

**FACTORS INFLUENCING BANK RISK IN EUROPE:
EVIDENCE FROM THE FINANCIAL CRISIS**

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FACTORS INFLUENCING BANK RISK IN EUROPE: EVIDENCE FROM THE FINANCIAL CRISIS

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Abstract

In this paper we use a dynamic panel data model to analyze bank-specific and macroeconomic determinants of bank risk for a large sample of commercial banks operating in the European Union. The selected time span, from 2005 to 2011, considers the impact of the recent financial and economic crisis on the Eurozone banking system. Our results indicate that capitalization, profitability, efficiency and liquidity are negatively and significantly related to bank risk. We also find that less competitive markets, lower interest rates and a context of economic crisis (with falling GDP and rising inflation rates) increase bank risk.

Key words: Bank risk; European banking system; non-performing loans; Z-score.

JEL classification: G21; G32; L11.

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1. Introduction

We are immersed in one of the worst financial crises in the history of the Western world, in which the banking sector has been blamed for its laxity in lending, its complex engineering of financing and, above all, the impact that its mismanagement has had on the real economy. This impact on the real economy, triggered by the problems in the banking sector, was extremely severe, producing record levels of unemployment and giving way to what is now referred to as the “Great Recession” (Altunbas et al., 2011).

Financial institutions in Europe continue to be confronted with significant challenges, mainly related to the weak economic environment, which has dampened profitability and increased credit risks. The bank bailout costs associated with the current global financial crisis and the large output losses experienced in several European countries clearly motivate the need for further understanding of the determinants of bank risk. Literature identifies various determinants of bank risk, including bank-specific variables (Arena, 2008; Poghosyan and Čihak, 2011) and macroeconomic variables (Borio and Lowe, 2002; Festic et al., 2011). To the best of our knowledge, however, this study is the first to investigate the effects of both bank-specific and macroeconomic variables on risk of European commercial banks in the context of the recent global financial crisis.

The non-performing loan ratio (NPLr), defined as the proportion of non-performing loans to gross loans, has commonly been used in the literature as a measure of bank soundness (Berger and De Young, 1997; Delis and Kouretas, 2011; Festic et al., 2011). As NPLr expresses the quality of a loan portfolio, we may expect that a higher (lower) value of this ratio will denote a higher (lower) probability of default. There is broad consensus concerning the inverse relationship of asset quality to bank risk. Poghosyan and Čihak (2011) go even further and advocate that asset quality should be taken into account in addition to bank capitalization in designing pan-European benchmarks of sound banking conduct. They conclude that bank earnings and asset quality have greater economic impacts on bank distress than capitalization, which reinforces our choice of the NPLr as a measure of bank risk.

As a complementary indicator we use the Z-score, which has also been used frequently to analyze the determinants of bank risk in the recent literature (Laeven and Levine, 2009, Demirgüç-Kunt and Huizinga, 2010, Altunbas et al., 2011). This metric is defined as the number of standard deviations that a bank's return on asset has to fall from the mean for the bank to become insolvent. The Z-score is considered a better measure of bank risk than the NPLr because non-performing loans are traditionally backward looking and highly procyclical (Laeven and Majnoni, 2003; Bikker and Metzmakers, 2005). In addition, NPLr only measures credit risk, while the Z-score is an overall measure of bank risk that captures not only credit but also liquidity and market risk that arises primarily from non-lending activities (Köhler, 2012).

This paper contributes to the existing literature in various ways. First, this work complements the previous literature by analyzing the factors (bank-specific and macro) that influence bank risk in European commercial banks. The selected time span, from 2005 to 2011, considers the impact of the recent financial and economic crisis on the Eurozone banking system. Second, we use the generalized method of moments (GMM) estimator, also referred to as the system-GMM estimator, developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998). This new technique has only been used in recent studies on determinants of bank risk (e.g., Porter and Chiou, 2012; Louzis et al., 2012).

The paper is structured as follows. Section 2 reviews the most significant empirical studies and presents our research hypotheses. Section 3 describes the data and methodology employed in the empirical research and defines the explanatory variables. Section 4 presents and discusses the results obtained. Section 5 summarizes the results obtained and conclusions drawn.

2. Literature review and research hypotheses

According to the literature, the factors that influence bank risk fall into two main groups. First, there is a group of determinants of risk that are specific to each bank and that, in many cases, are the direct result of managerial decisions. They include asset structure, capitalization, profitability, efficiency, revenue diversification and size. The second group of determinants includes factors that relate bank risk to the industry structure and to the macroeconomic environment within which the banking

system operates, such as industry concentration, economic growth, inflation, unemployment and interest rates.

2.1. Asset structure

One of the most criticized practices of banking has been the ease with which it has provided loans in times of economic expansion. The share of loans to the private sector in total banking assets is considered to be an important driver of credit risk. Many studies have found that the relative percentage of loans to total assets is positively correlated with banking problems, increasing NPL and insolvency as a result of long-term bank mismanagement (De Nicolo *et al.*, 2003; Fofack, 2005; Blasco and Sinkey, 2006; Männasoo and Mayes, 2009; among others). In this vein, Festic *et al.* (2011) show how the growth of credit and the amount of available financing have harmed the NPL dynamics of the five new EU member states.

This greater relative proportion of loans in the portfolio of the bank is usually coupled with a greater liquidity risk arising from the inability of banks to accommodate decreases in liabilities or to fund increases on the assets side of the balance sheet (Trujillo-Ponce, 2013). Consequently, a bank holding a high proportion of loan assets is more likely to have also lower Z-score ratios.

Therefore, we hypothesize the following relationship:

Hypothesis 1: There is a positive relationship between the relative percentage of loans in the assets of a bank and its risk.

2.2. Capitalization

Given the potential danger that bank distress can pose to the real economy and supported by the classical economic theory that claims leverage and risk to be directly related, the Basel Committee Accords (I, II and III) were mainly designed to strengthen bank capitalization and contain its leverage to reduce bank risk. In this vein, previous studies have found a significant inverse effect of capitalization on bank distress (e.g., Berger and Udell, 1994; Berger and Udell, 1997; Lehar, 2005; Poghosyan and Čihák, 2011).

Despite this, Porter and Chiou (2012) report empirical results that support the theory that banks respond to more capital by increasing the risk in their earning asset portfolios and off-balance-sheet activity. These results call into question the

effectiveness of Basel capital requirements. In addition, Laeven and Levine (2009) show that the relation between bank risk and capital regulations depends critically on each bank's ownership structure. Their results suggest that an increase in risk-taking policies is more likely to occur only when the bank has a large equity holder with enough decision power.

In conclusion, we find capitalization to be a controversial variable that could have either a positive or a negative effect on bank risk.

Hypothesis 2a: There is a negative relationship between bank capitalization and risk.

Hypothesis 2b: There is a positive relationship between bank capitalization and risk.

2.3. Profitability

There is widespread consensus about the negative relationship between bank performance, measured by the return-on-equity (ROE) ratio, and risk. Poghosyan and Čihak (2011) show how European banks that have good earnings profiles are less likely to experience distress in the upcoming year. Louzis *et al.* (2012) state that worse performance may be a proxy for lower-quality skills with respect to lending activities. Furthermore, they provide empirical evidence that performance may serve as a leading indicator of future problem loans.

Based on these findings, we expect a negative relationship between bank profitability and risk.

Hypothesis 3: There is a negative relationship between bank returns and its risk.

2.4. Efficiency

Most literature shows inefficiency to be a bank risk source. Recent studies use the cost-to-income ratio (CIR) as a proxy for efficiency or managerial quality (Mānasoo and Myers, 2009; Poghosyan and Čihak, 2011 and Louzis *et al.*, 2012 among others). In their "Bad Management I" Hypothesis, Louzis *et al.* (2012) state that low cost efficiency is positively associated with increases in future NPLs, as long as "bad" management leads poor skills in credit scoring, appraisal of pledged collaterals and monitoring borrowers.

Other authors, focusing either on cost efficiency (Berger and De Young, 1997; Williams, 2004) or on profit or revenue efficiency (Berger and Bonaccorsi di Patti, 2006; Fiordelisi *et al.*, 2011), report similar findings.

Our fourth hypothesis is therefore the following:

Hypothesis 4: There is a negative relationship between bank efficiency and bank risk.

2.5. Revenue diversification

Bank activity has evolved over the last few decades, resulting in a more diversified balance sheet. There are various activities that provide noninterest income, such as fees, commissions and trading. The greater the proportion of these activities is in a bank's portfolio, the more diversified the bank is. There is plenty of literature about how diversification influences bank risk, and the conclusions differ, in several cases, from the recommendations of traditional portfolio and banking theories (Deng *et al.*, 2007).

Portfolio theory, as well as traditional arguments based on Diamond (1984), suggests that diversification effects contribute to reduce risk in all types of firms, including financial intermediaries. Saunders and Cornett (2007) also state that decreased risk taking of diversified banks may result from the benefits of cost reduction and revenue synergies. Demirgüç-Kunt and Huizinga (2010) find that banks that had the most trouble in the recent crisis generated substantial noninterest income through the trading of, for instance, mortgage-backed securities, or they relied heavily on the wholesale capital markets to form their funding. They conclude that the relation between risk and the fee income share appears to be an inverted U. Similarly, Köhler (2012), using a sample that includes a large number of smaller unlisted banks, states that it may be beneficial for banks to increase their share of non-interest income.

However, many authors support the idea that diversification not only does not reduce bank risk but in fact may encourage it. One such author is De Jonghe (2010), who states that traditional banking activities are less risky. He concludes that banks that profitably focus on lending activities contribute more to banking system stability than diversified banks. In this vein, Stiroh (2002) finds that during the period from the late 1970s to 2001, a greater reliance on noninterest income by

U.S. banks, particularly on trading revenue, was associated with higher risk and lower risk-adjusted profits at the individual bank level. Mercieca *et al.* (2007) find similarly consistent results, based on the theory that diversification increases bank risks, showing negative net diversification effects for average profitability and corresponding positive effects on volatility for small European banks.

The ambiguity of the results on this subject leads us to propose hypotheses 5a and 5b:

Hypothesis 5a: There is a negative relationship between the revenue diversification of a bank and its risk.

Hypothesis 5b: There is a positive relationship between the revenue diversification of a bank and its risk.

2.6. Size

This topic has become a popular research topic, particularly since the last financial crisis, as the literature related to too-big-to-fail entities and systemic important banks (SIBs) has dramatically increased.

There is a widespread theory that claims that bigger banks tend to be riskier due to a moral hazard problem (Uhde and Heimeshoff, 2009). According to this theory, bigger entities may be more attracted to amplifying risk taking, reducing market discipline and creating competitive distortions, which could increase the probability of distress in the future, as they know they will be bailed out.

Paradoxically, there is also a view that supports the idea that larger banks tend to be less risky because of their managerial capacity and efficiency. This view is expressed by Boyd and Prescott (1986), who relate a larger size with a lower risk; they state that larger banks may be able to diversify loan portfolio risks more efficiently due to greater economies of scale and scope. In the same vein, García and Robles (2008) argue that larger banks may have more experience and capacity in the management of risk, as well as better conditions for diversifying their portfolios than smaller banks. Thus, we formulate two hypotheses of different signs.

Hypothesis 6a: There is a positive relationship between size and bank risk.

Hypothesis 6b: There is a negative relationship between size and bank risk.

2.7. Industry concentration

There has been a tendency toward concentration of the financial sector in recent decades that has increased substantially in recent years. We are experiencing the greatest era of mergers and acquisitions in history, especially since the most recent financial crises began. Empirical research shows that the influence of concentration on bank risk could be both positive and negative.

According to the so-called concentration stability view, monopolistic banks in concentrated banking systems may enhance profits and thus reduce financial fragility by providing higher “capital buffers” that protect them against external macroeconomic and liquidity shocks (Boyd *et al.*, 2004). Similarly, Beck *et al.* (2006) and Allen and Gale (2000) support the idea that crises are less likely to happen in economies with more concentrated banking systems, which are easier to monitor and which give them the advantage of obtaining extra profits so they can provide a buffer against adverse shocks.

Despite this, De Nicolo *et al.* (2004) state that highly concentrated banking systems exhibited levels of potential systemic risk higher than less concentrated systems during the 1993–2000 period and that this relationship strengthened during the 1997–2000 period. Similarly, Boyd *et al.* (2006) postulate that large entities with monopoly power can charge higher interest to their clients, who need to engage in riskier investments to meet their financing costs. This situation results in more loan defaults, which increase the likelihood of bank failure. Again, we propose two opposing hypotheses to be tested.

Hypothesis 7a: There is a negative relationship between industry concentration and bank risk.

Hypothesis 7b: There is a positive relationship between industry concentration and bank risk.

2.8. Economic growth

With few exceptions, the banking sector has exhibited clearly cyclical behavior.¹ Most of the literature states that higher rates of growth are associated with a more

¹ These exceptions refer to the Australian market over the 1990-1999 period (Arpa *et al.*, 2001) and to the Canadian banks over the 1982 to 2009 period (Guidara *et al.*, 2013).

stable macroeconomic environment and a relatively low likelihood of bank distress (e.g., Borio and Lowe, 2002, Festic *et al.*, 2011; Pophosyan and Cihak, 2011; among others).

Marcucci and Quagliariello (2008) analyze the cyclical behavior of the default rates of Italian bank borrowers over the last two decades and confirm that the default rates follow a cyclical pattern. The rates decrease in good macroeconomic times and increase during downturns. Similarly, Borio and Lowe (2002) analyze a sample of 35 industrial countries and state that since 1970, there has been a risk of greater amplitude in financial cycles going hand in hand with more disruptive booms and busts in real economic activity.

Therefore, we expect a negative association between economic growth and bank risk.

Hypothesis 8: There is a negative relationship between economic growth and bank risk.

2.9. Inflation

Arpa *et al.* (2001) conclude that the share of risk provisions in the total loans of the banking sector varies directly with consumer price index (CPI) inflation and real estate price inflation. Likewise, Baboucek and Jancar (2005) show that increasing inflation ratios deteriorate the NPLr.

Uhde and Heimeshoff (2009) state that the effect of changes in inflation rates depends on whether inflation is anticipated by banks or not and whether it coincides with general economic fragility; nevertheless, their empirical evidence, using an EU-25 sample, shows a direct effect on bank risk as measured by the Z score.

Therefore, we expect a positive association between inflation and bank risk.

Hypothesis 9: There is a positive relationship between inflation and bank risk.

2.10. Unemployment

Some researchers also use the unemployment rate to explain bank risk. Bofondi and Ropele (2011), for example, state that increasing unemployment had a significantly adverse effect on loan portfolio quality over a sample of Italian banks during the period 1990-2010. Similarly, Louzis *et al.* (2012) find that unemployment

has a direct and significant impact on all NPL categories (business loans, consumer loans and mortgages), mortgages being the least sensitive NPL type.

Therefore, we hypothesize a positive relationship between unemployment and bank risk.

Hypothesis 10: There is a positive relationship between unemployment and bank risk.

2.11. Interest rates

Finally, there is considerable research that supports the view that interest rates pose a strong influence in bank risk. Hoggarth *et al.* (2005) find that the important factors indirectly influencing financial stability and loan portfolio quality are the dynamics of inflation and interest rates. Furthermore, there is a recent line of research that shows how the low interest-rate environment of the last decade has encouraged bank risk taking in search of yield (e.g., Agur and Demertzis, 2012; Delis and Kouretas, 2011).

Therefore, we formulate the following hypothesis:

Hypothesis 11: There is a negative relationship between interest rates and bank risk.

3. Data and Methodological Aspects

3.1. Sample

We use a sample of 155 commercial banks operating in 14 European countries over the period from 2005 to 2011. We focus on countries that belong to the European Union and that have adopted the Euro as their common currency (Eurozone). By limiting our analysis to commercial banks only we expect to have similar attributes in ownership and corporate governance. Although these variables have not been explicitly considered in our model we control for unobserved heterogeneity by using the system-GMM methodology.² Similar considerations can be done regarding banking regulation and supervision by analyzing only Eurozone banks.³ Banks must have information available for all of the variables analyzed for at least four consecutive years during the period considered to test for the absence of second-order serial correlation. Those entities that present abnormal ratios or extreme values are eliminated from the sample as outliers. After completing this filtering, we obtain a final dataset consisting of an unbalanced panel with 959 observations. Table 1 shows the number of banks and observations in the sample by country.

² An evaluation of the impact of alternative ownership models, together with the degree of ownership concentration, on risk and profitability of European banks is provided by Iannotta *et al.* (2007).

³ We restrict the analysis to countries that have adopted the euro during the sample period and thus have a common monetary policy. We exclude the case of Cyprus, Estonia and Malta because we do not have at least four consecutive years after these countries adopted the euro. Slovakia is included in the sample as it pegged its currency to the euro since 2008.

Table 1. Commercial banks in sample by country

Country	Commercial banks	Observations
Austria	6	40
Belgium	5	35
Finland	3	21
France	36	200
Germany	8	56
Greece	6	42
Ireland	7	45
Italy	47	301
Luxembourg	2	14
Netherlands	6	37
Portugal	5	33
Slovakia	4	16
Slovenia	7	35
Spain	13	84
Total Eurozone	155	959

All bank balance sheet data and income statements are obtained from the BankScope database maintained by Bureau Van Dijk. We use unconsolidated statements when they are available and consolidated statements otherwise and ensure that each bank is included only once in the dataset. We limit our analysis to commercial banks only. Merged banks are considered separate entities before merger and a single entity subsequently. All of the ratios capturing bank-specific characteristics are calculated based on the standardized global accounting format.

3.2. Methodology

The bank-specific factors that influence bank risk may be endogenous (e.g., riskier banks may devote more resources to increase their loan portfolio, increasing the relative percentage of loans in the assets of a bank). In addition, some characteristics that affect bank risk taking are difficult to measure or identify in an equation (the so-called unobserved heterogeneity). If the influence of such characteristics is not considered, then one could observe correlations between some of the coefficients of the explanatory variables and the error terms that bias these coefficients. Finally, the persistence of bank risk is well documented in the literature (e.g., Delis and Kouretas, 2011).

To address these concerns, we use the GMM estimator developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998), also referred to as the system-GMM estimator. This method is an alternative to the first-difference GMM estimator used by Arellano and Bond (1991).

Our baseline equation is as follows:

$$Y_{i,t} = \alpha + \delta \cdot Y_{i,t-1} + \sum_{j=1}^J \beta_j \cdot X_{i,t}^j + \sum_{l=1}^L \beta_l \cdot X_{i,t}^l + \varepsilon_{i,t} \quad (1)$$

Where Y denotes the variable used to measure the risk of bank i at year t , $Y_{i,t-1}$ represent its lagged value, δ measures the speed of mean reversion (a value of δ that is not significantly different from 0 implies that bank risk is characterized by a high speed of adjustment, whereas a value that is not significantly different from 1 means that the adjustment is very slow), and the $X_{i,t}$ variables are the explanatory variables, which are grouped into bank-specific $X_{i,t}^j$ and industry and macroeconomic variables $X_{i,t}^l$. Finally, $\varepsilon_{i,t}$ is the disturbance term that contains the unobserved bank-specific effect (η_i) and the idiosyncratic error ($v_{i,t}$).

As previously stated, we proxy bank risk using two complementary metrics that are intuitive and easily measurable: the NPLr and the Z score. We employ logarithms to control for the skewness exhibited by the two original variables⁴. The Z score is calculated as the ratio of the return on assets (ROA) plus the capital–asset ratio (CAR) divided by the standard deviation of the return on assets (SDROA) over the whole sample period:

$$Z\text{-Score}_{i,t} = \frac{ROA_{i,t} + CAR_{i,t}}{SDROA_i} \quad (2)$$

The value of this term indicates the number of standard deviations below the expected value of a bank's return on assets at which equity is depleted and the bank is insolvent (Boyd *et al.*, 1993; Boyd and Runkle, 1993). Therefore, the Z score can be interpreted as an inverse measure of the probability of insolvency, i.e., a higher Z score implies that a bank incurs fewer risks and is more stable.

⁴By using logarithms, we excluded negative values for Z-score and therefore the number of observations was reduced from 959 to 936.

Table 2 summarizes explanatory variables that are considered in the current study and their expected signs for bank risk. To analyze the effect of asset structure on bank risk (H1), we use the ratio of loans to total assets (Loan/TA). To examine whether the level of capitalization is a determining factor in bank risk (H2a, H2b) we use the CAR. To measure the effect of performance on bank risk (H3) we choose the ROE. Following the example of other researchers, we use the CIR as a proxy for operational efficiency (H4). This ratio measures the overhead or running costs (the largest proportion of which is normally salaries) of a bank as a percentage of income generated before provisions. To analyze the effect of income diversification on bank risk (H5a, H5b) we use an adjusted Herfindahl–Hirschman index (HHIRD). This variable is calculated as follows:

$$HHIRD = 1 - \left[\left(\frac{INT}{TOR} \right)^2 + \left(\frac{COM}{TOR} \right)^2 + \left(\frac{TRAD}{TOR} \right)^2 + \left(\frac{OTH}{TOR} \right)^2 \right] \quad (3)$$

Where INT denotes gross interest income, COM denotes gross commission and fee revenue, TRAD denotes trading revenue, OTH denotes all other gross operating income, and TOR denotes total operating revenue and is equal to the sum of the absolute values of INT, COM, TRAD and OTH.⁵

⁵ By definition, HHIRD can take values between 0 (no revenue diversification) and 0.75 (indicating a bank that generates a fully balanced revenue mix from all four business areas).

Table 2. Explanatory variables

Classification	Explanatory variable	Notation	Hypotheses and Expected signs	Source	Literature
<i>Bank-specific variables</i>					
Asset structure	Loans/Total Assets (%)	Loan/TA	H1 (+)	Bankscope	Männasoo and Mayes (2009)
Capitalization	Equity/Total Assets (%)	CAR	H2a (-); H2b (+)	Bankscope	Poghosyan and Čihák (2011) Louzis <i>et al.</i> (2012)
Profitability	Return on Equity (%)	ROE	H3 (-)	Bankscope	Poghosyan and Čihák (2011)
Efficiency	Cost-to-Income Ratio (%)	CIR	H4 (-)	Bankscope	Männasoo and Mayes (2009), Louzis <i>et al.</i> (2012)
Revenue diversification	Herfindahl–Hirschman Index	HHIRD	H5a (-); H5b (+)	Bankscope	Mercieca <i>et al.</i> (2007), Stiroh and Rumble (2006)
Size	Log of Total Assets	Size	H6a (+), H6b (-)	Bankscope	Louzis <i>et al.</i> (2012)
<i>Industry and Macroeconomic variables</i>					
Industry Concentration	Herfindahl–Hirschman Index	HHIC	H7a (-), H7b (+)	Bankscope	Uhde and Heimeshoff (2009), Männasoo and Mayes (2009)
Economic growth	Annual Real GDP growth rate (%)	GDP	H8 (-)	Eurostat	Uhde and Heimeshoff (2009)
Inflation	Log of annual change in CPI rate	Inflation	H9 (+)	Eurostat	Männasoo and Mayes (2009)
Unemployment	Unemployment Rate (%)	UR	H10 (-)	Eurostat, EU Labour Force Survey	Bofondi, M. and Ropele, T. (2011)
Interest rates	Interest rate on the MRO of the ECB	Interest	H11 (-)	ECB	Uhde and Heimeshoff (2009)

Finally, because the effect of size on bank risk appears to be nonlinear, we use the logarithm of bank assets to accommodate this relationship (H6a, H6b).

With respect to the variables exogenous to the banks, industry concentration (H7a, H7b) is also measured in terms of a Herfindahl–Hirschman index (HHIIC), which is calculated as the sum of the squares of all banks' market shares of a country in terms of total assets (in percentage). This index more accurately reflects the entry of new and smaller banks and the impact of a single bank with a very large market share. It is often said that a market is highly concentrated when the index exceeds 1,800 (or 0.18 if we use units instead of percentages) and unconcentrated when the index is below 1,000 (or 0.1).

We use the annual growth rate of the real gross domestic product (GDP) of the country to explore the association between economic growth and bank risk. We measure the effect of inflation on bank profitability (H9) through the consumer price index (CPI) annual inflation rate. To assess the effect of unemployment on bank risk (H10), we use the harmonized and seasonally adjusted unemployment rate, which represents unemployed persons as a percentage of the labor force based on the International Labour Office (ILO) definition. Finally, we take the interest rate on the main refinancing operations (MRO) of the European Central Bank, which provides the bulk of liquidity to the European banking system, as a proxy for interest rates (H11).

4. Results

4.1. Determinants of bank risk in Europe

Table 3 provides an initial outline of the Eurozone banking situation from 2005 to 2011. All variables remain constant in the pre-crisis period, but this scenario dramatically changes in 2008, exhibiting an evident trend of an increasing proportion of impaired loans and thus bank risk coinciding with the beginning of the crisis in Europe.

Table 4 reports the results of the empirical estimation of Equation (1) for both measures of bank risk (NPLr and Z-score) in the Eurozone during the period from 2005 through 2011, using the system-GMM estimator suggested by Arellano and Bover (1995) and Blundell and Bond (1998).

The high levels of significance of the lagged risk variables confirm the dynamic character of the model specification. The values of δ indicate a strong persistence in bank risk, as found in previous studies of the European banking sector (e.g., Delis and Kouretas, 2011).

We confirm our first hypothesis, in which we predicted a positive relationship between the relative percentage of loans in the assets of a bank and its risk, based on the literature that finds that laxity in lending may be a source of banking problems (e.g., De Nicolo *et al.*, 2003; Männasoo and Mayers, 2009; Festic *et al.*, 2011).

In line with previous studies (e.g., Lehar, 2005; Poghosyan and Čihak, 2011), a negative relationship between bank capitalization and risk may be expected due to the potential danger of leverage. Our results confirm this hypothesis (H2a); i.e., the lower the capitalization, the higher the bank risk. Berger and DeYoung (1997) state that low-capital banks respond to moral hazard incentives by increasing the riskiness of their loan portfolios, which results in higher non-performing loans on average in the future. Mehran and Thakor (2011) argue that higher levels of capital lead to a more intensive screening of borrowers thus reducing bank risk.

We also find an inverse relationship between bank profitability and risk, supported by the high levels of significance of ROE in the equations. This proves our third hypothesis, in which we state that more profitable banks tend to be less risky, a

statement broadly agreed upon in the literature. Similarly, inefficiency (CIR) is shown to increase bank risk as measured by the Z-score (H4). As stated before, cost efficiency is positively associated with increases in bank risk, linking 'bad' management with poor skills in credit scoring, appraisal of pledged collaterals and monitoring borrowers (Louzis *et al.*, 2012).

Larger banks appear to be less risky, as indicated by their higher Z scores, which confirms the concentration stability view (Boyd and Prescott, 1986; García and Robles, 2008) stated in Hypothesis H6b. On the other hand, industry concentration has a positive relationship with NPLr, corroborating Hypothesis 7b, which states that the greater the banking sector concentration is, the higher the systemic risk tends to be (De Nicolo *et al.*, 2004).

Among the macroeconomic variables, GDP and inflation are highly significant in our equations, exhibiting negative and positive relationships, respectively, to risk. These findings confirm our hypotheses 8 and 9 and the abundant support in the literature for the view that bank risk exhibits clear cyclical behavior (Uhde and Heimeshoff, 2009; Marcucci and Quagliariello, 2008).

Finally, similar to Delis and Kouretas (2011), we reveal a negative relationship between bank risk and interest rates. Thus, a low-interest-rate environment definitely increases risk-related bank assets and alters the composition of Eurozone bank portfolios toward a more risky position, as we anticipated in hypothesis 11.

Revenue diversification and the unemployment rate are not found to be significant in our model.

Table 3. Summary statistics for European commercial banks

This table reports the means and standard deviations (in parentheses) for the entire sample for each year. The sample comprises 155 banks (959 observations). See Table 2 for a description of the variables.

	Bank risk variables		Bank-specific variables					Industry and macroeconomic variables					
	NPLr	Z-score	Loan/TA	CAR	ROE	CIR	HHIRD	Size	HHIC	GDP	Inflation	UR	Interest
2005	3.13 (2.75)	26.86 (39.56)	57.22 (19.43)	7.29 (3.89)	12.17 (7.48)	62.03 (12.98)	0.62 (0.07)	7.13 (0.91)	0.14 (0.07)	2.35 (1.83)	2.37 (0.57)	7.89 (2.24)	2.42
2006	3.20 (3.73)	27.93 (36.70)	58.60 (20.55)	7.47 (4.07)	13.63 (8.43)	60.39 (13.26)	0.61 (0.09)	7.06 (0.93)	0.12 (0.06)	3.53 (1.72)	2.49 (0.68)	7.19 (1.95)	3.68
2007	3.35 (3.33)	27.42 (33.43)	59.30 (20.81)	7.20 (4.55)	13.42 (9.52)	62.62 (20.64)	0.61 (0.09)	7.01 (0.95)	0.11 (0.05)	3.30 (2.09)	2.19 (0.71)	6.83 (1.84)	4.27
2008	4.08 (3.24)	26.23 (35.49)	60.90 (21.07)	6.74 (4.56)	3.41 (25.81)	72.86 (44.77)	0.59 (0.10)	7.04 (0.95)	0.10 (0.06)	0.22 (1.81)	3.61 (0.88)	7.01 (2.01)	2.50
2009	6.24 (4.82)	27.80 (36.69)	61.08 (20.62)	7.52 (5.06)	0.02 (28.28)	65.78 (20.42)	0.61 (0.08)	7.04 (0.94)	0.10 (0.06)	-4.55 (1.64)	0.38 (0.68)	9.12 (3.35)	1.00
2010	7.30 (7.16)	28.40 (38.39)	62.14 (20.41)	7.54 (5.45)	-0.95 (4.23)	66.41 (23.20)	0.60 (0.09)	7.05 (0.95)	0.10 (0.06)	1.40 (1.68)	1.63 (0.99)	10.08 (3.92)	1.00
2011	9.24 (9.55)	29.12 (40.09)	63.40 (20.45)	7.56 (4.63)	-4.06 (3.19)	67.90 (24.27)	0.60 (0.10)	7.06 (0.94)	0.10 (0.06)	0.82 (1.89)	2.74 (0.62)	10.53 (4.67)	1.00
Total	5.40 (6.00)	27.71 (36.95)	60.64 (20.58)	7.32 (4.69)	4.67 (27.27)	65.85 (26.09)	0.60 (0.09)	7.05 (0.94)	0.11 (0.06)	0.81 (3.18)	2.17 (1.24)	8.43 (3.41)	2.22 (1.29)

Table 4. Determinants of bank risk in Europe

This table presents the determinants of bank risk in the Eurozone during the period 2005–2011 using the system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). See Table 2 for a description of the independent variables. Except for *HHIC*, *GPD*, *Inflation*, *UR*, and *Interest*, all variables are considered as endogenous in our model. We report heteroskedasticity-consistent asymptotic standard errors in parentheses, and significance levels are indicated as follows: ***= significant at the 1% level; **= significant at the 5% level; *= significant at the 10% level. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as F under the null hypothesis of no significance, with degrees of freedom in parentheses. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation. Hansen is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null hypothesis of no correlation between the instruments and the error term, with degrees of freedom in parentheses.

Variables	(1) Log (NPLr)	(2) Log (Z-score)
Dep. Var. _{t-1}	0.727*** (0.050)	0.517*** (0.101)
Loan/TA	0.002** (0.001)	-0.001 (0.001)
CAR	-0.004 (0.005)	0.023*** (0.005)
ROE	-0.002*** (0.000)	0.007*** (0.001)
CIR	0.001 (0.001)	-0.001* (0.000)
HHIRD	-0.004 (0.157)	0.066 (0.148)
Size	-0.028 (0.041)	0.041** (0.017)
HHIC	0.175* (0.100)	-0.916 (0.680)
GDP	-0.022*** (0.004)	0.001*** (0.000)
Inflation	0.019*** (0.007)	-0.012*** (0.004)
UR	0.002 (0.005)	-0.003 (0.006)
Interest	-0.034** (0.015)	0.009* (0.005)
Constant	0.287 (0.379)	0.353 (0.429)
z_1	222.47 (12, 154)	146.88 (12, 153)
m_1	-3.82	-1.71
m_2	-1.27	0.54
Hansen	147.38 (155)	143.04 (155)
Number of obs.	959	936
Number of banks	155	154

4.2. Robustness checks

To confirm the aforementioned findings, we conduct a number of robustness checks. First, we evaluate the method of estimation used in the analysis by using simpler statistical methodologies. Similar to earlier studies on bank risk (e.g., Williams, 2004) we employ an ordinary least squares (OLS) regression to estimate our equations. The results obtained do not differ much from those obtained previously; most of the explanatory variables retain both their signs and their statistical significance, although the effect of size is the opposite of that found previously, exhibiting a significant negative relationship to the Z score (and, therefore, a negative relationship to risk). However, size has always been a controversial variable, and there is abundant support for a negative relationship between size and bank risk in the literature (e.g., Laeven and Levine, 2009). On the other hand, because panel data are used, we can re-estimate the models with either fixed or random effects. Hausman tests suggest that the fixed effects estimator is more appropriate in our case. This methodology has similarly been applied in previous studies to test bank risk determinants (e.g., Festic *et al.*, 2011; Cipollini and Fiordelisi, 2012). We now assume that the omitted variables (e.g., corporate governance) may potentially correlate with the existing regressors. Again, our findings do not change substantially from those obtained for the baseline equations.

Table 5. Robustness checks (I): Alternative regression models

This table presents alternative regression models for our baseline equations. The models in columns (1) and (3) are estimated using ordinary least squares (OLS) regression with robust standard errors clustered by bank (reported in parentheses). The models in column (2) and (4) use fixed-effects (within) regressions with robust standard errors clustered by bank (reported in parentheses). See Table 2 for a description of the independent variables. R^2 is the proportion of variation in the dependent variable explained by the model. *Hausman* is a test that compares the fixed versus random effects, asymptotically distributed as χ^2 under the null hypothesis that the individual effects are uncorrelated with the other regressors in the model, with degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)
Variables	Pool OLS Log (NPLr)	Fixed-effects Log (NPLr)	Pool OLS Log (Z-score)	Fixed-effects Log (Z-score)
Loan/TA	0.006*** (0.000)	0.003 (0.002)	-0.001* (0.001)	-0.000 (0.001)
CAR	-0.007** (0.003)	-0.007 (0.008)	0.024*** (0.004)	0.047*** (0.004)
ROE	-0.003*** (0.001)	-0.002*** (0.000)	0.012*** (0.001)	0.006*** (0.001)
CIR	0.000 (0.001)	0.001** (0.001)	-0.001 (0.001)	-0.001*** (0.000)
HHIRD	-0.110 (0.148)	-0.014 (0.213)	0.794*** (0.157)	0.047 (0.059)
Size	-0.041*** (0.015)	0.339* (0.180)	-0.104*** (0.016)	-0.102** (0.049)
HHIC	1.700 (1.820)	0.895 (0.718)	-0.727*** (0.242)	-0.019 (0.192)
GDP	-0.007* (0.004)	-0.004 (0.003)	0.004 (0.005)	0.000 (0.000)
Inflation	-0.006 (0.011)	0.007 (0.008)	-0.017 (0.012)	-0.002 (0.002)
UR	0.014*** (0.004)	0.051*** (0.007)	-0.003 (0.005)	-0.002 (0.002)
Interest	-0.083*** (0.012)	-0.055*** (0.012)	0.026 (0.032)	-0.006** (0.003)
Constant	0.683*** (0.182)	-1.994 (1.346)	1.332*** (0.191)	1.611*** (0.378)
R^2	0.3168	0.5311 (within)	0.2868	0.8180 (within)
Hausman	-	142.82 (11)	-	57.30 (11)
Number of obs.	959	959	936	936
Number of banks	155	155	154	154

Second, we consider four alternative measures of bank risk. The first of these metrics, the stock of NPLs, which has also been used in recent studies (e.g., García-Herrero *et al.*, 2009), yields expected signs and significance that are similar to those of our original model. We also use the reserve for losses, expressed as a percentage of total loans (LLR/GL) (Barry *et al.*, 2011). This ratio indicates how much of the total loan portfolio is covered by the bank's current reserves. Given a similar charge-off policy, a higher ratio corresponds to a lower-quality loan portfolio. Again, significance and signs agree with the original model. Another metric used to proxy bank risk is the loan loss provision (as a percentage of net interest revenue) ratio (e.g., Williams, 2004; Porter and Chiou, 2012). Using this metric, results similar to those for the baseline model are obtained for all variables⁶. Finally, we employ the Sharpe ratio to represent bank risk. The Sharpe ratio is a risk-adjusted rate of return, and it is calculated as the mean return on equity divided by the standard deviation of this return (Demirgüç-Kunt and Huizinga, 2010). The results obtained using the Sharpe ratio mostly agree with those for our original model, except for the strong significance of revenue diversification. This finding may reflect the fact that European banks are better able to exploit the diversification potential of fee-based activities than US banks, due to their experience with universal banking models (Köhler, 2012).

Third, we re-estimate our equation, changing some of the variables used as regressors. We employ the squared logarithm of bank assets to control for the potential nonlinear relationship between size and profitability. We also consider non-interest income as a percentage of total operating income (NonII/TOR) as a revenue diversification measure (De Jonghe, 2010) instead of HHIRD. These variables are not found to be significant. Finally, because liquidity has been identified as an important issue in banking during the recent European financial crisis, we replace the ratio of loans to total assets with the ratio of liquid to total assets to analyze the effect of the asset structure on bank risk.⁷ As expected, most liquid banks are also those with lower risk. This finding is in accordance with

⁶Because the negative values of the loan loss provision to net interest revenue (LLP/NIR) ratio, the number of observations was reduced from 959 to 908 by using logarithms.

⁷ Another source of potential liquidity risk (as well as interest rate risk) for a bank is the maturity mismatch between its assets and its liabilities (i.e. long-term loans are granted using short-term deposits). The loan to deposit ratio is used for this purpose (the higher the ratio, the bigger the risk). Our results (not reported) corroborate the inverse relationship between liquidity and bank risk.

the greater importance given to liquidity standards in the recent set of reforms developed by the Basel Committee on Banking Supervision to promote a more resilient banking sector (commonly known as Basel III).

Table 6. Robustness checks (II): Alternative measures of bank risk

This table presents regressions for alternative measures of bank risk using the system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). The dependent variables are as follows: (column 1) stocks of non-performing loans (*NPLs*) (in logarithmic form), (column 2) loan loss reserve divided by gross loans (*LLR/GL*) (in logarithmic form), (column 3) loan loss provisions divided by net interest revenue (*LLP/NIR*) (in logarithmic form), and (column 4) the Sharpe ratio. See Table 2 for a description of the independent variables. Except for *HHIC*, *GPD*, *Inflation*, *UR* and *Interest*, all variables are considered as endogenous in our model. We report heteroskedasticity-consistent asymptotic standard errors in parentheses, and significance levels are indicated as follows: ***= significant at the 1% level; **= significant at the 5% level; *= significant at the 10% level. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as F under the null hypothesis of no significance, with degrees of freedom in parentheses. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation. *Hansen* is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null hypothesis of no correlation between the instruments and the error term, with degrees of freedom in parentheses.

Variables	(1) Log (<i>NPLs</i>)	(2) Log (<i>LLR/GL</i>)	(3) Log (<i>LLP/NIR</i>)	(4) Sharpe
Dep. Var. _{<i>t-1</i>}	0.704*** (0.062)	0.898*** (0.041)	0.317*** (0.056)	0.451*** (0.073)
Loan/TA	0.006*** (0.001)	0.001 (0.001)	0.014*** (0.004)	-0.014* (0.007)
CAR	-0.004 (0.006)	-0.006 (0.007)	-0.027* (0.015)	0.045* (0.026)
ROE	-0.002*** (0.001)	-0.004*** (0.000)	-0.011*** (0.003)	0.012*** (0.003)
CIR	0.001 (0.001)	0.002** (0.001)	-0.001 (0.001)	-0.011*** (0.003)
HHIRD	-0.084 (0.160)	-0.455 (0.264)	-0.110 (0.798)	2.234*** (0.805)
Size	0.274*** (0.076)	0.013 (0.036)	-0.002 (0.032)	-0.371 (0.245)
HHIC	0.409 (0.614)	0.514** (0.215)	1.974** (0.931)	-0.686 (3.911)
GDP	-0.019*** (0.005)	-0.026*** (0.005)	-0.042*** (0.012)	0.052*** (0.019)
Inflation	0.019** (0.008)	-0.001 (0.010)	-0.037 (0.029)	-0.082 (0.052)
UR	0.002 (0.006)	-0.002 (0.005)	-0.007 (0.014)	-0.081 (0.052)
Interest	-0.030* (0.017)	-0.041*** (0.011)	-0.109*** (0.031)	0.159** (0.078)
Constant	-0.630 (0.485)	0.559 (0.381)	0.568 (1.026)	3.196 (2.249)
z_1	687.27 (12, 154)	159.63 (12, 154)	29.46 (12, 150)	50.08 (12, 154)
m_1	-3.57	-3.15	-4.57	-5.57
m_2	-1.10	0.39	1.81	1.38
Hansen	145.86 (155)	146.78 (155)	134.94 (155)	145.86 (155)
Number of obs.	959	959	908	959
Number of banks	155	155	151	155

Table 7. Robustness checks (III): Alternative independent variables

This table presents the results for our baseline equations after changing some of the independent variables. The models in columns (1) and (4) include $Size^2$ (the square of log (assets)) in place of $Size$. The models in columns (2) and (5) consider $NonII/TOR$ (non-interest income as a percentage of total operating revenue) in place of $HHIRD$. The models in columns (3) and (6) consider Liq/TA (liquid to total assets ratio) in place of $Loan/TA$. The rest of the variables remain the same (see Table 2). Regressions use the system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). Except for $HHIC$, GPD , $Inflation$, UR , and $Interest$, all variables are considered as endogenous in our model. We report heteroskedasticity-consistent asymptotic standard errors in parentheses, and significance levels are indicated as follows: ***= significant at the 1% level; **= significant at the 5% level; *= significant at the 10% level. z_1 is a Wald test of the joint significance of the reported coefficients, asymptotically distributed as F under the null hypothesis of no significance, with degrees of freedom in parentheses. m_i is a serial correlation test of order i using residuals in first differences, asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation. $Hansen$ is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null hypothesis of no correlation between the instruments and the error term, with degrees of freedom in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Log (NPLr)	Log (NPLr)	Log (NPLr)	Log (Z-score)	Log (Z-score)	Log (Z-score)
Dep. Var. _{t-1}	0.725*** (0.051)	0.750*** (0.050)	0.737*** (0.049)	0.519*** (0.098)	0.552*** (0.104)	0.542*** (0.099)
Loan/TA	0.002** (0.001)	0.002* (0.001)		-0.000 (0.000)	-0.001 (0.001)	
Liq/TA			-0.003*** (0.001)			0.002** (0.000)
CAR	-0.004 (0.005)	-0.003 (0.003)	-0.004* (0.003)	0.023*** (0.005)	0.024*** (0.005)	0.022*** (0.004)
ROE	-0.002*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	0.007*** (0.001)	0.007*** (0.001)	0.008*** (0.001)
CIR	0.001 (0.001)	0.000 (0.001)	0.001 (0.001)	-0.001* (0.000)	-0.001 (0.000)	-0.001* (0.000)
HHIRD	-0.004 (0.157)		-0.004 (0.121)	0.078 (0.146)		0.076 (0.182)
NonII/TOR		-0.032 (0.117)			0.042 (0.058)	
Size		-0.018 (0.019)	-0.045 (0.042)		0.036*** (0.013)	0.040** (0.020)
Size ²	0.001 (0.002)			-0.004 (0.003)		
HHIC	0.204* (0.119)	0.372 (0.497)	0.243* (0.170)	-0.828 (0.661)	-0.611 (0.479)	-0.716 (0.780)
GDP	-0.022*** (0.004)	-0.022*** (0.004)	-0.026*** (0.003)	0.001** (0.000)	0.002** (0.001)	0.001*** (0.000)
Inflation	0.019*** (0.007)	0.017** (0.007)	0.020*** (0.007)	-0.012*** (0.004)	-0.011** (0.004)	-0.013*** (0.004)
UR	0.002 (0.005)	0.001 (0.003)	0.002 (0.004)	-0.001 (0.003)	-0.002 (0.005)	-0.001 (0.006)
Interest	-0.034** (0.015)	-0.036*** (0.008)	-0.033*** (0.010)	0.007 (0.005)	0.014* (0.008)	0.010** (0.005)
Constant	0.167 (0.257)	0.151 (0.299)	0.189 (0.329)	0.453 (0.529)	0.328 (0.313)	0.388 (0.433)
z_1	214.48 (12, 154)	239.26 (12, 154)	222.47 (12, 154)	144.14 (12, 153)	165.90 (12, 153)	156.88 (12, 153)
m_1	-3.79	-3.85	-3.88	-1.71	-1.72	-1.73
m_2	-1.19	-1.27	-1.26	0.54	0.60	0.58
Hansen	148.10 (155)	144.68 (155)	149.32 (155)	144.28 (155)	143.23 (155)	144.04 (155)
No. obs.	959	959	959	936	936	936
No. banks	155	155	155	154	154	154

5. Summary and conclusions

This paper empirically analyzes the main factors influencing bank risk in the Eurozone from 2005 to 2011, using an unbalanced panel data set of 959 observations. This time span allows us to consider the impact of the recent financial and economic crisis on the Eurozone banking system. We apply the

system-GMM estimator, developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998), which has only recently been used in studies on the determinants of bank risk (e.g., Porter and Chiou, 2012; Louzis et al., 2012).

We examine both bank-specific and macroeconomic determinants of bank risk, analyzing 11 variables that have been proven to influence bank risk: asset structure, capitalization, profitability, efficiency, revenue diversification, size, industry concentration, economic growth, inflation, unemployment and interest rates. We proxy bank risk using two complementary metrics that are intuitive and easily measurable: NPLr, which focuses on credit risk, and the Z-score, which is an overall measure of bank risk that includes liquidity and market risk.

Our results indicate that capitalization, profitability, efficiency and liquidity are negatively and significantly related to bank risk. We also find that less competitive markets, lower interest rates and a context of economic crisis (with falling GDP and rising inflation rates) increase bank risk.

We apply different robustness checks, first by using simpler statistical methodologies such as OLS and re-estimating our panel data model using fixed effects, and second by considering four alternative measures of bank risk: the stock of NPLs, the reserve of losses to total loans (LLR/GL), the loan loss provision to net interest revenue and the Sharpe ratio. Finally, we re-estimate the baseline equation using alternative regressors. The results of these tests yield signs and significance levels that are similar to those in the original model for most of the independent variables, thus proving their robustness.

Nevertheless, we find that the effect of size exhibits contradictory behavior. The ambiguous results obtained for this variable, along with the high level of significance it exhibits in the different robustness tests and the controversy surrounding its effects on bank risk, makes size a noteworthy topic for further research.

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