calem and Rob 1999, Rochet 1992) under the pressure of both shareholders and subordinated debt holders.

On the whole, for severely undercapitalized banks, a change in equity capital is expected to positively affect risk but if market participants expect support or forbearance from regulators the same result will hold for changes in subordinated debt and hybrid capital which would behave as pure equity. At higher levels of capitalization (moderately undercapitalized and adequately capitalized banks), an increase in any of the three components of capital will moderate risk, but the effect should be stronger for subordinated debt and to a lesser extent for hybrid capital which is a mixture of equity and debt. For banks with large capital buffers, as argued above, the impact of an increase in capital in general is undetermined because banks might be either following riskier or more prudent strategies. However, subordinated debt and, to a lesser extent hybrid capital holders are always expected to curb potential higher risk taking (exclusively or essentially) benefitting pure equity holders. If banks that accumulate large buffers do so because they target higher risk, an increase in subordinated debt or, to a lesser extent, in hybrid capital will cause a lower increase in risk than would a change in pure equity. Furthermore, strong pressures from subordinated debt holders could possibly lead to a decrease in risk. If banks with important buffers adopt a more prudent behavior, an increase in any of the three components of regulatory capital will not generate higher risk. This leads us to

> ***Hypothesis 2 (H2)****: The impact of changes in capital on bank risk taking is different according to the ex ante regulatory capital position of the bank as well as the type of capital (equity, subordinated debt, hybrid capital) used to adjust capital ratios.*

Hypotheses 1 and 2 are tested using a sample of European banks over the period 1992-2006 by differentiating them according to their initial level of regulatory capital.

2.2 Bank risk measures

We use several measures of both bank asset risk and default risk. To assess bank asset risk, we need a measure that captures changes in risk management of the bank in a timely manner. We use the ratio of risk-weighted assets to total assets (*RWA*) based on the Basel Accord risk-based capital guidelines[2], as proposed by Shrieves and Dahl (1992) and used subsequently by Jacques and Nigro (1997), Aggarwal and Jacques (2001), Heid et al. (2004), Van Roy (2005) and Jokipii and Milne (2011). This ratio is a rough proxy of risk because it merely reflects the allocation of assets among the four weighting categories (0, 20, 50 and 100%) but not necessarily their actual riskiness. However, using such a measure allows us to assess the impact of capital changes on banks' portfolio reallocations among different weighting categories. This measure has often been considered as a reliable ex ante indicator of overall risk which is positively related to actual risk (Avery and Berger, 1991).

We also use the ratio of non-performing loans to net loans (*NPL*) as in Shrieves and Dahl (1992) and Aggarwal and Jacques (2001). Non-performing loans are computed as the sum of overdue loans, restructured loans and other non-performing loans. Unlike the ratio of risk-weighted assets to total assets, *NPL* is an ex post measure of risk, but it is also considered as a good predictor of future performance problems (Berger et al. 1991). *NPL* is used as a complementary risk measure as it might contain information on risk differences between banks not caught by *RWA*. We use the annual changes of our two risk measures (ΔRWA and ΔNPL) because our aim is to assess the implications of changes in bank capital on changes in risk taking.

As an additional risk indicator, we also compute a 3-year rolling window standard deviation of the return on assets (*SD_ROA*). Because we also aim to investigate if a change in capital affects bank default risk, we use the logarithm of a 3-year rolling window Z-score measure defined as $LOG_Z = \ln((100 + MROE)/SD_ROE)$, where *MROE* is the 3-year rolling window average return on equity and *SD_ROE* is the 3-year rolling standard deviation of the return on equity (all in percentages)[3]. A higher value of *LOG_Z* implies a lower probability of default.

[2] Throughout our sample period which ranges from 1992 to 2006, the ratio of risk-weighted assets to total assets we use is computed on a homogeneous basis. European banks have introduced the new methods allowed under Basel II after this period.

[3] It could be argued that the Z-score indicator might be inappropriate to investigate the relationship between capitalization and bank default risk because it is positively related to the capitalization variable by construction.

2.3 Bank capitalization

We use the annual changes in the ratio of total capital to total assets ($\Delta CAP = CAP_t - CAP_{t-1}$), following Shrieves and Dahl (1992). Total capital is composed of Tier 1 capital (equity and reserves) and Tier 2 capital (subordinated debt and hybrid capital)[4]. To focus on changes in each component of capital, we decompose total capital into three components, i.e. equity and reserves (EQ)[5], subordinated debt (SUB) and hybrid capital (HYB)[6]. This decomposition is important in light of the ongoing debate on what specific type of capital has to be considered in the regulatory capital definition. We use the annual changes in the ratios of equity to total assets (ΔEQ), subordinated debt to total assets (ΔSUB) and hybrid capital to total assets (ΔHYB).

We further need to measure the level of regulatory capital that banks hold at the beginning of each period to determine if this position matters for portfolio risk adjustments after a change in capital. For this purpose, we use the value of the regulatory risk-based capital ratio (*TCR*) measured at the end of the previous period[7] to classify banks in different categories. The risk-based capital ratio is defined as total regulatory capital (*TIER 1* and *TIER 2*) divided by risk-weighted assets. We follow Aggarwal and Jacques (2001) and Rime (2001) to classify banks that exhibit a *TCR* strictly lower than 8% as undercapitalized banks (*UNDER*). Banks with a *TCR* ranging from 8 to 10% are regarded as adequately capitalized (*AD*), and banks with a *TCR* above 10% as highly capitalized (*HIGH*). The thresholds used to

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However, the correlation between the Z-score measure and the ratio of capital to total assets is very low (0.125) in our sample. Its correlation with the annual changes in capital is also insignificant (-0.045). Because the Z-score variable is highly skewed, we use the natural logarithm of the Z-score as in Laeven and Levine (2009) and Houston et al. (2010).

[4] We define the numerator as the sum of equity capital (equity and reserves), subordinated debt and hybrid capital. This definition differs from the one used by regulatory authorities. Our aim is to consider the impact of a change in capital in general and is not restricted to regulatory capital per se. We take the amount of total assets as the denominator and not the amount of risk-weighted assets. Following the previous literature we consider a measure to capture changes in the proportion of capital in the balance sheet. Changes in the regulatory ratio could reflect a reallocation of assets among the different risk categories without any change in the actual proportion of capital in the balance sheet. However, a change in the capital ratio could also be driven by a change in the amount of liabilities such as a decline or increase in deposits.

[5] For simplicity we use the term equity to refer to the sum of equity and reserves (TIER 1) in the remainder of the paper. We therefore equally consider increases in TIER 1 associated to increases in reserves or to equity issuance.

[6] Hybrid capital contains a number of capital instruments combining some characteristics of equity and some characteristics of debt. Several elements are qualified as hybrid capital: for example, perpetual preference shares carrying a cumulative fixed charge, long-term preferred shares in Canada, titres participatifs and titres subordonnés à durée indéterminée in France, Genussscheine in Germany, perpetual debt instruments in the United Kingdom and mandatory convertible debt instruments in the United States.

[7] Our approach is based on discrete time. At time t, we consider the value taken by *TCR* at time t-1 to assign a bank in a given category. This is because we consider capital changes from t-1 to t and risk changes from t-1 to t.

classify banks are consistent with the principles of Prompt Corrective Action (PCA)[8] implemented in the US in 1991. We further consider a more detailed breakdown of undercapitalized banks than in previous studies. We define as moderately undercapitalized (*UNDERMODER*), banks that do not meet the total capital requirement ($TCR < 8$) but do comply with the narrower capital ratio, i.e. the *TIER1* risk-based capital ratio (*TIER1 ratio* $\geq$ 4%). Banks that do not comply with these two requirements ($TCR < 8$ and *TIER1 ratio* $< 4\%$) are considered as strongly undercapitalized (*UNDERSTRONG).* These two categories of undercapitalized banks might react differently in adjusting their capital positions. Strongly undercapitalized banks need to increase equity capital (*TIER1*) to comply with capital requirements whereas moderately undercapitalized banks can either increase equity capital *(TIER1)* or subordinated debt and hybrid capital (*TIER2*). Therefore the impact on bank risk taking can be different. We consider five dummy variables, one for each capitalization category : (i) *D_HIGH* for highly capitalized banks with $TCR \geq 10$; (ii) *D_AD* for adequately capitalized banks with $8 \leq TCR < 10$; (iii) *D_UNDER* for undercapitalized banks with $TCR < 8$; (iv) *D_UNDERMODER* for undercapitalized banks with $TCR < 8$ but *TIER1 ratio* $\geq 4\%$; and (v) *D_UNDERSTRONG* for undercapitalized banks with $TCR < 8$ and *TIER1 ratio* $< 4\%$. A bank can be classified in different capitalization categories throughout our sample period.

2.4. Model specification

We now present the empirical specifications used to test Hypotheses 1 and 2:

$$\begin{aligned}\Delta Risk_{i,t} &= \alpha_{0,i} + \alpha_1 Risk_{i,t-1} + \alpha_2 D_AD_{i,t-1} + \alpha_3 D_UNDER_{i,t-1} + \alpha_4 \Delta CAP_{i,t} \\ &+ \alpha_5 \Delta CAP_{i,t} * D_AD_{i,t-1} + \alpha_6 \Delta CAP_{i,t} * D_UNDER_{i,t-1} + \sum_{j=7}^{11} \alpha_j CONTROL_{i,t} + \varepsilon_{i,t}\end{aligned} \quad (1.a)$$

[8] The PCA involves that banks are classified into one of five categories (well capitalized, adequately capitalized, undercapitalized, significantly undercapitalized and critically undercapitalized) depending on their total risk-based capital ratio, Tier 1 risk-based capital ratio, and Tier 1 leverage ratio. Because a formal corrective action has not been implemented in Europe we simply use the thresholds defined by PCA in the US to classify banks according to the level of their regulatory risk-based capital ratio. The minimum capital requirement in Europe is 8% as in the US, except in Germany where the minimum TCR is equal to 12.5% for newly established banks in the first three years of business. We do not have to deal with such regulatory differences as we do not have in our final sample German banks that are newly established (see Section 3). The Financial Services Authority in the United Kingdom sets additional unpublished capital requirements called "trigger" and "higher target" ratios for each bank; the FSA considers that the basic 8% regulatory minimum capital requirement is only appropriate for a well-diversified bank. This implies that some banks have to comply with a higher capital ratio. However, as this information is not publicly available, we use the same thresholds of 8% and 10% for UK banks. We test the robustness of our results by using other thresholds (see Section 5 on robustness checks).

$$\Delta Risk_{i,t} = \alpha_{0,i} + \alpha_1 Risk_{i,t-1} + \alpha_2 D_AD_{i,t-1} + \alpha_3 D_UNDERMODER_{i,t-1} + \alpha_4 \Delta CAP_{i,t} + \alpha_5 \Delta CAP_{i,t} * D_AD_{i,t-1} + \alpha_6 \Delta CAP_{i,t} * D_UNDERMODER_{i,t-1} + \sum_{j=7}^{11} \alpha_j CONTROL_{i,t} + \varepsilon_{i,t} \quad (1.b)$$

$$\Delta Risk_{i,t} = \alpha_{0,i} + \alpha_1 Risk_{i,t-1} + \alpha_2 D_AD_{i,t-1} + \alpha_3 D_UNDERSTRONG_{i,t-1} + \alpha_4 \Delta CAP_{i,t} + \alpha_5 \Delta CAP_{i,t} * D_AD_{i,t-1} + \alpha_6 \Delta CAP_{i,t} * D_UNDERSTRONG_{i,t-1} + \sum_{j=7}^{11} \alpha_j CONTROL_{i,t} + \varepsilon_{i,t} \quad (1.c)$$

We use specification (1.a) to test Hypothesis 1 that a change in capital is associated with different risk-taking behaviors according to the ex ante regulatory capital positions of banks. We further use two alternative specifications, (1.b) and (1.c), to examine if the sign of the relationship for undercapitalized banks depends on whether they are undercapitalized in terms of both the total risk-based capital ratio and the TIER1 risk-based capital ratio (strongly undercapitalized, *D_UNDERSTRONG*) or only in terms of the total risk-based capital ratio (moderately undercapitalized, *D_UNDERMODER*).

For the dependent variable ($\Delta RISK$), we use alternative measures of risk changes (annual change in the ratio of risk-weighted assets to total assets *ΔRWA*, and annual change in the ratio of non-performing loans to net loans *ΔNPL*), the 3-year rolling window standard deviation of the return on assets *SD_ROA*, and a measure of default risk (the 3-year rolling window Z-score *LOG_Z*), as previously defined in Section 2.2[9]. We consider a dynamic adjustment by including the one year lagged value of risk variables (in level) as our measures of risk could exhibit time dependency ($RISK_{t-1}$). We expect a negative sign for the coefficient of this variable. *ΔCAP* stands for the annual change in the ratio of total capital to total assets[10]. We first consider in specification (1.a) three categories of banks according to the level of their regulatory capital at *t-1:* highly capitalized (*D_HIGH*), adequately capitalized (*D_AD*) and undercapitalized (*D_UNDER*). We remove, however, the dummy variable *D_HIGH* representing highly capitalized banks to avoid singularity. Highly capitalized banks are therefore the reference banks upon which we base and compare the coefficient estimates of our vector of capitalization variables. To measure the impact of changes in capital on risk

[9] Two of our measures, *SD_ROA* and *LOG_Z*, are computed using a 3-year rolling window making first order differencing problematic. We do not therefore consider the annual changes for these variables. However, we also perform our estimations using the changes in these variables as robustness checks.

[10] Because the change in risk might only be observable with a lag, for robustness, we also consider the lagged value of the change in the capital ratio.

changes conditional on the level of regulatory capital, we interact *ΔCAP* with the dummy variables *D_AD* and *D_UNDER*. α_4 captures the relationship between changes in capital and changes in risk for highly capitalized banks. α_5 and α_6 indicate whether adequately and undercapitalized banks behave differently than highly capitalized banks (α_5 and/or α_6 significant) or not (α_5 and/or α_6 not significant) respectively. In our investigation, we also test the significance of the sum of the coefficients associated to changes in capital and the appropriate interaction term ($\alpha_4+\alpha_5$ and $\alpha_4+\alpha_6$) to focus more closely on the relationship between changes in capital and changes in risk for each category of banks. As discussed above, we expect either a positive or negative link between capital changes and risk changes for highly capitalized banks. The net impact on their default probability will depend on the extent of the change in risk relatively to that in capital. Adequately capitalized banks are expected to adopt a prudent behavior but the sign of the relationship between changes in capital and changes in risk is ambiguous for undercapitalized banks. Banks that are moderately undercapitalized at the beginning of the period might reduce risk to avoid supervisory as well as market sanctions. On the other hand, strongly undercapitalized banks might be tempted to take higher risk. Such behavior might increase their default probability.

Hypothesis 2, which focuses on the impact on risk of a change in a specific component of capital (equity or subordinated debt or hybrid capital), is tested using a desaggregated version of specifications (1.a), (1.b) and (1.c) as follows:

$$\begin{aligned}\Delta Risk_{i,t} = {} & \beta_{0,i} + \beta_1 Risk_{i,t-1} + \beta_2 D_AD_{i,t-1} + \beta_3 D_UNDER_{i,t-1} \\ & + \beta_4 \Delta EQ_{i,t} + \beta_5 \Delta EQ_{i,t} * D_AD_{i,t-1} + \beta_6 \Delta EQ_{i,t} * D_UNDER_{i,t-1} \\ & + \beta_7 \Delta SUB_{i,t} + \beta_8 \Delta SUB_{i,t} * D_AD_{i,t-1} + \beta_9 \Delta SUB_{i,t} * D_UNDER_{i,t-1} \\ & + \beta_{10} \Delta HYB_{i,t} + \beta_{11} \Delta HYB_{i,t} * D_AD_{i,t-1} + \beta_{12} \Delta HYB_{i,t} * D_UNDER_{i,t-1} \\ & + \sum_{j=13}^{17} \beta_j CONTROL_{i,t} + \varepsilon_{i,t}\end{aligned} \qquad (2.a)$$

$$\begin{aligned}\Delta Risk_{i,t} = {} & \beta_{0,i} + \beta_1 Risk_{i,t-1} + \beta_2 D_AD_{i,t-1} + \beta_3 D_UNDERMODER_{i,t-1} \\ & + \beta_4 \Delta EQ_{i,t} + \beta_5 \Delta EQ_{i,t} * D_AD_{i,t-1} + \beta_6 \Delta EQ_{i,t} * D_UNDERMODER_{i,t-1} \\ & + \beta_7 \Delta SUB_{i,t} + \beta_8 \Delta SUB_{i,t} * D_AD_{i,t-1} + \beta_9 \Delta SUB_{i,t} * D_UNDERMODER_{i,t-1} \\ & + \beta_{10} \Delta HYB_{i,t} + \beta_{11} \Delta HYB_{i,t} * D_AD_{i,t-1} + \beta_{12} \Delta HYB_{i,t} * D_UNDERMODER_{i,t-1} \\ & + \sum_{j=13}^{17} \beta_j CONTROL_{i,t} + \varepsilon_{i,t}\end{aligned} \quad (2.b)$$

$$\begin{aligned}\Delta Risk_{i,t} = {} & \beta_{0,i} + \beta_1 Risk_{i,t-1} + \beta_2 D_AD_{i,t-1} + \beta_3 D_UNDERSTRONG_{i,t-1} \\ & + \beta_4 \Delta EQ_{i,t} + \beta_5 \Delta EQ_{i,t} * D_AD_{i,t-1} + \beta_6 \Delta EQ_{i,t} * D_UNDERSTRONG_{i,t-1} \\ & + \beta_7 \Delta SUB_{i,t} + \beta_8 \Delta SUB_{i,t} * D_AD_{i,t-1} + \beta_9 \Delta SUB_{i,t} * D_UNDERSTRONG_{i,t-1} \\ & + \beta_{10} \Delta HYB_{i,t} + \beta_{11} \Delta HYB_{i,t} * D_AD_{i,t-1} + \beta_{12} \Delta HYB_{i,t} * D_UNDERSTRONG_{i,t-1} \\ & + \sum_{j=13}^{17} \beta_j CONTROL_{i,t} + \varepsilon_{i,t}\end{aligned} \quad (2.c)$$

We decompose the ratio of total capital to total assets (*CAP*) into three components: equity to total assets (*EQ*), subordinated debt to total assets (*SUB*) and hybrid capital to total assets (*HYB*). We consider the annual changes in these components (*ΔEQ, ΔSUB, ΔHYB*) to estimate the impact of a change in each component on risk[11]. Because subordinated debt holders are the first to bear losses after shareholders without benefiting from possible higher returns, we expect that highly and adequately capitalized banks will take lower risk when facing positive changes in the ratio of subordinated debt. However, the interests of subordinated debt holders can be aligned with those of shareholders when a bank faces distress; in that case, they might support a riskier strategy. Because hybrid capital presents both the characteristics of equity and debt, the expected sign is similar to that of subordinated debt when banks are poorly capitalized but ambiguous when they are well capitalized.

We introduce a set of control variables in all our specifications. We control for bank size measured as the natural logarithm of total assets (*SIZE*). Large banks are expected to better diversify and manage risk. However, large banks could also benefit from safety net and too-big-to-fail policies (systemic risk concerns) and increase the riskiness of their assets. The growth rate of gross domestic product in each country (*GDP*) is also introduced in our regressions to account for changes in the macroeconomic environment. This variable captures

[11] Note that the sum of the coefficients of *ΔEQ, ΔSUB* and *ΔHYB* ($\beta_4 + \beta_7 + \beta_{10}$) in specifications (2) equals, for a given sample, the coefficient associated with *ΔCAP* (α_4) in specifications (1). It is therefore possible to find the results of specifications (1) using specifications (2). However, to facilitate the interpretation of the results, we present the results obtained for both specifications (1) and (2).

the differences in the macroeconomic conditions of the European countries included in our sample. While good macroeconomic conditions are expected to reduce banks' non-performing loans, banks might also be taking more risk during the boom period. Therefore, the impact of *GDP* on bank risk changes is ambiguous. In addition, we account for bank efficiency by considering the cost-to-income ratio defined as the ratio of total costs to total income before provisions and taxes (*EFF*). Less efficient firms may be tempted to take on higher risk to offset the lost returns incurred by a more stringent capital regulation. However, regulators may allow more room for leverage for efficient firms with better management (Altunbas et al. 2007). Finally, dummy variables are included to control for bank type (commercial, cooperative & mutual or savings banks) and we consider individual and time fixed effects.

3. Data description and statistical analysis

Our sample covers banks from 17 European countries from 1992 to 2006, a period which covers the Basel I regulatory environment (Cooke ratio). 16 of these countries are members of the European Union (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom) to which we add Switzerland. The first year corresponds to the adoption of the Basel I capital requirement accord which came into effect in January 1993. Since risk and capital measures are first differenced, 1992 is included in our sample. After 2006 banks have to comply with a different method to compute their risk-weighted assets under Basel II (McDonough ratio). We consider commercial, mutual & cooperative and savings banks, as they all play an important role in the European banking context while having different ownership structures. European commercial banks are joint stock companies whereas mutual & cooperative banks are owned by their members (customers). Savings banks are generally held by stakeholders such as employees and local or regional authorities. These three types of banks have to comply with the same capital requirements. Raising capital is traditionally considered as more difficult for cooperative & mutual banks. However, the development of a wide range of tools and mechanisms has facilitated capital issues on financial markets (nonvoting shares, debt instruments and hybrid securities).

The data are taken from BankScope Fitch IBCA, which provides annual accounting data for 6304 commercial, cooperative & mutual and savings European banks during this period. We use the World Bank database to collect our macroeconomic data. Because BankScope CDs only report data for the last 8 years, we use three BankScope CDs to gather

data for our period of study (September 2000, February 2006 and June 2008). We consider consolidated data but also use unconsolidated data when consolidated balance sheets are not available. All the banks in our sample publish their annual financial statements at the end of the calendar year. For accuracy, we only retain banks providing information for at least five consecutive years of time series observations as we estimate a dynamic panel data model including dependent and explanatory variables in first order differences (annual changes)[12]. Out of the initial 6304 banks, we are left with 1451 commercial, mutual & cooperative and savings European banks after data cleaning and imposing data availability for risk-based capital ratios (596 commercial banks, 574 mutual & cooperative banks and 281 savings banks, see Table A1 in appendix for a breakdown by country[13]). We end up with a smaller sample of 1142 banks when we require information on non-performing loans.

On average, our sample covers 64% of the total assets reported in Bankscope in 2006 but is relatively smaller for some countries such as Denmark, Germany, Ireland, Luxembourg, Norway and the United Kingdom (see Table A1 in the appendix). We check that the major European commercial and savings banks are included in our sample. Our sample is dominated by Italian and French banks (respectively 677 and 226). Both countries, along with Germany, have the banking systems with the largest number of banks in Europe. Table 1 presents descriptive statistics for both our sample of 1451 banks and the largest sample of 6304 banks available in BankScope Fitch IBCA.

Tables 1, 2 and 3 provide some general statistics on our sample as well as a correlation matrix for our variables of interest. During our sample period, 1384 banks are highly capitalized and 431 banks are adequately capitalized corresponding to respectively a total of 8851 and 1199 observations (see Tables 1 and A3 in the appendix). A smaller number of banks are, at some stage, undercapitalized (101 banks for 178 observations). Among these undercapitalized banks, 33 are strongly undercapitalized (i.e. undercapitalized in terms of both *TCR* and *TIER 1* risk-based capital ratios) and 57 are moderately undercapitalized (i.e. in

[12] We check if this restriction leads us to exclude banks that are classified as “in bankruptcy” or “in liquidation” or “dissolved” or “dissolved for mergers” by BankScope over our period of analysis. Out of the 73 banks that are classified as “in bankruptcy” or “in liquidation”, 11 are present in our final sample. Our sample includes 311 banks that were dissolved out of the 1744 listed by BankScope. 1422 banks are not included in our final sample because BankScope does not report information on their total risk-based capital ratio and their risk-weighted assets.

[13] As BankScope provides few information on total capital ratio and risk-weighted assets for German banks, we end up with only 27 banks for this country. All these German banks have been established before 1989, so the capital requirement required by the regulator over our period of analysis is 8% (and not 12.5% as it holds for new established banks).

terms of *TCR* only) corresponding respectively to 44 and 99 observations[14]. Many commercial banks are categorized as undercapitalized compared to cooperative & mutual and savings banks (see Table A3 in the appendix). Among undercapitalized banks, around 60 % are undercapitalized during 1 year only, 20% during 2 years and 13% during 3 years (see Table A2 in the appendix). The same proportions hold for moderately undercapitalized banks whereas strongly undercapitalized mostly experience such a situation during only 1 year. A closer look at our data shows that among the undercapitalized banks, around 30% remain undercapitalized during several consecutive years.

We further observe that, on average, undercapitalized banks exhibit significantly higher risk (*NPL*, *SD_ROA* and *LOG_Z*), lower profitability (*ROA* and *ROE*) and a higher cost to income ratio (*EFF*) than highly and adequately capitalized banks (see Tables 1 and 2)[15]. Strongly undercapitalized banks are the smallest in terms of total assets. These banks also exhibit a relatively higher ratio of equity to total assets than adequately capitalized and moderately undercapitalized banks. As the total risk-based capital ratio of strongly undercapitalized banks is very low (below 2.50% on average), such banks seem to suffer more from their asset quality (high level of risk-weighted assets) than from lower capitalization than other banks.

We note (Table A4) that, on average for European commercial and savings banks, the total risk-based capital ratio and the Tier 1 ratio increased from 1992 to 1996, when they reached a peak. A similar trend can be observed for cooperative banks but until 1999. The implementation of the Basel I accord in 1992 led to an important increase in capital ratios of European banks during a transitory period of 4 to 7 years.

Insert Tables 1, 2 and 3 here

4. Estimation results

We could potentially encounter endogeneity issues in our regressions; we therefore test for the presence of an endogeneity bias in the estimated equations using the Hausman test. For specification (1), endogeneity is presumably a problem for the two variables representing changes in capital (ΔCAP) and the level of efficiency[16] (*EFF*). We use as instruments the

[14] Among the 11 banks listed as "in bankruptcy" or "in liquidation" by BankScope in our sample, only 1 bank appears as undercapitalized (and more precisely as strongly undercapitalized); similarly, among the 311 banks listed as "dissolved", 28 are undercapitalized (of which 9 are strongly undercapitalized).

[15] Mean tests are available from the authors on request.

[16] Efficiency could be affected by changes in bank risk. If a manager is not very good at assessing and monitoring loans, she/he will presumably not reach a high level of operating efficiency. Moreover, a bank which

lagged value (in level) of the capital ratio CAP_{t-1} for ΔCAP_t and the lagged value in first difference ΔEFF_{t-1} for EFF_t [17]. Table 4 shows that we have endogeneity for ΔCAP for the risk measures ΔRWA and *SD_ROA*, whereas we only have endogeneity for *EFF* with ΔRWA. We run the same tests for the different components of capital based on specification (2) and find that only the variable measuring changes in equity (ΔEQ) is endogenous for the measures of risk ΔRWA, *SD_ROA* and *LOG_Z* (see Table 5).

To deal with endogeneity, we can either use 2SLS/3SLS or the generalized method of moments (GMM) procedure. The first approach is used in most of the previous studies which analyze the effectiveness of capital adequacy regulations and the relationship between an increase in bank capital and risk (Shrieves and Dahl 1992; Jacques and Nigro 1997; Aggarwal and Jacques 2001; Rime 2001; Altunbas et al. 2007). However, GMM estimators provide more efficient estimators in the presence of individual specific heteroscedascticity, as it is the case with our data. Moreover, in our framework, 2SLS or 3SLS estimations would not be tractable for specification (2) where simultaneous equations need to be estimated for $\Delta RISK$, ΔEQ, ΔSUB and ΔHYB. We therefore opt for the GMM procedure but we also use a simultaneous equations approach for specification (1) as a robustness check (see section 5). We use the estimator of Arrelano and Bover (1995) by considering lagged values (in level) of the capital ratio CAP_{t-1} and the equity ratio EQ_{t-1} as instruments for, respectively, the variables ΔCAP_t and ΔEQ_t, the lagged value in first difference ΔEFF_{t-1} for the efficiency variable EFF_t and for the risk variables which are introduced in the model with a one-year lag, we use the two-year-lagged values as instruments. For robustness, we also use the first difference lagged value of capital and equity as instruments.

Insert Tables 4 and 5 here

Changes in capital and risk for banks with different initial regulatory capital positions

The estimation results regarding Hypothesis 1 (specifications (1a-c)) are presented in Tables 6a-b for our three different measures of asset risk and for our measure of default risk;

wants to maximize its long-run performance can reduce the funds devoted to underwriting and monitoring loans. Such a behavior will boost efficiency in the short-run but will also increase bank risk. See Berger and DeYoung (1997) for more details.

[17] We first regress, using OLS, each presumably endogenous variable on the instrumental variables and a set of exogenous variables not suspected to be endogenous. We then obtain the fitted values (ΔCAP_FIT and *EFF_FIT*) and the residuals (ΔCAP_RES and *EFF_RES*) for the two variables suspected to be endogenous that we substitute for ΔCAP and *EFF* in specification (1). We then obtain the results presented in Table 4. An endogeneity problem potentially exists if ΔCAP_RES and/or *EFF_RES* are significantly different from zero. We finally run a join test to confirm that we have an endogeneity problem.

similarly, the results for specifications (2a-c) are given in Tables 7a-b. As we remove the dummy variable *D_HIGH*, highly capitalized banks are the baseline banks we compare the coefficient estimates for the other capitalization categories with. For each category (adequately capitalized, undercapitalized, moderately undercapitalized and strongly undercapitalized), we test for hypothesis 1 (specifications (1a-c)), the significance of the sum of the coefficients associated with changes in capital and the appropriate interaction term. For hypothesis 2 (specifications (2a-c)), we also test the significance of the sum of the coefficients associated with changes in equity, subordinated debt and hybrid capital and the appropriate interaction term.

The results are consistent with hypothesis 1 that the ex ante regulatory capital positions of banks influence their risk-taking behavior differently when they adjust their capital (see Tables 6a-b). For highly capitalized banks, we find a positive relationship between changes in capital and changes in asset and loan risk (*ΔRWA*, *ΔNPL* and *SD_ROA*). Indeed, α_4 is significant and positive. These results indicate that highly capitalized banks invest in riskier assets when they increase their capital ratio. We also find that such a behavior increases their default probability (*LOG_Z*) indicating that the increase in asset risk more than offsets the reduction in default risk attributable to higher capitalization. Regarding adequately capitalized banks, we find that they do not behave differently than highly capitalized banks with regards to risk-weighted assets and non-performing loans*;* but the magnitude of the impact of changes in capital on changes in risk is generally lower for adequately capitalized banks[18]. Moreover, changes in capital do not significantly impact the standard deviation of the return on assets and the default risk of adequately capitalized banks, indicating that these banks adopt a more prudent behavior than highly capitalized banks.

For undercapitalized banks (equation (1.a), we find a significant negative relationship between changes in capital and changes in asset risk. Undercapitalized banks seem to adopt a prudent behavior when they improve their capital standards to catch up with regulatory requirements. Such banks might want to avoid regulatory and/or market sanctions when rebuilding their capital ratio. However, when we further separate undercapitalized banks into two sub-categories, we note that the reduction in risk only holds for banks that are simply undercapitalized in terms of the total risk-based capital ratio, i.e. for moderately undercapitalized banks (equation (1.b)). The opposite result holds for institutions that neither meet the *TCR* nor the *TIER 1* requirement (equation (1.c)). For such strongly undercapitalized

[18] Wald tests are available on request.

banks, we highlight the same behavior as highly capitalized banks as regards to *ΔRWA* and *ΔNPL*, i.e. a positive relationship between changes in capital and changes in the risk-weighted assets ratio and in loan risk. These banks, which exhibit a very low mean value of *TCR* and *TIER 1*, respectively of 2.48 and 1.59% (see Table 1) might be suffering from the persistence of negative outcomes from past investments in poor quality projects. They might also be aiming for a higher expected return on equity by reallocating their asset portfolio and by selecting riskier and more profitable assets. These institutions seem to be less prudent than banks which are simply undercapitalized in terms of *TCR* and which are close to the minimum regulatory requirement since the mean value of *TCR* for such institutions is equal to 7.10% (see Table 1). However, these results have to be considered with caution since, in our sample, the number of strongly undercapitalized banks is relatively low (33 banks for a total of 44 observations). We also find that a change in capital is associated with a higher default risk for strongly undercapitalized banks. Therefore, similarly to highly capitalized banks, the increase in asset risk for such banks more than offsets the reduction in default risk initially driven by a higher capitalization. The net impact is a higher default probability.

Insert Tables 6a-b here

Changes in different components of capital and risk, for banks with different initial regulatory capital positions

We further decompose bank total capital into equity, subordinated debt and hybrid capital and we measure the impact of a change in each component of capital on changes in bank risk to test hypothesis 2. Tables 7a-b give the estimation results and show that both the type of capital used by a bank and its capital position impacts its risk-taking behavior, which is consistent with Hypothesis 2. We find a positive relationship between changes in the equity ratio (*ΔEQ)* and changes in the risk-weighted assets ratio (*ΔRWA*) for adequately (1% level) and highly capitalized banks (10% level). However, no significant link is found for these two categories of banks between changes in equity and the standard deviation of ROA *(SD_ROA)*. Our results also show that a change in the equity ratio implies an increase in the probability of default (*LOG_Z*), but only for highly capitalized banks. Conversely, and consistently with our previous results, we also find a negative and significant relationship between changes in equity and changes in the risk-weighted assets ratio (*ΔRWA*) for undercapitalized banks. We still observe the same differences for our two groups of undercapitalized banks. Our results show a negative relationship between changes in the equity ratio and changes in the ratio of risk-

weighted assets to total assets for moderately undercapitalized banks. However, strongly undercapitalized banks do not behave differently from highly capitalized banks. Strongly undercapitalized banks have little to lose in the event of insolvency and seem to take higher risk to meet capital requirements by investing in riskier assets to increase their expected return, resulting in a higher standard deviation of ROA *(SD_ROA)*. Similarly to highly capitalized banks, this reallocation towards riskier assets increases the default risk of strongly undercapitalized banks whereas we do not find a significant impact of a change in the equity ratio on default risk for the more prudent moderately undercapitalized banks.

Our results further highlight a significant positive relationship between a change in the ratio of subordinated debt (*ΔSUB)* and a change in the risk-weighted assets ratio (*ΔRWA)* for any initial level of bank capitalization, but we also observe a negative link with the standard deviation of the return on assets (*SD_ROA*), with a larger magnitude for undercapitalized banks and particularly for strongly undercapitalized banks. On the whole, market discipline exerted by subordinated debt holders seems to curb incentives to adopt riskier strategies, especially for strongly undercapitalized banks.

Regarding changes in the ratio of hybrid capital (*ΔHYB)*, there is no significant impact for highly capitalized banks whereas we find a positive relationship with the risk-weighted assets ratio (*ΔRWA)* for adequately (10% level) and undercapitalized banks (1% level). No significant link is found with the standard deviation of ROA *(SD_ROA)* and default risk (*LOG_Z*). Nevertheless, at low levels of capital buffer, hybrid capital appears to impact bank asset reallocation (*ΔRWA)* as pure equity.

For the control variables, the cost to income ratio (*EFF*) is positively linked to changes in the ratio of non-performing loans and to the standard deviation of the return on assets (*ΔNPL, SD_ROA*) (Table 6a). This result suggests that higher expenses are not successful in reducing the importance of non-performing loans and asset risk in general. The effect of bank size on changes in risk (*ΔNPL* and *SD_ROA*) is positive suggesting that larger banks might hold riskier portfolios which leads to an increase in default risk (Table 6a and 6b). As expected, better economic conditions contribute to lower the amount of non-performing loans in bank balance sheets. Furthermore, the growth rate of gross domestic product exerts a positive and significant effect on changes in the ratio of risk-weighted assets to total assets suggesting that, during booms, banks tend to focus on assets with higher risk coefficients such as corporate loans. The coefficients of the dummy variables which differentiate adequately and undercapitalized banks are always negative when they are significant; these findings are consistent with those of Shrieves and Dahl (1992) and Aggarwal and Jacques (2001).

Overall, we find that banks' risk-taking behavior depends on both the amount of regulatory capital they hold and on the type of capital they use to adjust their position. An increase in equity is positively associated with an increase in the risk-weighted asset ratio and default risk for highly and adequately capitalized but also for strongly undercapitalized banks. But the opposite link is found for moderately undercapitalized banks. Although it positively affects the portion of risky assets held by banks (*ΔRWA)*, an increase in the ratio of subordinated debt reduces risk taking (*SD_ROA*) regardless of their initial level of capitalization. An increase in the ratio of hybrid capital only affects the riskiness of adequately and undercapitalized banks. For such banks hybrid capital contributes to increase the share of risky assets (*ΔRWA).* This finding is consistent with Basel III's focus on a narrower definition of regulatory capital separating hybrid capital from bank core capital.

Insert Tables 7a-b here

5. Deeper investigation and robustness checks

In order to further examine issues related to the influence of capital changes on the risk-taking behavior of banks, we carry out a deeper investigation of our sample[19].

Isolating the impact of increases and decreases in capital ratios

We consider in our regressions both positive and negative capital changes. To go deeper in our investigation, we estimate specifications (1a-c) on two separate samples, including respectively positive and negative changes in capital[20]. We are more concerned about increases in capital than decreases in capital since we focus on changes in risk when banks are forced to improve their capital ratios, namely undercapitalized banks. Around 40% of capital changes in our sample are positive changes (increase in capital). The results of the estimations on the whole sample (including both increases and decreases in capital) are consistent with those of the sample restricted to increases in capital which is the sample consistent with our investigation (see Tables A5 and A6 in Appendix).

[19] Some of the estimation results discussed in this section are not presented in the paper but are available from the authors on request.

[20] We are not able to run our specifications (2a-c) when we differentiate positive and negative equity, subordinated debt and hybrid capital changes due to lack of sufficient observations.

Ownership type

We consider in our sample three types of banks with different ownership. Shareholder wealth maximization is the traditional objective of commercial banks. However, mutual & cooperative banks are owned by their customers and might thus put their interests first (O'Hara 1981, Altunbas et al. 2001). Savings banks, on the other hand, are generally held by stakeholders such as employees and local or regional authorities and aim to boost savings, develop the local economy and support social work (Gardener et al. 1997). These characteristics may lead to different business strategies regarding bank lending and investment, which can result in differences in profitability and risk (Goddard et al. 2007, Iannotta et al. 2007). Moreover, mutual & cooperative and savings banks might experience difficulties in raising as much capital as they would like. We therefore run our econometric specifications on each type of banks separately. The number of observations for moderately and strongly undercapitalized banks does not allow us to run regressions (1.b) and (1.c) separately for the three types of banks (commercial, mutual & cooperative and savings banks) The main results presented in Section 4 hold for commercial banks. For cooperative & mutual banks we find no significant relationship between changes in capital and changes in the risk-weighted assets ratio (*ΔRWA)*, but we find a positive relationship between changes in capital and changes in the other measures of risk taking (*ΔNPL* and *SD_ROA*) for highly and adequately capitalized banks. For savings banks, a change in capital positively affects the portion of risky assets in total assets (*ΔRWA)* but not the standard deviation of ROA and changes in nonperforming loans.

Market discipline

It could be argued that banks that are closely monitored by market participants might behave differently than institutions heavily reliant on explicitly or implicitly insured deposits and that do not issue large amounts of market debt. We therefore run our regressions on two sub-samples. The first sub-sample includes banks with a ratio of deposits to total assets below the sample median (54.95%). The second sub-sample is restricted to banks that are strongly reliant on deposits i.e. institutions with a ratio of deposits to total assets above the median. Highly and adequately capitalized banks that are relatively more reliant on market debt do not behave differently than banks that are more dependent on deposits (see Tables A7a-b and A8a-b). We also observe that strongly undercapitalized banks adopt riskier behavior even when they are more reliant on market debt. But moderately undercapitalized banks behave differently when their liability structure is different. Our results show a negative relationship

between changes in capital and changes in risk for moderately undercapitalized banks that are relatively more reliant on market debt. Conversely, we find that moderately undercapitalized banks that are more deposit-oriented do not behave differently than highly capitalized banks. For such banks that are presumed to be less closely monitored by uninsured market debt holders, our findings highlight that an increase in capital positively affects risk, similarly to strongly undercapitalized banks. Market discipline is therefore only effective to temper risk-taking behavior, following changes in capital, for moderately undercapitalized banks, but not for strongly undercapitalized banks or well capitalized and adequately capitalized banks.

Reaction in terms of risk the following year

Because a bank's reaction, in terms of risk taking, to an increase in its capital ratio might only be observable with a lag, we also run our regressions by considering the one year lagged values in capital changes. We find a significant relationship between changes in capital and changes in risk only when the dependent variable is the change in non-performing loans (*ΔNPL)*. No significance is found regarding the link between a change in capital and the other measures of risk (*ΔRWA, SD_ROA)* or the link between a change in capital and default risk (*LOG_Z)*. Presumably, a contemporaneous increase in risk, driven by an increase in capital, is expected to affect the extent of non-performing loans in the longer run which is consistent with our results. But our findings also show that such an increase in risk has no impact on the future level of a bank's risk weighted assets, i.e. its asset portfolio allocation, or on its future default risk.

Robustness checks

Several robustness checks are also performed. First, we estimate specification (1.a) by using a simultaneous equations approach for *ΔRWA* and *SD_ROA* for which we identified endogeneity issues[21].We introduce the same set of control variables used in equation (1.a) with, in addition, the return on assets (*ROA*). We use the two stage least square method by using instruments to tackle endogeneity issues. Our main results are unaltered (see Tables A9a-b in Appendix). Second, we include the annual changes in the risk-weighted assets to total assets *ΔRWA* in specifications where *ΔNPL* is the dependent variable, as in Shrieves and Dahl (1992). Third, we use another threshold to classify highly and adequately capitalized banks. We define banks with a *TCR* ranging from 8 to 12% as adequately capitalized, and

[21] We are not able to run our specifications (1b-c) when we use simultaneous equations due to an insufficient number of observations.

banks with a *TCR* above 12% as highly capitalized. Our results also remain unchanged for both specifications (1.a-c) and (2.a-c). Furthermore, to be consistent with the other risk proxies we use, we run our regressions using the changes in the standard deviation of *ROA* and the Z-score instead of their levels. Again, our findings are unaltered. Finally, to check for stability, we also carry out estimations on two sub-periods, 1992-1998 and 1999-2006. Table A4 in the appendix shows that, on the whole for commercial, cooperative and savings banks, capital ratios exhibit an upward trend until 1998 and remain relatively stable after this period. We can assume that after their implementation in January 1993, capital rules were initially binding for at least some banks that were catching up with the new standards. Our main results are stronger for the second sub-period 1999-2006 in which increases in capital ratios are presumably not influenced by the implementation of new regulatory standards. Regarding the earlier sub-period 1992-1998, we find a positive relationship between changes in capital and changes in nonperforming loans for highly and adequately capitalized banks whereas this relationship is negative for undercapitalized banks.

6. Summary and Conclusion

The purpose of this paper is to investigate whether the impact of changes in capital on bank risk taking is conditional on the ex ante regulatory capital positions of banks and on the type of capital they use to adjust their capital positions. We distinguish different categories of banks based on the initial level of their risk-weighted capital ratio (highly capitalized, adequately capitalized, undercapitalized, moderately undercapitalized and strongly undercapitalized banks). First, we find that banks react differently in terms of risk taking to capital changes. Highly capitalized banks increase their risk while undercapitalized banks tend to reduce it. However, when we separate undercapitalized banks into two sub-categories, we find that only moderately undercapitalized banks lower their risk exposure. Conversely, strongly undercapitalized banks take higher risk. Moreover, an increase in capital in highly capitalized and strongly undercapitalized banks is associated with higher default risk while default risk is not affected for adequately capitalized or moderately undercapitalized banks.

Sensitivity analysis shows that strongly undercapitalized banks, but also highly capitalized and adequately capitalized banks, do not behave differently when they are heavily reliant on market debt, i.e. when they are presumed to be more closely monitored by uninsured market debt holders. However, for moderately undercapitalized banks, the negative

relationship between changes in capital and changes in risk only holds when they are more reliant on market debt.

We also disaggregate bank capital into equity, subordinated debt and hybrid capital and find that regardless of their degree of capitalization, an increase in the ratio of subordinated debt systematically reduces the riskiness of banks even when they are severely undercapitalized. At low levels of capital buffer, hybrid capital has the same effect as equity. An increase in the ratio of hybrid capital positively affects the risk exposures of banks.

Our results support the need to implement explicit thresholds to classify European banks according to their capital ratios. This would help to clearly specify the conditions for supervisory intervention in troubled banks. Our results are also in favor of a clearer distinction between hybrid instruments, subordinated debt and pure equity capital in regulatory capital standards.

Table 1. General descriptive statistics, on average over the 1992-2006 period

	DEP_TA	NL_TA	ROA	ROE	Net_margin	EFF	TCR	TIER1	TA
Full sample of commercial, mutual & cooperative and savings banks available in BankScope (6304 banks)									
Mean	78.05	56.23	0.53	6.36	3.06	68.11	16.72	15.16	6149.8
Std. Dev.	17.23	21.83	1.92	10.98	2.11	18.18	8.34	8,93	43171
Our sample									
All banks (1451 banks)									
Mean	66.57	58.07	0.80	8.57	3.34	67.66	16.28	14.71	18800
Std. Dev.	15.71	19.01	0.93	9.88	1.57	16.25	7.51	8.09	79104
Highly capitalized banks (1384 banks)									
Mean	66.83	57.37	0.85	8.73	3.41	67.51	17.45	15.92	17469
Std. Dev.	15.60	18.95	0.95	8.91	1.59	15.96	7.39	8.01	81527
Adequately capitalized banks (431 banks)									
Mean	65.16	63.13	0.49	8.34	2.83	67.98	9.14	7.27	29056
Std. Dev.	16.43	18.37	0.61	12.15	1.35	16.94	0.55	1.51	63220
Undercapitalized banks (101 banks)									
Mean	63.08	58.92	0.32	1.88	3.07	72.81	5.80	4.77	15902
Std. Dev.	15.63	20.75	1.23	25.55	1.29	23.46	2.54	2.44	36826
Moderately undercapitalized banks (57 banks)[a]									
Mean	61.19	59.95	0.34	5.45	2.85	71.77	7.10	6.18	22065
Std. Dev.	16.26	21.45	1.02	19.77	1.38	22.17	0.77	1.06	45566
Strongly undercapitalized banks (33 banks)[a]									
Mean	63.69	50.59	0.31	-7.77	3.21	73.34	2.48	1.59	12008
Std. Dev.	14.17	22.02	1.77	37.76	1.13	29.30	2.46	1.45	24552

Variable definitions (all variables are expressed in percentages, except *TA* which is in millions of Euros): *DEP_TA* = deposits/total assets; *NL_TA* = net loans/total assets; *ROA* = return on assets; *ROE*= return on equity; *Net_margin*= net interest income/total earning assets*; EFF* = total costs/total income before provisions and taxes; *TCR* = total capital/ risk-weighted assets; *TIER1*= tier 1 capital/ risk-weighted assets; *TA*= total assets (millions of Euros).

We classify banks in different categories of capitalization: highly capitalized when $TCR \geq 10$; adequately capitalized when $8 \leq TCR < 10$; undercapitalized when *TCR* < 8%; moderately undercapitalized when *TCR*<8% and $TIER1 \geq 4$; strongly undercapitalized when *TCR*<8% and *TIER1*<4.

[a] The sum of banks classified as moderately and strongly undercapitalized (90 banks) does not perfectly match with the number of undercapitalized banks (101 banks) because some of these banks do not provide information on *TIER1*.

Table 2. Descriptive statistics of risk measures and capitalization variables, on average over the 1992-2006 period

	RWA	ΔRWA	NPL	ΔNPL	SD_ROA	LOG_Z	CAP	ΔCAP	EQ	SUB	HYB
Highly capitalized banks (1384 banks)											
Mean	66.967	1.082	6.739	-0.366	0.314	4.142	11.318	-0.034	10.428	1.293	0.098
Std. Dev.	16.761	7.281	6.845	3.072	0.567	1.083	4.573	1.884	4.829	1.379	0.344
Adequately capitalized banks (431 banks)											
Mean	73.042	2.183	6.228	-0.192	0.218	4.033	7.394	-0.101	5.956	1.567	0.254
Std. Dev.	17.685	9.218	5.305	2.26	0.326	1.109	2.516	1.172	2.54	1.129	0.532
Undercapitalized banks (101 banks)											
Mean	72.59	5.308	9.975	0.376	0.424	3.647	7.776	-0.027	6.689	1.342	0.145
Std. Dev.	18.245	13.328	10.189	4.286	0.661	1.243	4.713	1.831	4.918	1.159	0.363
Moderately undercapitalized (57 banks)											
Mean	72.124	5.281	9.884	0.397	0.435	3.656	6.841	-0.217	6.117	1.011	0.048
Std. Dev.	18.663	12.306	10.104	4.892	0.683	1.289	3.805	1.357	3.972	0.89	0.145
Strongly undercapitalized banks (33 banks)											
Mean	75.476	4.974	10.100	0.566	0.551	3.586	10.914	0.17	9.564	1.571	0.053
Std. Dev.	17.417	19.794	11.667	3.012	0.791	1.376	6.125	2.502	6.765	1.256	0.127

Variable definitions (all variables are expressed in percentages): *RWA* = risk-weighted assets to total assets; *ΔRWA* = annual changes of *RWA*; *NPL* = non performing loans/net loans; *ΔNPL* = annual changes of *NPL*; *SD_ROA* = 3-year rolling standard deviation of the return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *CAP* = total capital /total assets =(Equity capital+Subordinated debt+Hybrid capital)/total assets; *ΔCAP*= annual changes of *CAP*; *EQ*=equity capital/Total assets; *SUB*=subordinated debt/total assets; *HYB*=hybrid capital/total assets.

We classify banks in different categories of capitalization: highly capitalized when $TCR \geq 10$; adequately capitalized when $8 \leq TCR < 10$; undercapitalized when *TCR* < 8%; moderately undercapitalized when *TCR*<8% and $TIER1 \geq 4$; strongly undercapitalized when *TCR*<8% and *TIER1*<4.

[a] The sum of banks classified as moderately and strongly undercapitalized (90 banks) does not perfectly match with the number of undercapitalized banks (101 banks) because some of these banks do not provide information on *TIER1*.

Table 3. Correlation matrix

	ΔRWA	ΔNPL	SD_ROA	LOG_Z	ΔCAP	ΔEQ	ΔSUB	ΔHYB	EFF	SIZE	GDP
ΔRWA	1										
ΔNPL	-0.034	1									
SD_ROA	-0.068	0.000	1								
LOG_Z	0.059	0.012	-0.418	1							
ΔCAP	0.119	0.042	0.002	-0.032	1						
ΔEQ	0.104	0.031	0.008	-0.037	0.935	1					
ΔSUB	0.053	0.034	-0.004	0.007	0.249	-0.022	1				
ΔHYB	0.018	0.007	0.006	-0.004	0.052	-0.010	-0.049	1			
EFF	0.055	-0.004	0.037	-0.052	-0.036	-0.039	0.000	-0.026	1		
SIZE	-0.080	-0.022	-0.118	-0.027	0.003	-0.004	0.020	0.014	-0.155	1	
GDP	0.002	-0.053	0.071	-0.138	0.018	0.013	0.007	0.016	-0.159	0.135	1

ΔRWA = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *ΔCA P*= annual changes in the ratio of total capital to total assets; *ΔEQ*= annual changes in the ratio of equity capital to total assets; *ΔSUB*= annual changes in the ratio of subordinated debt to total assets; *ΔHYB*= annual changes in the ratio of hybrid capital to total assets; *EFF* = cost to income ratio*; SIZE* = logarithm of total asset; *GDP*= growth rate of Gross Domestic Product.

Tableau 4. Hausman test for endogeneity, specification (1)

	ΔRWA	ΔNPL	SD_ROA	LOG_Z
D_AD	-2.819 (-4.809)***	0.681 (2.339)***	-0.004 (-0.123)	-0.376 (-4.821)***
D_UNDER	-6.689 (-3.696)***	1.235 (1.561)	0.001 (0.015)	-0.363 (-1.462)
ΔCAP_FIT	0.561 (1.429)	-0.245 (-1.077)	0.340 (12.675)***	-0.174 (-2.882)***
ΔCAP_RES (γ_4)	1.367 (8.767)***	-0.014 (-0.174)	0.035 (3.493)***	-0.005 (-0.276)
EFF_FIT	0.136 (3.297)***	0.052 (3.543)***	0.021 (11.562)***	0.025 (6.530)***
EFF_RES (γ_6)	0.028 (2.167)**	0.006 (0.928)	0.0002 (0.330)	-0.004 (-2.360)**
RWA_{t-2}	-0.068 (-6.865)***			
NPL_{t-2}		-0.136 (-13.141)***		
SD_ROA_{t-2}			0.338 (8.002)***	
LOG_Z_{t-2}				0,347 (17.326)***
SIZE	0.261 (3.147)***	-0.114 (-2.366)**	-0.033 (-5.895)***	0.115 (10.214)***
GDP	-0.265 (-1.829)*	0.121 (1.627)	0.078 (8.473)***	-0,046 (-2.548)**
D_SAV	-6.335 (-1.944)*	-1.912 (-1.917)*	-0.928 (-6.886)***	-0.553 (-2.009)**
D_COOP	-5.623 (-1.724)*	-1.457 -1.470	-1.028 (-7.644)***	-0.330 (-1.201)
F-test : $\gamma_4 = \gamma_6 = 0$	(40.117)***	(0.070)	(6.101)***	(2.792)*
R^2 Observations	0.065 2557	0.102 1665	0.184 2195	0.189 2169

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP_FIT*=Fitted values of changes in the ratio of total capital to total assets obtained when we regress *ΔCAP* on the instrumental variables and a set of exogenous variables; *ΔCAP_RES*=Resid obtained when we regress *ΔCAP* on the instrumental variables and a set of exogenous variables; *EFF_FIT*=Fitted values of the ratio of cost to income obtained when we regress *EFF* on instrumental variables and a set of exogenous variables; *EFF_RES* =Resid obtained when we regress *EFF* on instrumental variables and a set of exogenous variables; RWA_{t-2} =Two years lagged values of the ratio of risk weighted assets to total assets; NPL_{t-2}= Two years lagged values of the ratio of non-performing loans to net loans; SD_ROA_{t-2} = Two years lagged values of standard deviation of return on assets; LOG_Z_{t-2}= Two years lagged values Z-score; *SIZE* = logarithm of total assets; *GDP*= growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Tableau 5. Hausman test for endogeneity, specification (2)

	ΔRWA	ΔNPL	SD_ROA	LOG_Z
D_AD	-0.377	0.445	0.016	-0.188
	(-0.451)	(1.940)	(0.815)	(-2.051)**
D_UNDER	-11.312	-0.099	-0.006	0.122
	(-3.416)***	(-0.110)	(-0.083)	(0.730)
ΔEQ_CHAP	-0.733	-0.310	-0.009	0.015
	(-0.900)	(-1.408)	(-0.462)	(0.175)
ΔEQ_RES (η_4)	0.985	0.028	0.013	-0.089
	(3.532)***	(0.392)	(2.079)**	(-3.044)***
ΔSUB_FIT	-3.335	-0.874	0.0006	0.387
	(-3.335)	(-1.354)	(0.009)	(1.400)
ΔSUB_RES (η_6)	0.173	0.241	-0.025	0.049
	(0.389)	(1.755)*	(-2.317)**	(1.015)
ΔHYB_FIT	6.069	0.683	-0.327	2.700
	(0.645)	(0.268)	(-1.413)	(2.610)***
ΔHYB_RES (η_8)	-1.520	0.070	-0.002	-0.169
	(-1.045)	(0.207)	(-0.059)	(-1.146)
EFF_FIT	0.084	0.013	0.002	0.018
	(1.945)*	(0.985)	(1.845)*	(3.813)***
EFF_RES (η_{10})	0.014	0.001	0.0005	-0.004
	(0.621)	(0.260)	(1.024)	(-1.838)*
RWA_{t-2}	-0.067			
	(-3.647)***			
NPL_{t-2}		-0.083		
		(-6.200)***		
SD_ROA_{t-2}			-0.376	
			(-14.773)***	
LOG_Z_{t-2}				-0.306
				(-11.007)***
SIZE	0.003	-0.051	-0.007	0.016
	(0.032)	(-1.393)	(-2.273)**	(0.219)
GDP	0.387	-0.133	-0.001	0.028
	(1.969)**	(-2.355)*	(-0.377)	(1.272)
D_SAV	-0.363	0.038	0.056	-0.198
	(-0.127)	(0.037)	(0.721)	(-0.574)
D_COOP	-1.048	0.164	0.012	-0.035
	(-0.366)	(0.156)	(0.158)	(-0.100)
F-test : $\eta_4 = \eta_6 = \eta_8 = \eta_{10}$	(3.598)***	(0.815)	(2.735)**	(3.576)***
R^2	0.061	0.118	0.280	0.183
Observations	773	231	241	679

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *D_UNDER* = 1 when bank-risk based capital ratio<8% in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔEQ_FIT*=Fitted values of *ΔEQ* obtained when we regress *ΔEQ* on the instrumental variables and a set of exogenous variables; *ΔEQ_RES*=Resid obtained when we regress *ΔEQ* on the instrumental variables and a set of exogenous variables; *ΔSUB_FIT*= Fitted values of *ΔSUB* obtained when we regress *ΔSUB* on the instrumental variables and a set of exogenous variables; *ΔSUB_RES*= Resid obtained when we regress *ΔSUB* on the instrumental variables and a set of exogenous variables*; ΔHYB_FIT*= Fitted values of *ΔHYB* obtained when we regress *ΔHYB* on the instrumental variables and a set of exogenous variables; *ΔHYB_RES*= Resid obtained when we regress *ΔHYB* on the instrumental variables and a set of exogenous variables; *EFF_FIT*= Fitted values of *EFF* obtained when we regress *EFF* on the instrumental variables and a set of exogenous variables; *EFF_RES*= Resid obtained when we regress *EFF* on the instrumental variables and a set of exogenous variables; RWA_{t-2} =Two years lagged values of the ratio of risk-weighted assets to total assets; NPL_{t-2}= Two years lagged values of the ratio of non-performing loans to net loans; SD_ROA_{t-2} = Two years lagged values of standard deviation of return on assets; LOG_Z_{t-2}= Two years lagged values Z-score; *SIZE* = logarithm of total assets; *GDP*= growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table 6a. Ex ante regulatory capital position of European banks and risk-taking behavior, specification (1) (1992-2006)

	ΔRWA			ΔNPL		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
D_AD (α_2)	-3.506 (-5.60)***	-3.335 (-5.13)***	-3.027 (-4.75)***	-0.101 (-0.54)	-0.074 (-0.37)	-0.030 (-0.15)
D_UNDER (α_3)	-5.549 (-3.96)***			0.289 (0.71)		
D_UNDERMODER (α_3)		-4.296 (-2.89)***			-0.036 (-0.06)	
D_UNDERSTRONG (α_3)			-15.348 (-3.39)***			0.026 (0.03)
ΔCAP (α_4)	1.206 (3.63)***	1.183 (3.53)***	1.003 (3.04)***	0.523 (4.52)***	0.439 (4.14)***	0.397 (3.79)***
ΔCAP*D_AD (α_5)	-0.128 (-0.30)	-0.049 (-0.11)	0.124 (0.29)	-0.350 (-2.14)**	-0.250 (-1.53)	-0.239 (-1.49)
ΔCAP*D_UNDER (α_6)	-2.640 (-4.77)***			-0.665 (-3.45)***		
ΔCAP*D_UNDERMODER (α_6)		-2.881 (-4.89)***			-0.535 (-2.59)***	
ΔCAP*DUM_UNDERSTRONG (α_6)			-0.047 (-0.02)			-0.446 (-1.16)
RWA_{t-1}	-0.098 (-1.92)*	-0.110 (-1.98)**	-0.144 (-2.64)***			
NPL_{t-1}				-0.213 (-7.25)***	-0.260 (-8.51)***	-0.261 (-8.83)***
EFF	-0.051 (-1.40)	-0.039 (-1.07)	-0.035 (-0.97)	0.103 (5.48)***	0.104 (5.41)***	0.098 (5.35)***
SIZE	-0.760 (-1.12)	-0.979 (-1.47)	-1.138 (-1.72)*	0.756 (2.86)***	0.652 (2.34)**	0.624 (2.26)**
GDP	0.277 (2.05)**	0.324 (2.30)**	0.304 (2.18)**	-0.226 (-3.90)***	-0.161 (-2.54)**	-0.124 (-1.98)**
D_SAV	2.016 (0.50)	1.927 (0.48)	1.622 (0.41)	0.429 (0.33)	0.668 (0.36)	0.574 (0.31)
D_COOP	-3.192 (-0.80)	-0.872 (-0.18)	1.542 (0.31)	0.061 (0.06)	-0.382 (-0.21)	-0.442 (-0.24)
F-test: $\alpha_4 + \alpha_5 = 0$	1.077 (11.83) ***	1.134 (12.61) ***	1.127 (12.74) ***	0.173 (2.23)	0.189 (2.17)	0.158 (1.55)
$\alpha_4 + \alpha_6 = 0$	-1.434 (10.59) ***	-1.698 (12.72) ***	0.956 (0.35)	-0.141 (0.83)	-0.095 (0.28)	-0.048 (0.01)
J-stat	86.238	81.389	92.728	193.873	219.152	242.135
Observations	4761	4445	4402	3716	3183	3144

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; RWA_{t-1} = Previous year ratio of risk - weighted assets to total assets; EFF = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table 6b. Ex ante regulatory capital position of European banks and risk-taking behavior, specification (1) (1992-2006)

	SD_ROA			LOG_Z		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
D_AD (α_2)	-0.032 (-1.44)	-0.069 (-2.67)***	-0.064 (-2.51)**	-0.025 (-0.55)	0.015 (0.28)	0.010 (0.20)
D_UNDER (α_3)	0.032 (0.58)			-0.027 (-0.22)		
D_UNDERMODER (α_3)		0.023 (0.31)			0.005 (0.03)	
D_UNDERSTRONG (α_3)			0.072 (0.65)			-0.081 (-0.32)
ΔCAP (α_4)	0.157 (9.27)***	0.214 (9.35)***	0.213 (9.48)***	-0.140 (-4.30)***	-0.174 (-3.49)***	-0.186 (-3.80)***
ΔCAP*D_AD (α_5)	-0.167 (-7.71)***	-0.220 (-7.82)***	-0.221 (-7.95)***	0.108 (2.49)**	0.152 (2.50)**	0.169 (2.81)***
ΔCAP*D_UNDER (α_6)	-0.256 (-9.56)***			0.101 (1.64)		
ΔCAP*D_UNDERMODER (α_6)		-0.313 (-9.34)***			0.165 (2.15)**	
ΔCAP*DUM_UNDERSTRONG (α_6)			-0.232 (-3.95)***			0.006 (0.04)
SD_ROA_{t-1}	0.550 (19.33)***	0.508 (12.81)***	0.498 (12.39)***			
LOG_Z_{t-1}				0.661 (16.76)***	0.621 (13.72)***	0.601 (13.54)***
EFF	0.014 (7.06)***	0.013 (6.34)***	0.012 (5.84)***	-0.007 (-1.57)	-0.015 (-3.38)***	-0.015 (-3.26)***
SIZE	0.288 (8.40)***	0.304 (7.01)***	0.299 (6.97)***	-0.393 (-5.79)***	-0.448 (-5.06)***	-0.461 (-5.25)***
GDP	0.004 (0.56)	0.011 (1.16)	0.009 (1.07)	-0.001 (-0.05)	-0.008 (-0.43)	-0.011 (-0.62)
D_SAV	-0.103 (-0.76)	0.050 (0.26)	0.049 (0.25)	0.185 (0.64)	-0.080 (-0.20)	-0.087 (-0.22)
D_COOP	0.080 (0.80)	0.155 (0.82)	0.129 (0.67)	-0.154 (-0.72)	-0.178 (-0.46)	-0.174 (-0.44)
F-test: $\alpha_4 + \alpha_5 = 0$	-0.010 (0.61)	-0.005 (0.12)	-0.008 (0.26)	-0.031 (1.26)	-0.021 (0.45)	-0.016 (0.26)
$\alpha_4 + \alpha_6 = 0$	-0.098 (23.15) ***	-0.098 (16.95) ***	-0.019 (0.13)	-0.039 (0.53)	-0.008 (0.01)	-0.179 (1.961)
J-stat	457.863	326.958	354.455	40.297	6.233	37.971
Observations	4923	3959	3927	4850	3903	3870

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP*= annual changes in the ratio of total capital to total assets; SD_ROA_{t-1} = previous year *SD_ROA*; ; LOG_Z_{t-1} = previous year *LOG_Z*; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP*= growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table 7a. Impact of changes in equity, subordinated debt and hybrid instrument on European banks' risk changes, specification (2) (1992-2006)

	ΔRWA			ΔNPL		
	(2.a)	(2.b)	(2.c)	(2.a)	(2.b)	(2.c)
ΔEQ (β_4)	0.687	0.979	0.962	-0.003	0.067	-0.062
	(1.11)	(1.74)*	(1.66)*	(-0.02)	(0.35)	(-0.32)
ΔEQ *D_AD (β_5)	1.609	1.502	1.450	-0.026	0.026	-0.002
	(1.94)*	(1.82)*	(1.72)*	(-0.10)	(0.09)	(-0.01)
ΔEQ*D_UNDER (β_6)	-3.725			-0.211		
	(-4.14)***			(-0.77)		
ΔEQ * D_UNDERMODER (β_6)		-4.999			-0.011	
		(-5.30)***			(-0.03)	
ΔEQ * D_UNDERSTRONG (β_6)			0.503			-0.601
			(0.28)			(-1.65)*
F-test : $\beta_4 + \beta_5 = 0$	2.297	2.481	2.413	-0.030	0.094	-0.065
	(12.81) ***	(14.43) ***	(13.24) ***	(0.02)	(0.184)	(0.09)
$\beta_4 + \beta_6 = 0$	-3.037	-4.019	1.466	-0.215	0.057	-0.663**
	(22.54) ***	(31.23) ***	(0.73)	(1.061)	(0.04)	(4.25)
ΔSUB (β_7)	0.961	0.968	0.964	-0.069	-0.089	-0.112
	(3.38)***	(3.46)***	(3.40)***	(-0.60)	(-0.82)	(-1.02)
ΔSUB *D_AD (β_8)	-0.649	-0.306	-0.209	0.107	0.147	0.134
	(-0.96)	(-0.45)	(-0.30)	(0.43)	(0.63)	(0.57)
ΔSUB *D_UNDER (β_9)	0.346			0.817		
	(0.19)			(1.40)		
ΔSUB * D_UNDERMODER (β_9)		1.083			1.157	
		(0.41)			(1.33)	
ΔSUB * D_UNDERSTRONG (β_9)			1.494			0.853
			(0.56)			(1.02)
F-test : $\beta_7 + \beta_8 = 0$	0.311	0.662	0.754	0.038	0.057	0.02
	(0.25)	(1.18)	(1.45)	(0.03)	(0.08)	(0.01)
$\beta_7 + \beta_9 = 0$	1.307	2.052	2.458	0.748	1.068	0.741
	(0.56)	(0.62)	(0.85)	(1.71)	(1.55)	(0.80)
ΔHYB (β_{10})	0.097	0.293	0.242	0.150	0.149	0.116
	(0.12)	(0.37)	(0.30)	(0.52)	(0.56)	(0.43)
ΔHYB *D_AD (β_{11})	3.013	3.068	3.175	0.001	0.058	0.060
	(1.60)	(1.64)*	(1.68)*	(0.002)	(0.10)	(0.11)
ΔHYB *D_UNDER (β_{12})	79.046			0.881		
	(3.40)***			(0.28)		
ΔHYB * D_UNDERMODER (β_{12})		233.431			21.258	
		(3.82)***			(1.65)*	
ΔHYB * D_UNDERSTRONG (β_{12})			NA			2.709
						(0.26)
F-test : $\beta_{10} + \beta_{11} = 0$	3.111	3.361	3.417	0.151	0.207	0.176
	(3.39) ***	(3.98) **	(4.01) **	(0.09)	(0.19)	(0.13)
$\beta_{10} + \beta_{12} = 0$	79.144	233.72	NA	1.031	21.407	2.825
	(11.62) ***	(14.70) ***	NA	(0.11)	(2.76) *	(0.074)

Table 7a (continue). Impact of changes in equity, subordinated debt and hybrid instrument on European banks' risk changes, specification (2) (1992-2006)

	ΔRWA			ΔNPL		
	(2.a)	(2.b)	(2.c)	(2.a)	(2.b)	(2.c)
RWA_{t-1}	-0.118	-0.098	-0.111			
	(-2.05)**	(-1.78)*	(-1.96)**			
NPL_{t-1}				-0.066	-0.235	-0.200
				(-1.23)	(-3.92)***	(-3.34)***
D_AD	-2.145	-2.060	-2.113	0.151	0.191	0.248
	(-3.03)***	(-2.96)***	(-2.96)***	(0.65)	(0.86)	(1.10)
D_UNDER	-5.19			0.602		
	(-2.76)***			(1.05)		
D_UNDERMODER		-4.296			-0.196	
		(-1.86)*			(-0.26)	
D_UNDERSTRONG			-17.064			2.71
			(-3.19)***			(2.61)***
EFF	-0.025	-0.001	0.009	-0.050	-0.049	-0.058
	(-0.43)	(-0.01)	(0.14)	(-1.56)	(-1.59)	(-2.00)**
SIZE	-2.193	-1.863	-2.381	-0.017	-0.265	-0.464
	(-2.21)**	(-1.91)*	(-2.38)**	(-0.04)	(-0.68)	(-1.19)
GDP	0.781	0.827	0.893	-0.181	-0.156	-0.084
	(4.56)***	(4.77)***	(5.06)***	(-2.94)***	(-2.66)***	(-1.42)
DUM_SAV	0.799	1.192	1.338	-0.443	-0.522	-0.706
	(0.21)	(0.33)	(0.36)	(-0.31)	(-0.40)	(-0.54)
DUM_COOP	-0.604	-0.165	2.630	-0.351	-0.928	-0.903
	(-0.14)	(-0.04)	(0.60)	(-0.22)	(-0.62)	(-0.55)
J-stat	52.758	48.794	57.132	83.721	119.274	125.583
Observations	1532	1428	1414	1187	1070	1060

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD*=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔEQ* = annual changes in the ratio of equity capital to total assets; *ΔSUB* = annual changes in the ratio of subordinated debt to total assets; *ΔHYB* = annual changes in the ratio of hybrid capital to total assets; RWA_{t-1}= previous year ratio of risk-weighted assets to total assets; ; NPL_{t-1} = previous year ratio of non-performing loans to net loans; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table 7b. Impact of changes in equity, subordinated debt and hybrid instrument on European banks' risk changes, specification (2) (1992-2006)

	SD_ROA			LOG_Z		
	(2.a)	(2.b)	(2.c)	(2.a)	(2.b)	(2.c)
ΔEQ (β_4)	-0.017 (-0.75)	-0.019 (-0.75)	-0.019 (-0.72)	-0.171 (-2.75)***	-0.193 (-3.13)***	-0.182 (-2.97)***
ΔEQ *D_AD (β_5)	0.016 (0.53)	0.008 (0.22)	0.009 (0.24)	0.113 (1.44)	0.230 (2.54)**	0.212 (2.35)**
ΔEQ*D_UNDER (β_6)	-0.010 (-0.24)			0.199 (1.81)*		
ΔEQ * D_UNDERMODER (β_6)		-0.057 (-1.14)			0.256 (2.22)**	
ΔEQ * D_UNDERSTRONG (β_6)			0.203 (2.18)**			0.880 (0.73)
F-test: $\beta_4 + \beta_5 = 0$	-0.001 (0.0003)	-0.011 (0.14)	-0.009 (0.106)	-0.057 (1.169)	0.036 (0.292)	0.030 (0.194)
$\beta_4 + \beta_6 = 0$	-0.028 (0.65)	-0.076 (3.43)*	0.184 (4.35)**	0.028 (0.098)	0.062 (0.42)	0.698 (0.338)
ΔSUB (β_7)	-0.011 (-0.85)	-0.023 (-1.66)*	-0.023 (-1.67)*	0.022 (0.68)	0.036 (1.08)	0.038 (1.13)
ΔSUB *D_AD (β_8)	0.007 (0.25)	0.024 (0.7467)	0.025 (0.7829)	0.025 (0.3327)	0.030 (0.3978)	0.027 (0.36)
ΔSUB *D_UNDER (β_9)	-0.184 (-2.05)**			-0.480 (-1.60)		
ΔSUB * D_UNDERMODER (β_9)		0.026 (0.16)			-0.255 (-0.70)	
ΔSUB * D_UNDERSTRONG (β_9)			-0.427 (-3.18)***			-2.308 (-1.03)
F-test: $\beta_7 + \beta_8 = 0$	-0.003 (0.017)	0.0005 (0.00)	0.001 (0.003)	0.047 (0.482)	0.066 (0.935)	0.065 (0.899)
$\beta_7 + \beta_9 = 0$	-0.195** (4.201)	0.002 (0.00)	-0.45*** (11.423)	-0.458 (2.38)	-0.218 (0.37)	-2.27 (1.034)
ΔHYB (β_{10})	-0.024 (-0.67)	-0.027273 (-0.7186)	-0.027326 (-0.7249)	-0.046388 (-0.5172)	-0.044496 (-0.5037)	-0.044 (-0.50)
ΔHYB *D_AD (β_{11})	0.019 (0.26)	0.023699 (0.3102)	0.023498 (0.3097)	-0.048315 (-0.2703)	-0.066404 (-0.3731)	-0.065 (-0.36)
ΔHYB *D_UNDER (β_{12})	-0.240 (-0.43)			-0.300320 (-0.2189)		
ΔHYB * D_UNDERMODER (β_{12})		0.009057 (0.0045)			-1.510809 (-0.3218)	
ΔHYB * D_UNDERSTRONG (β_{12})			2.279621 (1.2391)			6.892 (0.45)
F-test: $\beta_{10} + \beta_{11} = 0$	-0.005 (0.006)	-0.0035 (0.002)	-0.003 (0.003)	-0.094 (0.381)	-0.11 (0.521)	-0.109 (0.511)
$\beta_{10} + \beta_{12} = 0$	-0.264 (0.235)	-0.018 (0.00)	2.252 (1.499)	-0.346 (0.064)	-0.555 (0.109)	6.847 (0.199)

Table 7b (continue). Impact of changes in equity, subordinated debt and hybrid instrument on European banks' risk changes, specification (2) (1992-2006)

	SD_ROA			LOGZ		
	(2.a)	(2.b)	(2.c)	(2.a)	(2.b)	(2.c)
SD_ROA_{t-1}	0.488	0.412	0.425			
	(13.84)***	(10.642)***	(10.839)***			
LOG_Z_{t-1}				0.565	0.481	0.488
				(9.29)***	(7.22)***	(7.37)***
D_AD	-0.023	-0.032	-0.033	-0.011	-0.015	-0.007
	(-0.82)	(-1.01)	(-1.06)	(-0.16)	(-0.20)	(-0.10)
D_UNDER	0.107			0.085		
	(1.24)			(0.35)		
D_UNDERMODER		0.006			-0.207	
		(0.05)			(-0.65)	
D_UNDERSTRONG			-0.018			0.056
			(-0.10)			(0.07)
EFF	0.008	0.014	0.013	-0.004	-0.005	-0.006
	(3.21)***	(4.37)***	(4.04)***	(-0.60)	(-0.81)	(-0.97)
SIZE	0.024	0.004	0.002	-0.367	-0.396	-0.403
	(0.50)	(0.07)	(0.05)	(-3.09)***	(-3.19)***	(-3.24)***
GDP	0.004	0.005	0.003	-0.010	-0.006	-0.003
	(0.52)	(0.48)	(0.35)	(-0.46)	(-0.24)	(-0.11)
DUM_SAV	0.012	-0.030	-0.032	-0.026	-0.073	-0.072
	(0.08)	(-0.19)	(-0.20)	(-0.07)	(-0.20)	(-0.19)
DUM_COOP	0.108	0.168	0.132	-0.229	-0.293	-0.290
	(0.66)	(0.95)	(0.72)	(-0.53)	(-0.68)	(-0.67)
J-stat	439.169	420.809	427.591	36.122	46.405	45.188
Observations	1726	1438	1430	1702	1421	1411

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *D_UNDER* =1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔEQ* = annual changes in the ratio of equity capital to total assets; *ΔSUB* = annual changes in the ratio of subordinated debt to total assets; *ΔHYB* = annual changes in the ratio of hybrid capital to total assets; SD_ROA_{t-1} = previous year ratio *SD_ROA*; LOG_Z_{t-1} = previous year *LOGZ*; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP*= Growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

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Appendix

Table A1. Distribution of banks by country and type

Country	Number of banks	% Total assets[a]	Commercial banks	Savings banks	Mutual & cooperative banks
Austria	9	62.88	5	2	2
Belgium	26	92	18	5	3
Denmark	91	36.14	57	34	0
Finland	10	96.8	8	1	1
France	226	51.52	130	18	78
Germany	27	30.71	16	2	9
Greece	13	91.25	13	0	0
Ireland	11	47.79	9	2	0
Italy	677	71.18	139	65	473
Luxembourg	33	40.63	32	1	0
Netherlands	30	61.56	29	1	0
Norway	51	36.73	15	36	0
Portugal	22	86.48	18	3	1
Spain	77	91.21	26	46	5
Sweden	84	74.12	21	63	0
Switzerland	19	84.15	16	1	2
United Kingdom	45	31.48	44	1	0
Total	**1451**	**63.92**	**596**	**281**	**574**

[a] % Total assets represents total assets of commercial, savings and mutual & cooperative banks we consider in our sample divided by total assets of commercial, savings and mutual & cooperative banks of the largest sample of banks provided by BankScope Fitch IBCA for the year 2006.

Table A2. Frequency of banks capitalization status, over the 1992-2006 period

	Highly capitalized	Adequately capitalized	Undercapitalized	Moderately undercapitalized	Strongly undercapitalized
1 year	83	155	62	33	26
2 years	100	97	19	12	5
3 years	86	52	13	9	2
4 years	104	46	3	1	0
5 years	165	25	2	1	0
6 years	195	35	1	1	0
7 years	194	7	1	0	0
8 years	191	4	0	0	0
9 years	69	8	0	0	0
10 years	37	2	0	0	0
11 years	43	0	0	0	0
12 years	42	0	0	0	0
13 years	29	0	0	0	0
14 years	22	0	0	0	0
15 years	24	0	0	0	0
Total	**1384**	**431**	**101**	**57**	**33**

We classify banks in different categories of capitalization: highly capitalized when $TCR \geq 10$; adequately capitalized when $8 \leq TCR < 10$; undercapitalized when $TCR < 8\%$; moderately undercapitalized when $TCR<8\%$ and $TIER1 \geq 4$; strongly undercapitalized when $TCR<8\%$ and $TIER1<4$. The sum of banks classified as moderately and strongly undercapitalized does not perfectly match with the number of undercapitalized banks because some of these banks do not provide information on *TIER1*. *TCR* = total capital/ risk-weighted assets; *TIER1*= tier 1 capital/ risk-weighted assets.

Table A3. Distribution of the sample by year, by type of bank and category of capitalization

Years	Highly capitalized			Adequately capitalized			Undercapitalized			Moderately undercapitalized			Strongly undercapitalized			Total observations
	COM	COOP	SAV	COM	COOP	SAV	COM	COOP	SAV	COM	COOP	SAV	COM	COOP	SAV	
1992	91	10	23	10	46	2	9	1	1	3	1	1	2	0	0	193
1993	163	47	58	11	49	3	7	1	1	2	1	0	2	0	0	340
1994	204	66	69	11	31	3	11	0	0	4	0	0	3	0	0	395
1995	230	83	97	12	42	4	8	1	0	2	0	0	3	0	0	477
1996	242	90	112	10	49	4	8	1	0	2	0	0	2	0	0	516
1997	252	83	118	14	47	3	7	0	0	7	0	0	0	0	0	524
1998	251	160	136	15	51	10	9	8	1	4	3	0	2	5	1	641
1999	267	365	120	20	53	9	13	5	0	10	2	0	2	3	0	852
2000	245	412	117	24	61	18	7	7	1	6	3	1	0	4	0	892
2001	228	363	176	18	77	20	10	3	2	8	1	2	1	2	0	897
2002	232	420	185	21	64	18	7	4	4	4	3	4	2	1	0	955
2003	243	430	176	26	49	19	4	3	4	2	1	4	1	2	0	954
2004	225	435	158	17	48	26	4	1	2	1	0	1	2	1	1	916
2005	218	337	173	17	52	17	4	3	5	2	1	4	1	0	0	826
2006	198	387	156	22	56	20	7	1	3	5	1	3	1	0	0	850
Total number of observations	**3289**	**3688**	**1874**	**248**	**775**	**176**	**115**	**39**	**24**	**62**	**17**	**20**	**24**	**18**	**2**	**10228**

We classify banks in different categories of capitalization: highly capitalized when $TCR \geq 10$; adequately capitalized when $8 \leq TCR < 10$; undercapitalized when $TCR < 8\%$; moderately undercapitalized when $TCR < 8\%$ and $TIER1 \geq 4$; strongly undercapitalized when $TCR < 8\%$ and $TIER1 < 4$. The sum of banks classified as moderately and strongly undercapitalized does not perfectly match with the number of undercapitalized banks because some of these banks do not provide information on *TIER1*.
COM = commercial banks; *COOP* = cooperative & mutual banks; *SAV* = savings banks. *TCR* = total capital/ risk-weighted assets; *TIER1*= tier 1 capital/ risk-weighted assets.

Table A4. Evolution of European banks capitalization over the 1992-2006 period

Years	Commercial banks			Cooperative & mutual banks			Savings banks		
	TCR	TIER1	CAP	TCR	TIER1	CAP	TCR	TIER1	CAP
1992	12.83	8.22	8.01	10.72	9.79	7.13	14.16	9.31	6.65
1993	14.03	9.68	8.85	13.98	12.25	7.93	15.16	9.76	8.28
1994	15.05	10.78	9.18	14.65	11.42	8.53	15.82	11.07	8.68
1995	15.32	11.28	9.26	15.36	10.86	8.92	16.58	11.63	9.20
1996	15.65	11.55	9.26	15.91	10.71	9.07	17.20	12.74	9.54
1997	15.28	11.44	9.38	15.72	11.41	9.35	16.32	12.99	9.70
1998	15.25	12.17	9.77	17.73	18.33	11.28	15.48	13.79	9.94
1999	14.59	12.01	9.83	20.72	21.09	12.85	14.91	13.84	10.34
2000	14.36	11.60	10.15	20.41	20.74	13.27	14.02	12.95	10.22
2001	13.86	11.15	10.01	20.11	19.77	12.34	16.03	12.39	11.42
2002	14.21	11.10	10.14	20.11	19.31	12.46	15.81	14.15	11.60
2003	14.67	12.09	10.46	18.81	17.91	12.27	15.58	13.76	11.73
2004	14.02	11.46	10.16	18.04	17.32	12.12	15.32	14.34	11.78
2005	13.96	11.29	10.07	16.66	15.96	11.64	15.11	13.65	12.39
2006	13.22	10.51	9.85	17.08	16.33	11.83	14.99	12.92	12.35

Variable definitions (all variables are expressed in percentages): *TCR* = total capital/ risk-weighted assets; *TIER1*= tier 1 capital/ risk-weighted assets; *CAP* = total capital/total assets.

Table A5a. Increase in capital (ΔCAP>0) and risk-taking behavior (1992-2006)

	ΔRWA			ΔNPL		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
ΔCAP (α_4)	-0.238	-0.104	0.192	0.559	0.496	0.541
	(-0.427)	(-0.191)	(0.360)	(1.742)*	(1.605)	(1.703)*
ΔCAP*D_AD (α_5)	1.876	1.739	1.595	-0.342	-0.331	-0.402
	(2.725)***	(2.535)**	(2.308)**	(-0.899)	(-0.951)	(-1.117)
ΔCAP*D_UNDER (α_6)	-1.430			-0.677		
	(-1.905)*			(-1.871)*		
ΔCAP*D_UNDERMODER		-1.848			-0.592	
(α_6)		(-2.314)**			(-1.621)	
ΔCAP*DUM_UNDERSTRONG			-0.887			-0.862
(α_6)			(-0.324)			(-1.126)
RWA_{t-1}	-0.206	-0.223	-0.251			
	(-2.988)***	(-2.886)***	(-3.371)***			
NPL_{t-1}				-0.211	-0.259	-0.215
				(-5.328)***	(-5.590)***	(-4.582)***
D_AD	-4.909	-4.730	-4.568	0.216	0.334	0.428
	(-5.421)***	(-5.040)***	(-4.947)***	(0.660)	(0.957)	(1.195)
D_UNDER	-3.413			0.767		
	(-1.923)*			(1.279)		
D_UNDERMODER		-2.295			0.445	
		(-1.183)			(0.599)	
D_UNDERSTRONG			-6.962			0.964
			(-0.857)			(0.572)
EFF	-0.051	-0.045	-0.066	0.098	0.121	0.145
	(-0.948)	(-0.785)	(-1.102)	(3.469)***	(3.647)***	(3.800)***
SIZE	-0.850	-0.534	-0.608	-0.020	-0.110	0.237
	(-0.991)	(-0.630)	(-0.721)	(-0.052)	(-0.275)	(0.568)
GDP	0.351	0.395	0.303	-0.132	-0.056	-0.084
	(1.876)*	(2.045)**	(1.578)	(-1.537)	(-0.594)	(-0.851)
D_SAV	-11.510	-11.297	-10.102	2.368		
	(-1.094)	(-1.071)	(-0.967)	(0.679)		
D_COOP	-1.066	-0.842	1.754	0.888		
	(-0.189)	(-0.148)	(0.283)	(0.689)		
F-test: $\alpha_4 + \alpha_5 = 0$	1.637	1.635	1.787	0.217	0.165	0.138
	(9.694)***	(8.996)***	(10.613)***	(1.354)	(0.596)	(0.391)
$\alpha_4 + \alpha_6 = 0$	-1.669	-1.953	-0.695	-0.118	-0.096	-0.320
	(10.206)***	(10.952)***	(0.065)	(0.360)	(0.201)	(0.202)
J-stat	67.383	67.162	73.540	97.214	73.193	68.893
Observations	2058	1894	1858	1522	1266	1233

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; RWA_{t-1} = Previous year ratio of risk-weighted assets to total assets; EFF = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A5b. Increase in capital (ΔCAP>0) and risk-taking behavior (1992-2006)

	SD_ROA			LOG_Z		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
ΔCAP (α_4)	0.0001	0.131	0.096	-0.092	-0.093	-0.106
	(0.006)	(4.101)***	(3.277)***	(-1.425)	(-1.300)	(-1.524)
ΔCAP*D_AD (α_5)	0.006	-0.101	-0.073	0.002	0.0006	0.013
	(0.276)	(-2.972)***	(-2.319)**	(0.030)	(0,008)	(0.162)
ΔCAP*D_UNDER (α_6)	-0.122			0.063		
	(-5.114)***			(0.707)		
ΔCAP*D_UNDERMODER		-0.253			0.115	
(α_6)		(-6.983)***			(1.146)	
ΔCAP*DUM_UNDERSTRONG			-0.030			-0.021
(α_6)			(-0.510)			(-0.124)
SD_ROA_{t-1}	0.524	0.412	-0.619			
	(17.779)***	(11.074)***	(-16.910)***			
LOG_Z_{t-1}				0.665	0.628	0.598
				(13.355)***	(11.077)***	(10.828)***
D_AD	-0.010	0.030	0.021	0.012	0.039	0.022
	(-0.420)	(0.926)	(0.710)	(0.171)	(0.476)	(0.271)
D_UNDER	0,173			0.025		
	(3.301)***			(0.151)		
D_UNDERMODER		0.254			0.083	
		(3.319)***			(0.399)	
D_UNDERSTRONG			0.041			-0.215
			(0.340)			(-0.633)
EFF	0.002	0.008	0.007	0.001	-0.009	-0.008
	(1.341)	(3.217)***	(2.927)***	(0.188)	(-1.488)	(-1.361)
SIZE	0.009	0.133	0.078	-0.288	-0.267	-0.290
	(0.266)	(2.598)***	(1.617)	(-2.623)***	(-2.190)**	(-2.392)**
GDP	-0.001	-0.007	-0.008	0.0008	-0.0009	-0.004
	(-0.238)	(-0.780)	(-0.996)	(0.039)	(-0.041)	(-0.180)
D_SAV	-0.356	0.071	0.028	0.348	-0.384	-0.399
	(-2.916)***	(0.351)	(0.147)	(0.968)	(-0.744)	(-0.779)
D_COOP	-0.033	0.106	0.069	-0.017	-0.035	-0.030
	(-0.389)	(0.594)	(0.399)	(-0.064)	(-0.074)	(-0.065)
F-test: $\alpha_4 + \alpha_5 = 0$	0.006	0.030	0.022	-0.090	-0.092	-0.093
	(0.171)	(2.293)	(1.493)	(3.843)*	(3.381)*	(3.484)*
$\alpha_4 + \alpha_6 = 0$	-0.122	-0.121	0.066	-0.029	0.021	-0.128
	(45.693)***	(28.259)***	(1.502)	(0.1643)	(0.078)	(0.620)
J-stat	156.694	121.687	128.108	42.009	37.046	41.120
Observations	2379	1847	1826	2339	1821	1801

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP*= annual changes in the ratio of total capital to total assets; SD_ROA_{t-1} = previous year *SD_ROA*; ; LOG_Z_{t-1} = previous year *LOG_Z*; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP*= growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A6a. Decrease in capital (ΔCAP<0) and risk-taking behavior (1992-2006)

	ΔRWA			ΔNPL		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
ΔCAP (α_4)	0.507	0.703	0.583	0.221	0.228	0.217
	(1.325)	(1.881)*	(1.583)	(1.877)*	(2.033)**	(1.906)*
ΔCAP*D_AD (α_5)	0.473	0.398	0.445	0.110	0.106	0.086
	(0.839)	(0.682)	(0.770)	(0.508)	(0.470)	(0.380)
ΔCAP*D_UNDER (α_6)	0.998			0.508		
	(0.959)			(1.085)		
ΔCAP*D_UNDERMODER		0,992			0.699	
(α_6)		(0.685)			(1.323)	
ΔCAP*DUM_UNDERSTRONG			3.989			0.279
(α_6)			(2.021)**			(0.372)
RWA_{t-1}	-0.152	-0.119	-0.125			
	(-2.432)**	(-1.879)*	(-1.986)**			
NPL_{t-1}				-0.343	-0.368	-0.366
				(-9.529)***	(-10.425)***	(-10.340)***
D_AD	-2.304	-2.633	-2.459	0.004	-0.163	-0.096
	(-2.624)***	(-2.893)***	(-2.741)***	(0.0146)	(-0.538)	(-0.317)
D_UNDER	-9.563			0.247		
	(-4.350)***			(0.387)		
D_UNDERMODER		-9.015			-0.045	
		(-3.706)***			(-0.054)	
D_UNDERSTRONG			-21.596			0.707
			(-3.121)***			(0.596)
EFF	-0.055	-0.038	-0.047	0.067	0.054	0.063
	(-1.332)	(-0.908)	(-1.127)	(3.213)***	(2.599)***	(3.053)***
SIZE	0.171	0.420	0.591	0.679	0.613	0.637
	(0.229)	(0.554)	(0.785)	(2.183)**	(1.855)*	(1.914)*
GDP	0.181	0.206	0.196	-0.092	-0.092	-0.090
	(1.132)	(1.201)	(1.149)	(-1.364)	(-1.257)	(-1.202)
D_SAV	2.821	3.248	3.155	0.261		
	(0.696)	(0.784)	(0.766)	(0.202)		
D_COOP	-3.301	0.932	0.828	-0.540		
	(-0.695)	(0.147)	(0.131)	(-0.458)		
F-test: $\alpha_4 + \alpha_5 = 0$	0.980	1.102	1.028	0.331	0.335	0.303
	(3.480)*	(4.068)**	(3.570)*	(2.776)*	(2.491)	(2.052)
$\alpha_4 + \alpha_6 = 0$	1.506	1.696	4.573	0.729	0.927	0.497
	(2.124)	(1.398)	(5.361)**	(2.488)	(3.154)*	(0.442)
J-stat	60.509	46.294	47.315	172.989	173.741	170.822
Observations	2644	2489	2479	2126	1863	1855

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; RWA_{t-1} = Previous year ratio of risk-weighted assets to total assets; EFF = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A6b. Decrease in capital (ΔCAP<0) and risk-taking behavior (1992-2006)

	SD_ROA			LOG_Z		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
ΔCAP (α_4)	0.129	0.277	0.266	-0.207	-0.246	-0.233
	(7.313)***	(8.424)***	(8.392)***	(-4.572)***	(-3.969)***	(-3.876)***
ΔCAP*D_AD (α_5)	-0.142	-0.269	-0.264	0.210	0.329	0.326
	(-5.589)***	(-6.647)***	(-6.575)***	(3.450)***	(4.237)***	(4.234)***
ΔCAP*D_UNDER (α_6)	-0.074			-0.174		
	(-1.124)			(-1.077)		
ΔCAP*D_UNDERMODER		-0.146			-0.030	
(α_6)		(-1.525)			(-0.172)	
ΔCAP*DUM_UNDERSTRONG			-0.246			-0.301
(α_6)			(-2.297)**			(-1.339)
SD_ROA_{t-1}	0.422	0.410	-0.613			
	(13.649)***	(7.181)***	(-10.697)***			
LOG_Z_{t-1}				0.536	0.538	0.543
				(8.526)***	(9.116)***	(9.357)***
D_AD	-0.095	-0.241	-0.232	0.111	0.273	0.273
	(-2.785)***	(-4.909)***	(-4.730)***	(1.391)	(2.939)***	(2.947)***
D_UNDER	-0.008			-0.453		
	(-0.081)			(-1.867)*		
D_UNDERMODER		-0.108			-0.277	
		(-0.761)			(-1.056)	
D_UNDERSTRONG			0.000			-0.620
			(0.000)			(-1.569)
EFF	0.016	0.023	0.025	-0.016	-0.017	-0.017
	(6.354)***	(7.427)***	(7.959)***	(-2.562)**	(-2.659)***	(-2.662)***
SIZE	0.185	0.357	0.340	-0.452	-0.561	-0.557
	(5.065)***	(6.353)***	(6.220)***	(-5.428)***	(-5.390)***	(-5.470)***
GDP	-0.004	-0.005	-0.007	-0.030	-0.034	-0.035
	(-0.504)	(-0.418)	(-0.566)	(-1.479)	(-1.491)	(-1.504)
D_SAV	-0.174	0.057	0.058	0.098	-0.074	-0.071
	(-1.119)	(0.230)	(0.236)	(0.281)	(-0.162)	(-0.154)
D_COOP	0.068	0.169	0.185	-0.483	-0.257	-0.252
	(0.550)	(0.672)	(0.739)	(-1.669)*	(-0.548)	(-0.540)
F-test: $\alpha_4 + \alpha_5 = 0$	-0.013	0.007	0.006	0.002	0.083	0.092
	(0.356)	(0.064)	(0.002)	(0.002)	(2.066)	(2.550)
$\alpha_4 + \alpha_6 = 0$	0.054	0.130	0.020	-0.382	-0.276	-0.534
	(0.702)	(1.956)	(0.037)	(5.727)**	(2.528)	(5.817)**
J-stat	555.666	377.847	386.152	63.088	43.606	42.922
Observations	2496	2078	2068	2459	2046	2034

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; ; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD*=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; SD_ROA_{t-1} = previous year *SD_ROA*; LOG_Z_{t-1} = previous year *LOG_Z*; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A7a. Impact of changes in capital on risk changes for European banks with a relatively low ratio of deposits to total assets (1992-2006)

	ΔRWA			ΔNPL		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
ΔCAP (α_4)	0.507	0.534	0.082	0.457	0.355	0.352
	(1.645)*	(1.763)*	(0.293)	(4.309)***	(3.887)***	(3.884)***
ΔCAP*D_AD (α_5)	0.498	0.509	0.901	-0.316	-0.198	-0.231
	(1.218)	(1.248)	(2.307)**	(-2.031)**	(-1.363)	(-1.615)
ΔCAP*D_UNDER (α_6)	-2.120			-0.706		
	(-4.012)***			(-3.492)***		
ΔCAP*D_UNDERMODER		-2.853			-0.636	
(α_6)		(-4.957)***			(-3.188)***	
ΔCAP*DUM_UNDERSTRONG			2.441			-0.041
(α_6)			(1.216)			(-0.089)
RWA_{t-1}	-0.244	-0.207	-0.291			
	(-3.675)***	(-2.993)***	(-4.478)***			
NPL_{t-1}				-0.262	-0.322	-0.322
				(-7.191)***	(-8.552)***	(-8.933)***
D_AD	-1.132	-1.392	-0.661	0.0799	0.154	0.139
	(-1.652)*	(-2.027)**	(-1.035)	(0.408)	(0.785)	(0.724)
D_UNDER	-2.161			0.184		
	(-1.436)			(0.413)		
D_UNDERMODER		-1.886			0.158	
		(-1.181)			(0.300)	
D_UNDERSTRONG			-11.134			-1.276
			(-2.344)**			(-1.391)
EFF	-0.024	-0.035	-0.026	0.072	0.081	0.066
	(-0.570)	(-0.829)	(-0.618)	(3.740)***	(4.389)***	(3.725)***
SIZE	-2.352	-2.464	-3.254	0.621	0.470	0.570
	(-2.394)**	(-2.500)**	(-3.379)***	(1.935)*	(1.468)	(1.790)*
GDP	0.261	0.303	0.120	-0.234	-0.112	-0.107
	(1.348)	(1.547)	(0.631)	(-3.410)***	(-1.616)	(-1.547)
D_SAV				0.1857		
				(0.136)		
D_COOP				0.132		
				(0.152)		
F-test: $\alpha_4 + \alpha_5 = 0$	1.005	1.044	0.983	0.140	0.157	0.120
	(9.792)***	(10.271)***	(9.778)***	(1.545)	(1.800)	(1.101)
$\alpha_4 + \alpha_6 = 0$	-1.613	-2.318	2.524	-0.249	-0.280	0.310
	(13.875)***	(10.271)***	(1.589)	(2.197)	(2.532)	(0.464)
J-stat	62.122	61.789	76.842	145.285	108.215	134.766
Observations	2395	2353	2318	2075	1804	1776

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; RWA_{t-1} = Previous year ratio of risk weighted assets to total assets; EFF = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A7b. Impact of changes in capital on risk changes for European banks with a relatively low ratio of deposits to total assets (1992-2006)

	SD_ROA			LOG_Z		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
$\Delta CAP\ (\alpha_4)$	0.111	0.079	0.078	-0.047	-0.131	-0.139
	(5.146)***	(3.929)***	(3.916)***	(-1.100)	(-2.418)**	(-2.587)***
$\Delta CAP*D_AD\ (\alpha_5)$	-0.128	-0.089	-0.089	0.017	0.120	0.131
	(-4.802)***	(-3.497)***	(-3.510)***	(0.315)	(1.777)*	(1.943)*
$\Delta CAP*D_UNDER\ (\alpha_6)$	-0.247			0.034		
	(-7.791)***			(0.447)		
$\Delta CAP*D_UNDERMODER$		-0.171			0.119	
(α_6)		(-5.406)***			(1.331)	
$\Delta CAP*DUM_UNDERSTRONG$			-0.079			-0.023
(α_6)			(-1.440)			(-0.133)
SD_ROA_{t-1}	0.597	0.355	0.346			
	(14.282)***	(9.484)***	(8.970)***			
LOG_Z_{t-1}				0.711	0.634	0.623
				(13.422)***	(10.718)***	(10.626)***
D_AD	-0.029	-0.033	-0.025	-0.070	-0.004	-0.011
	(-1.061)	(-1.335)	(-1.001)	(-1.186)	(-0.075)	(-0.186)
D_UNDER	-0.028			-0.013		
	(-0.400)			(-0.082)		
D_UNDERMODER		-0.031			0.097	
		(-0.432)			(0.513)	
D_UNDERSTRONG			0.143			-0.138
			(1.220)			(-0.384)
EFF	0.018	0.012	0.012	-0.008	-0.011	-0.012
	(6.507)***	(4.621)***	(4.344)***	(-1.320)	(-1.838)*	(-1.935)*
SIZE	0.268	0.127	0.121	-0.309	-0.441	-0.460
	(5.035)***	(2.580)***	(2.479)**	(-2.921)***	(-3.532)***	(-3.6796***
GDP	0.009	-0.0009	-0.003	-0.017	-0.031	-0.032
	(0.951)	(-0.092)	(-0.337)	(-0.785)	(-1.234)	(-1.249)
D_SAV	-0.352	0.067	0.074	0.295	-0.136	-0.140
	(-1.464)	(0.272)	(0.297)	(0.570)	(-0.215)	(-0.220)
D_COOP	0.127	0.179	0.182	-0.084	-0.244	-0.244
	(1.174)	(1.154)	(1.148)	(-0.348)	(-0.608)	(-0.606)
F-test: $\alpha_4 + \alpha_5 = 0$	-0.017	-0.009	-0.010	-0.029	-0.010	-0.008
	(1.266)	(0.379)	(0.463)	(0.809)	(0.081)	(0.048)
$\alpha_4 + \alpha_6 = 0$	-0.135	-0.091	-0.0008	-0.012	-0.012	-0.163
	(32.572)***	(15.009)***	(0.0002)	(0.030)	(0.024)	(0.979)
J-stat	421.756	342.768	326.390	34.542	37.043	33.219
Observations	2727	2261	2244	2680	2227	2208

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank-risk based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD*=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *ΔCAP* = annual changes in the ratio of total capital to total assets; SD_ROA_{t-1} = previous year *SD_ROA*; LOG_Z_{t-1} = previous year *LOG_Z*; *EFF* = cost to income ratio; *SIZE* = logarithm of total asset; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A8a. Impact of changes in capital on risk changes for European banks with a relatively high ratio of deposits to total assets (1992-2006)

	ΔRWA			ΔNPL		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
ΔCAP (α_4)	1.498	1.927	1.912	0.286	0.009	0.013
	(2.731)***	(3.276)***	(3.238)***	(1.398)	(0.047)	(0.067)
ΔCAP*D_AD (α_5)	0.034	-0.559	-0.489	-0.015	0.141	0.099
	(0.041)	(-0.612)	(-0.526)	(-0.046)	(0.363)	(0.248)
ΔCAP*D_UNDER (α_6)	-3.028			0.431		
	(-1.959)*			(1.093)		
ΔCAP*D_UNDERMODER		-0.844			0.947	
(α_6)		(-0.426)			(2.066)**	
ΔCAP*DUM_UNDERSTRONG			-1.683			-0.209
(α_6)			(-0.438)			(-0.266)
RWA_{t-1}	-0.104	-0.118	-0.125			
	(-1.705)*	(-1.703)*	(-1.799)*			
NPL_{t-1}				-0.234	-0.333	-0.300
				(-4.668)***	(-6.432)***	(-5.825)***
D_AD	-7.848	-7.592	-7.664	-0.428	-0.372	-0.180
	(-6.954)***	(-6.276)***	(-6.230)***	(-1.089)	(-0.834)	(-0.395)
D_UNDER	-10.973			0.238		
	(-3.684)***			(0.322)		
D_UNDERMODER		-8.434			-0.880	
		(-2.586)***			(-0.854)	
D_UNDERSTRONG			-28.075			1.727
			(-2.437)**			(1.389)
EFF	-0.036	-0.058	-0.069	0.095	0.107	0.117
	(-0.730)	(-1.048)	(-1.234)	(3.078)***	(3.279)***	(3.447)***
SIZE	-0.440	0.135	-0.155	0.333	0.043	0.056
	(-0.448)	(0.130)	(-0.147)	(0.691)	(0.080)	(0.104)
GDP	-0.055	0.015	-0.004	-0.124	-0.024	0.002
	(-0.293)	(0.074)	(-0.024)	(-1.303)	(-0.223)	(0.024)
D_SAV				0.491		
				(0.143)		
D_COOP				-0.516		
				(-0.201)		
F-test: $\alpha_4 + \alpha_5 = 0$	1.533	1.368	1.422	0.270	0.151	0.113
	(4.896)**	(3.261)*	(3.351)*	(0.957)	(0.199)	(0.104)
$\alpha_4 + \alpha_6 = 0$	-1.529	1.083	0.228	0.717	0.957	-0.196
	(1.167)	(0.322)	(0.003)	(4.117)**	(5.110)**	(0.065)
J-stat	46.795	39.201	37.440	160.277	173.699	169.956
Observations	2319	2046	2034	1580	1324	1307

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *ΔNPL* = annual changes in the ratio of non-performing loans to net loans; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; RWA_{t-1} = Previous year ratio of risk-weighted assets to total assets; EFF = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A8b. Impact of changes in capital on risk changes for European banks with a relatively high ratio of deposits to total assets (1992-2006)

	SD_ROA			LOG_Z		
	(1.a)	(1.b)	(1.c)	(1.a)	(1.b)	(1.c)
$\Delta CAP\ (\alpha_4)$	0.102	0.337	0.314	-0.198	-0.252	-0.249
	(6.519)***	(8.143)***	(8.125)***	(-5.027)***	(-3.629)***	(-3.720)***
$\Delta CAP*D_AD\ (\alpha_5)$	-0.088	-0.310	-0.288	0.129	0.154	0.155
	(-3.350)***	(-5.587)***	(-5.444)***	(1.903)*	(1.647)*	(1.667)*
$\Delta CAP*D_UNDER\ (\alpha_6)$	-0.092			0.115		
	(-2.400)**			(1.195)		
$\Delta CAP*D_UNDERMODER$		-0.351			0.185	
(α_6)		(-4.635)***			(1.510)	
$\Delta CAP*DUM_UNDERSTRONG$			-0.219			0.058
(α_6)			(-1.916)*			(0.294)
SD_ROA_{t-1}	0.398	0.342	0.318			
	(14.026)***	(6.249)***	(5.966)***			
LOG_Z_{t-1}				0.454	0.453	0.439
				(8.546)***	(7.463)***	(7.469)***
D_AD	-0.037	-0.074	-0.083	0.081	0.104	0.114
	(-1.214)	(-1.298)	(-1.522)	(1.017)	(1.076)	(1.170)
D_UNDER	0.090			-0.096		
	(1.234)			(-0.509)		
D_UNDERMODER		0.148			-0.053	
		(1.010)			(-0.215)	
D_UNDERSTRONG			0.018			-0.323
			(0.101)			(-1.008)
EFF	0.007	0.017	0.015	-0.001	-0.013	-0.011
	(3.399)***	(5.188)***	(4.783)***	(-0.335)	(-2.120)**	(-1.815)*
SIZE	0.132	0.263	0.227	-0.325	-0.438	-0.442
	(3.757)***	(3.838)***	(3.477)***	(-3.641)***	(-3.831)***	(-3.875)***
GDP	0.009	0.014	0.013	0.003	-0.012	-0.013
	(1.027)	(0.895)	(0.892)	(0.156)	(-0.458)	(-0.497)
D_SAV	-0.076			-0.188		
	(-0.419)			(-0.406)		
D_COOP	0.021			-0.784		
	(0.102)			(-1.4638)		
F-test: $\alpha_4 + \alpha_5 = 0$	0.013	0.026	0.025	-0.069	-0.097	-0.093
	(0.400)	(0.503)	(0.497)	(1.562)	(2.360)	(2.080)
$\alpha_4 + \alpha_6 = 0$	0.010	-0.014	0.094	-0.083	-0.066	-0.190
	(0.087)	(0.054)	(0.732)	(0.873)	(0.426)	(0.982)
J-stat	480.062	137.606	157.515	61.400	47.105	51.011
Observations	2165	1669	1649	2137	1645	1626

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. ; *SD_ROA* = 3-year rolling standard deviation of return on assets; *LOG_Z* = logarithm of 3-year rolling Z-score; *D_UNDER* = 1 when bank-risk based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD*=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; SD_ROA_{t-1} = previous year *SD_ROA*; LOG_Z_{t-1} = previous year *LOG_Z*; *EFF* = cost to income ratio; *SIZE* = logarithm of total asset; *GDP* = growth rate of Gross Domestic Product; *D_COOP* and *D_SAV* = dummies for mutual & cooperative and savings banks.

Table A9a. Simultaneous equations (1992-2006)

	ΔRWA	ΔCAP
ΔCAP (α_3)	3.225	
	(2.365)**	
ΔCAP*D_AD (α_4)	-2.215	
	(-3.77)	
ΔCAP*D_UNDER (α_5)	-6.748	
	(-3.142)***	
ΔRWA (α_3)		0.071
		(2.593)***
ΔRWA*D_AD (α_4)		-0.055
		(-1.864)*
ΔRWA*D_UNDER (α_5)		-0.096
		(-2.71)***
RWA_{t-1}	-0.051	
	(-2.839)***	
CAP_{t-1}		-0.062
		(-8.293)***
D_AD	-2.962	0.460
	(-3.77)***	(4.388)***
D_UNDER	-3.227	0.735
	(-1.438)	(2.384)**
ROA		1.053
		(5.189)***
EFF	0.164	0.062
	(2.532)**	(2.765)***
SIZE	0.442	0.129
	(3.752)***	(2.400)**
GDP	-0.218	0.118
	(-1.907)*	(4.338)***
Khi^2 test : $\alpha_3 + \alpha_4 = 0$	1.009	0.016
	(3.877)**	(2.338)
$\alpha_3 + \alpha_5 = 0$	-3.523	-0.024
	(6.049)**	(1.092)
R^2	-0.019	-0.382
Observations	3130	3130

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *ΔRWA* = annual changes in the ratio of risk-weighted assets to total assets; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP* = annual changes in the ratio of total capital to total assets; RWA_{t-1} = Previous year ratio of risk-weighted assets to total assets; CAP_{t-1} = Previous year ratio of total capital to total assets; ROA= return on average assets; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP* = growth rate of Gross Domestic Product.

Table A9b. Simultaneous equations (1992-2006)

	SD_ROA	ΔCAP
ΔCAP (α_3)	0.667	
	(5.439)***	
ΔCAP*D_AD (α_4)	-0.684	
	(-5.994)***	
ΔCAP*D_UNDER (α_5)	-0.604	
	(-3.458)***	
SD_ROA (α_3)		0.073
		(0.946)
SD_ROA*D_AD (α_4)		-0.536
		(-2.133)**
SD_ROA*D_UNDER (α_5)		0.368
		(0.828)
SD_ROA_{t-1}	0.468	
	(4.895)***	
CAP_{t-1}		-0.049
		(-5.854)***
D_AD	-0.006	0.507
	(-0.129)	(6.093)***
D_UNDER	-0.041	0.390
	(-0.298)	(1.966)**
ROA		0.504
		(7.484)***
EFF	-0.001	0.017
	(-0.185)	(1.218)
SIZE	-0.039	0.026
	(-3.176)***	(0.835)
GDP	-0.022	0.060
	(-1.481)	(2.765)
Khi^2 test : $\alpha_3 + \alpha_4 = 0$	-0.016	-0.463
	(0.121)	(3.957)**
$\alpha_3 + \alpha_5 = 0$	0.063	0.442
	(0.231)	(1.065)
R^2	-1.209	0.133
Observations	2869	3586

***, **, * indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics. *SD_ROA* = 3-year rolling standard deviation of return on assets; *D_UNDER* = 1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; *D_UNDERMODER* = 1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; *D_UNDERSTRONG* = 1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; *D_AD* = 1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise; *ΔCAP*= annual changes in the ratio of total capital to total assets; SD_ROA_{t-1} = previous year standard deviation of return on assets; CAP_{t-1} = Previous year ratio of total capital to total assets; ROA= return on average assets; *EFF* = cost to income ratio; *SIZE* = logarithm of total assets; *GDP*= growth rate of Gross Domestic Product.