

# CHANGES IN CAPITAL AND RISK: AN EMPIRICAL STUDY OF EUROPEAN BANKS

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**Abstract:** In this paper, we investigate the impact of changes in capital of European banks on their risk-taking behavior from 1992 to 2006. First, we assume that risk changes are different for 3 categories of banks (undercapitalized, adequately capitalized and highly capitalized). Second, we consider the impact of an increase in each component of regulatory capital (equity, subordinated debt, hybrid capital) on banks' risk changes. We find that, for undercapitalized banks, an increase in capital is associated with a decline in risk. We obtain the opposite result for adequately and highly capitalized banks. Our findings also highlight that the decrease in risk for undercapitalized banks only holds when banks increase their equity capital. Conversely, an increase in subordinated debt or hybrid capital is associated with an increase in risk. On the whole, our conclusions support the policy recommendations for a narrow definition of regulatory capital with a closer focus on core capital than on other hybrid instruments.

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## 1. Introduction

Capital adequacy rules are at the heart of international bank regulation. Since the first Basel accord of 1988, banks are required to hold a minimum amount of capital as a proportion of risk-weighted assets (risk-based capital requirement). The more recent regulatory framework known as Basel II<sup>1</sup> is based on 3 pillars in which capital adequacy plays a major role. Nevertheless, theoretical papers and empirical work on the relationship between changes in capital and risk in the steps of Shrieves and Dahl (1992) have revealed mixed results. Capital adequacy rules are based on the principle that an increase in the level of capital will decrease the bank's probability of default. However, capital regulation is likely to introduce indirect incentive effects (i.e. reduction in the effort to screen and monitor projects) or encourage banks to select riskier assets to offset its negative effect on leverage and on profitability. As a result, it has been argued that more stringent capital rules could under some conditions lead to an increase in banks' default risk.

Within a portfolio framework, Koehn and Santomero (1980) show that the probability of bank failure does not always decrease following the implementation of a more stringent capital ratio because the rational response of bank shareholders is to increase the riskiness of assets to offset the negative effect on their expected return. Kim and Santomero (1988) show that a minimum capital requirement could mitigate higher risk-taking behavior if risk weights are accurately defined by regulators. By taking into consideration the incentive effects of capital regulation on banks' efforts to screen and monitor projects, Blum (2003) argues that the introduction of a non binding capital requirement increases banks' probability of default. Higher probability of default prompts banks to hold less capital and to reduce their efforts to screen projects compared to the situation where capital regulation is absent. By taking the heterogeneity of banks' loan monitoring costs into consideration, Kopecky and VanHoose (2006) show that the implementation of a binding capital requirement on a previously unregulated banking system has an ambiguous effect on loan 'quality'. But when capital requirement is already in place, regulators may improve the overall loan 'quality' by tightening the capital requirement.

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<sup>1</sup> For more details on Basel II, see Basel Committee on Banking Supervision: "International Convergence of Capital Standard, a Revised Framework, Comprehensive Version", Bank for International Settlement, June 2006.

By studying the interaction between the three ‘pillars’ of the Basel II Accord, Decamps, Rochet and Roger (2004) focus on the conditions under which market discipline can reduce the minimum capital requirements needed to prevent moral hazard. They show that undercapitalized banks have no incentives to monitor their projects. In this context, the regulator acting in behalf of depositors has to limit banks’ leverage and to impose closure well before the net present value of the bank’s assets becomes negative. As a whole the theoretical literature dedicated to the link between capital regulation and bank risk focuses on various channels by which capital requirements might affect risk. However, empirical work in this area conducted in the steps of Shrieves and Dahl (1992) remains scarce. Using data for 1800 U.S. banks over the period 1983-1987, Shrieves and Dahl find that capital regulation was at least partially effective for undercapitalized banks. Their results also show that most banks actually limit their total risk exposure following an increase in the capital ratio. Similarly, Bichsel and Blum (2004) study the impact of capital ratios on portfolio risk and bank default risk for a panel of 19 Swiss banks. Using market data to measure risk and both market and accounting data to measure capital, over the period 1990-2002, the authors find a positive correlation between changes in capital and risk. However, they do not find any significant relationship between the probability of default and capital. Rime (2001) studies the impact of capital regulation on bank risk and capital for 154 Swiss banks over the period 1989 to 1995. He finds that regulatory pressure had a positive effect on bank capital. But this pressure does not affect the level of risk. Aggarwal and Jacques (2001) assess the impact of prompt corrective action (PCA)<sup>2</sup> on bank capital and risk for US banks using a sample of 1685 commercial banks over the period 1991-1996. They find that both adequately capitalized and undercapitalized banks increase their leverage ratio. In addition, their results suggest that the PCA standards led to significant reduction in credit risk.

In this paper, our aim is not to study the effect of a reinforcement of capital requirements on bank risk but simply to assess the impact of changes in capital on bank risk taking when banks have to comply with a minimum capital ratio requirement. We

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<sup>2</sup> In December 1991, the U.S. Congress adopted the Federal Deposit Insurance Corporation Improvement Act (FDICIA) with two key provisions: the first for early closure of institutions and the second for prompt corrective action (PCA). PCA involved early intervention in problem banks by bank regulators. Banks are classified into one of five categories (highly capitalized, adequately capitalized, undercapitalized, significantly undercapitalized and critically undercapitalized) function of their total risk-based capital ratio, Tier 1 risk-based capital ratio, and Tier 1 leverage ratio. Bank regulators impose increasingly severe restrictions to undercapitalized banks as their capital ratios decline.

therefore study the risk-taking behavior of banks that we consider as undercapitalized, adequately capitalized and highly capitalized with regards to the 8% minimum rule.

In addition, for deeper insights, we disaggregate bank capital into equity capital, subordinated debt and hybrid capital i.e. the different components of regulatory capital. Banks' risk-taking behavior may be different according to the type of capital that they choose to increase. Subordinated debt holders are expected to be very sensitive to individual bank risk exposure since they are the first to bear any losses in excess to the bank's equity (Evanoff and Wall, 2002). However, when banks face distress, their interests can be aligned with those of shareholders. Finally, hybrid capital presents the characteristics of both equity and debt. Their holders may also behave differently.

We consider banks in 17 European countries and we classify them in three categories: undercapitalized (total risk-based capital ratio lower than 8%), adequately capitalized (total risk-based capital ratio between 8 and 10%) and highly capitalized banks (total risk-based capital ratio at least equal to 10%). We take as a starting point the classification made in the FDICIA under the prompt corrective action in the US. In European countries there are only two categories of banks: undercapitalized (total risk-based capital ratio lower than 8%) and well capitalized banks (total risk-based capital ratio greater than 8%). Explicit prompt corrective action capital zones do not exist in Europe.

Our paper contributes to the existing banking literature in several ways. First we assess the risk-taking behavior of distressed European banks which do not comply with regulatory standards. Second, we investigate whether it might be useful to distinguish banks with different levels of total capital ratios from a regulatory perspective. Finally, we study the effect of a change in each component of regulatory capital (equity capital, subordinated debt and hybrid capital) on bank risk taking. We assume that bank risk-taking depends not only on the amount of capital held but also on the different components of capital defined by regulators. From this perspective, our approach is expected to help supervisors to better monitor banks with different regulatory capital structures.

The paper is organized as follows. Section 2 presents the hypotheses, the variables and the econometric specification. Section 3 describes the data and presents some preliminary statistics. Section 4 discusses our estimation results and robustness checks. Section 5 concludes the paper.

## 2.Hypotheses, variables and econometric specification

### 2.1 Hypotheses tested

The earlier literature has assessed the impact of capital requirement on banks' solvency in a complete market setting (Kahane, 1977, Kareken and Wallace, 1978, and Sharpe, 1978). Authors as Koehn and Santomero (1980) and Kim and Santomero (1988) have introduced an incomplete market setting using a portfolio approach<sup>3</sup>. Koehn and Santomero (1980) show that the rational response of bank shareholders to an increase in capital imposed by the regulator is to increase the riskiness of their asset portfolio. Based on the same portfolio approach, Kim and Santomero (1988) show that a minimum capital requirement could mitigate higher risk taking if risk weights are accurately defined by regulators. Calem and Rob (1999) model the dynamic portfolio choice that banks face. They consider that different banks have different capital positions and this may influence the relationship between risk and capital. They find that an ex-ante well-capitalized bank will take additional portfolio risk as it adds capital. They also highlight that a severely undercapitalized bank tends to take on maximal risk. As capital rises to a more modestly undercapitalized level, the bank will reduce its risk exposure. Severely undercapitalized banks have little to lose in the event of insolvency and higher risk taking is their best way to recapitalize<sup>4</sup>. At higher capital levels, the incentives to take on higher risk are mitigated because banks could experience a loss of capital without becoming insolvent. At still higher capital levels, banks have a larger 'cushion'. Therefore, additional risk is associated with a lower risk of becoming insolvent. The incentives to invest in riskier assets rises again. Consequently, we assume that the risk-taking behavior of a bank depends on its ex-ante capital position.

*H1: For highly capitalized and adequately capitalized banks an increase in capital is associated to higher risk taking. For undercapitalized banks the sign of the relationship is ambiguous.*

*H2: Banks that are severely undercapitalized behave differently than banks that are modestly undercapitalized.*

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<sup>3</sup> The portfolio approach applied to banks and more generally to financial intermediaries has been developed by Pyle (1971) and Hart and Jaffee (1974).

<sup>4</sup> Furlong and Keeley (1989) and Keeley and Furlong (1990) also show that the risk-shifting benefit of deposit insurance leads to extreme risk taking when banks hold little capital. Using a dynamic framework, Blum (1999), shows that, because raising equity is costly, the reaction of a bank to an increase in capital standards is to increase risk in the first period.

Furthermore, bank regulatory capital is composed of different elements (equity, subordinated debt, and hybrid capital). Banks' risk-taking behavior may be different according to the type of capital that they choose to increase. In fact, subordinated debt holders are expected to be very sensitive to individual bank risk exposure since they are the first to bear any losses in excess to the bank's equity. 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). When banks are adequately or well capitalized, subordinated debt holders prefer less risky assets. However, when banks face distress, the interests of subordinated debt holders can be aligned to those of shareholders. In that case, in the absence of regulatory prompt corrective action, troubled banks may "gamble for resurrection" (Calem and Rob, 1999, Rochet 1992). Hybrid capital presents both the characteristics of equity and debt. Their holders may also behave differently.

*H3: The impact of changes in capital on bank risk taking is different according to the type of capital (equity, subordinated debt, hybrid capital) increased.*

## **2.2. Variables**

### **2.2.1. Dependent variable**

We use two different measures of risk changes: the annual changes in the ratio of risk-weighted assets to total assets and those in the ratio of non-performing loans to net loans.

#### **Changes in risk-weighted assets**

The ratio of risk-weighted assets to total assets is a regulatory definition of asset risk. This ratio captures the allocation of bank assets among different risk categories. In the initial regulatory environment of Basel I designed in 1988 and implemented in January 1993, risk-weighted assets were computed to provide a rough measure of credit risk. Corporate loans were assigned a coefficient of 100%, loans secured by a mortgage a weight of 50%, loans to international organizations and non OECD States, 20% and loans to OECD States, 0%. Since 1996, risk-weighted assets have also taken market risk and off balance sheet risk into consideration. In its first pillar, the new capital requirement (Basel II) has also added operational risk in the computation of risk-weighted assets. However, banks can also use ratings defined internally or external ratings provided by private

agencies to evaluate their credit risk. Since Basel II came into effect in 2008, we focus on the Basel I weightings which cover our sample period (1992-2006).

This measure has already been broadly used in the literature focusing on the link between bank capital and risk (Aggarwal and Jacques (2001), Jacques and Nigro (1997), Rime (2001), and Shrieves and Dahl (1992)). Other studies based on smaller samples of publicly traded banks use market risk indicators (Bichsel and Blum (2004)). Because our study is based on a large sample of both publicly traded and private banks we limit our investigation to accounting-based measures. Our measure is a rough proxy of risk because it merely reflects the allocation of assets among the 4 weighting categories (0, 20, 50 and 100%) but not necessarily their actual riskiness. However, using such a measure also allows us to assess the impact of capital changes on banks' portfolio reallocations among different weighting categories. It should be noted that throughout our sample period which ranges from 1992 to 2006 the ratio of risk-weighted assets to total assets we use has been computed on a homogeneous basis. European banks have only introduced the new methods allowed under Basel II after this period. In our setting, we consider the annual changes in the ratio of risk-weighted assets to total assets ( $\Delta Rwa$ ).

Because this measure of risk is purely based on an institutional definition of risk categories we also use a second measure of risk used in the broader banking literature: the ratio of non-performing loans to net loans.

### **Changes in non-performing loans**

The amount of non-performing loans is an indicator of bank loan portfolio quality. Non-performing loans are generated as the sum of overdue loans, restructured loans and other non-performing loans. Meeker and Gray (1987), Nejezchleb and Morgan (1990), Shrieves and Dahl (1992) and Aggarwal and Jacques (2001) also use this measure of risk. We divide non-performing loans by the outstanding amount of net loans and we consider the annual changes in this ratio in our specification ( $\Delta Npl$ ). We use the annual changes of our risk measures because our aim is to assess the implications of changes in bank capital in terms of higher or lower risk taking. Using 2 proxies of risk changes based on different risk definitions enables us to investigate both the loan portfolio reshuffling effects and the loan quality effects of changes in capital and also to check for their robustness.

## **2.2.2.Explanatory variables**

### **Changes in capital**

In a first specification, we consider the annual changes in the ratio of total capital to total assets ( $\Delta\text{Cap}$ )<sup>5</sup>. Total capital is composed of Tier 1 capital (equity and reserves) and Tier 2 capital (subordinated debt, hybrid capital). In a second specification, we consider the annual changes in the ratios of: equity to total assets ( $\Delta\text{Equity}$ ); subordinated debt to total assets ( $\Delta\text{Sd}$ ) and hybrid capital<sup>6</sup> to total assets ( $\Delta\text{Hyb}$ ). We hence evaluate the impact of changes in each component of capital on bank risk changes for different categories of banks. This decomposition is important since there is an ongoing debate on what type of capital has to be considered in the regulatory capital definition.

### **Undercapitalized, adequately capitalized and highly capitalized banks**

The Basel capital requirement imposes that banks hold a risk-based capital ratio ( $\text{Tr}$ ) at least equal to 8%. This ratio corresponds to total regulatory capital (equity capital, hybrid capital, reserves and subordinated debt, etc) divided by risk-weighted assets. We construct dummy variables to differentiate 3 categories of banks. Banks that exhibit a ratio lower than 8% at the beginning of the year are classified as undercapitalized banks ( $\text{Dum\_under}$ ). Banks with a ratio ranging from 8 to 10% are defined as adequately

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<sup>5</sup> We define the numerator as the sum of equity capital (equity and reserves), subordinated debt and hybrid capital. This definition slightly differs from the one used by regulatory authorities. In practice, regulatory capital is composed of Tier 1 capital, Tier 2 capital and also Tier 3 capital for regulatory authorities in some countries. Tier 1 capital which is the core capital contains equity capital and disclosed reserves. Tier 2 capital is composed of undisclosed reserves, revaluation reserves, general provision/general loan loss reserves (subject to a limit of 1.25 % and 0.6% of risk-weighted assets for respectively the standardised approach and the Internal Rating Based (IRB) approach for credit risk), hybrid debt capital instrument and subordinated debt with a minimum original term to maturity of over five years (not exceeding 50% of Tier 1 capital). Banks can also use a Tier 3 capital, consisting of short term subordinated debt for the unique purpose of meeting a proportion of the capital requirements for market risks (Tier 3 capital limited to 250% of a bank's Tier1 capital that is required for market risks). Moreover, many Basel Committee members recommend that the sum of Tier 2 and Tier 3 capital should not exceed the amount of Tier 1 capital. Finally, some deductions (such as goodwill from Tier 1 capital) have to be made (for more detail, see Basel Committee on Banking Supervision: "International Convergence of Capital Standard, a Revised Framework, Comprehensive Version", Bank for International Settlement, June 2006).

<sup>6</sup> Hybrid capital contains a number of capital instruments combining certain characteristics of equity and certain characteristics of debt. Several elements qualify as hybrid capital: 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.

capitalized (Dum\_ad). Above 10%, banks are considered as highly capitalized (Dum\_high).

We focus on undercapitalized banks by further distinguishing different subsets of banks using other dummy variables. Some of the banks that do not meet the 8% requirement for the total risk-based capital ratio are also below the 4% requirement for the Tier 1 risk-based capital ratio (Dum\_under\_tier1). Some of these banks are only undercapitalized from a total risk-based capital ratio (Tcr) point of view (Dum\_under\_tcr). Bank can react differently to comply with capital regulation. In the first subset, banks have to increase equity capital (Tier 1). In the second subset banks can either increase equity capital or subordinated debt and hybrid capital (Tier 2) and therefore the impact on bank risk taking can be different. In fact equity and subordinated debt holders behave differently.

### **Interaction terms**

To measure the impact of changes in capital on risk changes of undercapitalized, adequately capitalized and highly capitalized banks, we introduce interaction variables by multiplying the changes in capital with each category dummy variable. We expect a positive link between capital and risk changes for adequately and highly capitalized banks but the sign of the relationship is ambiguous for undercapitalized banks. Banks that are undercapitalized at the beginning of the period may reduce risk when forced to increase regulatory capital to avoid supervisory as well as market sanctions. On the other hand, undercapitalized banks may also ‘gamble for resurrection’ by taking more risk when forced to increase capital.

We also assume that the sign of the relationship for undercapitalized banks depends on whether banks are undercapitalized in terms of both the total risk-based capital ratio (Tcr) and the Tier 1 risk-based capital ratio (Tier 1) or only in terms of the total risk-based capital ratio (adequately capitalized in terms of Tier 1). Eventually, we presume that the impact of capital changes on risk changes, for each category of banks, depends on the capital component (equity, subordinated debt, hybrid capital) used by the bank to increase regulatory capital.

### **Control variables**

Bank risk depends on other variables specific to the individual bank and country macroeconomic conditions. We consider several control variables and their expected effects on bank risk changes. We include the one year lagged value of risk with an expected negative sign. We also control for monitoring efforts in line with the theoretical model of Blum (2003) who analyses the impact of capital regulation on the bank's effort to screen and monitor projects. To control for the impact of monitoring on bank risk, we introduce the ratio of personnel expenses to total assets (Monit). A higher monitoring effort may be associated with a higher level of personnel expenses which in turn could alter changes in bank risk. Alternatively, banks with higher personnel expenses may take more risk because they might be able to better monitor borrowers. Therefore, the effect of monitoring costs on risk changes is ambiguous. We also 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 compensate for the lost returns incurred by a more stringent capital regulation. On the other hand, regulators may allow an efficient firm with better management more room for leverage (Altunbas et al., 2007). We also 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) 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 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. Finally, we also consider individual bank dummies and year dummies. Table 1 summarizes the expected signs of the explanatory variables.

Table 1: Explanatory variables and their expected sign

Explanatory variables	Expected sign
Previous year level of risk ( $Rwa_{t-1}$ , $Npl_{t-1}$ )	-
Annual change in undercapitalized bank capital ratio ( $\Delta Cap + \Delta Cap * Dum_{under}$ )	-/+
Annual change in undercapitalized bank equity ratio ( $\Delta Equity + \Delta Equity * Dum_{under}$ )	-/+
Annual change in undercapitalized bank subordinated debt ratio ( $\Delta Sb + \Delta Sb * Dum_{under}$ )	-/+
Annual change in undercapitalized bank hybrid capital ratio ( $\Delta Hyb + \Delta Hyb * Dum_{under}$ )	-/+
Annual change in adequately capitalized bank capital ratio ( $\Delta Cap + \Delta Cap * Dum_{ad}$ )	+
Annual change in adequately capitalized bank equity ratio ( $\Delta Equity + \Delta Equity * Dum_{ad}$ )	+
Annual change in adequately capitalized banks subordinated debt ratio ( $\Delta Sb + \Delta Sb * Dum_{ad}$ )	+
Annual change in adequately capitalized bank hybrid capital ratio ( $\Delta Hyb + \Delta Hyb * Dum_{ad}$ )	+
Annual change in highly capitalized bank capital ratio ( $\Delta Cap$ )	+
Annual change in highly capitalized bank equity ratio ( $\Delta Equity$ )	+
Annual change in highly capitalized bank subordinated debt ratio ( $\Delta Sb$ )	+
Annual change in highly capitalized bank hybrid capital ratio ( $\Delta Hyb$ )	+
Ratio of personnel expenses to total assets (Monit)	-/+
Ratio of costs to income (Eff)	-/+
Logarithm of total assets (Size)	-/+
Growth rate of gross domestic product (Gdp)	-/+

### 2.3. Econometric specification

We consider two specifications in our study. While the first one considers the total capital ratio as a measure of capital, the second decomposes capital into equity, subordinated debt and hybrid capital.

(1)

$$\Delta Risk_{i,t} = \alpha_{0,i} + \alpha_1 Dum\_under_{i,t-1} + \alpha_2 Dum\_ad_{i,t-1} + \alpha_3 \Delta Cap_{i,t} + \alpha_4 \Delta Cap_{i,t} * Dum\_under_{i,t-1} + \alpha_5 \Delta Cap_{i,t} * Dum\_ad_{i,t-1} + \alpha_6 Risk_{i,t-1} + \alpha_7 Monit_{i,t} + \alpha_8 Eff_{i,t} + \alpha_9 Size_{i,t} + \alpha_{10} Gdp_{i,t} + \alpha_{11} Year_t + \varepsilon_{i,t}$$

(2)

$$\Delta Risk_{i,t} = \beta_{0,i} + \beta_1 Dum\_under_{i,t-1} + \beta_2 Dum\_ad_{i,t-1} + \beta_3 \Delta Equity_{i,t} + \beta_4 \Delta Equity_{i,t} * Dum\_under_{i,t-1} + \beta_5 \Delta Equity_{i,t} * Dum\_ad_{i,t-1} + \beta_6 \Delta Sd_{i,t} + \beta_7 \Delta Sd * Dum\_under_{i,t-1} + \beta_8 \Delta Sd * Dum\_ad_{i,t-1} + \beta_9 \Delta Hyb_{i,t} + \beta_{10} \Delta Hyb * Dum\_under_{i,t-1} + \beta_{11} \Delta Hyb * Dum\_ad_{i,t-1} + \beta_{12} Risk_{i,t-1} + \beta_{13} Monit_{i,t} + \beta_{14} Eff_{i,t} + \beta_{15} Size_{i,t} + \beta_{16} Gdp_{i,t} + \beta_{17} Year_t + \varepsilon_{i,t}$$

For each category (undercapitalized, adequately capitalized and highly capitalized banks), we test in the first specification, the significance of the sum of the coefficients associated to changes in capital and the appropriate interaction term. In specification 2, we also test the significance of the sum of the coefficient associated to changes in equity, subordinated debt and hybrid capital and the appropriate interaction term.

## 3. Data description and statistical analysis

### 3.1 Data description

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 differentiated, 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). The data are taken from Bankscope Fitch IBCA,

which provides annual accounting data for 6304 commercial, cooperative 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. For accuracy, we impose the following restrictions. We only retain banks providing information for at least five consecutive years for each of our variables except for the risk-based capital ratio, the risk-weighted assets measure and the non-performing loans ratio. We ensure that the banks we retain in our sample operate during a relatively long period of time. Out of the initial 6304 banks we are left with 3459 commercial, cooperative and savings European banks. We further restrict our sample by excluding cooperative banks and end up with 2110 commercial and savings banks. As argued by Brewer III, Kaufman and Wall (2008), ‘cooperative banks objective function is likely to include more than maximizing long-run shareholder value and may be subject to broader safety-net and other government guarantees’.

Finally, we only retain banks providing information on the risk-based capital ratio. We end up with an unbalanced panel of 598 commercial banks and 274 savings banks. A description of our sample for each country is provided in table A1 in the appendix. During our sample period, 75 banks are, at some stage, undercapitalized corresponding to a total of 139 observations. 323 banks are adequately capitalized and 833 highly capitalized. Among undercapitalized banks, 18 are undercapitalized in terms of the risk-based capital ratio as well as in terms of the Tier 1 risk-based capital ratio.

The number of undercapitalized banks is higher in Italy (46 banks) and France (14 banks) than in other countries. In our sample, French banks remain undercapitalized during a longer period than Italian banks (2.78 years against 1.71 year on average). The Italian and French banking systems faced major difficulties during certain sub-periods of our study<sup>7</sup>. The majority of the French banks that appear as undercapitalized in our sample are tracked between 1992 and 1996. During this period, the French government started to disengage from credit institutions and there was a need to improve the efficiency of French banking system. In the case of Italy, most of the undercapitalized

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<sup>7</sup> For more details, see the Annual Report of the Banque de France (1996) and Carletti (2007).

banks of our sample are in this position from 1998 to 2006. The performance of Italian banks has been generally very poor since the mid 1990s and the Italian banking system has experienced two waves of mergers and acquisitions in the late 1990s (1998-2002) and in the mid 2000s (2005-2006).

The sample contains 464 large banks (with total assets greater than 1 billion of Euros) and 120 listed banks. To assess the representativeness of our sample, we divide the sum of the total assets of commercial and savings banks in our sample by the sum of the total assets of all the commercial and savings banks available in Bankscope for each country in 2001. The value of the ratio exceeds 50% except for Austria, United Kingdom, Ireland, and Luxembourg. The largest numbers of banks of our sample are in Italy and France (respectively 202 and 148). In fact, both countries (with Germany) also present the largest number of banks in their banking system. The distribution of the sample by year is relatively homogenous except for the first three years (see table A2). We check that the main European commercial and savings banks are in our sample. Table A3 provides information on risk-based capital ratios for the ten largest banks of our sample.

Bank risk-based capital ratios vary across countries and years. Table A4 shows that Swedish banks present the highest ratios whereas German banks present the lowest ones. We note (table A5) that, on average for European banks, the risk-based capital ratio increased from 13.03% in 1992 to 16.08% in 1996 when it reached a peak. A similar trend can be observed for the Tier 1 ratio showing that the implementation of the Basel I accord in 1992 led to an important increase in the capital standards of European banks from 1992 to 1996. Because the efficiency variable and the proxy of monitoring are highly correlated (see table A6 in the appendix) we do not include the efficiency variable in our general specification. We perform the estimations with the proxy of efficiency as robustness checks.

### **3.2. Statistical analysis**

Table 2 and 3 present descriptive statistics for our variables and mean difference tests for our 3 categories of banks (undercapitalized, adequately capitalized and highly capitalized). The mean of the total risk-based capital ratio variable (Tcr) is equal to 14.85%, 6.85% above the minimum regulatory requirement. However, the ratio of total capital to total assets is smaller (10.08%) than the Tcr ratio. On average, Tier1 capital

represents 11.95% of risk-weighted assets. Equity capital represents 80.40% of bank total capital.

Table 3 shows 139 bank-year observations for undercapitalized banks. 951 observations present a risk-based total capital ratio between 8 and 10%. For 5163 observations the risk-based total capital ratio is greater than 10%. Mean difference tests show that, on average, undercapitalized banks exhibit larger ratios of non-performing loans than adequately capitalized and highly capitalized banks. The ratio of risk-weighted assets to total assets is also statistically higher for undercapitalized banks than highly capitalized banks. However, there is no significant difference between the ratio of equity to total assets of undercapitalized and adequately capitalized banks. Highly capitalized banks hold a relatively higher portion of equity capital with respect to total Tier 1 and Tier 2 capital (82.05% of their total capital) than adequately and undercapitalized banks. Adequately capitalized banks are the largest banks. Highly capitalized banks are on average the most profitable ones and exhibit significantly higher ROAs (return on assets) and interest margins but also higher ROEs (return on equity) despite their lower leverage. They are also more efficient than adequately capitalized and undercapitalized banks. When we consider the two subsets of undercapitalized banks the results show that banks that are undercapitalized in terms of both the Tier 1 and the Tier 2 definition are significantly less profitable and exhibit on average a negative ROA value (-0.25%) and a negative mean ROE (-26.77%). Such banks also hold a relatively lower portion of equity capital in total capital. Moreover, banks that are undercapitalized in terms of both the Tcr and Tier 1 exhibit extremely low capital ratios with a mean Tcr and Tier 1 values respectively equal to 3.44% and 2.16%.

Table 2. Descriptive statistics

	$\Delta Rwa$	$\Delta Npl$	$\Delta Cap$	Npl	Rwa	Tcr	Tier1	Cap	Eqty	Eqty_Cap	Sub_Cap	Hyb_Cap	Monit	Eff	Asset	Gdp	Roa	Roe	Net
Mean	0.97	-0.36	0.02	5.02	68.32	14.85	11.95	10.08	8.78	80.40	16.95	2.63	1.46	66.186	26926846	2.15	0.72	8.96	3.21
Median	0.66	-0.21	0.00	3.51	67.57	12.87	9.90	8.99	7.59	80.67	17.34	0.00	1.40	65.554	2082999	2.01	0.68	9.02	3.12
Max	60.50	28.44	26.03	54.97	122.69	54.64	54.90	48.93	48.93	100	78.31	61.90	6.92	194.444	149000000	11.68	20.79	152.08	45.8
Min	-44.1	-35.4	-35.5	0	14.60	0.00	0.00	1.16	0.60	21.18	0.00	0.00	0.03	5.303	9540	-3.73	-42.34	-174.73	-4.6
Std	7.28	2.71	2.08	5.75	18.42	6.78	6.76	4.89	5.03	16.72	14.46	6.45	0.76	17.162	92474064	1.66	1.28	13.12	1.86

$\Delta Rwa$ = Annual changes in the ratio of risk-weighted assets to total assets;  $\Delta Npl$ = Annual changes in the ratio of non-performing loans to net loans;  $\Delta Cap$ = Annual changes in the ratio of total capital to total asset; Npl= Non-performing loans to net loans; Rwa= Risk-weighted assets to total assets; Tcr= Ratio of total capital to risk-weighted assets; Tier1= Ratio of Tier 1 capital to risk-weighted assets; Cap=Total capital/Total assets=(Equity capital+Subordinated debt+Hybrid capital)/Total assets; Eqty=Equity capital/Total assets; Eqty\_Cap= (Equity capital) / (Equity capital+Subordinated Debt+Hybrid capital); Sub\_Cap=(Subordinated debt) / (Equity capital+Subordinated Debt+Hybrid capital); Hyb\_Cap=(Hybrid capital) / (Equity capital+Subordinated Debt+Hybrid capital); Monit= Personnel expenses to total assets; Eff=Total costs to income before provisions and taxes; Asset= Total assets expressed in thousands of euros; Gdp= Growth rate of Gross Domestic product; Roa= Return on assets; Roe= Return on equity; Net\_margin=Net interest income to total earning assets.

Table 3. Mean difference tests between undercapitalized, adequately capitalized and highly capitalized banks' characteristics

		Npl	Rwa	Tcr	Tier1	Equity	Equity Cap	Sb Cap	Hyb Cap	Monit	Eff	Asset	Roa	Roe	Net margin
Under_tier1	Mean	7.45	75.65	3.44	2.16	6.80	58.08	39.45	2.47	1.51	78.49	18707026	-0.25	-26.77	2.95
	Std	5.27	13.63	2.33	1.39	6.76	25.11	23.74	4.63	0.78	31.188	29598038	2.19	56.11	1.32
	n	19	12	26	26	25	19	19	19	26	23	26	26	24	24
Under_tcr	Mean	7.35	71.15	7.15	6.11	5.08	81.09	17.72	1.19	1.31	72.043	25692701	0.42	7.26	2.66
	Std	7.06	17.89	0.71	1.05	1.93	14.86	14.20	2.89	0.60	21.559	49192825	0.73	17.48	1.42
	n	69	69	82	82	82	45	45	45	82	68	82	82	82	68
Undercap	Mean	7.56	71.78	6.34	5.16	5.29	70.99	25.28	3.71	1.45	74.475	19501347	0.24	0.04	2.87
	Std	6.40	17.13	1.96	2.04	3.56	21.28	18.9	7.31	0.67	23.564	40771988	1.20	31.21	1.31
	n	103	83	139	108	138	79	79	79	139	119	139	139	137	120
Adcap	Mean	5.90	70.88	9.11	7.11	5.67	72.86	22.57	4.56	1.35	68.021	33172822	0.46	8.20	2.76
	Std	5.08	16.89	0.55	1.47	2.56	16.11	13.09	8.03	0.65	16.955	68633404	0.72	12.68	1.44
	n	630	607	951	758	951	549	549	549	947	803	951	951	949	806
Highcap	Mean	4.71	67.74	16.13	13.17	9.44	82.05	15.69	2.25	1.48	65.625	25976279	0.80	9.01	3.31
	Std	5.83	18.68	6.77	6.95	5.15	16.22	14.25	6.02	0.78	17.65	97140269	1.33	11.24	1.93
	n	2658	3222	5163	3629	5161	2971	2971	2971	5131	4393	5163	5163	5161	4418
Under_tier1-Under_tcr		0.10 (0.05)	4.49 (0.82)	-2.70*** (-12.72)	-3.94*** (-15.31)	1.72 (1.25)	-23.00*** (-4.56)	17.51** (4.53)	1.27 (1.33)	0.20 (1.36)	6.447 (0.92)	-6985675 (-0.68)	-0.67** (-2.41)	-34.04*** (-4.79)	0.28 (0.86)
Undercap-Adcap		1.66** (2.50)	0.90 (0.45)	-2.77*** (-16.58)	-1.95*** (-9.57)	-0.38 (-1.22)	-1.87 (-0.74)	2.71 (1.23)	-0.85 (-0.95)	0.10* (1.75)	6.021** (2.88)	- (-3.32)	-0.29** (-2.41)	-10.20*** (-3.31)	0.11 (0.82)
Undercap-Highcap		2.85*** (4.44)	4.04** (2.11)	-9.79*** (-51.26)	-8.01*** (-35.12)	-4.15*** (-13.32)	-11.06*** (-4.58)	9.59*** (4.47)	1.46* (1.75)	-0.02 (-0.38)	65.625** (4.066)	-6474932* (-1.74)	-0.55*** (-5.31)	-8.97*** (-3.35)	-0.44*** (-3.57)
Adcap-Highcap		1.19*** (5.13)	3.13*** (4.12)	-7.02*** (-73.18)	-6.05*** (-47.62)	-3.76*** (-34.29)	-9.18*** (-12.26)	6.87*** (11.14)	2.31*** (6.41)	-0.12*** (-5.39)	2,396** (3,658)	7196543*** (2.76)	-0.33*** (-11.32)	-0.81* (-1.84)	-0.54*** (-9.35)

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level

Under\_tier1= Banks with a Tcr less than 8% and a Tier1 ratio less than 4%; Under\_tcr= Banks with a Tcr less than 8% and a Tier1 ratio at least equal to 4%; Undercap= Banks with Tcr less than 8%; Adcap= Banks with a Tcr between 8 and 10%; Wellcap= Banks with a Tcr greater than 10%; Npl= Non-performing loans to net loans; Rwa= Risk-weighted assets to total assets; Tcr= Ratio of regulatory total capital to risk-weighted assets; Tier1= Ratio of Tier 1 capital to risk-weighted assets; Equity=Equity capital/Total assets; Equity\_Cap= (Equity capital) / (Equity capital+Subordinated Debt+Hybrid capital); Sb\_Cap=(Subordinated debt) / (Equity capital+Subordinated Debt+Hybrid capital); Hyb\_Cap=(Hybrid capital) / (Equity capital+Subordinated Debt+Hybrid capital); Monit= Personnel expenses to total assets; Eff=Total costs to income before provisions and taxes; Asset= Total assets in thousand of euro; Roa= Return on assets; Roe= Return on equity; Net\_margin=Net interest income to total earning assets.

## 4. Estimation results

A first inspection of our variables shows that changes in capital ( $\Delta\text{Cap}$ ) and the ratio of personnel expenses (Monit) are endogenous. Following Arrelano and Bover (1995), we use the lagged value of capital (in level) and the lagged value of changes in personnel expenses as instruments for respectively the annual changes in capital and the ratio of personnel expenses to total assets. We also employ the second year lags of risk variables as an instrument for  $\text{Risk}_{i,t-1}$ . We use the generalized method of moments (GMM)<sup>8</sup> to estimate the coefficients of our model. We consider individual fixed effects and year dummy variables. Table 4 gives the results for the impact of changes in capital on changes in risk. The estimation results for the specification where capital is disaggregated in 3 components, equity, subordinated debt and hybrid capital, are presented in table 5.

### 4.1 Impact of changes in capital on risk taking

On the whole, the coefficients are significant with the expected signs. For each category (undercapitalized, adequately capitalized and highly capitalized banks), we test the significance of the sum of the coefficients associated to changes in capital and the appropriate interaction term. For undercapitalized banks, we find a significant negative relationship between changes in capital and changes in risk (Equations 1 and 4). 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. Such behavior should reduce their probability of default since lower leverage is associated with lower asset risk. When we separate undercapitalized banks into two sub-categories, we note that

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<sup>8</sup> This method is more consistent than OLS because the annual changes in capital as well as the monitoring variable are endogenous and the lag of the dependent variable is used as an explanatory variable. Using OLS would therefore leave our estimations biased. The two and three stage least square (2SLS/3SLS) estimators may help to solve these problems and produce consistent estimate. 3SLS produces asymptotically more efficient estimates (Heid et al, 2003) than 2SLS. 2SLS gives the estimation of the endogenous variables one by one whereas 3SLS provides simultaneous system estimations. However, any specification error in the structure of the model will be propagated in the entire system by 3SLS. Since we are interested in banks' risk-taking behavior and the correlation between the residuals of risk and capital equations are low, we do not estimate our equations in a system. Moreover, there is heteroscedasticity in our sample. Therefore, GMM estimation is more appropriate than the Instrumental Variable method.

the reduction in risk only holds for banks that are simply undercapitalized in terms of the total risk-based capital ratio, Tcr (Equation 2). The opposite result holds for institutions that neither meet the Tcr nor the Tier 1 requirement (Equation 3). For such banks, we highlight a positive relationship between changes in capital and changes in the ratio of risk-weighted assets to total assets. These banks which are extremely undercapitalized with a mean value of Tcr and Tier 1 respectively equal to 3.44% and 2.16% may be stuck in very bad projects. They also might be aiming a high expected return on equity by reshuffling 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 7.15%. However, these results have to be considered with caution since, in our sample, the number of undercapitalized banks in terms of Tcr as well as Tier1 is relatively low (18 banks).

For adequately capitalized and highly capitalized banks, we find a positive relationship between changes in capital and risk as expected.

Regarding the control variables, the ratio of personnel expenses to total assets is negatively linked to changes in the ratio of risk-weighted assets to total assets (Equations 2 and 3). This result suggests that higher monitoring efforts are successful in reducing the extent of risk in bank assets in general. Inversely, we find a positive relationship between monitoring and changes in the ratio of non-performing loans to net loans. The effect of bank size on changes in the ratio of risk-weighted assets to total assets is negative (Equations 2 and 3). Large banks are generally more diversified and hold different types of assets including those with very low risk weights such as government bonds, which could explain this negative sign. However, we find a positive relationship between bank size and changes in the ratio of non performing to net loans suggesting that larger banks might hold riskier loan portfolios. As expected, better economic conditions contribute to lower the amount of non-performing loans in bank balance sheets (Equations 4). Also, the significance of the coefficients confirm that, during booms, banks tend to focus on assets with higher risk coefficients such as corporate loans (Equation 1, 2 ).

## **4.2 Impact of changes in equity, subordinated debt and hybrid capital on bank risk taking**

We 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. Table 5 gives the estimation results and shows that the impact of changes in the equity ratio on changes in risk is negative for undercapitalized banks (Equations 1 and 4). Results are significant for both measures of risk. We still observe differences in the behavior of our two groups of undercapitalized banks. Equations 2 and 3 show a negative relationship between changes in the equity ratio and changes in the ratio of risk-weighted assets to total assets for the first group (banks undercapitalized in terms of Tcr) but a positive association between changes in the same ratios for the second group (banks undercapitalized in terms of both the Tcr and the Tier1). The results show a negative link between changes in the equity ratios and changes in the ratios of non-performing loans for undercapitalized banks in term of Tcr (Equation 5). Such banks seem to be cleaning up their assets by reducing non-performing loans. However, this relationship is not significant for undercapitalized banks in terms of both the Tcr and the Tier1). For adequately and highly capitalized banks, there is a positive relationship between changes in equity ratio and changes in the risk-weighted assets ratio (Equations 1, 2 and 3) . This finding is consistent with the previous result (impact of changes in the ratio of total capital).

The impact of changes in subordinated debt on risk changes is positive for undercapitalized banks (equations 2, 4 and 5). We also find a positive relationship between changes in hybrid capital and changes in risk (Equations 1 and 2). Undercapitalized banks do not seem to select less risky assets when they increase their Tier 2 capital. They seem to shift towards riskier assets. For adequately capitalized banks, changes in the ratio of hybrid capital are positively associated with changes in the ratio of risk-weighted assets to total assets (Equations 1 and 2). For highly capitalized banks, changes in the ratio of subordinated debt are positively linked to changes in the ratio of risk-weighted assets (Equations 1 and 2).

The signs of the control variables remain globally the same as those in the previous more general specification. We highlight a positive relationship between monitoring and changes in the ratio of non-performing loans to net loans (Equations 4 and 5). We find a

negative link between bank size and the ratio of risk-weighted assets to total assets (Equation 3) but a positive one with the ratio of non-performing loans to net loans (Equation 4). 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 (Equations 1, 2 and 3) but a negative and significant effect on changes in the ratio of non-performing loans to net loans (Equations 4 and 5).

### 4.3. Robustness checks

Several robustness checks are performed. We present in table 6 the results of the estimations taking the efficiency proxy into account. On the whole, the results remain unchanged. For undercapitalized banks, we find a negative relationship between changes in capital and changes in the ratio of risk-weighted assets to total assets (Equation 1). Conversely, adequately and highly capitalized banks experience an increase in risk when their capital increases (Equations 1 and 4). We find a positive link between the ratio of costs to income and changes in the ratio of non-performing loans to net loans. Less efficient banks seem to take higher risk to compensate for lower returns.

We run estimations on three sub-periods, 1992-1996, 1997-2001, and 2002-2006 (Table 7). In fact the data show that capital ratios increase until 1996 and remain relatively stable after this period (Table A5 in appendix). We can assume that the capital rule was binding on the sub-period 1992-1996. For undercapitalized banks, we find a negative link between changes in the ratio of risk-weighted assets to total assets and changes in the total capital ratio on the sub-periods 1992-1996 and 1997-2001. We also find a negative relationship between changes in the total capital ratio and changes in the ratio of non-performing loans to net loans on the sub-period 1997-2001. For adequately capitalized banks, we highlight a positive relationship between changes in the total capital ratio and changes in the ratio of risk-weighted assets to total assets on the sub-periods 1992-1996 and 1997-2001. The link between changes in capital and changes in non-performing loans is positive during the sub-period 2002-2006. For highly capitalized banks, the positive relationship between changes in capital and changes in risk-weighted assets is significant on the sub-periods 1997-2001 and 2002-2006. A significant positive relationship is found between changes in capital and changes in the ratio of non-performing loans to net loans on the sub-period 1992-1996 and a negative and significant link for the sub-period 1997-2001.

Since there are many undercapitalized Italian and French banks in our sample, we also estimate our equations with solely these banks and also provide results ignoring Italian and French banks (Table 8) in our estimations. For Italian and French undercapitalized banks we find a negative relationship between changes in the ratio of risk-weighted assets to total assets and changes in the total capital ratio. The relationship between changes in capital and changes in risk-weighted assets is positive and significant for Italian and French

adequately capitalized banks. For highly capitalized banks, changes in capital and changes in the ratio of risk-weighted assets are positively linked for both sub-samples. However, changes in capital and changes in non-performing loans are positively linked only for the sub-sample that excludes French and Italian banks.

We also run the estimations on the sub-samples of adequately, highly and banks that we specify as well capitalized banks (Table 9). Well capitalized banks are defined as banks with a total risk-based capital ratio greater than 8%, the minimum requirement. The impact of changes in capital on changes in risk is positive and significant for the three sub-samples (Equations 1, 2, 3, 5 and 6), a result which is in accordance with the results highlighted in table 4. Adequately, highly and well capitalized banks increase their risk taking when they increase capital.

Finally, as the literature recognizes that bank capital behavior is endogenous, we estimate the impact of changes in risk on changes in capital (Table 10). For adequately and highly capitalized banks, we find a positive relationship between changes in non-performing loans and capital changes which is consistent with the result found regarding the impact of capital changes on changes in non-performing loans. For undercapitalized banks we do not find a significant impact of changes in risk on capital changes. Such banks do not seem to adjust capital following an increase or decrease in risk.

Table 4. Impact of changes in capital on European banks' risk changes (1992-2006)

	$\Delta Rwa$			$\Delta Npl$		
	(1)	(2)	(3)	(4)	(5)	(6)
Dum_under ( $\alpha_1$ )	-5,825*** (-3,869)			0,568 (1,574)		
Dum_under_tcr ( $\alpha_1$ )		-5,343*** (-3,254)			-0,002 (-0,005)	
Dum_under_tier1 ( $\alpha_1$ )			-17,52*** (-3,452)			1,077 (1,326)
Dum_ad ( $\alpha_2$ )	-3,012*** (-4,868)	-3,017*** (-4,569)	-2,811*** (-4,248)	0,004 (0,022)	-0,036 (-0,214)	-0,027 (-0,157)
$\Delta Cap$ ( $\alpha_3$ )	1,807*** (6,493)	1,853*** (6,328)	1,755*** (5,962)	0,224*** (3,264)	0,2*** (3,019)	0,247*** (3,691)
$\Delta Cap * Dum\_under$ ( $\alpha_4$ )	-2,751*** (-5,773)			-0,444*** (-3,238)		
$\Delta Cap * Dum\_under\_tcr$ ( $\alpha_4$ )		-2,995*** (-5,698)			-0,33** (-2,248)	
$\Delta Cap * Dum\_under\_tier1$ ( $\alpha_4$ )			1,319 (0,796)			-0,51 (-1,47)
$\Delta Cap * Dum\_ad$ ( $\alpha_5$ )	-0,792* (-1,857)	-0,786* (-1,748)	-0,677 (-1,503)	-0,058 (-0,485)	-0,059 (-0,48)	-0,129 (-1,049)
$Rwa_{t-1}$ ( $\alpha_6$ )	0,026 (0,642)	0,019 (0,311)	0,016 (0,256)			
$Npl_{t-1}$ ( $\alpha_6$ )				-0,312*** (-11,529)	-0,314*** (-10,898)	-0,308*** (-10,642)
Monit ( $\alpha_7$ )	-2,528 (-1,213)	-7,173*** (-2,847)	-8,723*** (-3,313)	1,917** (2,46)	1,186 (1,456)	0,57 (0,672)
Size ( $\alpha_8$ )	-0,905 (-0,867)	-3,677*** (-2,908)	-4,279*** (-3,343)	1,127*** (3,003)	0,858** (2,244)	0,677* (1,715)
Gdp ( $\alpha_9$ )	0,675*** (4,084)	0,695*** (3,905)	0,642 (3,599)	-0,159*** (-2,933)	-0,093 (-1,599)	-0,043 (-0,738)
Jstat	111,307	96,614	113,021	228,625	251,44	273,178
F.test : $\alpha_3 + \alpha_4 = 0$	-0,944*** (4,265)	-1,142** (5,214)	3,074* (3,347)	-0,221* (2,915)	-0,13 (0,862)	-0,262 (0,59)
$\alpha_3 + \alpha_5 = 0$	1,014*** (8,828)	1,067*** (8,856)	1,078*** (9,02)	0,166* (2,82)	0,14 (1,691)	0,118 (1,209)
Obs	2644	2334	1762	2150	1762	1724

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics.

$\Delta Rwa$ = Annual changes in the ratio of risk weighted assets to total assets;  $\Delta Npl$ = Annual changes in the ratio of non-performing loans to net loans; Dum\_under=1 when bank-risk based capital ratio<8% in the previous year, 0 otherwise; Dum\_under\_tcr=1 when bank risk-based capital ratio<8% and tier1 ratio  $\geq 4$  in the previous year, 0 otherwise; Dum\_under\_tier1=1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; Dum\_ad=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise);  $\Delta Cap$ = Annual changes in the ratio of total capital to total assets;  $Rwa_{t-1}$ = Previous year ratio of risk weighed assets to total assets;  $Npl_{t-1}$  = Previous year ratio of non-performing loans to net loans; Monit= Personnel expenses to total assets; Size=Logarithm of total asset; Gdp= Growth rate of Gross Domestic product.

Table 5. Impact of changes in equity, subordinated debt and hybrid capital on European banks' risk changes (1992-2006)

	$\Delta Rwa$			$\Delta Npl$		
	(1)	(2)	(3)	(4)	(5)	(6)
Dum_under ( $\beta_1$ )	-4,3*** (-2,274)			-0,408 (-0,643)		
Dum_under_tcr ( $\beta_1$ )		-6,139** (-2,558)			-0,907 (-1,119)	
Dum_under_tier1 ( $\beta_1$ )			-19,479*** (-3,109)			1,373 (1,631)
Dum_ad ( $\beta_2$ )	-2,059*** (-2,828)	-1,877*** (-2,579)	-2,64*** (-4,168)	0,077 (0,299)	0,187 (0,78)	0,017 (0,101)
$\Delta Equity$ ( $\beta_3$ )	2,287*** (3,828)	1,924*** (3,477)	1,927*** (6,154)	-0,015 (-0,092)	-0,136 (-0,816)	0,251*** (3,349)
$\Delta Equity * Dum\_under$ ( $\beta_4$ )	-5,192*** (-6,384)			-0,448* (-1,651)		
$\Delta Equity * Dum\_under\_tcr$ ( $\beta_4$ )		-7,142*** (-7,649)			-0,479 (-1,493)	
$\Delta Equity * Dum\_under\_tier1$ ( $\beta_4$ )			1,233 (0,658)			-0,621* (-1,839)
$\Delta Equity * Dum\_ad$ ( $\beta_5$ )	0,13 (0,152)	0,536 (0,612)	-0,566 (-1,063)	-0,066 (-0,256)	0,182 (0,669)	-0,194 (-1,216)
$\Delta Sd$ ( $\beta_6$ )	1,158*** (3,915)	1,137*** (3,862)		-0,191 (-1,438)	-0,205 (-1,661)	
$\Delta Sd * Dum\_under$ ( $\beta_7$ )	0,862 (0,46)			1,401** (2,041)		
$\Delta Sd * Dum\_under\_tcr$ ( $\beta_7$ )		4,254 (1,363)			2,624** (2,371)	
$\Delta Sd * Dum\_under\_tier1$ ( $\beta_7$ )						
$\Delta Sd * Dum\_ad$ ( $\beta_8$ )	-0,467 (-0,624)	-0,005 (-0,007)		0,225 (0,771)	0,246 (0,914)	
$\Delta Hyb$ ( $\beta_9$ )	0,397 (0,486)	0,711 (0,878)		0,263 (0,817)	0,203 (0,696)	
$\Delta Hyb * Dum\_under$ ( $\beta_{10}$ )	76,166*** (3,257)			2,593 (0,797)		
$\Delta Hyb * Dum\_under\_tcr$ ( $\beta_{10}$ )					16,487 (1,226)	
$\Delta Hyb * Dum\_under\_tier1$ ( $\beta_{10}$ )		214,781*** (3,493)				
$\Delta Hyb * Dum\_ad$ ( $\beta_{11}$ )	3,02 (1,585)	3,312 (1,622)		-0,009 (-0,014)	0,101 (0,174)	
$Rwa_{t-1}$ ( $\beta_{12}$ )	-0,087 (-1,474)	-0,119** (-2,12)	0,033 (0,576)			
$Npl_{t-1}$ ( $\beta_{12}$ )				-0,057 (-1,041)	-0,261*** (-4,245)	-0,325*** (-11,404)
Monit ( $\beta_{13}$ )	3,836 (0,93)	9,654*** (2,268)	-8,774*** (-3,166)	3,829** (2,144)	3,47** (2,204)	0,397 (0,479)
Size ( $\beta_{14}$ )	0,82 (0,4)	3,256 (1,489)	-3,838*** (-2,85)	1,582** (2,098)	0,83 (1,22)	0,618 (1,62)
Gdp ( $\beta_{15}$ )	0,7*** (3,895)	0,881*** (4,794)	0,734*** (3,974)	-0,218*** (-3,258)	-0,187*** (-2,936)	-0,039 (-0,039)
Jstat	56,568	51,376	111,927	98,987	138,035	287,983
F.test: $\beta_3 + \beta_4 = 0$	-2,905*** (17,058)	-5,218*** (36,595)	3,16* (2,75)	-0,462* (3,071)	-0,615*** (3,686)	-0,37 (1,24)
$\beta_3 + \beta_5 = 0$	2,417*** (12,736)	2,459*** (12,186)	1,36*** (8,965)	-0,081 (0,143)	0,046 (0,039)	0,057 (0,151)
$\beta_6 + \beta_7 = 0$	2,02 (1,19)	5,391* (3,019)		1,21* (3,219)	2,419*** (4,88)	
$\beta_6 + \beta_8 = 0$	0,69 (1,003)	1,132 (2,659)		0,034 (0,018)	0,041 (0,03)	
$\beta_9 + \beta_{10} = 0$	76,563*** (10,747)	215,492*** (12,287)		2,856 (0,774)	16,691 (1,543)	
$\beta_9 + \beta_{11} = 0$	3,417*** (3,999)	3,823** (4,897)		0,254 (0,23)	0,304 (0,37)	
Obs	1354	1253	2295	1030	917	1724

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics.

$\Delta Rwa$ = Annual changes in the ratio of risk-weighted assets to total assets;  $\Delta Npl$ = Annual changes in the ratio of non-performing loans to net loans; Dum\_under=1 when bank risk-based capital ratio<8% in the previous year, 0 otherwise; Dum\_under\_tcr=1 when bank risk-based capital ratio<8% and tier1 ratio  $\geq 4$  in the previous year, 0 otherwise; Dum\_under\_tier1=1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; Dum\_ad=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise;  $\Delta Equity$ = Annual changes in the ratio of equity capital to total assets;  $\Delta Sd$ = Annual changes in the ratio of subordinated debt to total assets;  $\Delta Hyb$ = 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; Monit= Personnel expenses to total assets; Size=Logarithm of total asset; Gdp= Growth rate of Gross Domestic product.

Due to the lack of observations for subordinated debt and hybrid capital for undercapitalized banks in terms of Tcr as well as Tier1, we do not include these variables in regressions 3 and 6.

Table 6. Impact of changes in capital on European banks' risk changes (1992-2006): taking efficiency into account

	ΔRwa			ΔNpl		
	(1)	(2)	(3)	(4)	(5)	(6)
Dum_under (α <sub>1</sub> )	-3,57** (-2,431)			0,21 (0,505)		
Dum_under_tcr (α <sub>1</sub> )		-2,388 (-1,518)			-0,418 (-0,865)	
Dum_under_tier1 (α <sub>1</sub> )			-10,696** (-2,502)			0,876 (1,052)
Dum_ad (α <sub>2</sub> )	-2,731*** (-4,389)	-2,547*** (-3,978)	-1,886 (-3,213)	-0,164 (-0,847)	-0,083 (-0,416)	0,02 (0,106)
ΔCap (α <sub>3</sub> )	0,889*** (3,249)	0,917*** (3,463)	0,786*** (2,999)	0,315*** (3,835)	0,279*** (3,701)	0,251*** (3,367)
ΔCap*Dum_under (α <sub>4</sub> )	-2,472*** (-5,08)			-0,488*** (-3,05)		
ΔCap*Dum_under_tcr (α <sub>4</sub> )		-3,126*** (-6,087)			-0,332*** (-2,033)	
ΔCap*Dum_under_tier1 (α <sub>4</sub> )			1,658 (1,128)			-0,108 (-0,32)
ΔCap*Dum_ad (α <sub>5</sub> )	0,383 (0,837)	0,401 (0,872)	0,525 (1,138)	-0,11 (-0,747)	-0,126 (-0,827)	
Rwa <sub>t-1</sub> (α <sub>6</sub> )	-0,116** (-2,078)	-0,162*** (-2,583)	-0,166*** (-2,702)			
Npl <sub>t-1</sub> (α <sub>6</sub> )				-0,317*** (-9,97)	-0,389*** (-12,268)	-0,378*** (-11,925)
Eff (α <sub>7</sub> )	0,006 (0,138)	0,009 (0,225)	0,019 (0,468)	0,036*** (2,067)	-0,016 (-0,892)	-0,005 (-0,279)
Size (α <sub>8</sub> )	-0,707 (-0,82)	-0,895 (-0,95)	-0,813 (-0,853)	0,417 (1,317)	0,375 (1,146)	0,396 (1,209)
Gdp (α <sub>9</sub> )	0,59*** (3,604)	0,597** (3,522)	0,61*** (3,539)	-0,224*** (-3,727)	-0,151** (-2,384)	-0,14** (-2,18)
Jstat	84,392	89,782	86,19	208,822	255,619	252,195
F.test : α <sub>3</sub> + α <sub>4</sub> = 0	-1,583*** (13,089)	-2,209*** (22,252)	2,444 2,706	-0,174 (1,509)	-0,053 (0,123)	0,143 (0,187)
α <sub>3</sub> + α <sub>5</sub> = 0	1,273*** (10,275)	1,318*** (10,567)	1,311*** (10,67)	0,204* (2,757)	0,153 (1,261)	0,162 (1,483)
Obs	2030	1807	1774	1802	1447	1415

\*\*\*, \*\*, \* 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; Dum\_under=1 when bank-risk based capital ratio<8% in the previous year, 0 otherwise; Dum\_under\_tcr=1 when bank risk-based capital ratio<8% and tier1 ratio ≥4 in the previous year, 0 otherwise; Dum\_under\_tier1=1 when bank risk-based capital ratio<8% and tier1 ratio<4 in the previous year, 0 otherwise; Dum\_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<sub>t-1</sub>= Previous year ratio of risk weighed assets to total assets; Npl<sub>t-1</sub> = Previous year ratio of non-performing loans to net loans; Eff= Total income to total income before provisions and taxes; Size=Logarithm of total asset; Gdp= Growth rate of Gross Domestic product.

Table 7: Impact of changes in capital on European banks' risk changes for different sub-periods

	$\Delta Rwa$			$\Delta Npl$		
	1992-1996	1997-2001	2002-2006	1992-1996	1997-2001	2002-2006
Dum_under ( $\alpha_1$ )	1,075 (0,374)	-2,494 (-0,782)	-9,176*** (-4,114)	-2,015 (-0,889)	-0,035 (-0,055)	0,141 (0,317)
Dum_ad ( $\alpha_2$ )	-0,754 (-0,425)	-3,918*** (-3,328)	-3,462*** (-3,797)	-0,27 (-0,352)	0,376 (1,347)	0,14 (0,728)
$\Delta Cap$ ( $\alpha_3$ )	0,954 (1,15)	1,139** (2,224)	1,698*** (5,377)	0,754** (3,085)	-0,317** (-2,485)	-0,036 (-0,507)
$\Delta Cap * Dum\_under$ ( $\alpha_4$ )	-3,715*** (-3,101)	-5,095*** (-6,318)	-0,763 (-1,174)	-0,587 (-0,697)	-0,183 (-0,867)	-0,112 (-0,762)
$\Delta Cap * Dum\_ad$ ( $\alpha_5$ )	0,487 (0,438)	1,461* (1,91)	-1,306*** (-2,826)	-0,642 (-1,108)	0,373* (1,869)	0,203* (1,794)
$Rwa_{t-1}$ ( $\alpha_6$ )	-0,678*** (-3,331)	-0,12 (-0,923)	-0,071 (-0,727)			
$Npl_{t-1}$ ( $\alpha_6$ )				-0,215 (-1,522)	-0,643*** (-11,474)	-0,376*** (-8,007)
Monit ( $\alpha_7$ )	20,701 (1,431)	2,913 (0,736)	2,027 (0,404)	7,299 (0,895)	5,0*** (3,678)	0,492 (0,392)
Size ( $\alpha_8$ )	-3,098 (-0,661)	-2,669 (-1,017)	0,088 (0,028)	6,353 (1,556)	2,77*** (3,06)	0,04 (0,063)
Gdp ( $\alpha_9$ )	-0,092 (-0,214)	0,735* (2,197)	0,474 (1,587)	-0,309 (-1,953)	-0,148 (-1,449)	0,055 (0,594)
Jstat	11,218	59,737	34,678	35,84	40,215	138,419
F.test : $\alpha_3 + \alpha_4 = 0$	-2,761** (4,712)	-3,956*** (22,847)	0,935 (2,111)	0,167 (0,043)	-0,5** (4,81)	-0,148 (1,178)
$\alpha_3 + \alpha_5 = 0$	1,441* (1,856)	2,6*** (14,206)	0,392 (1,178)	0,112 (0,052)	0,056 (0,129)	0,168* (3,211)
Obs.	228	851	1510	255	841	967

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics.

$\Delta Rwa$ = Changes in the ratio of risk-weighted assets to total assets;  $\Delta Npl$ =Changes in the ratio of non-performing loans to net loans; Dum\_under=1 when bank total risk-based capital ratio less than 8% in the previous year, 0 otherwise; Dum\_ad=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise;  $\Delta Cap$ = Changes in the ratio of total 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; Monit= Personnel expenses to total assets; Size=Logarithm of total asset; Gdp= Growth rate of Gross Domestic product.

Table 8. Impact of changes in capital on European banks' risk changes for Italian and French banks and without Italian and French banks (1992-2006)

	Italian and French banks		Non Italian and Non French banks	
	$\Delta Rwa$	$\Delta Npl$	$\Delta Rwa$	$\Delta Npl$
Dum_under ( $\alpha_1$ )	-2,725 (-1,349)	0,596 (1,402)	-11,037*** (-3,277)	1,235 (1,338)
Dum_ad ( $\alpha_2$ )	-1,838 (-1,335)	0,275 (1,254)	-1,69** (-2,285)	-0,185 (-0,693)
$\Delta Cap$ ( $\alpha_3$ )	0,727** (2,502)	0,016 (0,191)	3,059*** (7,283)	0,585*** (6,663)
$\Delta Cap * Dum\_under$ ( $\alpha_4$ )	-1,9*** (-3,443)	-0,246 (-1,561)	-1,724 (-1,37)	-0,932** (-2,541)
$\Delta Cap * Dum\_ad$ ( $\alpha_5$ )	0,248 (0,491)	0,119 (0,823)	-2,317*** (-3,091)	-0,599** (-2,656)
$Rwa_{t-1}$ ( $\alpha_6$ )	-0,202*** (-2,617)		-0,013 (-0,216)	
$Npl_{t-1}$ ( $\alpha_6$ )		-0,402*** (-10,893)		-0,18*** (-4,693)
Monit ( $\alpha_7$ )	-4,718* (-1,911)	1,82* (1,978)	3,811* (1,76)	0,998 (1,02)
Size ( $\alpha_8$ )	-3,85** (-2,202)	0,695 (1,383)	2,28* (1,862)	1,315** (2,41)
Gdp ( $\alpha_9$ )	0,529 (0,87)	-0,066 (-0,442)	0,64*** (4,04)	-0,188*** (-3,166)
Jstat	76,229	142,261	75,403	177,397
F.test: $\alpha_3 + \alpha_4 = 0$	-1,173** (4,557)	-0,23 (2,357)	1,335 (1,213)	-0,347 (0,979)
$\alpha_3 + \alpha_5 = 0$	0,976** (5,036)	0,135 (1,28)	0,742 (1,399)	-0,014 (0,005)
Obs.	888	1147	1756	1003

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics.

$\Delta Rwa$ = Changes in the ratio of risk-weighted assets to total assets;  $\Delta Npl$ =Changes in the ratio of non-performing loans to net loans; Dum\_under=1 when bank total risk-based capital ratio less than 8% in the previous year, 0 otherwise; Dum\_ad=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise;  $\Delta Cap$ = Changes in the ratio of total 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; Monit= Personnel expenses to total assets; Size=Logarithm of total asset; Gdp= Growth rate of Gross Domestic product.

Table 9. Impact of changes in capital on European banks' risk changes for the sub-samples of adequately, well and highly capitalized banks (1992-2006)

	$\Delta Rwa$			$\Delta Npl$		
	( $8 \leq Tcr < 10$ ) (1)	( $Tcr \geq 8$ ) (2)	( $Tcr \geq 10$ ) (3)	( $8 \leq Tcr < 10$ ) (4)	( $Tcr \geq 8$ ) (5)	( $Tcr \geq 10$ ) (6)
$\Delta Cap$	1,089** (2,426)	1,387*** (5,412)	1,437*** (5,623)	0,263 (1,273)	0,271*** (4,072)	0,262*** (3,84)
$Rwa_{t-1}$	-0,609*** (-8,108)	-0,049 (-0,909)	-0,016 (-0,279)			
$Npl_{t-1}$				-0,265*** (-3,83)	-0,266*** (-9,823)	-0,271*** (-8,993)
Monit	-1,02 (-0,293)	-4,57** (-1,965)	-4,082* (-1,854)	-0,125 (-0,095)	0,967 (1,144)	0,804 (0,906)
Size	-4,645** (-2,04)	-2,259** (-2,101)	-2,149* (-1,903)	-0,093 (-0,125)	0,889** (2,154)	0,914* (1,907)
Gdp	-0,008 (-0,022)	0,695*** (4,364)	0,666*** (3,869)	-0,201 (-1,422)	-0,191*** (-3,409)	-0,206*** (-3,362)
Jstat	45,185	154,689	145,25	50,341	236,742	216,481
Obs	413	2605	2175	447	2198	1738

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represents the t statistics.  
Tcr= Total risk based capital ratio;  $\Delta Rwa$ = Annual changes in the ratio of risk-weighted assets to total assets;  $\Delta Npl$ = Annual changes in the ratio of non-performing loans to net loans;  $\Delta Cap$ = Annual changes in the ratio of total 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; Monit= Personnel expenses to total assets; Size=Logarithm of total assets; Gdp= Growth rate of Gross Domestic Product.

Table 10: Impact of changes in risk on European banks' capital changes (1992-2006)

	$\Delta\text{Cap}$	
Dum_under ( $\alpha_1$ )	0,393 (1,403)	-0,03 (-0,116)
Dum_ad ( $\alpha_2$ )	0,287** (2,365)	0,06 (0,708)
$\Delta\text{Rwa}$ ( $\alpha_3$ )	0,021 (1,308)	
$\Delta\text{Rwa}*\text{Dum\_under}$ ( $\alpha_4$ )	0,005 (0,145)	
$\Delta\text{Rwa}*\text{Dum\_ad}$ ( $\alpha_5$ )	-0,008 (-0,489)	
$\Delta\text{Npl}$		0,307*** (8,563)
$\Delta\text{Npl}*\text{Dum\_under}$		-0,35*** (-5,553)
$\Delta\text{Npl}*\text{Dum\_ad}$		-0,244*** (-5,984)
$\text{Cap}_{t-1}$ ( $\alpha_6$ )	-0,453*** (-7,736)	-0,591*** (-15,85)
Monit ( $\alpha_7$ )	3,108*** (7,728)	3,047*** (5,901)
Size ( $\alpha_8$ )	1,011*** (3,69)	0,361 (1,227)
Roa	0,678*** (7,426)	0,616*** (8,59)
Pib ( $\alpha_9$ )	0,043 (1,248)	0,047 (1,488)
Jstat	60,036	73,464
F.test: $\alpha_3 + \alpha_4 = 0$	0,027 (0,594)	-0,044 (0,651)
$\alpha_3 + \alpha_5 = 0$	0,013 (2,666)	0,063** (6,618)
Obs.	2644	

\*\*\*, \*\*, \* indicate statistical significance respectively at the 1%, 5% and 10% level; figures in brackets represent the t statistics.

$\Delta\text{Cap}$ = Changes in the ratio of total capital to total assets; Dum\_under=1 when bank total risk-based capital ratio less than 8% in the previous year, 0 otherwise; Dum\_ad=1 when bank risk-based capital ratio between 8% and 10% in the previous year, 0 otherwise;  $\Delta\text{Rwa}$ = Changes in the ratio of risk-weighted assets to total assets;  $\Delta\text{Npl}$ =Changes in the ratio of non-performing loans to net loans;  $\text{Cap}_{t-1}$ = Previous year ratio of total capital to total assets; Monit= Personnel expenses to total assets; Size=Logarithm of total asset; Gdp= Growth rate of Gross Domestic product; Roa=Return on assets.

## **5. Conclusion**

The purpose of this paper has been to assess the impact of changes in capital ratios on European banks' risk taking. We distinguish three categories of banks based on the initial level of their capital ratio (undercapitalized, adequately capitalized and highly capitalized banks). First, we find that banks react differently in terms of risk taking to capital changes. Undercapitalized banks reduce their risk taking while adequately and highly capitalized banks increase risk.

Then we disaggregate bank capital into equity, subordinated debt and hybrid capital and find that undercapitalized banks reduce their risk exposure when they increase capital by issuing equity but increase risk when it comes to subordinated debt or hybrid capital. On the whole, an increase in subordinated debt or hybrid capital ratios is associated with higher risk exposures.

Our findings suggest that regulatory capital requirements and market pressure are effective in reducing risk taking in undercapitalized banks. Moreover, our results support the implementation of 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. Finally, our results are in favour of a narrower definition of regulatory capital with a closer focus on core capital than on other hybrid instruments.

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## Appendix

### A1. Description of the sample

Country	n. of banks	% of country total asset in 2001	Commercial	Savings	Undercap	Under_tier1	Adcap	Highcap	Large	Listed
Austria	7	11.32	5	2	0	0	1	7	7	2
Belgium	23	57.08	18	5	0	0	7	22	20	0
Denmark	89	96.15	58	31	0	0	8	89	13	39
Finland	9	100	8	1	1	-	5	9	6	2
France	148	77.20	130	18	14	2	69	121	84	8
Germany	18	65.08	16	2	2	0	12	15	16	7
Greece	13	77.64	13	0	0	0	7	12	10	9
Ireland	11	40.84	9	2	0	0	2	10	10	4
Italy	202	97.25	139	62	46	11	123	192	110	14
Luxembourg	33	41.18	32	1	0	0	12	32	23	0
Netherlands	29	85.19	29	0	1	-	2	29	19	2
Norway	51	92.80	15	36	4	3	13	51	15	14
Portugal	21	83.26	18	3	0	0	12	20	17	3
Spain	72	90.64	26	46	4	1	33	69	66	9
Sweden	84	99.40	22	62	1	0	8	84	12	3
Switzerland	17	81.75	16	1	0	0	4	16	8	1
United Kingdom	45	38.81	44	1	2	1	5	45	28	3
Total	872	68.31	598	274	75	18	323	833	464	120

Undercap= Bank with total risk-based capital ratio (Tcr) less than 8%; Under\_tier1= Bank with Tcr less than 8% and Tier 1 risk-based capital ratio less than 4%; Adcap= Bank with total risk-based capital ratio between 8% and 10%; Highcap= Bank with total-risk based capital ratio at least equal to 10%; Large= Banks with a total assets at least equal to 1 billion; Listed= Listed banks.

% of country total assets in 2001= Total assets of each country in 2001 in our sample divided by total assets of commercial and savings bank of each country in 2001 in Bankscope Fitch IBCA.

### A2. Description of the sample by year

Year	Number of banks	Percentage of total obs.	Undercap	Adcap	Highcap
1992	172	2.75	10	48	114
1993	281	4.49	8	52	221
1994	318	5.09	11	34	273
1995	381	6.09	8	46	327
1996	415	6.64	8	53	354
1997	427	6.83	7	50	370
1998	458	7.32	10	61	387
1999	462	7.39	13	62	387
2000	449	7.18	8	79	362
2001	513	8.20	12	97	404
2002	510	8.16	11	82	417
2003	495	7.92	8	68	419
2004	463	7.40	6	74	383
2005	469	7.50	9	69	391
2006	440	7.04	10	76	354

Undercap= Bank with total risk-based capital ratio less than 8%; Adcap= Bank with total risk-based capital ratio between 8% and 10%; Highcap= Bank with total risk-based capital ratio at least equal to 10%.

A3. Total risk-based capital ratio (Tcr) of the ten largest banks of our sample

Bank name	Mean	Max	Min
UBS AG (Switzerland)	14.04	15.70	12.60
Société Générale (France)	10.81	12.50	9.10
Deutsche Bank (Germany)	11.88	13.90	9.90
BNP Paribas (France)	10.14	12.90	8.70
ING Bank NV (Netherlands)	10.90	11.50	10.30
Banco Santander (Spain)	11.03	12.90	9.20
Uni Credito (Italia)	10.47	11.90	8.50
Barclays Bank (United Kingdom)	10.82	12.80	7.31
Bayerische Hypo-und Vareinsbank (Germany)	10.76	19.90	8.20
Fortis (Belgium)	10.80	11.10	10.50

#### A4. Capital ratios and risk by country

	Tcr	Tier1	Large Bank Tcr	Large Bank Tier1	Rwa	Npl	Large Bank Rwa	Large Bank Npl
Austria	12.66	8.47	12.66	8.47	48.66	2.30	48.66	2.30
Belgium	12.82	8.02	12.00	8.02	46.16	2.13	46.16	2.13
Danmark	16.51	14.60	12.09	9.81	83.93	1.69	73.56	1.75
Finnland	13.59	8.72	12.57	8.62	57.56	1.92	57.71	1.96
France	14.07	9.42	11.51	8.32	49.28	8.38	49.32	7.34
Germany	11.46	7.55	11.26	7.55	46.33	4.03	46.33	4.03
Greece	13.21	10.49	12.72	10.49	55.44	5.12	54.70	5.38
Ireland	13.59	9.80	13.43	9.80	68.63	1.46	68.63	1.46
Italy	13.65	11.46	12.31	10.08	68.76	6.66	68.68	6.44
Luxembourg	15.15	11.26	14.93	10.67	35.21	2.29	35.21	2.26
Netherlands	16.32	11.60	14.86	10.76	58.61	1.53	58.77	1.53
Norway	13.40	10.70	11.90	9.21	70.45	2.88	72.77	3.54
Portugal	14.22	10.83	12.66	9.30	62.41	4.40	62.41	4.80
Spain	12.64	10.32	12.63	10.26	64.16	3.20	64.36	3.19
Sweden	19.24	18.73	13.38	10.10	65.38	3.74	56.14	4.09
Switzerland	15.58	11.32	14.19	10.65	52.36	3.65	30.06	4.60
United Kingdom	18.56	12.87	16.59	11.23	57.51	4.26	57.24	4.43

Tcr=Total risk-based capital ratio; Tier1=Tier 1 risk-based capital ratio; Large Bank Tcr= Total risk-based capital ratio of banks with a total assets at least equal to 1 billion ; Rwa= Ratio of risk-weighted assets to total assets; Npl= Ratio of non-performing loans to net loans.

## A5. Capital ratios by year

Year	Tcr	Tier1
1992	13.03	8.39
1993	14.50	9.69
1994	15.23	10.84
1995	15.66	11.36
1996	16.08	11.84
1997	15.57	11.84
1998	15.32	12.74
1999	14.68	12.57
2000	14.26	12.03
2001	14.69	11.56
2002	14.86	12.26
2003	15.04	12.71
2004	14.54	12.57
2005	14.44	12.22
2006	13.94	11.41

Tcr =Total risk-based capital ratio; Tier1=Tier 1 risk-based capital ratio.

## A6. Correlations

	$\Delta Npl$	$\Delta Rwa$	$Npl_{t-1}$	$Rwa_{t-1}$	$\Delta Cap$	$\Delta Equity$	$\Delta Sb$	$\Delta Hyb$	Monit	Size	Gdp	Eff
$\Delta Npl$	1	0.03	-0.32	0.04	0.06	0.04	0.02	0.008	0.02	-0.03	-0.11	-0.03
$\Delta Rwa$		1	0.02	-0.13	0.14	0.11	0.07	0.02	0.08	-0.10	0.02	0.05
$Npl_{t-1}$			1	-0.08	-0.001	0.007	0.02	-0.002	0.14	-0.03	-0.08	0.22
$Rwa_{t-1}$				1	-0.009	-0.02	0.06	0.01	0.15	-0.32	-0.09	-0.17
$\Delta Cap$					1	0.91	0.38	0.06	0.05	0.001	0.01	-0.04
$\Delta Equity$						1	-0.02	0.0008	0.04	-0.0005	0.01	-0.06
$\Delta Sd$							1	-0.11	0.03	0.003	-0.01	0.03
$\Delta Hyb$								1	0.01	-0.007	-0.01	0.008
Monit									1	0.01	-0.10	0.36
Size										1	0.04	-0.04
Gdp											1	-0.15
Eff												1

$\Delta Npl$ = Annual changes in the ratio of non-performing loans to net loans;  $\Delta Rwa$ = Annual changes in the ratio of risk-weighted assets to total assets;  $Npl_{t-1}$ = Previous year ratio of non-performing loans to net loans ;  $Rwa_{t-1}$ = Previous year ratio of risk-weighted assets to total assets;  $\Delta Cap$ = Annual changes in the ratio of total capital to total assets;  $\Delta Equity$ = Annual changes in the ratio of equity capital to total assets;  $\Delta Sb$ = Annual changes in the ratio of subordinated debt to total assets;  $\Delta Hyb$ = Annual changes in the ratio of hybrid capital to total assets; Monit= Ratio of personnel expenses to total assets; Size= Logarithm of total assets; Gdp= Growth rate of Gross Domestic product. Eff=Ratio of costs to income before provisions and taxes.