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The Effects of Capital on Bank Risk-Taking: New Evidence for the European Banking System

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Abstract

After the eruption of the global financial crisis, the banking sector has gone through profound regulatory reforms aimed at strengthening the stability of the entire financial system. Based on a sample of 62 listed banks in the European Economic Area Region, during the period 2005q1-2018q4, this paper investigates the impact of capital policies on bank risk-taking. Results show how the Tier 1 capital ratio and the Tier 1 leverage ratio represent a crucial factor in explaining bank risk, especially for small banks and during financial turmoil periods. Additionally, we find that the introduction of mandatory disclosure of the Tier 1 leverage ratio and the Tier 1 capital ratio reduced the bank risk-taking of higher leveraged and capitalized banks. Our findings have significant implications for both the banking industry and policymakers alike.

Keywords

Bank Capital, Leverage, Loan Coverage, Bank Regulation, Bank Risk, Bank Size

1. Introduction

The great financial crisis revealed all the weaknesses of the regulatory architecture and regulators around the world responded by introducing a program of financial reforms aimed at strengthening the banking sector preventing excessive risk-taking (EBA, 2016) and constraining moral hazard by too-big-to-fail institutions. In this paper, we investigate the impact of capital policies and loan coverage ratios on bank risk profiles in the European Economic Area Region (EEAR) following recent regulatory reforms in Europe. Since 1988, the Basel Capital Accord constitutes the centrepiece of the prudential regulation framework around the world. Nevertheless, the global financial crisis evidenced major flows in the capital adequacy regulation which prompted a thorough revision of prudential regulation with the Basel III Capital Accord strengthening both the amount and quality of bank capital (BIS, 2011).

In the years following the financial crisis, the deterioration of loan portfolio quality was a major problem for the banking industry (Constâncio, 2017) and is considered one of the principal causes of financial instability (Demirgüç-Kunt & Detragiache, 1998; Gonzalez-Hermosillo, 1999). Given that high levels of NPLs require additional capital cushions to cover loan losses and enhance lending to the real economy (Espinoza & Prasad, 2010; Klein, 2013), the ECB has recently tackled the issue by publishing the March 2018 addendum on the NPL draft guidance. In a nutshell, banks are expected to set 100% of coverage for the unsecured part after two years of NPE vintage and after seven years for the secured part (ECB, 2018). Nonetheless, this regulatory framework casts several challenges for bank management regarding timely provisions and the calibration of capitalization levels, with the assessment of market expectations as a fundamental driver of the overall bank approach to NPL reductions.

Literature on the effects of bank regulation on stability viewed an impressive growth (Demirgüç-Kunt & Detragiache, 2011; Hoque et al., 2015; Fratzscher et al., 2016; Nguyen, 2021) although with inconclusive results. The impact of bank capital levels on banks risk-taking constitutes an intriguing field of investigation especially in light of diverging theoretical predictions. Arguing on the basis of the "regulatory hypothesis" (Shrieves & Dahl, 1992; Jacques & Nigro, 1997; Murinde & Yaseen, 2004) or the moral hazard argument can lead to predictions of a negative or positive impact of capital levels on bank risk respectively. The issue has not been settled so far, thus calling for further investigation. Aiyar et al. (2015) argue that ill-defined Basel III concepts of liquidity ratios and book capital ratios didn't accomplish the task of enhancing the safety and soundness of the banking system, claiming the need to replace the current system.

First, our work represents the continuum of previous studies focused on the analysis of the external regulation mechanism on capital and its impact on banks' risk (Altunbas et al., 2007; Anginer et al., 2018, Bitar et al., 2018). Given the ambiguous results of previous studies, we extend the extant literature on the role of bank capital levels on risk in several directions. The ambiguous results of previous studies represent a strong motivation regarding the necessity to provide further empirical evidence. Moreover, with most of the existing studies focusing on the US market (see Jesswein, 2009), our paper draws on a sample of European banks.

Second, we extend the literature on loan coverage ratios by exploring the relations between capital levels, asset quality and provisioning policies. A vast body of research delves into the issue of using loan loss provisions for earning management (i.e. Kim & Kross, 1998; Zoubi & Al-Khazali, 2007), capital management and signalling purposes (i.e. Beaver & Engel, 1996). Increasing provisions for loan losses may respond to the rationale of signalling accounting conservatism or higher future earnings. While there is some evidence of a positive association between loan loss allowances and market performance (Beaver et al., 1989), nonetheless, the relationship between the coverage of troubled loans and bank riskiness is far from being a settled question. Delayed loan loss recognitions seemingly have an impact on different risk measures (Bushman & Williams, 2015). Current regulatory approaches prompting banks to cover troubled loans with capital and allowances claims for new research on the topic. Evidence on the effects of the Texas ratio is scant. We provide insights on whether the Texas ratio is effective in predicting bank distress; as a by-product, our results provide new evidence to the signaling hypothesis with reference to the impact of the ratio on market-based measures of risk.

Third, previous literature acknowledges that the impact of capital regulation on bank risk is contingent upon factors such as bank size, market power, and bank structure (Berger & Bouwman, 2013; Agoraki et al., 2011; Klomp & De Haan, 2015). We extend such literature by running a quasi-natural experiment investigating the different responsiveness of bank riskiness to Basel III adoption based on bank size and during the financial turmoil.

The rest of the paper is organized as follows: Section 2 discusses the literature review and develops the research hypotheses. Section 3 presents the empirical strategy. Section 4 describes the results. Section 5 discusses policy implications and conclusions.

Lastly, by implementing the Difference in Difference (DID) regression, we test if Basel 3 implementation affected bank risk by testing its impact on the Tier 1 leverage ratio and the Tier 1 capital ratio.

Based on quarterly data over the 2005q1-2018q4 period, allows us to have an adequate time depth to break down our timeframe and consider the mid- and long-term effects of the regulatory initiatives that followed the global financial crisis.

2. Theoretical Framework and Hypotheses Development

2.1. Bank Capital

The issue of how capital impacts bank risk is actually an outstanding question (Anginer & Demirguc-Kunt, 2014; Bitar et al., 2018). Literature has long investigated the relationship between capital requirements and risk-taking. It is acknowledged that the main purpose of the regulation on banks' capital is to provide both an adequate cushion of equity during recessive economic cycles and an exogenous mechanism able to contain the excessive risk-taking of institutions, in order to prevent bank insolvency and safeguard the stability of the financial system (see Rochet, 1992; Dewatripont & Tirole, 1994; Jokipii & Milne, 2011). However, the traditional theoretical literature on the capital-risk relation is not unanimous when it comes to the implications of capital regulation in the banking industry. Theoretically, the impact of capital requirements is ambiguous potentially leading to both increasing or reducing risk. Arguing in terms of a rebalancing of the portfolio of risky assets following a forced reduction in leverage under the first Basel Capital Accord. Kohen and Santomero (1980) and Kim and Santomero (1988) predict an increase in bank risk. In the same vein, Blum (1999) develops an elegant model where bank risk is actually increased to the extent that binding capital regulation reduces future profits thus reducing incentives to avoid default. Furlong and Keely (1989) and Keeley and Furlong (1990) demonstrate that bank capital may turn out to reduce risk.

Kohen and Santomero (1980) argue that risk-based capital ratios only, as opposed to flat capital requirements, are effective in constraining risk-taking incentives, constitute the theoretical underpinning of Basle capital accords.

In various empirical studies (Altunbas et al., 2007), higher capital adequacy constitutes a powerful incentive to increase risk-taking. Other prominent empirical research however finds evidence of the effectiveness of capital requirements in reducing risk-taking.

On a sample of US commercial banks, Jacques and Nigro (1997) found that risk-based capital standards are effective in increasing capital ratios and reduce the riskiness of the loans' portfolio. Berger and DeYoung (1997) investigate the moral hazard incentives finding that the level of troubled loans is negatively related to capitalization levels. Similar results are those of Salas and Saurina (2002) and Laeven et al. (2016) who find a negative association between bank capital and systemic risk exposure.

Although recent studies find scant evidence of capital ratios as ex ante predictors of systematic banking crisis (Jordà et al., 2017), better capitalized banks show up a greater resilience when losses materialize.

Basel III regulation reinforced the capital ratios in terms of both quality and entity along with introducing a simple leverage ratio which was intended to provide a transparent and credible measure to complement the traditional risk-based capital ratios. The new leverage ratio copes with those concerns and is aimed at avoiding destabilizing deleveraging processes and reinforcing capital standards.

One of the main reasons behind a simple unweighted leverage ratio is related to the procyclical effects of risk-based capital ratios. Procyclicality of capital regulation prompted a vast body of literature (Jokipii & Milne, 2008; Andersen, 2011; Repullo & Suarez, 2009; Valencia & Bolaños, 2018). Repullo and Suarez (2013) found that Basel II is more procyclical than Basel I although making banks safer. Its unweighted nature would confer the simple Basel III leverage ratio a countercyclical behaviour, thus counterbalancing the excessive building-up of risk during booms (Brei & Gambacorta, 2016).

Broadly speaking, while entailing marginal benefits in terms of reducing probabilities of banking crisis, increasing leverage ratios (i.e. a greater amount of equity capital on total assets) subtend risks of curtailing lending should banks able to pass on higher equity costs. Theoretically, an optimal regulatory design should trade off marginal benefits with marginal costs of the leverage ratios. Several studies moving from different assumptions derive optimal leverage ratios and risk-based capital ratios under a cost-benefit perspective (Firestone et al., 2017; Barth & Miller, 2018). Arguably, net benefits are contingent on different scenarios in terms of severity of crisis (cost and duration of a crisis) and the well known debt related features, such as tax benefits (Barth & Miller, 2018).

An intriguing argument in favour of a Basel III-style leverage ratio is that it would help constraining liquidity risk, thus fostering bank stability. With imperfect information on loan losses, capital reliefs under the Basel III IRB approach prompted by credit risk diversification or reduced probability of default would trigger bank runs. Putting a floor to the equity-to-asset ratio would reduce the probability of bank runs (Dermine, 2015).

Therefore, at light of the extant literature, we formulate the following hypotheses:

H_1: Higher capitalization levels result in a bank's lower riskiness.

2.2. Coverage and Risk

Metrics developed to represent a bank's ability to cover potential losses on the credit portfolio are often regarded as useful signals to warn credit problems or risks to bank stability. Managing NPLs is regarded as a way for preserving resilience of the banking sector. This includes provisioning policies and other measure to ease the workout of troubled loans. Loan Loss Provisioning plays an ambiguous role though. While designed for earnings' smoothing purposes they result in reduced market discipline on risk-taking; nonetheless, LLPs induce higher risk-taking discipline when conceived for timely recognition of losses (Bushman & Williams, 2012).

Bogdanova et al. (2018) account for a positive reaction of market values to increasing provisioning levels. Based on a standard coverage ratio (loan loss provisions on NPLs), Simoens and Vander Vennet (2021) account for a positive association with bank market-to-book valuations, thus advocating a crucial role of regulators in stimulating NPL resolution. A proactive tackling of NPLs proves to be particularly powerful to boost the banking sector recovery in a post-crisis environment (Borio et al., 2010). Beaver et al. (1989) account for a positive association between loan-loss allowances and market-to-book ratios. Bushman and Williams (2015) show that delayed expected loan loss recognition is associated with higher stock market illiquidity, higher correlations between bank level illiquidity and aggregate banking sector illiquidity and returns during recessions.

A suitable metric for measuring a bank's ability to cover potential losses is the Texas ratio. A bank showing an NPL level over and above loan loss provisions plus common equity capital (or even a ratio at or above some critical threshold) should be considered at high insolvency risk. Jesswein (2009) recognises the Texas ratio as a suitable measure of a potential bank failure despite its own limitations.

The ratio can act as a suitable tool for monitoring a bank's insolvency risk too. Markets values are expected to react to deterioration in the Texas ratio, should it act as a reliable early warning indicator. Siems (2012) confirms the consistency of the ratio as bank failure predictor across banks of different US member states. Acrey et al. (2019) account for an asymmetric effectiveness of the ratio in predicting bank failures according to the bank type (i.e. large banks vs community banks).

The risks associated with a poor and delayed coverage of NPLs is likely to increase equity financing costs and opportunities for banks to engage in risk shifting thereby jeopardizing bank stability.

Based on previous discussion we state the following hypothesis:

H_2: High coverage ratios are associated with a lower bank's risk profile and act as a signalling mechanism whereby market-based measures of risk decline.

2.3. Banks Size, Crisis and Risk

The capital-risk relationship is quite complex though, depending on contingencies related to attribute such as bank size, market power or periods of stress. Investigating the behaviour of equity values, Demirgüç-Kunt et al. (2013) find that better capitalized banks experience a lower contraction in values with the effect being stronger for larger banks than small ones. Berger and Bouwman (2013) provide evidence of a positive association between capitalization levels and bank's survival probability, with high capitalization levels benefiting small banks at all times and large banks over crisis periods.

When looking at the relation between capitalization levels, risk and crisis periods, Garel and Petit-Romec (2017) confirm the effect of bank capital in helping banks to withstand shocks during crisis. Recent evidence (Ashraf et al., 2020) accounts for an effective role of stringent capital regulation during pre-crisis periods in reducing bank default risk when a crisis occurs. Based on the discussion above, we state the following hypothesis:

H_3: The effect of capitalization levels on banks' riskiness depends on bank size, in the sense that higher capitalization benefit larger banks, and on crisis vs non-crisis periods, in the sense that higher capitalization have an higher effect in reducing risk when exiting a crisis period.

2.4. Enforcement of Basel III Capital Regulation

In a highly regulated industry as the banking industry actually is, a common research design pertains the effect of enforcing a particular piece of regulation on a specific group of institutions (e.g. Velliscig et al., 2023).

Regarding Basle III capital adequacy reforms prompted a body of research arguing in favour of a potential trade-off between the risk effect and a cost-of-intermediation effect. On the one hand, higher capital requirements would turn out to increasing the cost of financial intermediation with a significant effect on economic activity (Miles et al., 2013). On the other hand, increasing capitalization levels would make banks safer and sounder thus reducing the equity holders' required rate of return and eventually dampening risk-taking behaviour (Rahman et al., 2018). The so-called forced safety effect (Bahaj & Malherbe, 2020) predicts a U-shaped relationship between capital requirements and loan supply with respect to initial capital. Empirical evidence is quite mixed with studies (Hanafi & Santi, 2013) accounting for a U-shaped relationship between capital and risk and others (Zheng et al., 2017) finding no evidence of a non-linear relationship. Nonetheless, Murinde and Yaseen (2004) find that regulatory pressures lead banks with a capital ratio near to the minimum ratio to raise their capital and reduce riskier exposures.

The introduction of a simple leverage ratio casts the question of which concept of capital is more relevant and effective in influencing risk, even at light of criticisms raised to Basel II risk calibrations (Hellwig, 2010). Should risk calculations rules under Basel capital accords fail to adequately reflect actual risk, a simple leverage ratio might be considered much more informative (Blum, 2008). Demirgüç-Kunt et al. (2013) provide some support to these arguments finding that stock returns were more sensitive to a simple leverage ratio than a risk-based capital ratio during crisis.

H_{4a}: The enforcement of the Basel III regulation on both the leverage ratio and the minimum capital requirement turns out to reducing risk exposure for less capitalized banks.

H_{4b}: The enforcement of the Basel III regulation makes bank risk more responsive to a simple leverage ratio than to risk-based capital requirements.

3. The Sample

Our study is based on a sample of 62 listed European banks selected according to the following methodology. Starting from the entire ensemble of listed banks located in Eastern and Western Europe, we run the Equity Screening command on the Bloomberg Professional Platform with the aim to include only listed banks in line with the Industry Classification Benchmark (ICB) principle.

Then, in order to exclude less significant institutions, we introduce 6 filters, requiring banks to comply with at least one of these.

First, we require banks to be directly supervised by the European Central Bank (ECB) and to be subjected to Stress Test exercise either Transparency Test, carried out by European Banking Authority (EBA). Subsequently, we extend our sample incorporating: Global Systemically Important Banks (G-SIBs), Global Systemically Important Institutions (G-SIIs) and Other Systemically Important Institutions (O-SIIs), as defined by the Financial Stability Board (FSB). Finally, we perfect our sample excluding all the banks for which quarterly data were not available. The finale sample consists of 62 banks, covering 22 countries within the European Economic Area region.

Thus, we gathered consolidated on-balance sheet quarterly data from Bloomberg Professional Database, on a timeframe spanning the period 2005q1-2018q4.

Therefore, we are able to cover three crucial sub-periods of the last decade: the mortgage sub-prime crisis, the euro area sovereign debt crisis and the post-crisis period. Furthermore, these periods mirror the developing of the regulation frameworks (e.g. Basel accords, EBA 2011 Capital Exercise, ECB draft guidance on NPLs and the successive addendum to draft guidance on NPLs).

Summary statistics of the sample are outlined in Table 1.

4. Variables

4.1. Risk Variables

Crucial in our study for testing our hypotheses is the identification of the appropriate variables which capture different dimensions of risk in the banking sector at light of the extant literature. Based on a vast body of literature (e.g. Hannan & Hanweck, 1988; Boyd & Runkle, 1993), our main risk metric is the standard Z-Score. As a quite simple but effective measure of bank risk when it comes

Table 1. The sample (millions of euro).

Country	Average Assets
Austria	145,868.70
Belgium	359,753.50
Croazia	104,929.90
Cyprus	9,649.35
Czech Republic	782,552.00
Denmark	1,397,493.00
Finland	548,349.60
France	1,606,566.00
Germany	788,212.50
Greece	71,223.72
Hungary	9,744,507.00
Italy	220,083.70
Lithuania	1,094.47
Norway	123,249.30
Poland	90,535.36
Portugal	61,365.84
Slovenia	14,419.06
Spain	423,262.80
Sweden	1,809,116.00
Switzerland	1,245,532.00
Netherlands	877,833.60
UK	1,473,399.00
Total	723,556.10

to predicting insolvency (Chiaramonte et al., 2016), it relates a bank's capital level to the volatility in its returns. The standard Z-Score is measured as follows:

$$\text{z\_score}_{i,t} = \left(\mu\left(\text{ROA}\right) + \text{CAR}\right) \Big/ \sigma\left(\text{ROA}\right) \quad (1)$$

where z_score is the standard Z-Score for bank *i* at time *t*, μ(ROA) and σ(ROA) are the mean and standard deviation of ROA respectively while CAR is the equity-asset ratio. In that, it captures the variability in returns that a bank's capital can absorb without triggering bank's insolvency.

As robustness checks, we then employ alternative measures of bank's risk, namely the idiosyncratic volatility and the Merton's (1974) Distance-to-Default (DD) which allows us to complement the accounting-base Z-Score with market-based measures of risk. The DD (Gropp et al., 2006; Vassalou & Xing, 2004) is measured as follows:

$$\text{DD} = \left(\ln\left(V_A/D\right) + \left(r - \sigma_A^2/2\right)T\right) \Big/ \left(\sigma_A\sqrt{T}\right) \quad (2)$$

where V_A and σ_A are the value of assets and assets' volatility respectively while D is the face value of debt liabilities.

Finally, Idiosyncratic volatility is defined as the diversifiable component of market risk, calculated as the root mean squared error of the Capital Asset Pricing Model (CAPM) regression (see e.g. Hassan et al. 2023; Cuomo et al., 2022).

4.2. Bank Capital

This paper aims to explore the role of bank capital, provisioning policies and size as critical factors impacting on different dimensions of bank risk in the European Economic Area Region (EEAR).

Based on the Basel regulation, we measure capitalization levels in terms of capital adequacy (Zheng et al., 2017), proxied by the ratio of Total Regulatory Capital on Risk Weighted Assets.

In addition, as underlined by Demirgüç-Kunt et al. (2013), the relation between capital and default risk is stronger when capital is measured by non-risk-based measures as the common leverage ratio. In line with Basel III instructions which propose the leverage ratio as measure able to limit bank risk in a context of imperfect information about bank asset value (Dermine, 2015), we include in our study the traditional Equity-to-Asset ratio as capital measure.

4.3. Coverage Policies

Then, we employ several measures which capture the asset quality and the provisioning policies of the banks included in our study. The literature generally underlies as significative amounts of NPLs increase bank risk and jeopardise financial stability (Schaeck & Cihak, 2014; Hassan et al., 2018). Our study aims to deepen the role of provisioning policies and coverage levels on troubled loans and their effects on several bank market risk measures.

As underlined by our literature review and by our research hypotheses, the effect of provisions policies on troubled loans could act with double effects being perceived by the market in two directional ways: first, according to the signalling theory (Akerlof, 1970; Beaver & Engel, 1996) as a exhibitions of a prudential behaviour which might reduce bank riskiness, and in line with the expectations of bank authorities (see ECB, 2018) either as signal that banks expect higher losses from their loans portfolio hence possible increasing the level of risk.

According to previous literature, we measure the coverage of troubled loans by means of Loan Loss Provisions. Specifically, we employ the Loan Loss Provisions (LLP/GL) ratio scaling provisions on gross loans. It assesses the cost of loans on total gross loans; it's a measure of trouble on loan portfolio. Higher levels of provisioning determinates that a higher part of risk is already been accounted in the profit and loss statement.

Most of studies measure loan loss coverage ratios in terms of the ratio of loan loss provisions on gross loans (Bushman & Williams, 2012; Curcio & Hasan, 2015; Tran et al., 2020). Based on capital regulations allowing their inclusion on regulatory capital (namely, the Tier 2 under the Basel accord) under certain conditions, other literature focuses on Loan Loss Reserves (LLRs) instead. Ng and Roychowdhury (2014) provide insights on the behaviour of LLRs like capital finding a positive association of reserves with the risk bank failure, which is inconsistent with the view of capital as a cushion against failure risk (Beck & Narayanamoorthy, 2013). In line with this literature, we employ Loan Loss Reserves scaled on the gross value of non-performing loans (LLR/GL) as well, which represents the total amount of funds set aside by bank to cover the expected loss on its loan portfolio. Such a choice is consistent with our aim of providing insights on the relationship of capitalization levels with bank riskiness.

Finally, we include the Texas ratio (Jesswein, 2009; Siems, 2012), as a simple measure of the degree of coverage on troubled loans. It is traditionally calculated considering the gross value of non-performing loans divided by the sum of the Loan Loss Reserves (LLRs) and the available Tangible Common Equity (TCE). The level of LLR expresses, through an internal bank's estimation, the expected loss, that is the level of non-performing loans without a recovery value and already absorbed through write-downs.

TCE, instead, provides the cushion able to absorb the unexpected losses. The current regulatory framework imposed by the ECB substantially imposes to maintain a level of Texas ratio equal to one which represents the equilibrium level, expressing that the gross value of NPLs is totally covered by capital and reserves. Indeed, if on one side the expected loss of loans has been already accounted through loans loss provisions in the income statement, on the other side, the Basel's regulatory capital framework under Pillar I, expects to cover the unexpected loss with high quality capital.

In line with Velliscig et al. (2023), we run the following econometrical equation in order to estimate the residual term $\varepsilon_{i,t}$ (i.e. Texas ratio spreads), which represents a proxy of the departure from the equilibrium level (100%), which is considered as the limit beyond which the bank is in turmoil: indeed in this case the gross value of NPLs is higher than the sum between LLR and TCE.

$$\mathrm{NPL}_{G_{i,t}} / \mathrm{TA}_{i,t} = \alpha_{i,t} + \beta_1 \mathrm{LLR}_{i,t} / TA_{i,t} + \beta_2 \mathrm{TCE}_{i,t} / \mathrm{TA}_{i,t} + \varepsilon_{i,t} \tag{3}$$

This results that loan loss reserves and tangible capital are not able to absorb possible shocks on the loan portfolio. This approach allows us to test the market sensibility towards this indicator, thereby we want to verify the signalling effect of the index and its impact on banks risk.

Finally, to capture potential bank size effect we proxy banks size using the natural logarithm of total assets (Tan, 2016; Laeven et al., 2016).

4.4. Control Variables

We include several Control Variables (CVs) which possibly can influence the main variables of this study and give a general view of the banks' position. We include a variable which assesses banks liquidity position: the ratio between gross loans and short-term funding and deposits. According to Chiaramonte and Casu (2017), the relation with risk variables can be interpreted in different ways; if the market perceives negatively banks with a lower level of deposits and liquidity, this aspect leads to an increase in equity risk. Conversely, if the market exploits banks with a higher level of loans for a given level of deposit, we expect a negative sign with bank risk variables. In addition, we include the efficiency ratio given by the ratio between operating expenses and total revenues. We expect that banks that have a higher level of operational efficiency perform better than the others and exhibiting a lower level of risk.

We consider in our study as macro control variable the variation rate of the Gross Domestic Product (ΔGDP). We expect that positive variations of the gross domestic product reduce the overall risk of banks loans portfolio, hence lowering banks risk (Imbierowicz & Rauch, 2014). As measure aimed to capture the impact of the monetary policy on bank risk, we include the 3-month Euribor rate which mirrors market expectations about future conditions of financial markets. Finally, we incorporate in the models the Herfindahl-Hirschman Index (HHI) calculated as the sum of the squared market share in terms of total assets in each country. Higher levels of HHI are associated to a higher level of market power.

4.5. Descriptive Statistics

Table 2 shows the descriptive statistics of all variables included in our study. We run the pairwise correlations among explanatory and control variables as well. These are generally low, smaller than 0.4, which is the limit from which the collinearity problem becomes more important. Results are available upon request.

5. Model Specifications

Given a balanced panel data, in order to examine our hypotheses, we follow Berger

Table 2. Descriptive statistics.

Category	Variable	N	St. Dev.	Mean	Median	P25	P75
Dependent Variables	Z-Score	3363	1.139	4.652	4.750	3.973	5.438
	DD	3373	0.464	2.840	2.827	2.526	3.162
	Idio Vol	3363	0.047	0.045	0.031	0.014	0.060
Explanatory Variables	Total 1 Cap	3232	0.038	0.147	0.1424	0.118	0.17
	Tier 1 Lev	3336	0.031	0.070	0.064	0.047	0.087
	TEXASR	3007	0.232	0.200	0.135	0.050	0.274
	LLPGL	3196	0.713	0.796	0.621	0.484	0.780
	COV	3022	0.019	−0.001	−0.001	−0.009	0.003
	LIQ	3268	0.101	0.138	0.114	0.063	0.192
	EFF	3315	0.016	0.123	0.120	0.110	0.137
	SIZE	3336	0.151	−0.008	0.014	−0.034	0.052
	ΔGDP	3465	0.166	0.124	0.676	−0.027	0.216
	EURIBOR	3528	1.661	1.249	−0.027	0.677	2.162
	HHI	3136	0.233	0.182	0.039	0.095	0.210

The table shows the descriptive statistics of the variables selected in our study. Number of observations (N), the standard deviation, mean, median, the 25˚ percentile (P25) and the 75˚ percentile (P75) are reported.

and Bouwman (2013) and Bitar et al. (2018) running the following baseline pooled OLS regression model:

$$f\left(\text{Risk}\right)_{ij,t} = \alpha + \beta \cdot \text{CAP}_{ij,t-1} + \gamma \cdot \text{LEV}_{ij,t-1} + \delta \cdot \text{PROV}_{ij,t-1} + \theta \cdot \text{SIZE}_{ij,t-1} + \vartheta \cdot \text{BC}_{ij,t-1} + \sum\nolimits_{j=1}^{n} \tau_j \cdot C_j + \sum\nolimits_{t=1}^{T} \varphi \cdot T_t + \varepsilon_{ijt} \quad (4)$$

where $f(\text{Risk})_{ij,t}$ refer to our risk variables, as defined in sectiOn 3.2., in country j at time t. CAPis the total regulatory capital scaled on the risk weighted assets; LEV is the leverage ratio; PROV is the vector of provisioning and coverage policies variables and BC are the bank controls. All the variables are winsorized at 99% level. C and T are the country and time fixed effects. We include country and time dummy fixed variables in order to avoid eventually omitted variables effects in relation to "country" either "quarter" specifications (Anginer & Demirguc-Kunt, 2014).

We apply the Modified-Wald test which shows the presence of heteroskedasticity cross-sectional. Therefore, we estimate Equation (4) using the Huber-White sandwich estimators in order to obtain standard errors that are robust to cross-sectional heteroskedasticity and within panel correlation.

Robust standard errors with robust variance-covariance matrix are clustered at bank level in order to address for residual cross-sectional autocorrelation.

Further, we test the effect of the Basel III regulation on bank riskiness as regards both the mandatory disclosure of the Tier 1 leverage ratio to the banking authorities and the implementation of the Basel III Tier 1 capital requirement. Our empirical strategy consists of a difference-in-difference methodology according with the following specification:

$$\begin{aligned} f\left(\text{Risk}\right)_{ij,t} &= \alpha + \beta \cdot \text{Treated}_{ij,t} \cdot \text{Post\_shock} + \gamma \cdot \text{Treated}_{ij,t} \\ &\quad + \omega \cdot \text{D\_Post\_shock} + \delta \cdot \text{PROV}_{ij,t-1} + \theta \cdot \text{SIZE}_{ij,t-1} \\ &\quad + \vartheta \cdot \text{BC}_{ij,t-1} + \sum\nolimits_{j=1}^{n} \tau_j \cdot C_j + \sum\nolimits_{t=1}^{T} \varphi \cdot T_t + \varepsilon_{ijt} \end{aligned} \tag{5}$$

We run the regression above twice. First, when testing the effect of the mandatory disclosure of the leverage ratio we construct our treatment (Treated) group as comprising those banks falling in the lower quintile of the Tier 1 leverage ratio.

D_Post_shock is a dummy variable taking value 1 from 1/1/2013 when the disclosure of the leverage ratio becomes mandatory. Second, we estimate Equation (5) for the Basel III Tier 1 capital requirement. Here, treated comprises those banks within the lower quintile of the Tier 1 capital requirement.

D_Post_shock is a dummy variable taking value 1 from 1/1/2014 when the implementation of the Tier 1 capital requirement becomes mandatory. Finally, $f(\text{Risk})_{i,j,t}$ is the Z-Score variable while PROV, SIZE and BC are as defined in Equation (4).

We, then, perform a series of robustness checks. First, we estimate our models based on a Generalized Method of Moments (GMM approach) and a IV 2SLS method. In both cases we introduce one lag of the dependent variable. Finally, we estimate the capital-risk relationship employing alternative measures of risk, i.e. the Distance-to-Default and the idiosyncratic volatility.

As a final robustness check we estimate Equation (4) with the Z-Score as the dependent variable running a Bootstrapping Standard Errors with 1000 replications routine.

6. Results

6.1. Baseline Results and Dif-in-Dif Analysis

Table 3 reports the baseline results of the fixed effects and the pooled OLS regression model. Model 1 tests the capital ratio relationship with the risk variable whereas Model 2 tests the leverage ratio relationship with risk.

Our results reveal a positive association between capital and the Z-Score; the relationship holds both for both specifications of capital. Given the construction of the Z-Score, our results confirm that an increase in a bank's capital turns out to reduce bank riskiness. Therefore, our results provide support to Hypothesis 1.

Turning to the provisioning policies and trouble loans' coverage, we obtain the opposite results. Interestingly, the Texas ratio variable shows an inverse relationship with the Z-Score.

Representing the residuals in the estimation of Equation (3), the Texas Ratio variable is a measure of timeliness of NPLs recognition. An increase in the estimation

Table 3. Baseline analysis.

Variable	Z-Score			
	FE		OLS	
	(1)	(2)	(1)	(2)
Tier 1 Cap (−1)	4.688*** (1.815)		4.554** (1.861)	
Tier 1 Lev (−1)		13.44*** (2.522)		8.954*** (2.800)
LLPGL (−1)	−0.865*** (0.162)	−0.875*** (0.183)	−0.947*** (0.164)	−1.047*** (0.176)
COV (−1)	−0.160** (0.0720)	−0.149** (0.0622)	−0.184*** (0.0670)	−0.180*** (0.0577)
TEXASR (−1)	−12.05*** (3.620)	−11.96*** (3.145)	−10.75*** (3.507)	−9.758*** (3.294)
SIZE (−1)	−0.00523 (0.0593)	0.0399 (0.0666)	−0.0230 (0.0556)	0.00588 (0.0596)
LIQ (−1)	−0.666 (0.413)	−0.643 (0.429)	−0.746* (0.417)	−0.728 (0.438)
EFF (−1)	−0.538*** (0.112)	−0.429*** (0.0919)	−0.644*** (0.121)	−0.607*** (0.114)
ΔGDP (−1)	−0.0258 (0.238)	−0.0597 (0.225)	−0.0161 (0.249)	−0.0319 (0.242)
EURIBOR (−1)	−7.260 (36.93)	−13.86 (37.06)	−3.590 (37.63)	−4.868 (37.64)
HHI (−1)	0.142 (0.555)	−0.00715 (0.543)	0.390 (0.524)	0.305 (0.499)
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Cluster S.E. Bank	Yes	Yes	Yes	Yes
Observations	2545	2555	2545	2555

This table reports the baseline estimates. We run both a FE and an OLS estimation. In both cases, two models are tested. Model 1 tests the effect of the Tier 1 capital ratio as the capitalization variable while Model 2 is estimated using the leverage specification. Significance levels: ***1%, **5%, *10%.

of residuals, therefore, can be interpreted as a symptom of banks lagging behind in the coverage of non-performing loans.

Overall, our results suggest that even with adequate capitalization levels a lack of timeliness in NPLs recognition would translate in an increase of banks' riskiness. Specifically, the loan loss provisions ratio worsens all the bank risk profiles we include in our study.

Our findings corroborate the role of the ratio which appears to have a strong relationship with bank risk, even at light of its rapid acceptance in examining potential banks failures within the global assessments carried out by bank authorities. Hence, according to Jesswein (2009), the idea that moves the index is solid and it can be designed with only minimum effort.

As for provisioning policies and the coverage ratio, we find that LLP/GL and COV are negatively related to the Z-Score as well. Consistent with previous literature, an increase in the loan-loss provisions on gross loans and in the coverage ratio is perceived by the market as an assumption of incorrect level of coverage on banks' loan portfolios, thereby expressing a higher level of risk (Agusman et al., 2008; Ng & Roychowdhury, 2014). Hypothesis 2 is, therefore, not supported.

Looking at the control variables, bank size doesn't show a statistically significant effect on the Z-Score in all the models we tested. We, then, only find a weak negative association of bank liquidity with our risk variable in Model 1 of the OLS estimation. These results suggest, at least to some extent, that banks operating with high levels of loans compared to deposits low show a higher insolvency risk.

The other control variables (i.e. the variation in GDP, the 3-month Euribor and the Herfindal Index) do not express any statistically significant association with bank riskiness in any of the models we tested.

Moving further with the analysis, we test for the size effects (**Table 4**) and investigate the effects on risk in the during the crisis vs Post-crisis period (**Table 5**).

As for the size effect, we test the capital-risk relationship for both the Tier 1 capital ratio (Models 1 and 2) and the leverage ratio (Models 3 and 4) distinguishing large banks from small banks.

Our results show a strong positive association (at 1% level) for both the Tier 1 leverage ratio and the leverage ratio (coefficients 8.668 and 8.670 respectively) in the small banks regression.

For large banks, we fail to account for any statistically significant relationship between capital and risk. Overall, our results suggest that small banks are those benefitting of higher capitalization levels in terms of their risk exposure.

Similar results emerge for the Texas Ratio variable which shows a negative and statistically significant (1% level) association with riskiness for small banks only (coefficients −11.44 and −10.61 respectively) suggesting that a timely recognition of NPLs with provisions and capital especially benefit small institutions. Our estimations show similar results for coverage ratio.

In line with the baseline estimations, LLPGL instead generally shows a negative and strongly significative association with the Z-Score.

As for the control variables, efficiency is negatively and statistically significantly associated with risk for both small and large banks across all specifications. Liquidity, instead, shows a negatively relation for small banks only in Model 1.

Table 5 reports the estimations for the crisis and post crisis periods for the Tier 1 regression (Models 1 and 2 respectively) and for the leverage regression

Table 4. Size effect.

Variable	Z-Score			
	(1)	(2)	(1)	(2)
	Small Banks	Big Banks	Small Banks	Big Banks
Tier 1 Cap (−1)	8.668*** (2.856)	0.992 (2.330)		
Tier 1 Lev (−1)			8.670*** (3.257)	9.411 (5.737)
LLPGL (−1)	−0.924*** (0.186)	−0.806** (0.362)	−1.010*** (0.201)	−0.858** (0.385)
COV (−1)	−0.229*** (0.0808)	−0.101 (0.129)	−0.225*** (0.0742)	−0.0886 (0.120)
TEXASR (−1)	−11.44*** (3.870)	−3.277 (12.66)	−10.61*** (3.587)	−0.657 (12.64)
SIZE (−1)	0.00346 (0.109)	0.0822 (0.127)	0.0455 (0.116)	0.124 (0.125)
LIQ (−1)	−1.170** (0.534)	0.107 (0.656)	−0.833 (0.615)	0.0646 (0.582)
EFF (−1)	−0.713*** (0.206)	−0.490*** (0.132)	−0.661*** (0.196)	−0.477*** (0.121)
ΔGDP (−1)	0.176 (0.365)	−0.312 (0.316)	0.191 (0.348)	−0.320 (0.321)
EURIBOR (−1)	11.84 (51.36)	−14.36 (64.74)	16.14 (47.85)	−15.22 (67.01)
HHI (−1)	1.665 (1.498)	0.0336 (0.549)	1.034 (1.549)	0.0622 (0.533)
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Cluster S.E. Bank	Yes	Yes	Yes	Yes
Observations	1353	1193	1361	1194

This table reports the estimates for the size effect. The sample is split in small banks and large banks based on the median value of total assets where the small bank sample includes those banks with a total asset value below the median value. Equation (4) is estimated separately for the two subsamples. Model 1 is estimated using the Tier 1 capital ratio as a measure of bank capital while Model 2 employs the leverage ratio. Significance levels: *** 1%, ** 5%, * 10%.

(Models 3 and 4 respectively). Generally, both for the Tier 1 and the Leverage specification, an increase in the capitalization level turns out to increasing the Z-Score (i.e. reducing risk) both during crisis and in post-crisis periods.

Our results do not allow supporting Hypothesis 3. Neither larger banks benefit more than smaller ones of higher capitalization levers, neither there is an asymmetric response of bank riskiness to capitalization levels during crisis vs post-crisis periods.

Table 5. Crisis vs post-crisis period.

Variable	Z-Score			
	(1)	(2)	(1)	(2)
	Crisis	Post-Crisis	Crisis	Post-Crisis
Tier 1 Cap (−1)	6.938** (3.421)	5.470** (2.355)		
Tier 1 Lev (−1)			14.14*** (4.309)	9.016*** (3.475)
LLPGL (−1)	−1.252*** (0.285)	−0.504** (0.196)	−1.334*** (0.291)	−0.490** (0.208)
COV (−1)	−0.111 (0.114)	−0.148* (0.0883)	−0.0545 (0.117)	−0.152* (0.0919)
TEXASR (−1)	−13.55** (6.644)	−13.40*** (3.823)	−10.53 (6.508)	−13.16*** (3.757)
SIZE (−1)	−0.0188 (0.111)	−0.0871 (0.0906)	0.0250 (0.116)	−0.0543 (0.0917)
LIQ (−1)	−1.935*** (0.679)	−0.0324 (0.729)	−1.556** (0.670)	0.119 (0.736)
EFF (−1)	−0.225* (0.126)	−0.383*** (0.122)	−0.208* (0.120)	−0.352*** (0.119)
ΔGDP (−1)	−0.366 (0.421)	−0.249 (0.277)	−0.259 (0.422)	−0.269 (0.268)
EURIBOR (−1)	0.819*** (0.250)	0.364 (0.364)	0.648** (0.256)	0.191 (0.328)
HHI (−1)	0.130 (0.816)	−4.680** (2.165)	0.128 (0.785)	−5.164** (2.226)
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Cluster S.E. Bank	Yes	Yes	Yes	Yes
Observations	963	1,268	966	1,267

This table reports the estimates for the crisis vs post-crisis period. Accordingly, Equation (4) is estimated for two periods separately, i.e. *Crisis* comprised in the time span ranging from the I° quarter of 2008 to the IV° quarter of 2012 and *Post-Crisis* for the period afterwards. Model 1 is estimated using the Tier 1 capital ratio as a measure of bank capital while Model 2 employs the leverage ratio. Significance levels: ***1%, **5%, *10%.

Interestingly, the coverage ratio both in the Tier 1 and the leverage regressions is negatively, although weekly (10% significance level) associated with the Z-Score (−0.148 and −0.152 coefficient levels) in post-crisis periods. In normal times, therefore, increasing loan loss allowances turns out to increasing bank riskiness. Texas ratio variable is negatively and significantly associated with the Z-Score for the Tier 1 regression both during crisis and in post crisis periods with similar magnitudes (−13.55 and −13.40 coefficient levels respectively). For the leverage regression, the timeliness of NPLs recognition is significant for post-crisis periods (−13.16 at a 1% significance level).

Moving forward, we test the effect of the Basel III regulation on bank risk. Table 6 reports the dif-in-dif results for the Tier 1 leverage ratio disclosure.

We test three models. Model 1 clusters standard errors at bank level. Model 2

Table 6. Dif-in-Dif regression, test on Tier 1 leverage ratio.

Variable	Z-Score		
	(1)	(2)	(3)
TREATED*POSTSHOCK	0.945*** (0.316)	0.957*** (0.315)	0.984*** (0.330)
TREATED	−0.727* (0.392)	−0.733* (0.394)	−0.734* (0.422)
D_POSTSHOCK	−0.259 (0.200)	−0.286 (0.208)	−0.230 (0.225)
LLPGL (−1)	−0.646* (0.375)	−0.661* (0.378)	−0.0346 (0.421)
COV (−1)	−0.586 (0.373)	−0.590 (0.375)	−0.674** (0.325)
TEXASR (−1)	−18.21** (7.544)	−18.23** (7.586)	−1.057 (8.649)
SIZE (−1)	0.102 (0.111)	0.102 (0.111)	0.0519 (0.160)
LIQ (−1)	−0.895 (1.176)	−0.864 (1.164)	0.208 (1.057)
EFF (−1)	−0.706** (0.324)	−0.702** (0.325)	−0.228 (0.360)
ΔGDP (−1)	−0.211 (0.512)	−0.701 (1.115)	−1.141 (1.258)
EURIBOR (−1)	0.110 (0.165)	0.110 (0.165)	0.110 (0.165)
HHI (−1)	−0.277 (0.635)	−0.267 (0.634)	1.354 (10.82)
Time FE	No	Yes	Yes
Country FE	No	No	Yes
Cluster S.E. Bank	Yes	Yes	Yes
Observations	206	206	206

This table reports the results of the Dif-in-Dif estimates on the impact of the Tier 1 leverage ratio on the Z-Score. *Treated* identifies banks within the lower quintile of Tier 1 Leverage ratio while the control group comprises banks within higher quintile of Tier 1 Leverage ratio. *D_Postshock*: 1/1/2013, period of mandatory disclosure of Tier 1 Leverage ratio to sovereign bank authority. Significance levels: ***1%, **5%, *10%.

introduces time fixed effects while Model 3 includes country fixed effects as well. Overall, our results suggest that less capitalized banks benefit from mandating the disclosure of the leverage ratio.

Treated is negative and significant at 1% level in all the 3 models. However, the interaction between treated and Post_shock turns out positive (coefficients 0.945, 0.957 and 0.984) and strongly significant meaning that the mandatory disclosure plays the effect of increasing the Z-Score (i.e. reducing bank riskiness) for those banks operating with a lower leverage ratio.

As for the provisioning policies, results resemble our previous estimates. Both LLP/GL and the Texas ratio are negatively and significantly at least in Models 1 and 2) related with the Z-Score.

As for the control variables, only the EFF is significantly (and negatively) related with our risk variable.

Table 7 reports the dif-in-dif results for the implementation of the Basel III Tier 1 capital requirement. We test 3 models as specified in **Table 7**.

Our results confirm the findings for the leverage ratio dif-in-dif analysis. Treated shows a strong (at 1% level) and negative association with the Z-Score, implying that less capitalised banks are those operating with higher levels of riskiness.

The interaction with Post_shock turns out positive, although with a weak significance level (1%) meaning that mandating the implementation of the Basel III Tier 1 capital ratio benefits less capitalised banks inducing a reduction in the Z-Score. LLPGL, COV and the Texas ratio are strongly and negatively related with the Z-Score as in previous estimates.

Among control variables, we find the HHI which expresses the degree of market power has a negative impact on the Z-Score suggesting that banks with a higher level of market power tend to reduce bank riskiness, thus showing a higher level of financial stability (Agoraki et al., 2011).

Overall, our results allow rejecting Hypothesis H_{4b} in favour of the alternative Hypothesis H_{4a}.

6.2. Robustness Checks

To further validate our baseline results we run several robustness checks. After running our endogeneity tests, we test two models for both the GMM and the instrumental variable approach, i.e. the first based on the capital adequacy specification of bank capital and the second on the simple leverage ratio (**Table 8**).

We find no substantial differences compared to our previous estimates. Both the Tier 1 capital ratio and the leverage ratio show a positive and strongly significant association with the bank Z-Score.

We confirm our overall results pointing to a significant effect of bank capital in reducing a bank's riskiness with no different effects of our two specifications of capital. Looking at provisioning policies, we find similar results as well. Both the coverage ratio and the Texas Ratio variable are strongly significant and negatively associated with bank riskiness. Only LLPGL shows partially different outcomes in the sense that it is significant (and negatively related to the Z-Score) only in the IV 2SLS model. As for the control variables, the efficiency ratio only is significant and negatively related to the Z-Score when it comes to estimating our instrumental variable model.

Table 7. Dif-in-Dif regression, test on Tier 1 capital ratio.

Variable	Z-Score		
	(1)	(2)	(3)
TREATED*POSTSHOCK	0.535* (0.291)	0.527* (0.292)	0.534* (0.316)
TREATED	−1.308*** (0.346)	−1.298*** (0.349)	−1.483*** (0.485)
D_POSTSHOCK	−0.0954 (0.158)	7.123*** (1.190)	6.557*** (1.295)
LLPGL (−1)	−1.286*** (0.374)	−1.275*** (0.373)	−0.969** (0.463)
COV (−1)	−0.762*** (0.231)	−0.761*** (0.229)	−0.826*** (0.267)
TEXASR (−1)	−25.98*** (5.193)	−25.86*** (5.232)	−24.22*** (7.091)
SIZE (−1)	−0.0784 (0.0884)	−0.0775 (0.0876)	−0.136 (0.109)
LIQ (−1)	−0.818 (0.725)	−0.740 (0.733)	−1.087 (0.774)
EFF (−1)	−0.659* (0.385)	−0.697* (0.376)	−0.109 (0.425)
ΔGDP (−1)	−1.064 (0.667)	−1.802* (0.940)	−0.791 (1.156)
EURIBOR (−1)	0.138 (0.549)	0.137 (0.549)	0.136 (0.549)
HHI (−1)	−1.057** (0.431)	−1.036** (0.434)	−3.133 (4.397)
Time FE	No	Yes	Yes
Country FE	No	No	Yes
Cluster S.E. Bank	Yes	Yes	Yes
Observations	273	273	273

This table reports the results of the Dif-in-Dif estimates on the impact of the Tier 1 Capital ratio on the Z-Score. *Treated* identifies banks within the lower quintile of the Tier 1 Capital ratio while the control group comprises banks within higher quintile of the ratio. *D_Postshock*: 1/1/2014, period of implementation of Basel 3 Tier 1 Capital ratio requirements. Significance levels: ***1%, **5%, *10%.

Table 8. Endogeneity test.

Variable	Z-Score			
	GMM		IV 2SLS	
	(1)	(2)	(1)	(2)
Z-Score (−1)	0.347*** (0.0250)	0.328*** (0.0242)		
Tier 1 Cap (−1)	3.356*** (1.211)		6.932** (3.371)	
Tier 1 Lev (−1)		5.377*** (2.060)		21.32*** (6.163)
LLPGL (−1)	0.140 (0.101)	0.0929 (0.1000)	−0.935*** (0.177)	−1.089*** (0.201)
COV (−1)	−0.118*** (0.0414)	−0.116*** (0.0382)	−0.190*** (0.0706)	−0.174*** (0.0595)
TEXASR (−1)	−8.572*** (2.113)	−8.299*** (2.062)	−10.56*** (3.494)	−7.666** (3.663)
SIZE (−1)	−0.0186 (0.0422)	−0.000379 (0.0466)	−0.0264 (0.0555)	0.0291 (0.0680)
LIQ (−1)	−0.281 (0.268)	−0.284 (0.276)	−0.745* (0.424)	−0.567 (0.563)
EFF (−1)	0.0977 (0.0902)	0.0900 (0.0895)	−0.644*** (0.121)	−0.525*** (0.117)
ΔGDP (−1)	−0.319 (0.200)	−0.309 (0.198)	−0.0470 (0.271)	−0.0912 (0.266)
EURIBOR (−1)	0.0141 (0.0356)	−0.0144 (0.0331)	−16.33 (18.95)	−10.64 (15.24)
HHI (−1)	−0.0104 (0.326)	−0.0810 (0.315)	0.142 (0.569)	−0.00910 (0.571)
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Cluster S.E.	Yes	Yes	Yes	Yes
Hansen	1.00	1.00		
AR2	0.432	0.324		
Sargan's p			0.321	0.341
Observations	2498	2508	2466	2477

This table reports the results for the endogeneity tests. Both a *Generalized Method of Moments* and an *Instrumental Variable regression* (IV 2SLS) are estimated. Model 1 is estimated using the Tier 1 capital ratio as a measure of bank capital while Model 2 employs the leverage ratio. In each model one lag of the dependent variable (Z-Score) is introduced. Significance levels: ***1%, **5%, *10%.

Table 9 reports the estimations based on alternative measures of bank risk, including the DD and the idiosyncratic volatility. Results are similar to previous estimates.

Table 9. Alternative risk measures: DD and idiosyncratic volatility.

Variable	DD		Idio Vol	
	(1)	(2)	(1)	(2)
Tier 1 Cap (−1)	2.242*** (0.491)		−0.198*** (0.0535)	
Tier 1 Lev (−1)		3.853*** (1.145)		−0.167*** (0.0609)
LLPGL (−1)	−0.522*** (0.0605)	−0.562*** (0.0618)	0.0313*** (0.00834)	0.0377*** (0.00790)
COV (−1)	−0.0216 (0.0210)	−0.0227 (0.0196)	0.00344*** (0.00130)	0.00282*** (0.00105)
TEXASR (−1)	−3.287*** (1.087)	−3.428*** (0.931)	0.252*** (0.0758)	0.240*** (0.0699)
SIZE (−1)	−0.0254 (0.0401)	−0.0123 (0.0330)	−0.00194* (0.00107)	−0.00268** (0.00108)
LIQ (−1)	−1.076*** (0.132)	−1.146*** (0.145)	0.0310** (0.0125)	0.0337*** (0.0108)
EFF (−1)	−0.263*** (0.0394)	−0.257*** (0.0368)	0.00303 (0.00902)	0.00849 (0.00697)
ΔGDP (−1)	0.0261 (0.0662)	0.0103 (0.0686)	−0.0420*** (0.0137)	−0.0414*** (0.0139)
EURIBOR (−1)	47.93*** (11.94)	46.47*** (12.76)	3.254 (2.550)	3.294 (2.643)
HHI (−1)	0.145 (0.204)	0.131 (0.198)	0.0141 (0.0149)	0.0124 (0.0134)
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Cluster S.E. Bank	Yes	Yes	Yes	Yes
Observations	2622	2622	2620	2620

This table reports the estimation results for Equation (4) where alternative measures of the dependent variable are used, i.e. the *Distance-to-Default* (DD) and the *Idiosyncratic Volatility* (Idio Vol). Model 1 is estimated using the Tier 1 capital ratio as a measure of bank capital while Model 2 employs the leverage ratio. Significance levels: ***1%, **5%, *10%.

Both the Tier 1 capital ratio and the leverage ratio show a positive (the coefficients being +2.242 and +3.853 respectively) and significant (1%) association with the DD and a negative relationship with the Idiosyncratic volatility (−0.198 and 0.167 respectively with a 1% significance level).

The impact on risk flows, therefore, in the same direction. An increasing DD as a result of higher capitalization levels implies a lower riskiness; in the same vein, the negative relationship with Idiosyncratic volatility means that better capitalized banks turn out to dampening volatility, thus reducing the market's perceived riskiness. The same interpretation holds for LLPGL, COV and TEXASR which are all strongly significant (1% level) with a positive association with DD and a negative association with idiosyncratic volatility.

As for the control variables EFF and EURIBOR deploys a negative (thus increasing it) and a positive impact (thus reducing it) on the DD. Both are not significant in the idiosyncratic volatility regression. Increases in GDP, finally, turn out to reducing idiosyncratic volatility.

Finally, Table 10 reports the estimation results employing a Bootstrapping Standard Errors with 1000 replications routine.

Table 10. Bootstrapping standard errors with 1000 replications.

Variable	Z-Score			
	(1)	(2)	(3)	(4)
Tier 1 Cap (−1)	4.688*** (0.819)		4.554*** (0.819)	
Tier 1 Lev (−1)		13.44*** (1.190)		8.954*** (1.190)
LLPGL (−1)	−0.865*** (0.143)	−0.875*** (0.126)	−0.947*** (0.143)	−1.047*** (0.126)
COV (−1)	−0.160*** (0.0341)	−0.149*** (0.0318)	−0.184*** (0.0341)	−0.180*** (0.0318)
TEXASR (−1)	−12.05*** (1.499)	−11.96*** (1.553)	−10.75*** (1.499)	−9.758*** (1.553)
SIZE (−1)	−0.00523 (0.0241)	0.0399 (0.0255)	−0.0230 (0.0241)	0.00588 (0.0255)
LIQ (−1)	−0.666*** (0.216)	−0.643** (0.254)	−0.746*** (0.216)	−0.728*** (0.254)
EFF (−1)	−0.538*** (0.0995)	−0.429*** (0.102)	−0.644*** (0.0995)	−0.607*** (0.102)
ΔGDP (−1)	−0.0258 (0.394)	−0.0597 (0.379)	−0.0161 (0.394)	−0.0319 (0.379)
EURIBOR (−1)	−7.260 (50.51)	−13.86 (50.27)	−3.590 (50.51)	−4.868 (50.27)
HHI (−1)	0.142 (0.309)	−0.00715 (0.347)	0.390 (0.309)	0.305 (0.347)
Time FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Bootstrap Standard Errors	Yes	Yes	Yes	Yes
Observations	2545	2555	2545	2555

This table reports the estimation results of Equation (4) whit the Z-Score as the dependent variable. Equation (4) is estimated using a *Bootstrapping Standard Errors* with 1000 replications routine. Model 1 is estimated using the Tier 1 capital ratio as a measure of bank capital while Model 2 employs the leverage ratio. Significance levels: *** 1%, ** 5%, * 10%.

Results do not change. Tier 1 Cap and Tier 1 Lev are still positively and significantly (1% level) associated with the Z-Score. LLPGL, COV and TEXASR still are negatively and significantly (1% level) associated with the Z-Score.

7. Conclusion

The financial turmoil following the 2008-2009 crisis prompted a remarkable wave of reforms in the banking industry, specifically aimed at tightening the regulatory framework, especially for what it concerns the quantity and quality of bank capital. That resulted in a substantial revision of the Basel package. More recent pieces of regulation deal with the issue of non-performing exposures providing for adequate levels of coverage both through capital and provisions. This study contributes to the ample literature on bank risk-taking. The joint consideration of the effect of risk-based capital standards and the Basel III leverage ratio allows for providing a better insight into the capital-risk relation, overcoming those limitations that extant literature identified in merely considering the risk-based standards.

Adding to the analysis, the impact of the coverage policies of NPLs as mandated by the March 2018 ECB addendum on the NPL draft guidance provides further and new insights into the way coverage policies impact bank riskiness. Given that the ECB addendum provides for a timely full-coverage of non-performing exposures with both capital and provisions, incorporating in the analysis, a measure of adequate coverage against a specific target level (i.e. 100% of NPLs) allows gathering insights on how adequate and timely coverage affects riskiness. Specifically, as a market-based measure of risk, idiosyncratic volatility and the DD captures market perceptions of a bank's riskiness. We found three main results.

At first glance, our results support previous literature finding a positive effect of a bank's capital on risk. That holds for both the Tier 1 capital ratio and the leverage ratio and for all the measures of risk considered in the study. While these results suggest that better-capitalized banks keep up with reducing riskiness, a look at NPL's provisioning and coverage policies elicits more substantial considerations regarding the role of capital and in terms of regulatory implications though.

On the one hand, our results point to a negative effect of provisioning policies on the Z-Score in the sense that increasing provisions heighten a bank's risk profile as measured by the Z-Score. On the other hand, our Texas ratio variable suggests that banks lagging behind in timely coverage of NPLs experience an increase in their riskiness.

As a second result, we found a significant size effect as well. Our results reveal that higher capitalization levels and timely recognition of non-performing exposures specifically benefit small banks.

As a third result, less capitalized banks are those benefitting from the mandatory disclosure of the leverage and the implementation of the Basel III Tier 1 capital requirement. Specifically, those banks operating with a lower level of leverage ratio and those having lower Tier 1 capital ratios experience a significant reduction in their riskiness following the implementation of the Basel III package.

In our view, our findings elicit to argue in favour of the strengthened regulatory framework as emerged in the aftermath of the financial turmoil as it allowed for reinforcing the resilience of the weakest institutions. Nonetheless, our findings suggest that even well-capitalized banks face a surge in riskiness in case of a lack of timeliness in NPLs recognition, which has implications in light of the most recent pieces of regulation in the EU. Overall, our results lead us to claim that a simple Texas ratio-like index as that mandated by the ECB addendum on the NPL draft guidance is sufficiently robust and easy to implement.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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