Regulatory Bank Capital Ratios and Market Measures of Risk

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Master Thesis Policy Economics

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Date final version: 08-05-2018

Abstract

This paper analyzes how bank capital ratios affect the safety of banks. The main finding is that higher capital ratios following Basel III significantly reduced risk for large European banks. Large banks with a higher capital ratio have a higher asset quality, a lower stock return volatility, and a lower contribution to systemic risk. These results indicate that Basel III has been effective in increasing the safety of the financial sector. The novelty of this paper is that it proposes a method to estimate a Tier 1 capital ratio that is not influenced by changes in the definition of capital, thus allowing for a better comparison of pre- and post-Basel III Tier 1 ratios. Using this new measure, this paper finds that banks have increased their Tier 1 ratio by 6 to 9 percentage points on average, compared to pre-crisis levels.

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† Views expressed here are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

This thesis was written during an internship at the Supervisory Policy division of De Nederlandsche Bank. I am very thankful to Joost Van der Burgt for invaluable supervision during the internship. I also thank Paul Cavelaars, Carsten Folkertsma, Gibran Borst, and Tjeerd de Vries for useful comments. All remaining errors are mine.

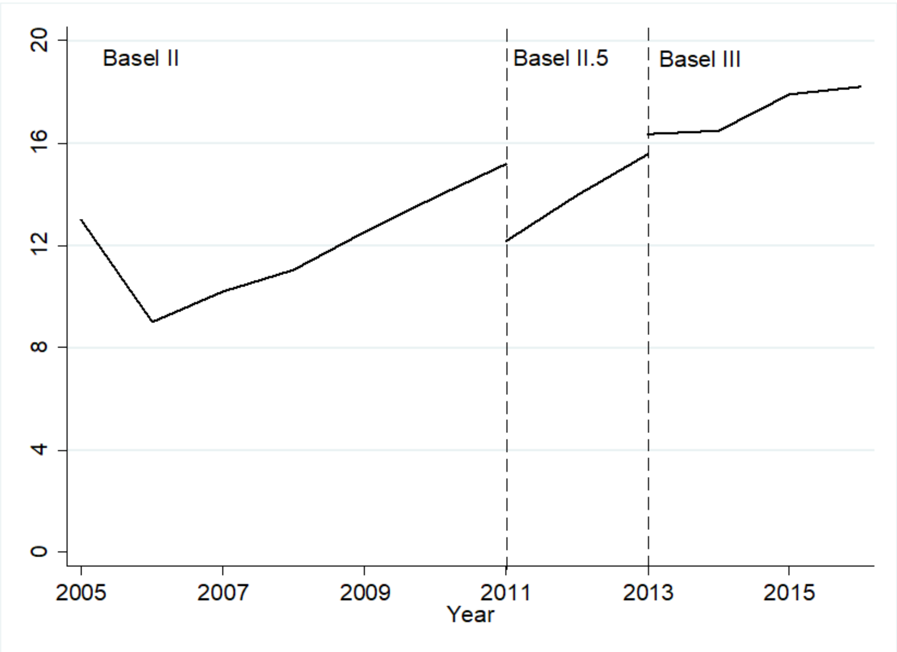
Contents

1.Introduction

After the financial crisis a new regulatory framework was put in place by the Basel Committee on Banking Supervision (BCBS). The Basel III agreement focused on increasing capital ratio requirements and more stringent definitions of capital (Basel Committee on Banking Supervision, 2011). Figure 1 shows the average Tier 1 ratio for a subsample of large banks across different regulatory frameworks. However, because of the change in the definition of capital, Tier 1 ratios before and after Basel III are not comparable. Therefore, one cannot say by how much capital ratios increased compared to the pre-crisis level. This paper proposes a method to construct a consistent Tier 1 capital ratio across regulatory regimes. Higher capital ratios are not a goal in itself, they are meant to improve the safety of banks and to reduce the risk of default. Therefore, the research question of this paper is:

How do bank capital ratios affect the safety of banks?

Figure 1. Tier 1 ratios under different Basel frameworks



Source: SNL Financial Database and author's calculations.

Notes: The sample used consists of banks with a Tier 1 capital of at least 3 billion euros.

This paper adds to the existing literature by constructing a consistent capital ratio that controls for the change in the definition of capital and risk-weighted assets (RWA). Moreover, this paper empirically estimates the effect of capital ratios on market measures of risk. Although higher capital ratios are expected to decrease risk, Sarin and Summers (2016) show that large

US banks did not become safer compared to the pre-crisis period. Using market measures of risk, such as volatility, beta, and the credit default (CDS) swap, they show that risk in the financial sector has not decreased, compared to before the crisis (Sarin & Summers, 2016). A shortcoming of their research is that they do not formally test the effect of capital ratios on risk, but only compare group averages over time. Furthermore, they do not take into account the change in the definition of Tier 1 capital.

Using a consistent Basel II Tier 1 ratio, this paper finds that banks have on average increased their capital ratios by 6 to 9 percentage points. Banks with a higher capital ratio have a lower Texas ratio, which indicates that banks have a higher asset quality. Furthermore, higher capital ratios reduce stock return volatility and the marginal expected shortfall, which measures contribution to systemic risk. This effect is significant for globally systemically important banks (G-SIBs) and other large banks. For smaller banks, however, higher capital ratios do not ostensibly lead to lower levels of the selected risk measures, except for the Texas ratio. Since the Basel III reforms mainly focused on large banks, the results show that Basel III has been effective in reducing risk in the banking sector. However, contrary to expectations, no significant effect of capital ratios on the CDS spread is found. The reason for this may be that capital ratios based on the market value of equity did not increase as much as book value capital ratios. Additionally, since with the new European resolution regime government bail-outs are less likely to occur, investors have to bear part of the losses in case of a failure. Even though the probability of a failure may have been reduced, in case of a failure, risk has increased.

The remainder of this paper is as follows. Section 2 gives an overview of the relevant literature on the relationship between capital ratios and bank safety. Section 3 describes the empirical methodology and discusses several risk measures. Section 4 constructs a consistent capital ratio for the pre- and post-Basel III period and gives basic descriptive statistics for the relevant variables. Section 5 gives the empirical results of the regressions for the relationship between capital ratios and risk. Robustness checks are performed in section 6. Section 7 concludes and gives policy recommendations.

2.Literature review and research hypotheses

2.1 Literature review

The objective of the Basel III framework is to “strengthen global capital and liquidity rules, … to improve the banking sector’s ability to absorb shocks, … improve risk management …and raise the quality, consistency and transparency of the capital base" (Basel Committee on Banking Supervision, 2011, pp. 1-2). Basel III consists of three pillars. Pillar I focuses on capital requirements, Pillar II on the process of reviewing capital adequacy and the calculation of risk, and Pillar III focuses on disclosure requirements regarding risk and capital management, with the aim of strengthening market discipline (Basel Committee on Banking Supervision, 2011). The Basel II framework allowed banks to use their own models to calculate capital and risk-weighted assets (RWA), which were thus suspect to 'gaming'. The use of internal models to calculate RWA is still allowed[1]. However, in order to "constrain excessive leverage in the banking system and provide an extra layer of protection against model risk and measurement error", Basel III combined a risk-weighted capital ratio with an unweighted leverage ratio requirement (Basel Committee on Banking Supervision, 2011, p. 2). The leverage ratio requirement reduces the incentive to move risky assets to off-balance sheet vehicles, which would reduce the effective capital ratio of banks (Kiema & Jukivuolle, 2014). Theoretically, a leverage ratio requirement can increase bank safety, but in some cases it may also induce a shift from low-risk to high-risk portfolios, thereby hurting bank stability (Kiema & Jukivuolle, 2014). In addition, a leverage ratio requirement can decrease the probability of a bank run (Dermine, 2015). Others argue that a risk-weighted measure is not necessary, because a leverage ratio takes into account the same risks as a Value-at-Risk measure and is preferable because of simplicity and comparability across financial institutions (Jarrow, 2013). However, even if the leverage ratio would take into account the same risks as the risk-weighted capital ratio, it does not give information on these risk levels. Therefore, most researchers argue in favor of a combination of a risk-weighted capital ratio and a leverage ratio, because each measure corrects for the other's shortcomings (Bair, 2015).

Regarding the effect of capital ratios on risk, the BCBS (2010) found in an economic impact evaluation of the Basel II.5 capital requirements that a higher capital ratio reduces the probability of a banking crisis, volatility of output, and likely the severity of a crisis. However, stronger capital requirements also lead to a higher cost of bank credit. Moreover, the possibility of shifting risk to the non-regulated or shadow banking sector could lead to even higher costs. Overall, the BCBS study finds that higher capital ratios lead to a net benefit for the economy. According to Cecchetti (2014), these net benefits are underestimated. He finds that lending

[1] A comprehensive revision of the calculation of RWA resulted in the Basel III.5 agreement in 2017.

spreads and interest margins have hardly increased, and, except for Europe, credit growth has been robust.

Klomp and De Haan (2012) conduct a factor analysis of 25 measures of bank risk and find that capital regulation mitigates risk. However, the authors do not discuss the types of capital regulations in place, only whether some form of regulation exists. Although a higher capital ratio could induce risk taking by banks, it usually increases the probability of survival for US banks (Berger & Bouwman, 2013). Because well-capitalized banks are more likely to survive, they attract more borrowers and thus increase their market share. Moreover, well-capitalized banks had higher stock returns during the financial crisis. This positive effect was even stronger for the leverage ratio, indicating that market participants perceived the leverage ratio as a more accurate measure of risk (Demirgüç-Kunt, Detragiache, & Merrouche, 2013). However, following Goodhart's Law, the leverage ratio may lose its power as risk measure once it becomes a requirement (Goodhart, 1975). Vazquez and Federico (2015) show that higher structural liquidity and a higher leverage ratio significantly reduce the likelihood of bank failure, especially for global, system-relevant banks. They find that a 3.5 percentage point increase in the ratio of equity to total assets would lead to a 48 percentage point lower probability of failure. Other research, however, finds that a higher equity-to-assets ratio does not reduce risk, when considering the CDS spread, asset volatility and the Z-score (Bruno, Nocera, & Resti, 2015). Finally, a higher Basel II Tier 1 capital ratio is found to reduce standalone and systemic risk in the financial sector (Laeven, Ratnovski, & Tong, 2016), although a higher Tier 2 capital ratio does not have a similar effect (Anginer & Demirgüç-Kunt, 2014). This indicates that the quality of capital matters for bank safety.

A paper with a similar research objective as this one found that US banks did not become safer after the crisis (Sarin & Summers, 2016). The authors use several market measures of risk, such as stock price volatility, beta, the price-earnings ratio, and the CDS spread, and compare these before and after the financial crisis. They expect to see lower values of the risk measures, because banks have a higher capital ratio due to higher capital requirements. However, the post-crisis values for the risk measures are higher than in the pre-crisis period, implying that banks did not become safer. They do not regard this as evidence against the use of capital requirements, but rather argue they should be higher. As an explanation for the increase in risk they argue that this is due to the decline in franchise value of banks, which decreases the market-based leverage ratio and increases risk. As support for this argument they show evidence that the market value of equity to total assets ratio has decreased, despite the increase in the regulatory capital ratio.

However, there are some shortcomings in this paper. Sarin and Summers (2016) do not show that increased capital requirements made banks less safe. They only compare pre- and post-crisis averages, thus not giving a causal estimate of the effect of capital ratios on risk. Additionally, they use the regulatory Tier 1 capital ratio, but do not explicitly recognize that the definition of this ratio has significantly changed due to the Basel III framework. Therefore, a clear comparison of pre- and post-crisis capital ratios is absent, casting further doubt on the robustness of their results.

2.2 Hypotheses

Basel III brought about substantial changes in the definition of capital and capital ratio requirements, to improve the capital position of the banking sector. Average Tier 1 ratios are now higher than before the crisis. However, since a simple comparison of Tier 1 ratios does not take into account the change in definition, the development of capital ratios should be further analyzed. Therefore, the first hypothesis of this paper is:

H_1: Bank capital ratios have improved due to the implementation of Basel III.

As mentioned before, higher capital ratios are meant to reduce risk, but researchers have not yet reached consensus on this effect. This leads to the second hypothesis of this paper:

H_2: Higher bank capital ratios decrease the risk of banks.

This paper contributes to the existing literature by constructing a consistent risk-weighted capital ratio. Furthermore, this consistent capital ratio is used to empirically test the relationship between capital ratios and bank safety using an elaborate dataset on European banks and several market-based risk measures.

3. Methodology

Tier 1 capital ratios cannot easily be compared over time, due to changes in the definition of capital and RWA. Therefore, this paper constructs a Tier 1 ratio that is consistent over time and not influenced by these changes. Section 3.1 describes the methodology of the construction of this capital ratio. However, the main focus of this paper is on the relationship between this constructed capital ratio and various measures of bank risk. The empirical strategy for this is given in section 3.2. Finally, the risk measures are described in section 3.3.

3.1 Construction of a consistent capital ratio

Since risk-weighted capital ratios are the core of the Basel regulatory framework, this paper constructs a consistent, *risk-weighted* Basel II Tier 1 ratio. The Basel II period is chosen because due to larger data availability for the Basel II period, the results are likely to be more robust. Furthermore, the literature generally uses the Basel II Tier 1 ratio, since Basel III was only implemented in 2014.The two advantages of this paper's approach are that the Tier 1 ratio generally relates to higher-quality capital and that it is a risk-weighted capital ratio.

A study by the BCBS (2010) constructs the Basel II Tier 1 ratio using the risk-weighted tangible common equity (TCE) ratio. The definition of TCE has not changed over time, and it relates to high-quality capital. This makes TCE comparable to Tier 1 capital. TCE consists of common equity minus intangible assets and goodwill.

$$\mathrm{TCE_{RW}\ ratio} = \frac{\text{common equity} - \text{intangible assets} - \text{goodwill}}{\mathrm{RWA}} = \frac{\mathrm{TCE}}{\mathrm{RWA}} \qquad (1)$$

The subscript RW refers to risk-weighted, since a TCE ratio can also be unweighted. This paper uses a similar method to relate the $\mathrm{TCE_{RW}}$ ratio to the Basel II Tier 1 ratio. The methodology gives an approximation of what would have been the Tier 1 ratio, were Basel II still the relevant framework. To construct a consistent Basel II Tier 1 ratio, three steps have to be taken.

1. Calculate the historical relationship between the $\mathrm{TCE_{RW}}$ ratio and the Tier 1 ratio for the Basel II period by performing a simple regression.
2. Correct the Basel III $\mathrm{TCE_{RW}}$ ratio for the change in the calculation of RWA under Basel III.
3. Multiply the corrected $\mathrm{TCE_{RW}}$ ratio with the coefficients from step 1.

This procedure is repeated for three groups of banks, G-SIBs, group 1 and group 2 banks[2].

3.1.1 Historical relationship between the $\mathrm{TCE_{RW}}$ ratio and Tier 1 ratio

The advantage of the $\mathrm{TCE_{RW}}$ ratio is that it is fairly easy to calculate, as the definition of TCE did not change over time and it does not include equity instruments or hybrid capital. As such, the $\mathrm{TCE_{RW}}$ ratio focuses on high-quality capital. The following regression is performed for the Basel II period for each group of banks separately[3]:

[2] This classification is also used by the BCBS. Group 1 banks have Tier 1 capital above three billion euros and are internationally active, and group 2 banks are the remaining banks. This paper uses this division between banks, but slightly changes the condition for being a group 1 bank. Since the database used did not give information on which bank is internationally active, the sole criterion was that Tier 1 capital should be above three billion euros.

[3] Applying fixed effects to capture time-invariant bank-specific factors does not change the results.

$$\frac{Tier1}{RWA}_{i,t} = \beta_0 + \beta_1 \frac{TCE}{RWA}_{i,t} + \varepsilon_{i,t} \quad (2)$$

Subscripts *i* and *t* refer to bank and year, and $\varepsilon_{i,t}$ is the error term. This regression enables the approximation of the Basel II Tier 1 ratio using the TCE_{RW} ratio. The coefficients capture the average historical relationship between the two capital ratios.

3.1.2 Correction for the change in Basel III RWA calculation

Before the coefficients from regression (2) can be applied to the TCE_{RW} ratio for the Basel III period, the RWA have to be corrected. Although Basel III did not change the calculation of risk weights fundamentally, some components changed. The change in the calculation of counterparty credit risk and credit valuation adjustment led to higher risk weights under Basel III than under Basel II. Furthermore, for large financial institutions an asset valuation correlation multiplier of 1.25 was added, increasing RWA even further (Basel Committee on Banking Supervision, 2011).

These changes lead to a higher RWA than under Basel II calculations. As a result, when keeping Tier 1 capital fixed, applying these higher risk weights result in a lower Tier 1 ratio, *ceteris paribus*. In a monitoring report, the BCBS estimated that the change in the calculation of risk weights led to an increase in RWA of 8.3% for group 1 banks (including G-SIBs), and 6.5% for group 2 banks (Basel Committee on Banking Supervision, 2014, p. 40). Although these are average estimates on the group level, one can use these estimates to approximately correct for the change in RWA due to changed calculation standards.

Approximated Basel II RWA under the Basel III period are calculated as follows:

$$\text{Approximated Basel II RWA} = \frac{\text{Basel III RWA}}{1.083} \text{ for Group 1 banks} \quad (3)$$

$$\text{Approximated Basel II RWA} = \frac{\text{Basel III RWA}}{1.065} \text{ for Group 2 banks} \quad (4)$$

Applying these corrections brings the Basel III TCE_{RW} ratio on an equal footing with the Basel II TCE_{RW} ratio.

3.1.3 Approximating Basel II Tier 1 ratio for the entire period

The final step is to extrapolate the relationship between the Basel II Tier 1 ratio and the TCE_{RW} ratio to the Basel III period. Since the RWA under Basel III are brought on an equal footing with Basel II RWA, the *constructed* Basel II Tier 1 ratio for the Basel III period is devised as follows:

$$\frac{Tier1}{RWA}_{constr_{i,t}} = \hat{\beta}_0 + \hat{\beta}_1 \frac{TCE}{RWA_{Basel\ II_{i,t}}} \tag{5}$$

$\hat{\beta}_0$ and $\hat{\beta}_1$ are the estimated coefficients from regression (2).

There are several caveats to this approach. Under Basel III, banks must hold relatively more high-quality capital, which is more closely related to TCE capital. The share of TCE capital relative to Tier 1 capital is therefore likely to have increased. Hence, one would expect a stronger relationship between the TCE_{RW} ratio and the Tier 1 ratio, thus a higher coefficient[4]. The estimated coefficient under Basel II ($\hat{\beta}_1$ from regression (2)) is thus likely lower than the 'true' coefficient for the Basel III period. If the 'true', larger, coefficient for the Basel III period would have been used, the constructed Basel II Tier 1 ratios would have been larger than the ones presented in this paper. Hence, the results presented in this paper are a lower bound. If this paper finds a significant increase in the Tier 1 ratio over time using this constructed ratio, it will also find a significant increase when the caveat above would be controlled for.

Furthermore, the coefficient only represents a proportional relationship for a certain group of banks for a specific period. Individual coefficients may also differ from the group coefficient. In order to extrapolate the relationship between the Tier 1 ratio and TCE_{RW} ratio under the Basel II period to the Basel III period, it is crucial that the estimated relationship is stable. For individual banks, one outlier may change the entire relationship, making it less suitable for extrapolation. On the other hand, when group coefficients are used, the estimated coefficients are less prone to outliers. The relationship between the Tier 1 ratio and the TCE_{RW} ratio is more stable and thus more suitable for extrapolation.

3.2 Empirical model capital ratios and risk

The main objective of this paper is to test the relationship between capital ratios and bank risk. The previous subsection describes the methodology of constructing a capital ratio that is

[4] Suppose $Tier\ 1\ ratio = \frac{TCE+X}{RWA}$, where X is other Tier 1 capital. Keeping RWA and X fixed, a $\delta\%$ increase in $\frac{TCE}{RWA}$ ratio leads to a new Tier 1 ratio of $\frac{(1+\delta)TCE+X}{RWA}$. The percentage increase in the Tier 1 ratio is $\frac{(1+\delta)TCE+X-TCE-X}{RWA} \Big/ \frac{TCE+X}{RWA} \times 100\% = \delta \frac{TCE}{Old\ Tier\ 1} \times 100\%$. Thus, if the share of TCE to Tier 1 capital increases, the effect of a $\delta\%$ increase in the TCE_{RW} ratio on the percentage change in the Tier 1 ratio, captured by the coefficient in the regression, becomes larger.

comparable over time. This constructed capital ratio, then, is the main explanatory variable in the regressions described here.

The analysis focuses on multiple banks over several years, therefore this paper performs a panel regression with fixed effects for individual banks. The relevant capital ratio is the constructed Basel II Tier 1 ratio. Since the balance sheet data are reported at the end of the year and the market measures of risk are calculated as averages over the entire year, the contemporaneous value of the capital ratio is unsuitable and lagged values should be used instead. Furthermore, lagged balance sheet and macroeconomic control variables are included, which are described in section 4.5. The basic form of the regression looks as follows:

$$Risk_{i,t} = \beta_0 + \beta_1 CR_{i,t-1} + \beta X_{i,t-1} + \alpha_i + \gamma_t + \varepsilon_{i,t} \qquad (6)$$

$Risk_{i,t}$ is the risk measure for bank *i* in year *t*. $CR_{i,t-1}$ is the relevant capital ratio in the previous year, α_i is the bank-level fixed effect, γ_t is the year fixed effect, and $\varepsilon_{i,t}$ is the error term. $X_{i,t-1}$ is the first lag of the set of control variables that are described in section 4.5. The second hypothesis of this paper states that higher capital ratios reduce risk, which implies that $\beta_1 < 0$. Risk measures are the volatility of stock returns, volatility of stock returns relative to market volatility, the marginal expected shortfall, the Texas ratio (which takes into account asset quality), and the CDS spread. The risk measures are described in more detail in section 3.3.

3.3 Risk measures

Risk is a very broad concept and cannot be captured in a single variable. Ideally, this paper aims to capture the probability of default, since avoiding default is essential for a bank in order to be stable. Furthermore, a default at one bank can lead to a chain reaction and result in a financial crisis. During the crisis, several banks suffered great losses because their asset portfolios turned out to be of low quality. Therefore, asset quality is an important risk measure for tail risk. In addition, since the crisis was an episode of systemic risk and contagion in the financial sector, another measure should represent to what extent a bank is vulnerable to systemic risk. Finally, high stock price volatility indicates high uncertainty about the future earnings of a bank. This can thus serve as a risk indicator for equity investors. This paper also uses volatility of a bank relative to the volatility to of the market, to see whether a bank is riskier compared to other banks.

3.3.1 Volatility

The first risk measure is the volatility of stock returns. Volatility is calculated as the standard deviation of daily returns in a certain year. Volatility measures risk for shareholders, but also for the bank itself. The more volatile stock returns are, the higher the risk associated with that stock. The stock price reflects the future earnings perception, and if this perception is very volatile, it means that the future earnings of a bank are subject to high uncertainty. If a bank has a sufficiently large capital ratio, a negative shock will have a smaller effect on its future earnings capacity, because the bank can use its capital to absorb the shock. Therefore, the stock price is expected to be less volatile.

3.3.2 Relative volatility

Alternatively, the relative volatility of the stock volatility in relation to the market volatility can be used, as is also done by Sarin and Summers (2016). Whereas volatility measures the general level of uncertainty for a bank, relative volatility indicates whether a bank faces more uncertainty than the market. The Euro Stoxx Banks Index is chosen as the relevant index, and the market volatility is calculated as the standard deviation of the daily index returns.

$$\text{Relative volatility} = \frac{\text{volatility stock return}}{\text{volatility return index}} \tag{7}$$

3.3.3 Marginal expected shortfall

The third measure of risk is the Marginal Expected Shortfall (MES) of a bank, as proposed by Acharya, Pedersen, Philippon and Richardson (2012). It measures a bank's exposure to systemic risk. The Expected Shortfall (ES) is the expected loss, given that the loss exceeds the Value at Risk (VaR), which is in this case $\alpha = 0.05$. Or to put it differently, the ES is the loss on the days that the portfolio loss exceeds the VaR limit.

$$ES_{\alpha} = -E[R|R \leq -VaR_{\alpha}] \tag{8}$$

One can think of the financial system as a portfolio of banks, in which case R is the return of the aggregate banking sector. The contribution of each component of the portfolio to the ES can be measured with the MES. Here, the MES is the expected loss for a bank, given that the index return is at its lowest 5% in a certain year. A higher MES thus indicates a higher level of systemic risk.

$$MES_{\alpha}^{i} = -E[r_i|R < -VaR_{\alpha}] \tag{9}$$

3.3.4 Texas ratio

Fourth, asset quality can be measured by the Texas ratio, based on non-performing loans (NPLs), which is defined as follows (Jesswein, 2009):

$$\text{Original Texas ratio} = \frac{\text{NPLs} + \text{loans delinquent for 90 days} + \text{foreclosed property}}{\text{tangible equity} + \text{loan loss reserve}} \times 100\% \tag{10}$$

This paper, however, uses an alternative definition of the Texas ratio for two reasons. First, data on foreclosed property are not available. Second, the denominator includes tangible equity. Since the capital ratio includes tangible equity in the numerator, there is a negative relationship between the capital ratio and the Texas ratio by definition. To ensure that the coefficient on the capital ratio does not capture a mechanic effect, this paper uses a slightly adjusted measure, henceforth referred to as the Texas ratio.

$$\text{Adjusted Texas ratio} = \frac{\text{NPLs} + \text{loans delinquent for 90 days}}{\text{total assets}} \times 100\% \tag{11}$$

The Texas ratio has a reasonable track record as an early warning indicator (Jesswein, 2009). Furthermore, it relates to tail risk. Especially during a downturn, when the probability of default generally increases, asset quality is very important. If a bank has a low Texas ratio, the probability that it has to write down an asset is lower. Therefore, a lower Texas ratio indicates a lower level of expected losses, and thus a lower level of risk. However, for NPLs, the recovery option is important in its significance for risk. If a bank has a high probability of recovery, NPLs have a weaker relationship with risk than if the probability of recovery is low. However, "the recovery option should take into account the existence of collateral, type of legal documentation, type of borrower, local market conditions and the macroeconomic outlook, the legislative framework in place and potential historical recovery rates per option vs. the costs involved per option" (European Central Bank, 2016, p. 109). Since these factors differ per country and even per bank, one cannot simply compare NPL ratios across banks. This risk measure can still be used if one assumes those factors to be time-invariant, because a fixed effects panel regression absorbs time-invariant variables.

3.3.5 CDS spread

Finally, the 5-year CDS spread on senior debt is used, which is commonly considered "the annual cost of protection against a default by a company" (Sarin & Summers, 2016, p. 66). A higher capital ratio should reduce the probability of failure, because well-capitalized banks are better able to absorb losses. If the probability of failure is lower, the CDS spread should be lower (Sarin & Summers, 2016). Furthermore, the CDS spread also measures to what extent debt holders can expect to be repaid given a default. If a bank enters default with more capital, the debt holders can expect a larger share of their debt to be repaid. Thus, a higher capital ratio should lead to a lower CDS spread.

4.Data

This section describes the data sources, constructs the Basel II Tier 1 capital ratio based on the methodology of the previous section, and gives descriptive statistics for the risk measures and the control variables for the second part of the analysis.

4.1 Data sources

This paper uses balance sheet data for 389 commercial banks in 23 European countries[5]. The data are obtained from the SNL Financial database[6]. The relevant time period is from 2005-2016, although not all banks have data available for each year. The sample includes 15 G-SIBs and 110 publicly listed banks. Furthermore, only consolidated data are taken into account. Observations with a Tier 1 capital ratio below 0 or above 100 are dropped from the sample to exclude the influence of outliers. Additionally, if a bank does not have data for total assets in a certain year, it is dropped as well, resulting in 3,938 useable observations. Data for GDP growth are obtained from the International Monetary Fund World Economic Outlook database[7] of April 2017. This paper uses the volatility of stock returns, relative volatility of stock returns, the MES, an adjusted Texas ratio, and the 5-year CDS spread on senior debt as risk measures. Volatility, relative volatility and the MES are obtained from stock price data available for more than 100 banks in the SNL database. The Texas ratio is calculated using balance sheet data from the SNL database. Finally, the CDS spread is obtained from Reuters Datastream. CDS spread data are available from 2008 onwards. For banks that did not report their CDS spread in Datastream, but did report them in the SNL database, the earliest available year is 2013.

4.2 Overview Tier 1 ratio under Basel II and Basel III

As a general overview of capital ratios, table 1 shows the average capital ratios for different groups of banks, distinguishing between the Basel II and Basel III period. On average, all banks

[5] Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

[6] www.snl.com

[7] www.imf.org

increased their risk-weighted and unweighted capital ratios during the observed period. Nevertheless, this table does not take into account the change in the definition of capital.

Table 1. Average capital ratios under Basel II and Basel III

Type of bank	Basel II (2007-2013)				Basel III (2014-2016)			
	CET1	Tier 1	TCE_{RW}	LR	CET1	Tier 1	TCE_{RW}	LR
G-SIB	8.8%	11.0%	8.5%	4.5%	13.2%	14.9%	13.8%	5.6%
Group 1	12.7%	13.7%	12.0%	5.8%	17.0%	17.9%	17.9%	7.5%
Group 2	12.8%	13.3%	13.5%	7.2%	15.6%	16.0%	17.1%	8.2%
All	12.7%	13.3%	12.9%	6.7%	16.0%	16.6%	17.2%	7.8%

Notes: CET1 and Tier 1 are risk-weighted capital ratios, TCE_{RW} is the TCE_{RW} ratio as defined in the previous section, and LR is the leverage ratio, measured by total equity to total assets. Group 1 bank exclude G-SIBs.

4.3 Construction of the Tier 1 ratio

Table 2. Regression of Tier 1 ratio on TCE_{RW} ratio

	Dependent variable: Tier 1 ratio		
Type of bank	G-SIB	Group 1	Group 2
TCE_{RW} ratio	0.770***	0.857***	0.826***
	(0.080)	(0.015)	(0.010)
Constant	4.464***	3.421***	2.151***
	(0.713)	(0.226)	(0.162)
Observations	49	542	1256
R^2	0.662	0.860	0.838

Notes: *, **, and *** refer to significance at the 10%, 5%, and 1% level, respectively. Regressions are performed for all years in which Basel II was the relevant regulatory framework. Group 1 banks do not include G-SIBs.

Following the methodology described in section 3.1, table 2 shows the coefficients for the construction of the Tier 1 ratio[8]. The regressions are performed per group of banks, to calculate bank type-specific conversion factors, in order to detect any heterogeneity between G-SIBs, group 1 and group 2 banks[9]. The estimated coefficient is calculated such that the constant plus

[8] The results for the construction of the CET1 ratio are shown in the appendix for the interested reader.

[9] Performing the regression of table 2 for all banks gives a constant of 2.659 and a coefficient on the TCE_{RW} ratio of 0.828. These results are quite similar to the results for group 2 banks, because they constitute the largest share of banks in the sample. However, for G-SIBs and group 1 banks the group-specific coefficients differ substantially, especially the constants.

the TCE_{RW} ratio multiplied by that coefficient gives the Tier 1 ratio, in the Basel II period[10]. Hence the reported Tier 1 ratio and the constructed Tier 1 ratio should be approximately the same for the Basel II period, otherwise the coefficients are not a good conversion factor. Since the definition of capital became stricter for the Basel III period, the constructed Basel II Tier 1 ratio for the Basel III period should exceed the reported Basel III Tier 1 ratio.

Table 3. Average reported and constructed Tier 1 ratios

Type of bank	Basel II (2007-2013)		Basel III (2014-2016)	
	Tier 1 ratio	Constr. Tier 1 ratio	Tier 1 ratio	Constr. Tier 1 ratio
G-SIB	11.0%	11.0%	14.9%	16.0%
Group 1	13.4%	13.5%	17.0%	19.2%
Group 2	13.0%	13.1%	15.9%	17.1%

Notes: Group 1 banks do not include G-SIBs.

Table 3 calculates the average constructed Tier 1 ratio for different groups of banks under Basel II and Basel III[11,12]. The coefficients in table 2 are accurate when the reported and constructed Tier 1 ratios in the Basel II period are very close to each other. As expected, there is a maximum difference of 0.1 percentage point on average for the Basel II period. There is also a very small difference when banks are considered individually. Figure 2 further shows that for group 1 banks the constructed and reported Basel II Tier 1 ratios are very close to each other[13]. The constructed Tier 1 ratio is thus accurate for the Basel II period.

Furthermore, the constructed Tier 1 ratios exceed the reported Basel III Tier 1 ratios. The constructed Tier 1 capital ratios are around 1.1 to 2.2 percentage points higher than the mean Basel III Tier 1 ratios (2014-2016). Table 3 shows that the average capital ratio in 2014-2016 exceeds the average capital ratio in 2007-2013 by 4 to 6 percentage points on average. For all groups of banks, the increase in the Tier 1 ratio is significant at the 1% level. Therefore, the first hypothesis of this paper cannot be rejected, banks have increased their capital ratios due to the implementation of Basel III.

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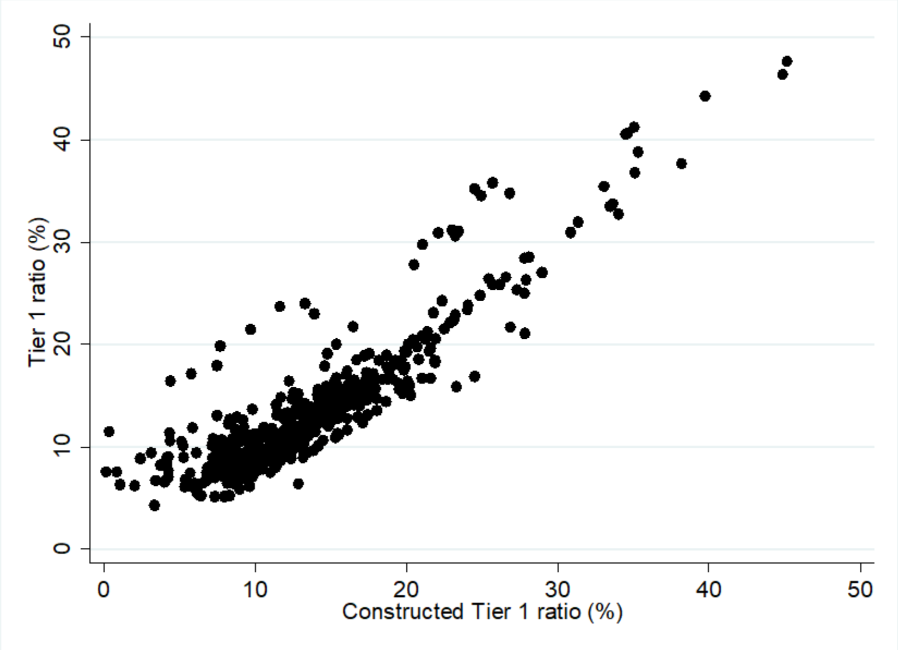
[10] To test the stability of the coefficients per year, one could perform the regressions for each year. The coefficients reported in table 2 are almost always within the 95% confidence interval of these yearly coefficients. Thus, they are stable.

[11] Constructed Tier 1 ratios below 0 or above 50 are regarded as outliers and excluded.

[12] Table A2 in the appendix shows a conversion scheme for the TCE_{RW} ratio and the CET1 and Tier 1 ratio.

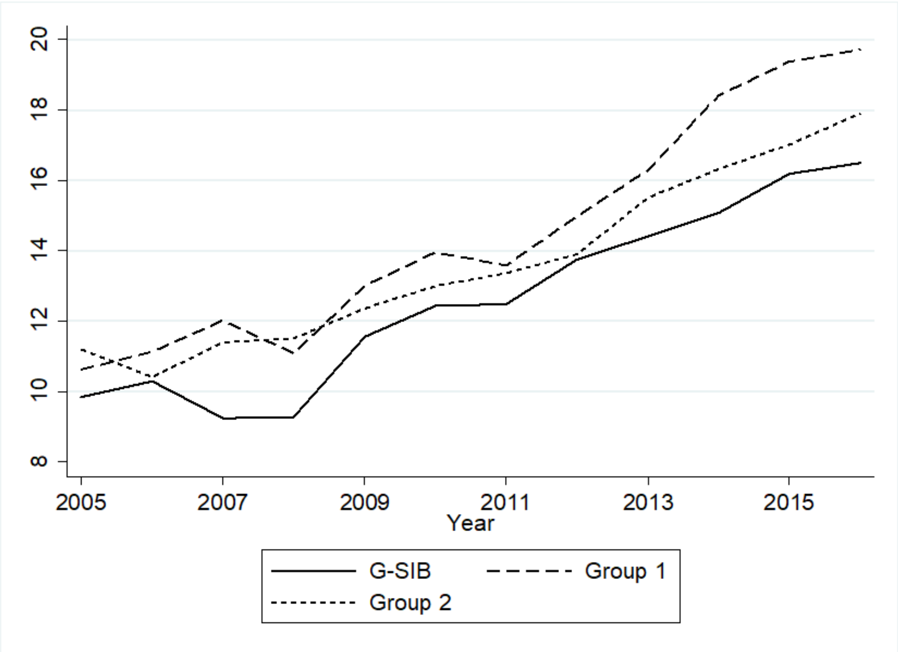
[13] Similar figures for G-SIBs and group 2 banks are reported in the appendix

Figure 2. Constructed and reported Basel II Tier 1 ratio group 1 banks – Basel II



Source: SNL Financial Database and author's calculations.

Figure 3. Average constructed Tier 1 ratio



Source: SNL Financial Database and author's calculations.

Table 3 does not provide information on the development of capital ratios since the beginning of the crisis until recent years, because it only shows average Tier 1 ratios for two periods. Figure 3 shows the average constructed Tier 1 ratio, per group of banks, per year. During the crisis, capital ratios decreased but then substantially increased afterwards. Banks increased their Basel II Tier 1 ratio by 6 to 9 percentage points on average in the period 2006-2016. The confidence interval of Tier 1 ratio is narrow as well, figure A4 in the appendix shows this for group 1 banks.

4.4 Descriptive statistics risk measures

The descriptive statistics of the risk measures are given in table A3 in the appendix. The volatility and MES are based on stock price data and therefore only available for listed banks. The CDS spread is available for listed and non-listed banks, but less than 50% of the banks report it in the databases used. Table 4 shows the correlations between several capital ratios and the risk measures and most correlations have the predicted sign. A higher capital ratio correlates with lower volatility and a lower MES, and thus a lower risk. Furthermore, a higher capital ratio corresponds to a lower Texas ratio. It is surprising that the correlation between the reported Tier 1 ratio and the CDS spread is insignificant, because one would expect that the probability of default decreases when the Tier 1 ratio increases. Nevertheless, the correlation is significant when the TCE_{RW} ratio or the constructed Tier 1 ratio is used.

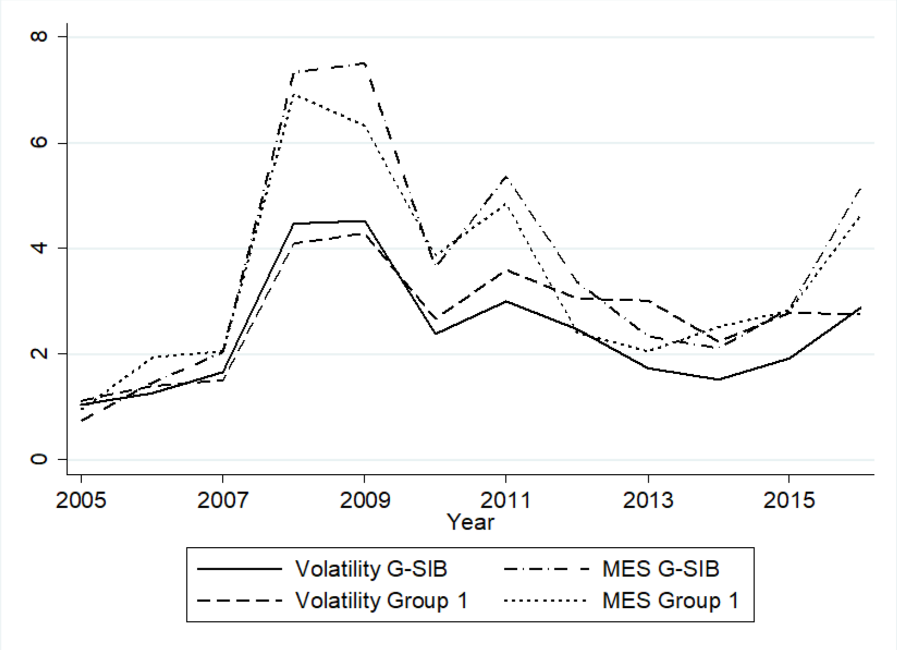
Table 4. Correlation capital ratios and risk measures

Variable	TCE_{RW}	Tier 1 ratio	Constructed Tier 1 ratio
Volatility return	-0.25***	-0.05	-0.22***
Relative volatility	-0.22***	-0.07**	-0.22***
MES	-0.25***	-0.14***	-0.21***
Texas ratio	-0.15***	-0.15***	-0.15***
CDS spread 5-year	-0.17***	-0.04	-0.15***

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

Figure 4 below shows the development of stock return volatility and the MES over time for G-SIBs and group 1 banks. In the pre-crisis years, risk measures were at a low level. However, this can likely be explained by the fact that markets, at the time, did not fully appreciate the risk. During the crisis, risk measures increased substantially and declined again after 2010, albeit generally remaining at a higher level than in the pre-crisis years. Since 2014 there has been a general increase in risk.

Figure 4. Return volatility and MES over time



Source: SNL Financial Database and author's calculations.

4.5 Control variables

In order to establish a reliable relationship between capital ratios and bank risk, several other factors should be controlled for. The selection of control variables is mainly based on what is commonly used in the literature (Demirgüç-Kunt et al., 2013; Berger & Bouwman, 2013; Laeven et al., 2013; Anginer & Demirgüç-Kunt, 2014). The natural logarithm of total assets controls for the size of the bank. The type of business model can be approximated by the ratio of loans to total assets. Liquidity is measured by the ratio of liquid assets to total assets. The ratio of NPLs to gross loans controls for asset quality. The risk profile of a bank can have an effect both on the level of risk and on the capital ratio. The ratio of RWA to total assets indicates the risk profile of a bank, but since it is never significant it is omitted from the regressions. Return on average equity measures profitability, since this may influence both risk and capital ratios. Furthermore, GDP growth is included because a decrease in economic growth may be related to an increase in risk. The long-term interest rate captures the stance of monetary policy. Usually the short-term interest rate is taken to approximate the stance of monetary policy, but for the largest part of the sample the short-term interest rate is at the zero lower bound. The long-term interest rate is then a better indicator. For consistency, each model contains the same set of control variables. The only exception is when the Texas ratio is the risk measure. Since the Texas ratio and the NPL ratio are by definition closely related to each other, for this risk measure the NPL ratio is not used as a control variable.

5. Results

This section describes the baseline empirical results for the panel regressions of risk on capital ratios. This section also evaluates whether, following the main hypothesis of this paper, an increase in the capital ratio leads to a decrease in risk. Risk measures are the volatility of the return, volatility relative to market volatility, MES, the (adjusted) Texas ratio, and the CDS spread. After a discussion of the baseline results, this paper presents evidence that the effect of capital ratios on risk depends on the size of the bank.

5.1 Baseline results

There is no clear-cut evidence that a higher Tier 1 ratio leads lower values for risk measures across the board. Only for the Texas ratio is there a robust and negative effect of the Tier 1 ratio. Banks with a higher capital ratio generally have a higher asset quality as well. Therefore, their loan portfolio is less risky. Volatility of stock return is also found to be affected by higher capital ratios, because banks can absorb shocks better if they have a higher capital ratio. However, this effect is only significant at the 10% level.

For relative volatility, the MES and the CDS spread, the effect of the Tier 1 ratio is insignificant, meaning that it cannot explain variation in these risk measures[14]. This is surprising, since a priori one would expect that banks with a higher capital ratio have a lower probability of default, and thus a lower CDS spread. When the TCE_{RW} ratio is used instead of the Tier 1 ratio, the results are very similar, as shown in table A4 in the appendix.

The baseline results indicate that other factors are more important in explaining risk than the Tier 1 ratio. Banks with a higher NPL ratio typically have a higher volatility and higher contribution to systemic risk. Profitability also has a significant impact on most risk measures, banks with a higher return on average equity generally have a lower volatility and also a lower CDS spread. Since the bank is profitable, its probability of default is lower, hence the CDS spread is lower. Finally, macroeconomic factors such as GDP growth and the long-term interest rate have a significant impact on risk. Higher GDP growth and lower interest rates lead to a decrease in risk in the financial sector. The baseline results support the finding by Bruno et al. (2015) that a higher capital ratio does not lead to a decrease in the CDS spread. Instead, they find that RWA density, profitability, and GDP growth are the main drivers of the CDS spread.

[14] The results are almost identical when the dependent variable is the MES in excess of the return of the index in the 5% worst trading days (regressions not shown). The same applies to the CDS spread in excess of the CDS spread of an index (regressions also not shown).

Table 5. Baseline results with the constructed Tier 1 ratio

Dependent variable:	(1) Volatility	(2) Relative volatility	(3) MES	(4) Texas ratio	(5) CDS spread
Tier 1 ratio constr. (-1)	-0.056*	-0.026	-0.058	-0.248***	0.057
(–)	(0.029)	(0.019)	(0.054)	(0.086)	(0.038)
Ln(TA) (-1)	0.974*	0.289	2.854***	-0.332	-0.885**
(+)	(0.572)	(0.294)	(0.788)	(0.665)	(0.418)
Loans/TA (-1)	-0.028	-0.015	0.023	-0.015	-0.048
(–)	(0.025)	(0.013)	(0.023)	(0.050)	(0.034)
Liquid assets/TA (-1)	-0.033	-0.020	0.014	-0.091*	-0.034
(–)	(0.022)	(0.013)	(0.020)	(0.049)	(0.036)
NPL/loans (-1)	0.044**	0.025***	0.102***		0.029
(+)	(0.017)	(0.009)	(0.031)		(0.021)
Return on average equity (-1) (–)	-0.023**	-0.013**	0.011	-0.022	-0.029***
	(0.009)	(0.006)	(0.008)	(0.015)	(0.010)
GDP growth (-1)	-0.089***	-0.036**	0.023	0.001	-0.110*
(–)	(0.030)	(0.017)	(0.076)	(0.098)	(0.063)
10Y interest rate (-1)	0.008	-0.009	-0.002	1.133***	0.251**
(+)	(0.080)	(0.043)	(0.092)	(0.266)	(0.110)
Constant	-12.510	-1.968	-51.970***	11.357	21.570**
	(11.681)	(6.324)	(13.915)	(12.202)	(9.602)
Observations	516	516	515	1290	426
Banks	72	72	72	192	63
Adjusted R^2	0.426	0.330	0.451	0.231	0.425

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

5.2 Discussion baseline results

There are several possible explanations for the insignificant results. One is the relatively small sample size compared to the regression with the Texas ratio. Since only publicly listed banks or banks with a market for CDS spreads are used, the sample is small. With a smaller sample, there is less variation in the variables, which can explain the insignificance of the coefficients.

In addition, resolution of bankrupt banks has changed after the crisis. Before and during the crisis, banks could expect to be bailed out in case of bankruptcy. However, the focus is now on investors bearing the losses, not the government. This means that for debt holders, given a failure, losses have increased. Even though the probability of a failure may have decreased due to higher capital ratios, the impact in terms of expected losses for investors in case of a failure have increased. Therefore, higher capital ratios do not significantly reduce CDS spreads.

Sarin and Summers (2016) also find that higher capital ratios do not decrease risk. Their argument is that the decline in franchise value is the cause of higher levels of risk. With increased banking regulations and a changing macroeconomic environment, banks have lost part of their franchise value and are therefore less profitable. This can be shown using the market value of equity instead of the book value. Whereas the book value of equity increased substantially following financial regulation, the market value of equity did not. In that case, one would expect to see the same or higher levels of the risk measures.

Table 6. Market capitalization to total assets ratio (%)

Year	G-SIB	Group 1	Group 2
2006	7.59	7.96	13.91
2007	5.52	6.39	9.81
2008	2.22	2.26	5.31
2009	4.47	3.07	6.11
2010	4.13	2.55	6.24
2011	2.68	2.24	5.15
2012	3.55	2.26	5.10
2013	4.48	4.53	6.30
2014	4.28	4.28	6.31
2015	4.55	3.57	7.63
2016	4.12	3.22	6.35

Notes: Group 1 banks do not include G-SIBs. Observations with a market capitalization to total assets ratio above 100% are regarded as outliers and thus excluded.

Table 6 shows some evidence supporting this explanation. The ratio of market capitalization to total assets for the three subgroups of banks has not improved substantially since 2009. Compared to pre-crisis levels, the market-based capital ratios are even lower. Market-based capital ratios do not only take into account the book value of equity, but also the future earnings perspective. A decrease in franchise value could thus explain the fact that market-based capital ratios have not increased as much as regulatory capital ratios.

Finally, it could be that yearly averages of the CDS spread and volatility are less appropriate than quarterly averages. However, table A5 in the appendix shows that the Tier 1 ratio also does not have a significant effect on volatility and the CDS spread when quarterly data are used.

5.3 Different effect of capital ratios for large banks

The baseline results are different for G-SIBs and other banks, as shown in table 7. Although for group 1 and group 2 banks the Tier 1 ratio has no significant effect on volatility and relative volatility, for G-SIBs there is a large and significant effect. A one percentage point increase in the Tier 1 ratio reduces volatility by 0.18 percentage points and relative volatility by 0.08 percentage points. Furthermore, the effect of the Tier 1 ratio is jointly significant at the 1 percent level. The same applies to the effect of the Tier 1 ratio on the Texas ratio. For G-SIBs, a one percentage point increase in the capital ratio reduces the Texas ratio by 0.48 percentage points, whereas the effect for other banks is 0.24 percentage points. Again, this is highly significant. Only for the MES and the CDS spread a significant effect is not found. The baseline results discussed in section 5.2 thus hide heterogeneity between groups of banks.

Another way to test whether the effect of capital ratios on risk depends on the size of the bank, is to include an interaction effect between the capital ratio and the logarithm of total assets. Table 8 shows a significant effect of the Tier 1 ratio on all risk measures except the CDS spread. There is a negative relationship between relative volatility and the Tier 1 ratio for banks with assets above €17 million, although this is only significant at the 10% level. A higher Tier 1 ratio reduces the Texas ratio for banks with more than €130 million assets. For banks with assets above €2 billion, there is a negative effect on volatility. For the MES, the threshold lies at approximately €22 billion. These results support the findings for G-SIBs. In addition, using the interaction effect with total assets, a higher Tier 1 ratio significantly reduces the contribution to systemic risk for large banks.

Table 7. Different effect of capital ratios on risk for G-SIBs

Dependent variable:	**(1)** Volatility	**(2)** Relative volatility	**(3)** MES	**(4)** Texas ratio	**(5)** CDS spread
Tier 1 ratio constr. (-1)	-0.050	-0.023	-0.058	-0.244***	0.058
(–)	(0.031)	(0.020)	(0.054)	(0.086)	(0.038)
G-SIB × Tier 1 ratio	-0.130***	-0.054**	0.001	-0.239**	-0.026
constr. (-1)	(0.049)	(0.025)	(0.126)	(0.105)	(0.032)
(–)					
Ln(TA) (-1)	0.820	0.224	2.855***	-0.390	-0.928**
(+)	(0.566)	(0.302)	(0.819)	(0.679)	(0.420)
Loans/TA (-1)	-0.030	-0.015	0.023	-0.012	-0.046
(–)	(0.025)	(0.014)	(0.023)	(0.051)	(0.035)
Liquid assets/TA (-1)	-0.030	-0.019	0.014	-0.088*	-0.032
(–)	(0.021)	(0.013)	(0.020)	(0.049)	(0.037)
NPL/loans (-1)	0.040**	0.024**	0.102***		0.028
(+)	(0.017)	(0.009)	(0.031)		(0.021)
Return on average equity	-0.023**	-0.013**	0.011	-0.022	-0.029***
(-1)	(0.009)	(0.006)	(0.008)	(0.014)	(0.010)
(–)					
GDP growth (-1)	-0.091***	-0.037**	0.023*	-0.004*	-0.111*
(–)	(0.030)	(0.017)	(0.076)	(0.098)	(0.064)
10Y interest rate (-1)	0.009	-0.008	-0.002	1.125***	0.250**
(+)	(0.079)	(0.043)	(0.092)	(0.266)	(0.111)
Constant	-9.506	-0.709	-52.000***	12.292	22.314**
	(11.653)	(6.496)	(14.595)	(12.479)	(9.625)
F-statistic Tier 1 ratio	7.05***	5.26***	0.58	7.05***	1.35
Observations	516	516	515	1290	426
Banks	72	72	72	192	63
Adjusted R^2	0.432	0.334	0.450	0.232	0.424

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

Table 8. Different effect of capital ratios on risk for large and small banks

Dependent variable:	**(1)** Volatility	**(2)** Relative volatility	**(3)** MES	**(4)** Texas ratio	**(5)** CDS spread
Tier 1 ratio constr. (-1)	0.218*	0.039	0.828***	0.459	0.400
(–)	(0.116)	(0.082)	(0.213)	(0.584)	(0.311)
Ln(TA) (-1) × Tier 1	-0.015**	-0.004	-0.049***	-0.039	-0.017
ratio constr. (-1)	(0.006)	(0.004)	(0.012)	(0.030)	(0.015)
(–)					
Ln(TA) (-1)	1.053*	0.307	3.110***	0.218	-0.627
(+)	(0.546)	(0.292)	(0.726)	(0.803)	(0.536)
Loans/TA (-1)	-0.031	-0.015	0.011	-0.012	-0.042
(–)	(0.024)	(0.013)	(0.024)	(0.050)	(0.034)
Liquid assets/TA (-1)	-0.032	-0.020	0.016	-0.092*	-0.031**
(–)	(0.022)	(0.013)	(0.021)	(0.049)	(0.036)
NPL/loans (-1)	0.039**	0.024**	0.086***		0.025
(+)	(0.017)	(0.009)	(0.031)		(0.019)
Return on average equity	-0.022**	-0.013**	0.014*	-0.021	-0.030***
(-1)	(0.009)	(0.006)	(0.008)	(0.014)	(0.010)
(–)					
GDP growth (-1)	-0.087***	-0.035**	0.031	0.002	-0.110*
(–)	(0.030)	(0.017)	(0.079)	(0.098)	(0.064)
10Y interest rate (-1)	0.019	-0.006	0.033	1.135***	0.257**
(+)	(0.081)	(0.044)	(0.084)	(0.274)	(0.107)
Constant	-13.896	-2.294	-56.476***	1.005	15.992
	(11.140)	(6.280)	(12.805)	(15.077)	(11.710)
F-statistic Tier 1 ratio	5.40***	2.63*	9.50***	7.82***	1.47
Observations	516	516	515	1290	426
Banks	72	72	72	192	63
Adjusted R^2	0.430	0.330	0.471	0.234	0.427

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

An explanation for this finding is that G-SIBs, compared to other banks, had low capital ratios before the crisis. An increase in capital ratios is likely to have a larger effect when the initial capital ratio is lower. For banks with a high initial capital ratio, the increase has a smaller effect. Because G-SIBs have larger buffers now than before the crisis, they are better able to mitigate negative shocks. This leads to a decrease in risk. Additionally, G-SIBs have become subject to higher capital charges, which also led to higher capital ratios.

The results presented here support the effectiveness of the Basel III framework. During the crisis, risk in the banking sector mainly arose from instability at large banks, with spillovers through the entire financial sector (Sarin & Summers, 2016). Therefore, if large banks become more stable, there are smaller spillover effects. Hence, one would expect to find that higher capital ratios reduce risk to a greater extent at large banks.

6. Robustness checks

This section performs several robustness checks. First of all, the Tier 1 ratio is replaced by a simple leverage ratio, because the leverage ratio can be taken directly from balance sheet data and does not require any transformations, as is the case with the constructed Tier 1 ratio. Furthermore, this section also analyzes whether capital ratios have a different effect on risk for banks from Northern and Southern European countries. Given the fact that the sovereign debt crisis hit Southern countries more severely, capital regulation may also have a different effect for those banks. Finally, credit ratings from Standard & Poor's and Fitch are used as a risk measure, to see whether higher capital ratios lead to higher credit ratings.

6.1 Effect of the leverage ratio on risk

When the leverage ratio, measured by total equity over total assets, is used, instead of the Tier 1 ratio, the results in table A6 in the appendix are very similar to the baseline results. In neither model the coefficient for the leverage ratio is significant, and it has the wrong sign in the model with the MES and the CDS spread. Surprisingly, the leverage ratio does not have an effect on the Texas ratio either. As before, asset quality, profitability, and GDP growth affect the chosen risk measures most.

6.2 Effect of capital ratios on risk varies for Southern European countries

Since mainly Southern European countries[15] were hit by a deep sovereign debt crisis, increased capital regulation may have been less effective in reducing risk for banks in these countries. An increase in capital ratios may therefore have a different impact on risk for Northern and for Southern European countries. The results in table A7 indicate that for the Northern countries,

[15] Portugal, Spain, Italy, Greece, and Cyprus.

an increase in the Tier 1 ratio leads to a significant decrease in volatility, the MES, and the Texas ratio. Furthermore, the effect on relative volatility is significant at the 10% level. There is still no significant effect on the CDS spread, but that is the case in every variation of the model. However, for Southern countries the increase in capital ratios did not decrease risk. In fact, the coefficients are significantly positive. The increase in capital ratios following Basel III coincided with the unfolding crisis in the banking sector of Southern countries. The increase in capital ratios has not ostensibly reduced the chosen risk measures.

6.3 Credit ratings

Instead of the risk measures used in the previous section, one can also take the credit rating given by a rating agency, such as Standard & Poor's or Fitch. These ratings reflect the creditworthiness of a bank, which is a measure of safety. The long-term corporate rating by several rating agencies is given in the SNL database. The ratings are transformed into ordinal numerical values, with a low value indicating a low rating and a high value indicating a higher rating. Although the interpretation of the numerical variables of the coefficients is not straightforward, the sign and the significance of the coefficients tell a clear story. Table A9 shows evidence that higher capital ratios relate to higher credit ratings.

7. Conclusion

The research question of this paper is: *How do bank capital ratios affect the safety of banks*? First of all, when controlling for the change in the definition following Basel III, Basel II-equivalent Tier 1 ratios have substantially increased since 2006, by 6 to 9 percentage points on average. Therefore, the first hypothesis – that capital ratios have improved since Basel III – cannot be rejected.

This paper further shows that tightened capital regulation has led to a reduction in stock return volatility and an improvement in asset quality. This effect is more pronounced for G-SIBs and other large banks. Furthermore, for large banks, a higher Tier 1 ratio reduces a bank's contribution to systemic risk. The effect of higher capital ratios on risk is stronger for banks from Northern European countries than for banks from Southern European countries. Although higher capital ratios do not ostensibly reduce risk for all banks, particularly large banks have become safer due to higher capital ratios. Therefore, Basel III can be said to have been effective in improving the safety of the banking sector. There is no evidence, however, that a higher Tier 1 ratio reduces the CDS spread. This can be explained by the new resolution framework, causing debt holders to bear a larger part of the losses in case of a failure. Overall, the second hypothesis – that higher bank capital ratios decrease the risk of banks – cannot be rejected for large banks, but its evaluation depends on the risk measure used.

The policy implication is that supervisors should resist the backswing of the regulatory pendulum, since Basel III has been effective in reducing risk for large banks and thereby increasing financial stability. Furthermore, this paper highlights the importance of combining the regulatory perspective with the market perspective on risk, since the relationship between regulatory capital ratios and market-based risk measures is in some cases weaker than expected. Supervisors should thus use both approaches to come to a more balanced overview of risk in the financial sector. Addressing this more balanced overview of risk in the financial sector in communication can improve the credibility of supervisors and the support for financial regulation.

Further research could extend the scope to include the United States, as US banks improved their capitalization earlier after the crisis. The US differed from Europe in this respect, so that the results of this analysis cannot directly be applied to the US. Second, other risk measures such as implied volatility using option data, the Moody's KMV probability of default, and stress test data could be used to extend the analysis. Finally, since Basel III.5 has recently been announced and will be adopted over the next decade, it would be interesting to see whether the results hold when this research is repeated taking into account Basel III.5 reforms.

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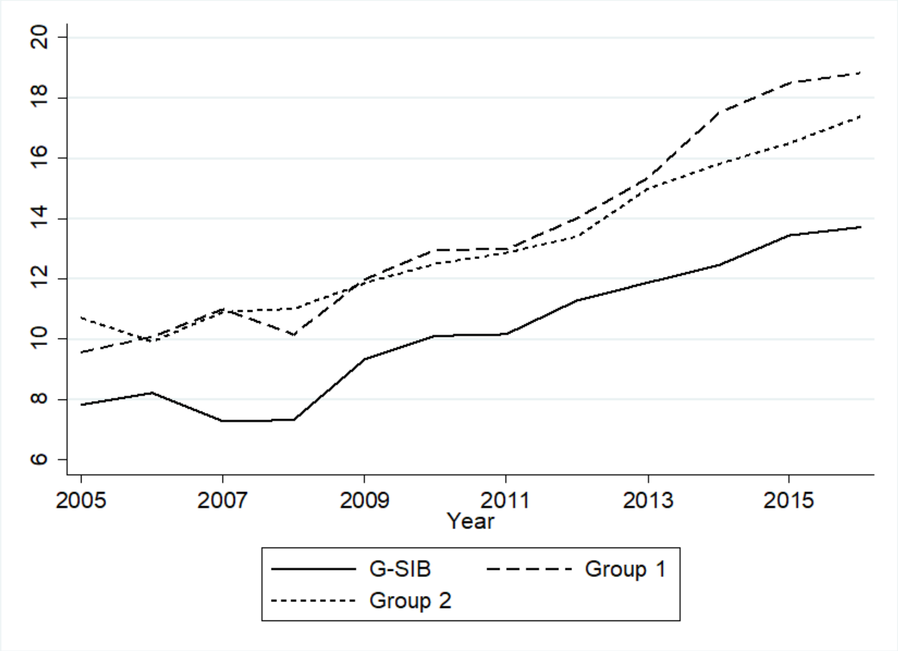
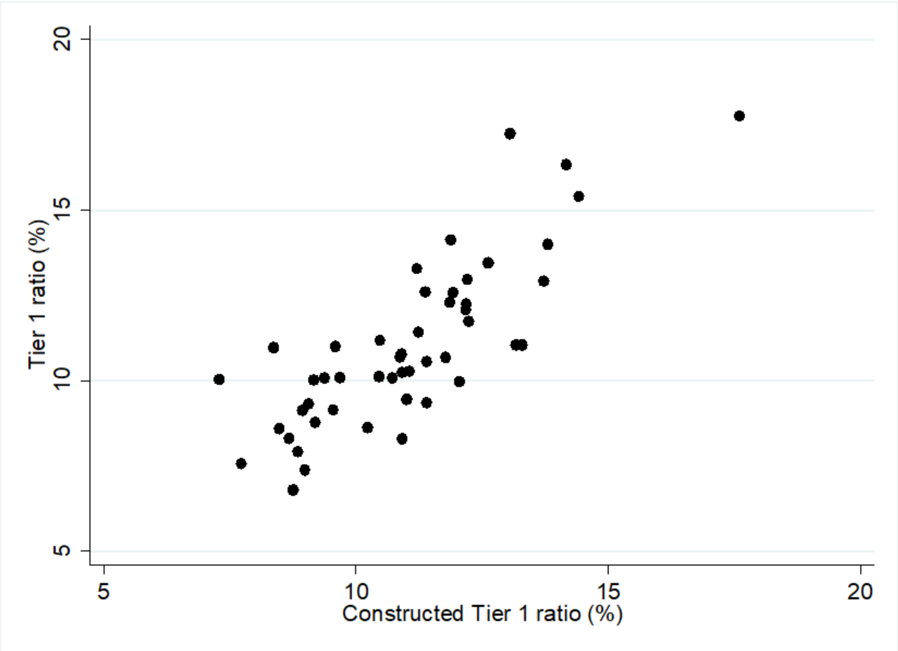
9. Appendix

Figure A1. Average constructed CET1 ratio



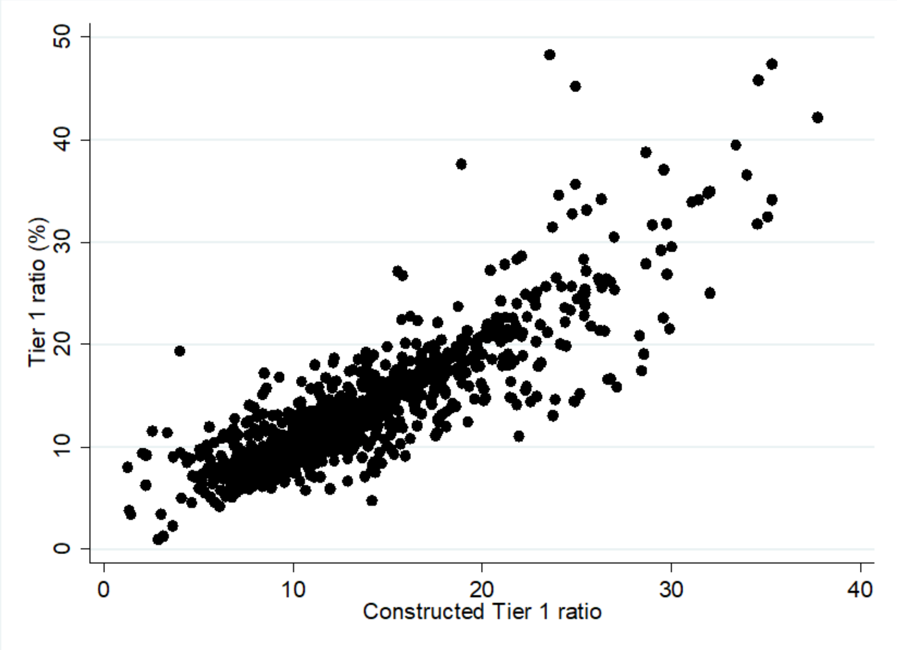
Source: SNL Financial Database and author's calculations.

Figure A2. Constructed and reported Tier 1 ratio G-SIBs – Basel II



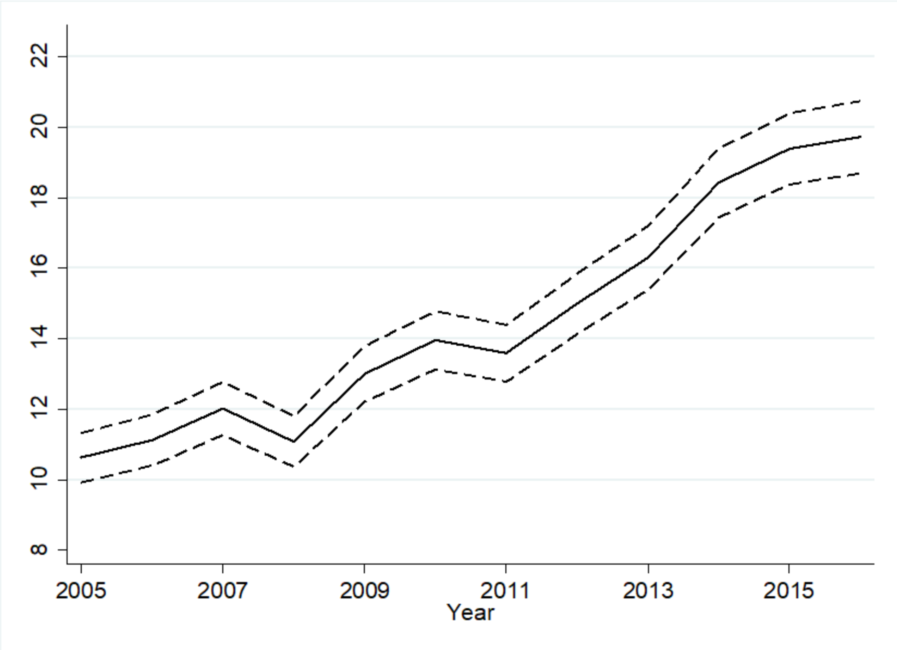
Source: SNL Financial Database and author's calculations.

Figure A3. Constructed and reported Tier 1 ratio group 2 – Basel II



Source: SNL Financial Database and author's calculations.

Figure A4. Average constructed Tier 1 ratio ± 2 standard errors – Group 1



Source: SNL Financial Database and author's calculations.

Table A1. Regression of CET1 on TCE_{RW} ratio

	Dependent variable: CET1 ratio		
Type of bank	G-SIB	Group 1	Group 2
TCE_{RW} ratio	0.683***	0.874***	0.822***
	(0.057)	(0.014)	(0.009)
Constant	3.049***	2.224***	1.692***
	(0.506)	(0.208)	(0.141)
Observations	49	527	1190
R^2	0.754	0.885	0.877

Notes: *, **, and *** refer to significance at the 10%, 5%, and 1% level, respectively. Regressions are performed for all years in which Basel II was the relevant regulatory framework. Group 1 banks do not include G-SIBs.

Table A2. Conversion scheme of TCE_{RW} ratio to CET1 ratio and Tier 1 ratio

Type of bank	**TCE_{RW} ratio**	**CET1 ratio**	**Tier 1 ratio**
G-SIB	6%	7.1%	9.1%
	9%	9.2%	11.4%
	12%	11.2%	13.7%
	15%	13.3%	16.0%
Group 1	6%	7.5%	8.6%
	9%	10.1%	11.1%
	12%	12.7%	13.7%
	15%	15.3%	16.3%
Group 2	6%	6.6%	7.1%
	9%	9.1%	9.6%
	12%	11.6%	12.1%
	15%	14.0%	14.5%

Notes: Group 1 banks do not include G-SIBs.

Table A3. Descriptive statistics risk measures and control variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Capital ratios					
TCE_{RW} ratio	3375	13.69	8.70	-9.55	94.98
Tier 1 ratio	3474	13.78	7.49	0.55	99.08
Constructed Tier 1 ratio	3346	14.12	6.09	0.13	49.83
Risk measures					
CDS spread 5-year (%)	511	2.22	2.76	0.46	24.27
MES	1084	2.24	2.76	-8.27	17.69
Texas ratio (%)	1824	5.38	7.76	0.00	72.13
Volatility return	1086	2.25	1.63	0.11	20.32
Relative volatility	1086	1.19	0.82	0.05	12.66
Control variables					
GDP growth (%)	3938	1.10	2.77	-9.13	26.26
Liquid assets/assets (%)	2906	30.43	19.77	0.02	100.00
Loans/assets (%)	3684	62.17	20.90	0.00	97.92
Long-term interest rate (%)	3938	3.09	1.93	-0.35	22.50
NPL/gross loans (%)	2225	6.96	9.01	0.00	90.34
Return on average equity (%)	3544	2.38	34.02	-832.96	106.90
Total assets (bln. €)	3938	194	445	0	3540

Table A4. Baseline results with the TCE_{RW} ratio

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Volatility	Relative volatility	MES	Texas ratio	CDS spread
TCE_{RW} ratio (-1)	-0.042*	-0.019	-0.027	-0.206***	0.054
(–)	(0.024)	(0.014)	(0.043)	(0.073)	(0.034)
Ln(TA) (-1)	0.912	0.262	2.785***	-0.370	-0.866**
(+)	(0.571)	(0.293)	(0.794)	(0.669)	(0.419)
Loans/TA (-1)	-0.028	-0.015	0.023	-0.011	-0.048
(–)	(0.026)	(0.014)	(0.024)	(0.050)	(0.034)
Liquid assets/TA (-1)	-0.034	-0.020	0.012	-0.088*	-0.034
(–)	(0.022)	(0.013)	(0.020)	(0.048)	(0.036)
NPL/loans (-1)	0.044**	0.025***	0.101***		0.029
(+)	(0.016)	(0.009)	(0.031)		(0.021)
Return on average equity	-0.023**	-0.013**	0.010	-0.022	-0.030***
(-1)	(0.009)	(0.006)	(0.008)	(0.015)	(0.010)
(–)					
GDP growth (-1)	-0.091***	-0.036**	0.019	-0.001	-0.109*
(–)	(0.029)	(0.016)	(0.078)	(0.099)	(0.063)
10Y interest rate (-1)	0.008	-0.008	0.000	1.135***	0.254**
(+)	(0.079)	(0.044)	(0.091)	(0.266)	(0.109)
Constant	-11.476	-1.550	-50.900***	11.019	21.324**
	(11.703)	(6.330)	(13.950)	(12.080)	(9.606)
Observations	518	518	517	1293	426
Banks	72	72	72	192	63
Adjusted R^2	0.426	0.330	0.447	0.230	0.426

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

Table A5. Baseline results using quarterly data

	(1)	(2)	(3)	(4)
Dependent variable:	Volatility		CDS spread	
Tier 1 ratio constr. (-1)	-0.045		0.083	
(–)	(0.087)		(0.079)	
TCE_{RW} ratio (-1)		-0.030		0.068
(–)		(0.055)		(0.049)
Ln(TA) (-1)	0.741*	0.737**	-1.762***	-1.741***
(+)	(0.362)	(0.357)	(0.504)	(0.516)
Loans/TA (-1)	0.008	0.006	-0.112*	-0.108*
(–)	(0.040)	(0.041)	(0.057)	(0.056)
Liquid assets/TA (-1)	-0.036	-0.037	-0.082*	-0.081*
(–)	(0.044)	(0.043)	(0.044)	(0.044)
NPL/loans (-1)	0.085***	0.085***	0.031	0.031
(+)	(0.023)	(0.024)	(0.027)	(0.026)
Return on average equity (-1)	-0.002	-0.002	-0.005	-0.006
(–)	(0.002)	(0.002)	(0.006)	(0.006)
GDP growth (-1)	-0.630***	-0.632***	-0.304***	-0.305***
(–)	(0.134)	(0.131)	(0.080)	(0.084)
10Y interest rate (-1)	0.166*	0.164*	0.747***	0.753***
(+)	(0.081)	(0.081)	(0.147)	(0.146)
Constant	-10.771	-10.751	41.198***	40.817***
	(8.427)	(8.277)	(13.379)	(13.655)
Observations	326	326	391	391
Banks	29	29	32	32
Adjusted R^2	0.488	0.488	0.684	0.686

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

Table A6. Baseline results with the leverage ratio

Dependent variable:	**(1)** Volatility	**(2)** Relative volatility	**(3)** MES	**(4)** Texas ratio	**(5)** CDS spread
Leverage ratio (-1)	-0.041	-0.026	0.057	-0.069	0.131
(–)	(0.029)	(0.019)	(0.042)	(0.274)	(0.096)
Ln(TA) (-1)	0.874	0.231	2.801***	-0.216	-0.920**
(+)	(0.604)	(0.310)	(0.832)	(0.869)	(0.393)
Loans/TA (-1)	-0.018	-0.010	0.033	0.017	-0.047
(–)	(0.026)	(0.014)	(0.023)	(0.050)	(0.036)
Liquid assets/TA (-1)	-0.033	-0.020	0.016	-0.080*	-0.025
(–)	(0.023)	(0.014)	(0.020)	(0.045)	(0.037)
NPL/loans (-1)	0.046***	0.027***	0.097***		0.022
(+)	(0.016)	(0.009)	(0.030)		(0.020)
Return on average equity	-0.024***	-0.013**	0.008	-0.030*	-0.030***
(-1)	(0.008)	(0.005)	(0.008)	(0.017)	(0.010)
(–)					
GDP growth (-1)	-0.093***	-0.037**	0.006	-0.003	-0.113*
(–)	(0.029)	(0.016)	(0.076)	(0.097)	(0.063)
10Y interest rate (-1)	0.015	-0.006	0.021	1.169***	0.262**
(+)	(0.081)	(0.046)	(0.093)	(0.293)	(0.105)
Constant	-11.489	-1.262	-52.424***	4.700	21.746**
	(12.355)	(6.718)	(14.473)	(16.599)	(9.243)
Observations	534	534	533	1348	432
Banks	73	73	73	194	63
Adjusted R^2	0.427	0.330	0.441	0.214	0.424

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

Table A7. Different effect of capital ratios for Northern and Southern countries

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	Volatility	Relative volatility	MES	Texas ratio	CDS spread
Tier 1 ratio constr. (-1)	-0.083**	-0.033*	-0.165***	-0.363***	0.049
(–)	(0.032)	(0.017)	(0.061)	(0.092)	(0.033)
South × Tier 1 ratio	0.095**	0.024	0.377***	0.644***	0.096
constr. (-1)	(0.045)	(0.029)	(0.092)	(0.149)	(0.113)
(+)					
Ln(TA) (-1)	0.842	0.256	2.331***	-0.825	-1.008**
(+)	(0.562)	(0.292)	(0.690)	(0.640)	(0.466)
Loans/TA (-1)	-0.027	-0.014	0.026	0.006	-0.043
(–)	(0.025)	(0.014)	(0.023)	(0.045)	(0.032)
Liquid assets/TA (-1)	-0.032	-0.019	0.018	-0.076*	-0.031
(–)	(0.022)	(0.013)	(0.021)	(0.043)	(0.035)
NPL/loans (-1)	0.034**	0.023**	0.063**		0.015
(+)	(0.016)	(0.009)	(0.030)		(0.021)
Return on average equity	-0.023**	-0.013**	0.011	-0.020	-0.030***
(-1)	(0.009)	(0.006)	(0.008)	(0.014	(0.010)
(–)					
GDP growth (-1)	-0.081**	-0.034**	0.055	0.031	-0.104
(–)	(0.031)	(0.017)	(0.065)	(0.096)	(0.062)
10Y interest rate (-1)	0.041	0.000	0.127	1.219***	0.279**
(+)	(0.077)	(0.041)	(0.089)	(0.278)	(0.112)
Constant	-10.379	-1.429	-43.512***	16.768	23.367**
	(11.424)	(6.255)	(11.957)	(12.152)	(10.473)
F-statistic Tier 1 ratio	4.84**	2.95*	8.61***	13.17***	1.21
Observations	516	516	515	1290	426
Banks	72	72	72	192	63
Adjusted R^2	0.433	0.331	0.496	0.268	0.428

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans, South is a dummy variable with value one if the bank is located in Portugal, Spain, Italy, Greece, or Cyprus. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.

Table A8. Effect of capital ratios on credit ratings

	(1)	(2)	(3)	(4)
Dependent variable:	S&P rating		Fitch rating	
Tier 1 ratio constr. (-1)	0.066***		0.061***	
(+)	(0.025)		(0.023)	
TCE_{RW} ratio (-1)		0.064***		0.047**
(+)		(0.021)		(0.020)
Ln(TA) (-1)	-0.314	-0.217	0.140	0.153
(–)	(0.419)	(0.420)	(0.327)	(0.327)
Loans/TA (-1)	0.008	0.009	0.020	0.016
(+)	(0.026)	(0.026)	(0.013)	(0.013)
Liquid assets/TA (-1)	-0.011	-0.012	0.001	-0.002
(+)	(0.020)	(0.020)	(0.011)	(0.012)
NPL/loans (-1)	-0.074***	-0.074***	-0.093***	-0.091***
(–)	(0.018)	(0.018)	(0.015)	(0.015)
Return on average equity	0.001	0.001	0.000	0.000
(-1)	(0.001)	(0.001)	(0.001)	(0.001)
(+)				
GDP growth (-1)	0.026	0.028	0.025	0.027
(+)	(0.035)	(0.035)	(0.033)	(0.033)
10Y interest rate (-1)	-0.509***	-0.505***	-0.336***	-0.341***
(–)	(0.130)	(0.131)	(0.059)	(0.059)
Constant	26.527***	24.778***	17.464***	17.805***
	(8.612)	(8.598)	(6.244)	(6.136)
Observations	856	861	822	824
Banks	124	124	130	130
Adjusted R^2	0.648	0.644	0.642	0.638

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Each model includes bank-level fixed effects and year dummies. Robust standard errors are given between brackets. TA is total assets, NPL is non-performing loans. Of all variables, the first lag is used. (+) and (–) denote the expected sign of the coefficient.