Bangor Business School Working Paper

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BBSWP/12/003

Bank Risk during the Financial Crisis: Do business models matter?

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February 2012

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Abstract
We exploit the 2007-2009 financial crisis to analyze how risk relates to bank business models. Institutions with higher risk exposure had less capital, larger size, greater reliance on short-term market funding, and aggressive credit growth. Business models related to significantly reduced bank risk were characterized by a strong deposit base and greater income diversification. The effect of business models is non-linear: it has a different impact on riskier banks. Finally, it is difficult to establish in real time whether greater stock market capitalization involves real value creation or the accumulation of latent risk.

JEL classification: G21; G15; E58; G32
Keywords: bank risk, business models, bank regulation, financial crisis, Basle III

We are grateful to Thorsten Beck, Geert Bekaert, Allen Berger, Giancarlo Corsetti, Andrew Ellul, Charles Engel, Carlos Garcia, Juan Angel Garcia, Leonardo Gambacorta, Philipp Hartmann, Harald Hau, Florian Heider, Harry Huizinga, Sam Langfield, Jyoti Patel, Jose Peydro, Alexander Popov, Alberto Franco Pozzolo, Philipp Schnabl and an anonymous referee for very useful comments and discussions. We are also grateful to Katerina Deligiannidou, Francesca Fabbri, Luiz Paulo Fichtner and Silviu Oprica for their help in obtaining data. We thank the participants at the seminars held at the Bank of England, Tilburg University, Bank for International Settlements, New York University and New York Federal Reserve conference on systemic risk and the European Central Bank for their valuable insights. The opinions presented here are those of the authors only and do not necessarily reflect those of the European Central Bank (ECB). For further information, please contact:

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In cauda venenum [1]

The 2007-2009 financial crisis resulted in the largest realization of bank risk since the Great Depression. The decimation of the market value of banking shares during this period was unprecedented: more than 3 trillion euros were erased from the market capitalisation of banks in Europe and the United States. This corresponds to a decrease of 82% in the stock market value of these banks between May 2007 and March 2009. The 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". However, while the loss in value was widespread, the effects of the crisis were very diverse across banks. A case in point is provided by the increased dispersion of cross-sectional stock market returns after the crisis, suggesting a strong degree of heterogeneity in ex-ante risk-taking (see Figure 1). This paper has three main objectives in this regard. First, we analyse the impact of different business models on bank distress. Second, we examine whether this impact is non-linear at the cross-sectional level. Third, we assess whether the high stock market values experienced by a number of banks prior to the crisis were actually related to an accumulation of latent risk.

{Insert Figure 1}

For a large sample of listed banks operating in the European Union and the United States, we measure the risk that materialised during the crisis in three ways: the likelihood of a bank rescue, systematic risk, and the recourse to central bank liquidity. This multifaceted approach lends robustness to our results, as it captures the different dimensions of risk as they unfold during a

[1] "In the tail (is) the poison" or "To save the worst for last". Roman aphorism.

crisis. We then consider how these variables are related to the characteristics of individual banks during the pre-crisis period using a database laboriously compiled for the purposes of this study. We group individual bank information into four categories – capital, asset, funding, and income structures – which concisely and effectively summarize the underlying bank business models. We therefore use the crisis as a laboratory in which risks that were not apparent on bank risk indicators prior to the crisis are manifested and link the dispersion of the ex-post manifestation of risks to the ex-ante (i.e. before risk materialized) variability in bank business models.[2]

We find that credit expansion, a lower dependence on customer deposits, bank size, and a weaker capital base (especially for undercapitalised banks) in the run-up to the crisis accounted for higher levels of ex-post risk. Other contributing factors include the amount of market funding used and the lack of diversification in income sources. These results are robust with regard to the use of different indicators measuring diverse aspects of bank risk. Taking into consideration macroeconomic and institutional factors – including the role of deregulation, the economic cycle, competition, and developments in asset prices – does not significantly alter the main results.

Second, we show that ex-post measures of managerial abilities considerably augment the explanatory power of the regressions, suggesting that bank business models still leave a significant portion of risk unaccounted for. In this respect, and in line with Rajan (2005), our results suggest that for some banks the large market-to-book values attained prior to the crisis occurred on the back of latent systematic risk, whereas for others it reflected better managerial ability. The results also show that it is difficult to disentangle ex-ante the

[2] See Beltratti and Stulz (2011); Bekaert et al. (2011); Demirguc-Kunt et al. (2011) for similar applications analysing stock market performances.

different factors behind the creation of stock market value (Rajan, 2005; Acharya et al., 2011).

Finally, our results also indicate that the effect of business models on bank risk is highly non-linear. This impact was identified by estimating a quantile regression version of the baseline specification. This estimation reveals whether the risk determinants of the riskiest banks (those belonging to the higher quantiles of the cross-sectional distribution of risk during the crisis) are identical to those of the less risky banks (those belonging to the lower quantiles of the distribution). In fact, the "riskier" banks were found to be more sensitive to loan growth, customer deposits and market funding, in terms of their levels of distress. More precisely, a stronger customer deposit base is relatively more effective in reducing distress for these banks than for the less risky ones. Finally, a higher proportion of market funding increases the probability of distress for the riskiest banks, but has no effect on the less risky institutions.

Our findings have a bearing on the current prudential regulatory debate. From a long-term perspective the run-up to the 2007-2009 crisis was characterised by a process of financial deregulation and rapid innovation, with the widespread use of new financial instruments. Both of these factors altered the business models as well as the incentives for banks to take on new risks. The regulatory answer to these incentives, via the initial Basel I Accord, mostly focused on efforts aimed at applying common minimum capital requirements related to banks' credit risk exposures.[3] The Basel II Accord, however, did not require a minimum common standard for capital charges, but rather allowed large and sophisticated institutions to use their own internal risk assessment

[3] The initial Basel I Accord was triggered by a widespread discontent on the part of regulators with the capital ratios of many banking institutions, particularly the larger ones, after the 1982 Mexican debt moratorium and the following banking crisis.

models. With the benefit of hindsight, the results presented here suggest that the lower reliance on rules, as well as a stronger dependence on market discipline and self-regulation recommended by the Basel II Accord, contributed to the build-up of risk by many institutions in the period before the crisis.

Our results support the Basel III initiatives aimed at raising the core capital levels of institutions, in particular of undercapitalized ones (See BIS, 2010). They concur with efforts directed at reducing the cyclicality of credit and increases in the capital charges for those institutions relying more strongly on short-term market funding. Our findings also clearly indicate that excessive loan growth leads to the accumulation of risk by banks so the introduction of capital charges linked to this variable could be considered. In this respect, and given its quantitative importance, a careful assessment of the implementation of the anti-cyclical capital buffers proposed by Basel III is recomended.

This paper also suggests that regulators should increase their involvement in and understanding of bank business models and incentives to take on risk, issues which have not been explicitly incorporated in Basel III. In particular, regulators need to consider risk-taking incentives in real time and focus on the potential impact of different business models on risk. Our findings provide valid reasons for the closer scrutiny of banks experiencing rapid increases in their stock market valuations, to ascertain whether it is driven by improved managerial abilities or by increasing the bank's exposure to hidden risks.

The remainder of this paper is organized as follows. Section I provides an overview of the transformation of the financial system over the past three decades and the impact that this has had on bank business models and risk-taking incentives. Section II reviews the literature on business models and bank risk, while Section III describes the model, data sources, and how the dataset was

constructed. Section IV presents the main empirical findings, together with robustness tests and further refinements based on quantile regression techniques. Section V presents conclusions and makes recommendations for future regulation and research.

I. The transformation of the financial system and its impact on business models and bank risk

The evaluation, management and sharing of risk is one of the core features of the banking sector. In fact, a key reason for the existence of banks is that they are better at screening and managing risks than other institutions, so they can act as delegated monitors for uninformed depositors (Diamond, 1984). Compared with financial markets, banks are also better at handling those risks which cannot be diversified away (Allen and Gale, 1997). Despite this ability, the huge accumulation of risk that subsequently materialized during the recent crisis raises significant doubts as to whether banks face the right incentives to manage risk effectively on behalf of depositors and investors. Indeed structural developments in the banking industry have probably helped distort incentives towards more risk-taking and a closer dependence on financial markets (Rajan, 2005; Boot and Thakor, 2010).

The first major structural development was deregulation. Over the past 25 years, there has been a strong process of liberalization of the banking sector in most developed countries – a development that has also altered incentives to take on risk. In the wake of the globalization of financial markets, deregulation aimed to achieve economic gains on the back of greater competition. The result was an unparalleled loosening of the regulatory constraints on banks; a development that has increased competition and lowered their charter values (Hellman et al.,

2000).[4] In the United States this liberalization de facto dismantled barriers to the geographical expansion of banks and included a far-reaching deregulation of investment bank activities, prompting the creation of large financial institutions involved in a broad range of banking activities.[5] There was a parallel experience with deregulation in the European Union which (supported by the creation of the Single Market in 1992 and the introduction of the euro in 1999) removed some residual regulations limiting certain bank activities.

The second major structural development was financial innovation. Large increases in the use of direct funding available via the financial markets and securitization activity formed part of a wider trend of innovation that intensified the trading of credit risk between banks and financial markets. An important implication of this was that banks became more integrated with financial markets and increased their share of non-interest income as a proportion of total revenues derived from own-trading, brokerage and investment banking activities (Boot and Thakor, 2010).

Deregulation and financial innovation led to a profound change of bank business models while altering their incentives to take on risks. These changes impacted on several dimensions, such as: size, recourse to non-interest income revenues, corporate governance, and funding practices, which, in turn, were all affected by the macroeconomic and competitive environments.

[4] Deregulation mainly involved the loosening of regulations related to structure and conduct. Structure regulations are primarily concerned with whether institutions can undertake certain activities (such as those involving the functional separation of institutions, entry restrictions or discriminatory rules against foreign banks), whereas conduct regulations focus on normative rules specifying appropriate firm behaviour and business practices, mainly in respect of bank interaction with customers (some typical examples being the regulations on fees and commissions, deposit and lending rates or branching limitations).

[5] One notorious example is the Gramm-Leach-Bliley Act of 1999 in the United States, which repealed the Banking Act of 1933 (the Glass-Steagall Act) that had previously imposed a separation or "firewall" between commercial and securities-related banking activities.

At the global level, the regulatory response to these enhanced incentives to acquire new risks concentrated on the Basel recommendations, which focused on capital requirements as the cornerstone of prudential regulations for banks.[6] Whereas the initial 1988 Basel I Accord set a standardized minimum level of bank capital for all banks, the Basel II Accord aimed at more closely connecting capital requirements with underlying banks' risks. It also lowered the degree of regulators and supervisors involvement in the conduct of banks' activities by favoring best practices from financial markets. For instance Basle II allowed a stronger reliance of capital requirements on banks' internal risk assessment models and encouraged a greater role for financial markets as a supervisory disciplining device. A potential side-effect of the Basel II Accord might have been to compound the problems of cyclicality of the financial system, which were already exacerbated by ongoing changes in the financial system (Kashyap and Stein, 2004).

Despite the significant build-up of risks arising from these factors, the majority of the most commonly used indicators of bank risk showed a fairly benign picture in the years preceding the crisis. Indeed, even the forward-looking measures of bank risk regularly used by financial institutions, investors, central banks, and regulators to monitor the health of the financial system remained at very low levels (IMF, 2009; ECB, 2009). In parallel, existing evidence indicates that there was a convergence or "flattening" in the differences in performance between banks before the crisis broke (as measured, for instance, by stock market returns: see Figure 1 above). The crisis, however, revealed huge variability across individual banks, as evidence by the cross-sectional dispersion of risk indicators, which widened significantly during this period. This raises the

[6] In other words, the general trend was to introduce competition in banking and to contain risk-taking incentives via capital requirements (Vives, 2000).

question of whether the variability in specific bank characteristics, due to their different business models, could have helped in the early identification of hidden risks, which would only materialize in the long-term or in the event of a substantial shock.

II. Bank risk and business models: a literature review

A number of studies have focused on the relationship between certain business model characteristics and bank risk. Already, prior to the crisis, research has focused on the interaction between risk and a number of key factors: capital (see, for instance, Wheelock and Wilson, 2000), operating efficiency (Kwan and Eisenbeis, 1997), funding sources (Demirgüc-Kunt and Huizinga, 2010), securitization and links with financial markets (Boot and Thakor, 2010; Keys et al., 2008; Mian and Sufi, 2009), corporate governance (Laeven and Levine, 2009) and diversification (Stiroh, 2010).[7]

During the recent crisis a number of recent studies have focused on the determinants of performance using stock market information relating to large banks. Beltratti and Stulz (2011), for example, found that banks with more Tier I capital (in countries with stronger capital supervision) and a higher loan to total assets ratio performed better in the initial stages of the crisis, while banks with more shareholder-friendly boards performed worse.[8] A larger deposit base and more liquid assets were associated with higher returns (Demirguc-Kunt et al., 2010). Moreover, banks with stronger internal risk controls also fared better, while the impact of corporate governance was mixed (Ellul and Yerramilli, 2010; Peni and Vähämaa, 2011).

[7] A parallel body of literature has analyzed the impact of bank competition on bank risk (e.g. Boyd and De Nicolò, 2005).
[8] Idiosyncratic bank performance also seems persistent when comparing this to the previous banking crisis (Fahlenbrach, Prilmeier and Stulz, 2011).

The focus of our study is exclusively on bank risk. As the realisation of risk is a complex and multifaceted phenomenon, we consider a number of different risk indicators to gauge the level of distress that banks experienced. Namely, we analyse: the probability of a bank rescue, systematic risk, and recourse to central bank liquidity facilities (which allows for assessing the consistency of our results across risk indicators). The rest of this section offers a selective overview of the existing literature linking specific aspects of bank business models with risk. We structure the review by grouping business models into four main broad categories, used later in our empirical investigation.

II.A Capital structure

As previously highlighted, the period of banking deregulation was partly counterbalanced by regulators giving bank capital a more prominent role in the prudential regulatory process, as reflected in the initial Basel Accord on capital standards, and subsequent amendments. Depending on the particular focus and modelling strategy involved, the literature offers contradictory results as to the effects of capital requirements on bank risk (Freixas and Rochet, 2008). In principle, the higher the capital reserves, the stronger the buffer to withstand losses. Less leverage (more capital) also reduces risk-shifting incentives from shareholders towards excessively risky projects at the expense of debt holders. This is specially so in the banking industry where a quasi-flat (i.e. not fully risk-adjusted) deposit insurance exists creating an incentive for shareholders to optimize the option value of the deposit insurance by taking on excessive risks (Bhattacharya and Thakor, 1993). Recent studies on bank capital also analyze the possibility of asset-shifting in favor of riskier assets, where moral hazard considerations play a role. These generally find that a higher level of capital is

also conducive to a more intensive screening of borrowers and, therefore, less bank risk (Coval and Thakor, 2005; Mehran and Thakor, 2011).

Nonetheless, a positive relationship between capital and risk can also exist. More specifically, agency problems between shareholders and managers can lead to excessive risk-taking via managerial rent-seeking. According to the corporate finance literature, increasing leverage reduces agency conflicts between managers and shareholders since informed debt holders intensify the pressure on bank managers to become more efficient (Jensen and Meckling, 1976; Calomiris and Kahn, 1991; Diamond and Rajan, 2001). A positive relationship between bank capital and risk can also occur if regulators (or the markets) force riskier banks to build up capital, or simply if banks with more capital have a greater risk absorption capacity and, as a result, take on more risk (Berger and Bouwman, 2010). Finally, it is also possible that there is a non-linear relationship and that both very low and very high levels of capital induce banks to take on more risk (Calem and Rob, 1999).[9] Overall, the empirical literature tends to support the view that more capital increases bank soundness particularly during periods of crisis and for higher quality (i.e. core) forms of capital (Gambacorta and Mistrulli, 2004; Wheelock and Wilson, 2000; Demirguc-Kunt et al., 2010; Berger, and Bouwman, 2010).

II.B Asset structure

Size can be an important determinant of banks' risk (Huang et al., 2011; Drehmann and Tarashev, 2011; Tarashev et al., 2009). Compared to smaller

[9] Acharya, Mehran and Thakor (2010) show that banks face two moral hazard problems – asset substitution by shareholders and managerial rent-seeking – which require a level of bank leverage that is neither too low nor too high. According to their model, the optimal capital regulation requires that a part of bank capital be unavailable to creditors upon failure, and be available to shareholders only contingent on good performance.

banks, larger institutions could have different incentives due to the "too-big-to-fail" problem or diversification possibilities (Demirgüc-Kunt and Huizinga, 2010).

Another major factor is securitisation, which enables banks to off-load part of their loans from the asset side of their balance sheet to financial market investors. The years preceding the crisis also coincided with a rapid growth in off-balance sheet financing by banks that was supported by the massive expansion of securitisation markets. This changed banks' business models dramatically altering their incentives to hedge and take on new risks (Shin, 2009; Marques-Ibanez and Scheicher, 2010). Structurally, securitization allowed banks to turn traditionally illiquid claims (overwhelmingly in the form of bank loans) into marketable securities. The development of securitization therefore allowed banks to off-load part of their credit exposure, thereby lowering regulatory pressures on capital requirements and raising new funds. In principle, from the perspective of individual banks, securitization allowed banks to manage and diversify their credit risk portfolio more easily, both geographically and by sector. Scant empirical evidence from the pre-crisis period also went in this direction. In particular, banks that were more active in the securitization market were often found to have lower solvency risk, higher profitability levels, and were better capitalized (see, among others, Cebenoyan and Strahan, 2004, and Wu et al., 2011). However, banks might also respond to the static reduction in risks due to securitization by taking on new ones; for instance, by loosening their lending standards, increasing their leverage, or becoming systemically riskier (Mian and Sufi, 2009; Keys et al., 2010; Nijskens and Wagner, 2011).

II.C Funding structure

The deregulation and financial innovation developments led banks to increase their dependence on financial markets for their funding. This involved borrowing

more intensively from wholesale markets, where funds are usually raised on a rollover basis through instruments such as mortgage bonds, repurchase agreements and commercial paper.

An alternative source of funding is represented by retail deposits, which tend to be more stable in periods of crisis (Shleifer and Vishny, 2010): since they are typically insured by the government, their withdrawals in most circumstances are usually predictable at the aggregate level and mostly linked to depositors' liquidity needs (Song and Thakor, 2007; Huang and Ratnovski, 2011). The "stickiness" of deposits is also related to high switching costs and the transaction services that retail depositors receive from banks (Kim et al., 2003). Deposits, however, are often less flexible in adapting to changes in financing needs, to fund investment opportunities, compared with wholesale markets.

In terms of the impact of the funding structure on bank risk, most of the earlier literature pointed to the benefits derived from the use of market financing. Banks can raise in the interbank markets large new amounts of funding swiftly and at relatively low cost. It was also argued that, compared to depositors, financial market investors tend to be relatively sophisticated, and hence they were expected to provide more market discipline (Calomiris and Kahn, 1991).[10] The recent financial crisis, however, pointed to a "dark side" of wholesale funding. For instance, Huang and Ratnovski (2008) show that, on the basis of cheap and noisy signals, wholesale financiers have lower incentives to conduct costly monitoring. This can trigger the liquidation of solvent institutions due to sudden withdrawals based on negative public signals. Indeed, the recent crisis has starkly illustrated that market sources of funding are heavily dependent on market perceptions, raising doubts concerning the monitoring role of wholesale

[10] The empirical evidence relating to the market discipline of banks (from debt holders in financial markets) is mixed (see Flannery and Sorescu, 1996, and Krishnan et al., 2005).

investors. Recent evidence suggests that when funding from financial markets became unavailable, or prohibitively expensive, the market valued more positively those institutions more heavily funded via customers' deposits (Beltratti and Stultz, 2011; Demirguc-Kunt et al., 2010).

II.D Income structure

Another consequence of deregulation has been a geographical expansion of a number of financial institutions, a phenomenon which usually coincides with high rates of credit growth. Strong credit growth was also fuelled by raised collateral values, due to sharp increases in housing prices in some countries and the more easily available access to wholesale funding, linked to financial innovation.

Historically, most systemic banking crises have been preceded by periods of excessive lending growth (Reinhart and Rogoff, 2009). While macroeconomic and structural changes, such as increases in banking competition, could affect aggregate changes in lending, added to these factors, microeconomic dynamics could also play a role. For instance, individual banks could intend to seize new lending opportunities, expand to new geographic markets, or gain market share, loosening credit standards in the process (e.g. Dell'Ariccia and Marquez, 2006; Ruckes, 2004). Microeconomic evidence from large international banks suggests that loan growth represents an important driver of risk (Laeven and Majnoni, 2003; Foos et al., 2010; Keeton, 1999).

The global trend towards more diversification in bank income sources and an expansion of non-interest income revenues (i.e. those revenues derived from trading, investment banking, brokerage fees and commissions) has provided banks with additional sources of revenue (Stiroh, 2010). Such diversification can,

in principle, help foster stability in overall income. At the same time, it is not clear whether the stronger reliance on non-interest income reduces overall banking risk. Since this type of income tends to be a more volatile source of revenue than interest rate income, in periods of financial stress there could be a decline in the traditional sources of revenue, together with an even larger decline in revenues from fees and brokerage services. It is then possible that the financial stability benefits that may be obtained from diversification accrue only in cases of minor idiosyncratic risk, but not in the context of a wider systemic shock.

The empirical evidence for the impact of diversification on bank risk in the U.S. and around the world is mixed (Stiroh, 2010). A general conclusion from these studies is that the growing reliance on non-interest income has not been associated with reduced volatility in earnings (DeYoung and Roland, 2001; Stiroh, 2004), or a decline in bank systematic risk, as derived from stock market returns (Baele et al., 2007; De Jonghe, 2010).

II.E Additional control variables

While our focus is on bank business models, in the empirical specifications we do control for a number of variables that account for major macroeconomic and institutional factors, such as developments in housing and equity markets, competition, and corporate governance.

The role of macroeconomic variables in relation to bank risk works via lenders' economic expectations and borrowers' net worth: increases in borrowers' collateral values cause an overall improvement in the perceived creditworthiness of both borrowers and banks. In this situation, there is a greater incentive for

banks to ease financial constraints and increase lending, thereby taking on more risks (Matsuyama, 2007).

The impact of competition on bank risk is ambiguous. Enhanced competition could lead to greater (and possibly excessive) risk-taking by banks (Jimenez and Lopez, 2007). This is because increased competition reduces market power which, coupled with limited liability and the application of flat rate deposit insurance, could in turn encourage banks to take on more risk (Hellman et al., 2000). In contrast, Boyd and De Niccoló (2005) argue that the theoretical basis for linking increased competition with greater risk-taking is fragile. Other recent empirical work is consistent with this view (Boyd et al., 2006; Cihak et al., 2006). The intensity of bank supervision could also have had an impact on the amount of risk undertaken (Beltratti and Stulz, 2011). In particular, it is necessary to verify whether more permissive legislation regarding bank activities could have led financial intermediaries to take more risks (Barth et al., 2004).

Conflicts between bank managers and owners might also have an impact on bank risk-taking. In principle, companies with a diversified shareholder ownership advocate more risk-taking, as each shareholder tends to have a substantial equity stake in the bank concerned (Laeven and Levine, 2009). Firms with a higher degree of institutional ownership also appear to have undertaken more risk prior to the crisis, prompting large losses for their shareholders during the crisis (Erkens et al., 2009).

III. Model and data

In line with the previous discussion, our empirical investigation is based on the following specification:

$$r_{i,c} = \beta_0 + \underbrace{\beta_1 eta_{i,b} + \beta_2 eta\_reg_{i,b} * k_{i,b}}_{\text{Capital structure}} + \underbrace{\beta_3 size_{i,b} + \beta_4 loan\_ta_{i,b} + \beta_5 abs_{i,b}}_{\text{Asset structure}} +$$
$$+ \underbrace{\beta_6 mkt\_assets_{i,b} + \beta_7 stdeb_{i,b}}_{\text{Funding structure}} + \underbrace{\beta_8 niinco_{i,b} + \beta_9 exlend_{i,b}}_{\text{Income structure}} + \underbrace{\beta_{10} beta\_edf_i + \beta_{11} alpha\_edf_i}_{\text{Managerial abilities}} + \quad (1)$$
$$+ \underbrace{\beta_{12} return\_on\_assets_{i,b} + \beta_{13} macro_{k,b} + \beta_{14} governance_{i,b} + \beta_{15} reg_{k,b} + \beta_{16} comp_{k,b}}_{\text{controls}} + \varepsilon_i$$

The dependent variable ($r_{i,c}$) measures the distress of bank i during the crisis period c (2007Q4 to 2009Q4),[11] while the regressors include the averages for bank characteristics and for controls in the pre-crisis period b (2003Q4 to 2007Q3). The use of average information for the pre-crisis period serves to minimize short-term distortions in bank characteristics, since our main objective is to show whether certain medium or long-term business characteristics present in the pre-crisis period can be systematically linked to the risks that materialised during the financial crisis. By combining information from the pre-crisis period and the manifestation of risk during the crisis, we are able to minimize endogeneity problems by using the crisis as a laboratory (see Beltratti and Stulz, 2011; Bekaert et al., 2011; Demirguc-Kunt et al., 2011).

The statistical sources used and a brief description of the main variables included in our study are provided in Table I, while Table II shows the main descriptive statistics. Our initial dataset had more than 1,100 listed banks from 16 countries; namely: Austria, Belgium, Denmark, Germany, Greece, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom, and United States. The final dataset comprises only listed banks (which typically adhere to international accounting standards) for which all the necessary information was available. From a macroeconomic point of view, it

[11] Hence, our sample horizon excludes the period of tension in sovereign bond markets. This is because the spillover effects on the banking sector would distort our model and, thus, our final results. For instance, between 2009 and 2010, the yield for 10-year Greek government bonds increased from 5.2% to 9.3%, raising the spread with the government bonds of euro area counterparts from 110 basis points to 530 basis points. This also affected all the indicators of bank risk for Greek banks.

is highly representative, as it covers around two-thirds of the total aggregate balance sheet of banks operating in the European Union and United States. The rest of this section describes in detail the construction of each variable.

{Insert Tables I and II}

III.A Construction of bank risk variables

The purpose of our analysis is to identify the main determinants behind the accumulation of bank risk and its subsequent realization during the recent financial crisis. During a crisis, however, the appearance of bank risk unfolds progressively and manifests itself in different dimensions. To ensure that our results do not depend on a specific definition of bank risk, we employ three alternative measures to capture the different aspects of its realization.

i. Financial support (*resc*) – Our first measure of bank risk captures whether an institution received any government support. The construction of this variable is based on the collection of information relating to the public rescue of banks via capital injections, the issuance of state-guaranteed bonds, or other government-sponsored programmes. We use several sources, including the European Commission, central banks, the Bank for International Settlements, Bloomberg, and the websites of a number of government institutions.[12] The resulting dependent dummy variable takes the value of one if public financial support was received during the crisis and zero if otherwise.

[12] For a comprehensive overview of the public measures in support of the financial sector see Stolz and Wedow (2010).

ii. Systematic risk *(risk)* – Our second measure of bank risk is based on the concept of a bank market exposure during the financial crisis. It is constructed using a simple capital asset pricing model (*CAPM*), based on the following equation:

$$R_{i,k,t} = \beta_{i,k,t} * R_{m,k,t} + \varepsilon_{i,k,} \quad (2)$$

where $R_{i,k,t}$ is the daily logarithmic excess stock market returns for each bank i from country k at time t;[13] $R_{m,k,t}$ is the daily logarithmic excess stock market returns from the broad stock market index m for country k; and the term $\varepsilon_{i,k,t}$ is a bank-specific residual. To ensure comparability, we use the broad stock market index for each country available from Datastream. For each bank i, we calculate the systematic component $\beta_{i,k,t}$ by running separate regressions on daily data for every quarter q from 2007Q4 to 2009Q4. We then calculate the average beta for each individual bank during the crisis period. Because it has been constructed with data from an extreme event as the recent financial crisis, this measure captures the dependence of banks on the market in tail periods. Hence, in a cross-sectional analysis, we are able to detect which banks are relatively more exposed to tail risks.[14]

iii. Central bank liquidity demand *(bid)* – Our third measure of bank risk is based on information on liquidity provided to banks by the Eurosystem (i.e European System of Central Banks, see ECB, 2011). It is constructed as the overall liquidity position of each institution with the Eurosystem and encompasses two main types of liquidity provision: weekly main refinancing operations and longer-term refinancing operations, with a maturity ranging from one month to one year. This

[13] We calculate excess returns as the difference between stock market returns and the 10-year government bond yield for the country concerned.
[14] Acharya et al. (2011), Brownlees and Engle (2010) and Adrian and Brunnermeier (2008) propose more sophisticated although conceptually similar alternative measures of systemic risk based on stock market information.

overall liquidity exposure is divided by total assets in order to make the amounts comparable across institutions.[15] Unlike the two previous measures, this variable also accounts for liquidity risk, covering another aspect of bank risk that is, in principle, transitory in nature, but which might signal future banking problems.

III.B Bank business models

We match information on average bank risk during the period of the crisis with data for bank characteristics from the pre-crisis period (2003Q4 to 2007Q3). We start with the approximation of business models using a dataset of consolidated quarterly financial statements obtained from Bloomberg. We then select and group the regressors according to different bank business models, following the insights gleaned from the literature on bank risk discussed previously (in Section II). Our aim is to discover whether certain business models operating in the pre-crisis period could be linked to the emergence of greater risk during the crisis. Consequently we separate our regressors into four main groups, accounting for: the bank capital structure (i), asset structure (ii), funding structure (iii), and income structure (iv).

i. Capital structure – We approximate bank capital by using a ratio of Tier I capital to total assets *(eta)*. We aim to capture high-quality (i.e. core) equity, such as Tier I capital, which is expected to be more effective in safeguarding a bank's financial viability (Demirguc-Kunt et al., 2011). As already discussed, the impact of capital on the bank's risk is ambiguous. It might be negatively related to the probability of distress if it serves as an ex-ante buffer against potential losses. It could also be positively related to bank distress if it is driven by regulatory or

[15] We restrict our results to the period of full allotment of liquidity provision by the European Central Bank (starting in October 2008) to avoid any distortions arising from changes in the central bank operational framework. We include only information on listed banking groups for which consolidated financial statements are available via Bloomberg. This limits the size of our sample to just 83 banking groups but these cover, nonetheless, more than 90% of the average liquidity provided by the Eurosystem.

market actions imposing stricter requirements on riskier banks. In line with Calem and Rob (1998), Perotti et al. (2011) and the proposals made by the Basel Committee on Banking Supervision (2010), our measure of capital interacts with a dummy indicator (*eta_reg*) for banks with low capital ratios (below 6%) to account for the possible non-linear effect that bank capital may have on bank risk

ii. Asset structure – The first variable characterizing the asset structure is size *(size)*, measured as the average logarithm of total assets of the consolidated institution before the crisis. It allows us to capture the effects of diversification and other economies of scope (such as access to markets) related to reduced levels of risk for larger banks. Alternatively, larger banks may be more prone to concerns about being "too big to fail", or be too complex to manage. They may also suffer more severely from the effects of greater inefficiencies in their internal capital markets and thus become riskier (Stein, 1997).

A second variable capturing a different aspect of the asset structure is the ratio of loans to total assets *(loan_ta)*. This provides a summary indication of the extent to which a bank is involved in traditional lending activities.

The amount of securitization activity *(abs)* represents another important aspect of how banks manage their asset structure. However, the impact of securitization on bank risk is uncertain. Securitization may fulfil a funding function and allow banks to remove credit risk from their balance sheets and pass it on to investors. Alternatively, it might lead banks to take on additional risk with the new funds generated or to simply lower their overall credit standards. Dealogic, an independent data provider, is the source of information on securitization activity. This data has been matched with balance sheet information made public by individual banks and then used to calculate the

private securitization originated per quarter by each individual bank as a proportion of total bank assets during the same period.[16]

iii. Funding structure – The third group of regressors is concerned with the structure of on-balance sheet funding. It accounts for reliance on short-term wholesale funding, measured as the ratio of short-term marketable securities to total assets *(mkt_assets)*, which might make banks more exposed to funding liquidity shocks. We also include the ratio of retail customer deposits to total assets *(dep)*, as this represents an important component of the liabilities of traditional commercial banks. In light of the ubiquitous government deposit guarantees in place, we expect retail deposits to be a more stable source of funding than wholesale markets. Thus banks with a broader deposit base should be more resilient in periods of crisis.

iv. Income structure – It captures the two major income drivers of strategic importance to financial institutions. First, an aggressive lending strategy has traditionally been associated with a concentration of risk linked to looser credit standards (Dell'Ariccia and Marquez, 2006; Tornell and Westermann, 2002). This is measured as a bank's average quarterly loan growth minus the national average *(exlend)*. Second, we capture the degree of income diversification and the extent to which a bank has moved towards more volatile non-interest income by calculating their value as a percentage of total revenue *(niinc)*.[17]

[16] We look at individual deal-by-deal issuance patterns in the private securitization market. The advantage of using data on securitization activity from Dealogic is that the name of the originator, date of issuance and deal proceeds are registered. The sample includes public offerings of funded asset-backed securities (ABSs) as well as issues of cash flow (balance-sheet) collateralized debt obligations (CDOs). In other words, the securities included in the sample involve a transfer of funding from market investors to originators so that pure synthetic structures (such as synthetic CDOs which transfer credit risk only) and public securitization are not included.

[17] See Stirohl (2010, 2004).

III.C Ex-post measures of managerial abilities

The run-up to the crisis coincided with an unprecedented increase in the stock market valuation of bank shares. Essentially, stock market value creation can be associated with managerial ability or the build-up of latent risk. In other words, the banks' creation of high market-to-book values ex-ante (i.e. in the pre-crisis period) could have been due to genuine managerial ability ("true" *alpha*) or to the accumulation of hidden risks, generating high returns in the short-term but making institutions prone to catastrophic losses in the case of an exceptional event (high "fake" *alpha* or "hidden" *beta*). Yet, as Rajan (2005) has indicated, in most cases it is difficult to measure in real time (i.e. ex-ante) managerial ability to generate "true" *alpha*.[18] This was particularly true in the period prior to the crisis as the profuse use of innovative financial instruments and banking expansion led to the emergence of new banking models, in which managers had stronger incentives to reap short-term returns (Acharya et al., 2010). According to Rajan (2005), "true" *alpha* can only be measured in the long-run and with the benefit of hindsight. Thus the realisation of risk during the financial crisis enables us, with hindsight, to distinguish between value creation due to "true" *alpha* and that merely due to the generation of tail risk.

We separate the "true" *alpha* from the "hidden" *beta*, by combining ex-ante information on banks' market-to-book values with data on their ex-post realization of risk. We hypothesize that those banks which created high levels of market-to-book value in the pre-crisis period (i.e. ex-ante) and achieved relatively low levels of risk during the crisis (i.e. ex-post) were more likely led by more able managers. On the other hand, the combination of a high ex-ante market-to-book

[18] A vivid example here is provided by the Anglo Irish bank. This bank, which defaulted after receiving large amounts of government funding assistance, was previously ranked the world's top performing bank (for the period 2001 to 2005) by Mercer Oliver Wyman, a consultancy specialising in financial services strategy and risk management. For further details, see "Anglo Irish Bank is world's top performer" (www.independent.ie), 27 January 2006.

value and high ex-post risk serves to identify those banks where value creation in the run up to the crisis was mostly driven by a build-up of latent risk. Figure 2 illustrates our reasoning.

We identify four types of banks in accordance with our main hypotheses. A bank will exhibit high "real" *alpha* if it showed a higher than average ex-ante market-to-book ratio as well as low levels of risk during the crisis – our "good management" hypothesis. On the other hand, the "fake" *alpha* hypothesis applies to those banks that were also creating higher than average market-to-book values ex-ante but which eventually encountered a high level of risk during the crisis.

{Insert Figure 2}

More precisely, we construct a dummy variable ($high\_risk_i^{ex\text{-}post}$) which takes a value of one for those banks that experienced the highest level of risk during the crisis. These banks are identified by looking at the upper quartile of the cross-sectional distribution of the average one-year ahead expected default frequencies *(edf)*[19] for the crisis period. The *edf* value, expressed as a percentage, is calculated by combining the financial statements released by banks with stock market information and material from Moody's proprietary default database. The source of the expected default frequency series is Moody's KMV.

[19] The "expected default frequency" is a forward-looking indicator of credit risk computed by Moody's KMV based on financial markets data plus information from company balance sheets and Moody's proprietary Bankruptcy Database. Here, we employ a different measure of bank risk that has not already been incorporated into our analysis as a proxy for bank risk. The use of the edf seems appropriate: although this may have underestimated risk in the pre-crisis period, it was a relatively good predictor of default during the recent credit crisis (see, for instance, Munves et al., 2009 and Dwyer and Qu, 2007).

We also construct a second dummy variable ($low\_risk_i^{ex\text{-}post}$), identifying those banks belonging to the lower quartile of the same cross-sectional distribution. We then construct our measures of alpha *(Alpha_edf)* and beta *(Beta_edf)*:

$$Alpha\_edf_i \equiv T_i^* \cdot low\_risk_i^{ex-post} \cdot I(T_i^* > 0) + T_i^* \cdot high\_risk_i^{ex-post} \cdot I(T_i^* < 0)$$
$$\beta eta\_edf_i \equiv T_i^* \cdot high\_risk_i^{ex-post} \cdot I(T_i^* > 0) + T_i^* \cdot low\_risk_i^{ex-post} \cdot I(T_i^* < 0)$$

(3)

Here T_i^* is the demeaned market-to-book value of bank *i* in the pre-crisis period (2003Q4 to 2007Q3) and *I* is an indicator function:

$$I(T_i^* > 0) \equiv \begin{cases} 1 & \text{if } T_i^* > 0 \\ 0 & \text{if } T_i^* \leq 0 \end{cases}$$

(4)

III.D Additional controls

In our empirical analysis, we also include a number of additional controls. The first accounts for bank profitability *(roa)*, calculated as the quarterly return on assets (i.e. the ratio of net income to total assets). This control tests whether those banks attaining higher levels of actual (i.e. accounting) profits prior to the crisis were also those accumulating hidden risks that only materialized during the crisis.

Some of our specifications incorporate a group of macroeconomic controls, encompassing variables that have been found to be related to the likelihood of a

banking crisis in developed countries (Reinhart and Rogoff, 2009). These include changes in real housing prices *(hp)*, based on the country series constructed by the Bank for International Settlements (see Borio and Drehmann, 2009), and also changes in the broad stock market indices for non-financial corporations *(sm)*, as calculated by Datastream. Both of these asset price indices are demeaned from their long-term historical averages to capture abnormal changes in borrowers' collateral values.

We account for the impact on bank risk of potential corporate governance problems arising from the bank ownership structure (Laeven and Levine, 2009, Erkens, Hung and Matos, 2009) with a Herfindahl index of ownership concentration, calculated as the sum of the squared values of the percentage of equity held by each individual shareholder. The corporate governance variable *(cgov)* is calculated by combining information on the ownership of each individual bank obtained from Thomson Reuters and Bankscope-Bureau van Dijk, two private data providers. According to earlier literature, the precise impact of a concentration in ownership on bank risk remains unclear.

Following Barth et al. (2004), the model includes a variable that accounts for the intensity of bank supervision and regulation in a given country during the pre-crisis period *(regu)*.[20] In particular, we focus on regulations that inhibit a bank's ability to engage in securities underwriting, brokering and dealing (see Barth et al., 2004). For the countries analyzed in this study, our regulation index takes a value between 5 and 12, with the latter figure indicating a more deregulated banking market.

We also construct a competition variable *(comp)* from the responses of bank credit officers to the European Central Bank (ECB) Bank Lending Survey

[20] The last survey by the World Bank includes data for 2007.

for Euro area banks and to the Senior Loan Officer Opinion Survey for United States banks. Data from these surveys is used to capture the effect of competition on the credit conditions for all borrowers in a net percentage index.[21] This index represents the difference between the number of banks that reported a tightening in credit conditions due to competition and the number that reported an easing. Negative index values would imply that increased competition led to lower credit standards. We would expect a negative sign for this variable, indicating that lower credit standards prompted by market competition resulted in more bank risk-taking.

IV. Results

This section discusses the empirical findings of our analysis. We first present the results from probit and linear regression models applied to our three measures of risk. Thereafter, we look at the robustness of the results. Finally, we discuss the insights that can be derived from regression quantile estimates applied to systematic risk. To facilitate a comparison of our results, we use identical specifications throughout the models.

IV.A Probit and linear regressions

Column I of Tables III-V provides the estimates of the baseline specification for the three different measures of risk. Columns II to V include additional firm-specific characteristics (such as low capital and profitability) and specifications including country-specific macroeconomic control variables. Columns VI to VIII add the variables accounting for firm managerial performance, economic growth, and asset prices. Table V, based on central bank liquidity demand, does not

[21] We harmonised both surveys in a linear manner (see Maddaloni and Peydrò, 2011).

include all the controls because of the low number of observations for the dependent variable.

The results across the three tables are remarkably consistent, suggesting that they do not depend on a specific definition of bank risk:

i. Capital structure – A higher level of Tier I capital ex-ante generally decreases the likelihood of bank distress during the crisis. This result holds for all three definitions of bank risk, albeit being weaker for systematic risk. It also confirms the earlier results of Beltratti and Stulz (2011) on bank performance during the crisis, and strengthens and extends them as regards bank risk (Mehran and Thakor, 2011). In addition, capital is even more important for undercapitalised banks, as indicated by the negative and highly statistically significant coefficients. This non-linear relationship between capital and risk is in line with Calem and Rob (1998), Perotti et al. (2011) and the proposals made by the Basel Committee on Banking Supervision in 2010 (BIS, 2010).

ii. Asset structure – In terms of the asset structure, both bank size and the ratio of loans to total assets are positively related to our measures of bank risk, while securitization is negatively related. The results regarding size are consistent with the view that large banks were significantly riskier during the recent crisis. Large banks might have also probably been more often considered as "too big to fail", and thus deemed more likely to be rescued (Huang, et al., 2011; Demirgüc-Kunt and Huizinga, 2010; Tarashev et al., 2009).

The apparently contradictory negative sign for size in Table V is explained by the fact that the dependent variable is in this case constructed as the ratio of central bank liquidity demand scaled by the size of the financial institution. Since

size appears in the denominator of the dependent variable, higher size is mechanically associated with lower liquidity/size ratio.

The positive coefficient on loans to total assets disappears or becomes less significant when controlling for macroeconomic variables. Loans are likely correlated with broad macroeconomic variables such as house price developments, which blur their cross-sectional differences. In addition, bank exposure to their loan book is heavily influenced by national factors.

The negative sign for securitization is robust to alternative specifications in Tables III-V, suggesting that banks, as originators, use traditional securitization to off-load riskier loans from their balance sheets rather than as an instrument for taking on more risk. This is line with findings by Knaup and Wagner (2009) on the determinants of tail risks for US banks.

{Insert Tables III to V}

iii. Funding structure – Relying on a more solid funding structure reduces bank risk during times of crisis. The finding for deposits funding is robust across different specifications and also across alternative definitions of the dependent variable. In line with the previous discussion, customer deposits provide funding stability to banks and reduce the probability of a bank rescue. In contrast, the use of short-term marketable securities increases the probability of distress, which is in line with results from the pre-crisis period, based on risk measures derived from accounting information (Demirgüc-Kunt and Huizinga, 2010). In appears that those institutions more reliant on market funding are clearly more exposed

to liquidity risk during the crisis, as it becomes problematic to roll over short-term debt to finance illiquid assets.

iv. Income – On the income side, excessive loan growth enters with a strongly significant positive coefficient. An aggressive expansion in loan growth in the run-up to the crisis is generally associated with a relaxation of credit standards and a deterioration in the quality of the asset side of the balance sheet. The economic significance of this variable, plus its consistency, emphasises the similarity of the recent crisis with earlier episodes of financial turmoil (Tornell and Westermann, 2002). This raises the question of why remedial measures (such as anti-cyclical loan loss provisions) were not implemented at the supervisory level to smooth the credit cycle. It also informs the regulatory debate going forward (Reinhart and Rogoff, 2009). Non-interest income, however, reduces the likelihood of distress during the crisis, vouching for the validity of income diversification to mitigate bank risk (Stiroh, 2010).

v. Managerial performance – The financial crisis offers a unique opportunity to distinguish those banks that were relatively well-managed and created real value for their shareholders from those accumulating excessive risks on their balance sheets. The latter are essentially those institutions which attained high levels of stock market value in the pre-crisis period with little understanding of (or concerns for) the potential for systematic risk. The increased complexity and greater international scope of the banking business in the years preceding the crisis made it more difficult for investors to separate financial institutions generating high alpha from those with just a high but "hidden" *beta*. The importance of disentangling "true" *alpha* from "hidden" *beta* is confirmed by the regression results for columns VI in Table IV. Indeed, our proxies for *alpha* and *beta* are significant and economically intuitive: banks characterized by high alpha

experience significantly lower distress during the crisis, while those leveraging their books by increasing their *beta* exhibit, ex-post, significantly higher systematic risk. It is also telling that these measures increase the overall fit of the regression by more than 5 percentage points, suggesting that controlling for ex-ante bank business models still leaves a significant portion of risk unaccounted for. Our proxies for *alpha* and *beta* are constructed using ex-post data for the crisis and, therefore, are not useful for regulators who need to judge the performance of bank management in real time. Nonetheless, they do suggest that a prompt increase in the intensity of supervision for those banks experiencing a large expansion in their stock market valuation is warranted.

IV.B Robustness

Table VI shows the results of our empirical specifications after controlling for an additional group of variables accounting for corporate governance at the individual bank level, bank competition and deregulation at the national level, since all these factors have been found to impact on bank risk-taking.

Our results suggest that while these control factors do indeed appear to have an effect on bank risk, most of our earlier results still stand. The impact of market funding on banking and on revenue diversification, however, becomes more blurred, and the role of managerial performance strengthens significantly. Nevertheless, the findings for all the other business characteristics remain strong in terms of their impact on bank risk.

The increase in banking competition experienced in the pre-crisis period is associated with higher bank risk-taking, suggesting that the decline in credit standards associated with more intensive bank competition (i.e. negative values) has an impact on bank risk-taking (see Hellman et al., 2000). A more

concentrated ownership structure (i.e. a higher Herfindahl index) is found to be related to lower levels of risk. It would appear that those banks whose ownership is more diversified have a stronger incentive to increase risk while the effect of regulation remains erratic and seems to depend on the specification concerned.

{Insert Table VI}

IV.C Regression quantiles: a more nuanced consideration of the determinants of bank distress during a crisis

In the previous section we described how the risk encountered by the average bank during the crisis is related to variables linked to the underlying business model. From a financial stability perspective, it would be particularly interesting to discover whether bank business models themselves have a differentiated impact in terms of the levels of risk experienced. More precisely, we would like to know whether capital, asset, funding or income structures are of equal importance in determining the level of distress of banks with a high and low degree of risk.

By construction, probit and linear regression models give only a measure of the central tendency of the relationship between dependent and independent variables. This assumes that covariates affect only the location of the conditional distribution of y. Heteroskedasticity models can be used to estimate the dependence of y on x, but the impact on other aspects of the shape of the conditional distribution are assumed to be unchanged. Still, covariates can affect the conditional distribution in other ways, for instance, by stretching one tail but

not the other. To give a concrete example, in the previous section we found that size is generally associated with an increase in bank distress during the crisis. But does this result necessarily hold for all banks (as the ordinary least squares, OLS, estimates would suggest) or does size disproportionately increase risk for riskier banks relative to the less risky ones? We can obtain a more complete picture of the distributional dependence between the bank business model and bank risk by estimating quantile regressions.

Regression quantiles were first introduced to applied economics by Koenker and Bassett (1978) and have been widely used ever since (for an introductory survey, see Koenker and Hallock, 2001). Our regression quantile estimates are obtained by minimizing the following objective function:

$$\min_{\beta} \sum_{i=1}^{N} \rho_{\tau}(r_i - X_i \beta_{\tau})$$

(5)

Here N is the number of observations, $r_t(/)^{o} /(t - I(/ < 0))$, I is the indicator function whereby I equals one if the expression in parenthesis is true and zero if otherwise, and $t \hat{I} (0,1)$ is the probability associated with the quantile. To facilitate a comparison with the results discussed in the previous sub-section, we use the same empirical specification of the earlier models, that is:

$$X_i\beta_\tau = \beta_{\tau,0} + \underbrace{\beta_{\tau,1}eta_i + \beta_{\tau,2}eta\_reg_{i,b} * k_{i,b}}_{\text{Capital structure}} + \underbrace{\beta_{\tau,3}size_{i,b} + \beta_{\tau,4}loan\_ta_{i,b} + \beta_{\tau,5}abs_{i,b}}_{\text{Assets structure}} +$$

$$+ \underbrace{\beta_{\tau,6}mkt\_assets_{i,b} + \beta_{\tau,7}stdeb_{i,b}}_{\text{Funding structure}} + \underbrace{\beta_{\tau,8}niinco_{i,b} +, \beta_{\tau,9}exlend_i}_{\text{Income}}$$

(6)

Figures 3 and 4 illustrate the usefulness of the quantile regression approach. Figure 3 presents the scatter plot of size and the ex-post measure of risk for all the banks in our sample. Superimposed on this chart are the regression line (the dark line), as well as the 25% and 75% quantile regression lines (the upper and lower continuous lines). The scatter plot clearly reveals that the dispersion of risk increases considerably with the size of the bank and that size has a different impact on the upper and lower quantiles (compared with the mean), as illustrated by the different slopes of the lines.

Figure 4 provides a summary illustration of the impact of size on bank risk for each percentile. The solid line represents the 99 estimates of the quantile regression coefficient ($b_{t,3}$) for t, ranging from 0.01 to 0.99, together with the 95% confidence intervals. Superimposed on the diagram is a dashed line representing the OLS estimate, again together with a 95% confidence interval. Note that, for up to around the 15% quantile, the quantile regression estimate lies outside the mean regression confidence interval, indicating that the mean is not a sufficient statistic to summarize the relationship between the distribution

of the bank risk and size. The chart confirms the key finding discussed in the previous sub-section, namely that size is indeed associated with higher levels of risk during the crisis. However, the Figure also shows that size has a lower impact on the left side of the conditional distribution of bank risk (i.e. the side where the relatively less risky banks are to be found) than on the right side (where the relatively riskier banks are located).

{Insert Figures 3 and 4}

The estimates of the full model for the 10%, 25%, 50%, 75% and 90% quantiles are presented in Table VII. Again, we distinguish between four types of business models, as identified by: (i) capital, (ii) asset, (iii) funding, and (iv) income structures. The last column in the table reports the results of the equality test that the slope coefficients of the regression quantiles are all the same. Unsurprisingly, and quite reassuringly, the signs of the regression quantile coefficients are coherent with the OLS results. However, for variables related to the asset and funding structure, we notice that the test results reported in the last column of the table reject the null hypothesis that all regression quantile coefficients are equal.[22]

In the asset structure, the ratio of loans to total assets is not significant in the lower part of the conditional distribution of bank distress, but statistically significant for the upper quantiles, i.e. for the group of (conditionally) most

[22] The test for the size variable does not reject the null hypothesis that the coefficient of size is equal across all the quantile specifications. Unlike in the example shown in Figure 3 – where size enters the quantile regression by itself and the estimated coefficient is different in the upper and lower parts of the distribution – when controlling for other variables, size appears to affect all quantiles in the same way.

distressed banks. This suggests that loans to total assets contribute to an increase in distress for the riskiest institutions (in the higher quantiles), but have no effect on less risky ones. Opposite results hold for securitization: greater amounts of securitization decrease the level of distress of the riskiest banks, but are irrelevant for less risky ones.

The bank funding structure affects bank risk across the entire conditional distribution. However, the results show that reliance on short-term funding is relatively more significant for the distress experienced by the riskiest banks than that of less risky ones. Similarly, a solid deposit base is disproportionately more significant for lowering the distress of banks in the upper part of the conditional distribution of the dependent variable than for those in the lower part. Finally, excessive loan growth increases the risk of distress during the crisis disproportionately for the riskiest banks.

{Insert Table VII}

V. Conclusion

One of the main reasons for the existence of banks is that they are better at evaluating and managing risks than other institutions. In the recent financial crisis, however, banks suffered losses on a scale not witnessed since the Great Depression. It is precisely this special "risk evaluator" role that makes the banking industry particularly opaque.

The opacity of the sector has probably increased in recent years due to the structural changes brought about by deregulation and financial innovation; changes that have made the industry significantly more complex, larger, more global and dependent on financial markets. We take advantage of the opportunity

provided by the crisis to analyze whether the differences in bank business models can be related to the bank risk that materialized during the period of crisis.

Using several measures of ex-post bank risk, we show that the distress experienced during the financial crisis was driven ex-ante by bank size, undercapitalization, and the degree of credit expansion in the years preceding it. The bank funding structure also seems to be of significance, with those banks relying on a large deposit base suffering less than those more dependent on market funding. In addition, by implementing quantile regression techniques, we show that the impact of business model characteristics is non-linear, as it changes according to the level of bank risk encountered: for the group of "riskier" institutions, bank distress is relatively more sensitive to loan expansion and customer deposits. We also find that stock market value creation in the run-up to the crisis often involved the accumulation of systematic risks, which cannot entirely be accounted for by ex-ante business models.

Our results support the prudential regulatory initiatives via Basel III, aimed at raising the core capital levels of institutions, in particular of undercapitalized ones. They also concur with efforts directed at reducing the cyclicality of credit provided by banks and increasing the capital charges for those institutions relying more strongly on short-term market funding. Given its quantitative importance, a careful assessment of the implementation of the anti-cyclical capital buffers proposed by Basel III is warranted. For instance, we show that agressive loan growth seems to be a very good leading indicator of bank risk, so that capital charges linked to this variable might be considered.

Although Basel III has not incorporated this issue explicitly, our findings also suggest that regulators would need to intensify supervisory interference significantly. Namely, the importance of business models, and divergence in the

realization of risk across institutions during the crisis, would imply that a better supervisory understanding of bank incentives in real time (i.e. before they materialize) is warranted. In particular, our results call for supervisors to enhance their knowledge of the impact of different business models on bank risk. Finally, our findings recommend a better understanding of the risk-taking incentives, in particular by those banks experiencing rapid increases in their stock market valuations.

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Table I
Data Sources and Variables Definitions

This table presents the names of all the variables employed in our empirical analysis (preliminary and final). It also includes the data sources as well as a brief description of how the variables have been constructed. More detailed information, plus all publicly available data, is available upon request.

Variables	Symbol	Source	Description
Panel A: Bank risk			
Financial support	*resc*	European Commission, central banks, Bank for International Settlements, governmental institutions and Bloomberg.	Binary variable – with a value of 1 if public financial support was received during the crisis period (2007Q4 to 2009Q4) and 0, if otherwise
Systematic risk	*risk*	Authors' calculation and Datastream	Average of the quarterly non-overlapping beta in a capital asset pricing model calculated for each bank using daily stock market data during the crisis period (2007Q4 to 2009Q4)
Expected default frequency	*edf*	Moody's KMV	Probability of a bank defaulting within a year during the crisis period (2007Q4 to 2009Q4) calculated by Moodys KMV
Central bank liquidity	*bid*	European Central Bank	Ratio of total liquidity received from the Eurosystem to total assets * 100 during the crisis-period (2007Q4 to 2009Q4)
Panel B: Other variables			
Capital structure			
Tier I capital	*eta*	Bloomberg	Tier I capital to total assets * 100 during the pre-crisis period (2003Q4 to 2007Q3)
Undercapitalised	*etareg*	Authors' calculation	Low capital dummy variable (1 indicates a bank with a Tier I ratio below 6%) for the pre-crisis period (2003Q4 to 2007Q3)
Asset structure and securitization			
Size	*size*	Bloomberg	Logarithm of total assets (USD millions) during the pre-crisis period (2003Q4 to 2007Q3)
Loans to total assets	*loanta*	Bloomberg	Total loans to total assets * 100 during the pre-crisis period (2003Q4 to 2007Q3)
Securitization	*abs*	DCM Analytics Dealogic	Ratio of total securitization to total assets * 100 during the pre-crisis period (2003Q4 to 2007Q3)
Funding structure			
Short-term market funding	*mktassets*	Bloomberg	Short-term marketable securities (i.e. less than 2 years) to total assets * 100 during the pre-crisis period (2003Q4 to 2007Q3)
Deposit funding	*dep*	Bloomberg	Customer deposits to total assets * 100 during the pre-crisis period (2003Q4 to 2007Q3)
Loan growth and income			
Excessive loan growth	*exclend*	Authors' calculation	Individual bank lending growth minus the average loan growth of all banks over a specific quarter during the pre-crisis period (2003Q4 to 2007Q3)
Non-interest income	*niinc*	Bloomberg	Non-interest income to total revenues * 100 during the pre-crisis period (2003Q4 to 2007Q3)
Managerial performance			
Market-to-book	T^*	Bloomberg	Market-to-book value of equity demeaned during the pre-crisis period (2003Q4 to 2007Q3)
High_risk ex post	$high\_risk^{ex\text{-}post}$	Authors' calculation	Dummy variable - with a value of 1 if a bank is positioned at the upper quartile (i.e. with the riskier banks) of the bank average expected default frequencies during the crisis period (2007Q4 to 2009Q4)
Low_risk ex post	$low\_risk^{ex\text{-}post}$	Authors' calculation	Dummy variable – with a value of 1 if a bank is positioned in the lower quartile (i.e. with the relatively safe banks) of the cross-sectional distribution of bank average expected default frequencies during the crisis period (2007Q4 to 2009Q4)
Alpha_edf	*alpha_edf*	Authors' calculation	See Section 4. Calculated as the average market-to-book value during the pre-crisis period (2003Q4 to 2007Q3) of those banks among the group of relatively safe institutions (in the lowest quartile) in the crisis period (2007Q4 to 2009Q4) based on their 1-year ahead expected default frequencies at this time
Beta_edf	*beta_edf*	Authors' calculation	See Section 4. Calculated as the average market-to-book value during the pre-crisis period (2003Q4 to 2007Q3) of those banks among the group of riskier institutions (in the highest quartile) in the crisis period (2007Q4 to 2009Q4) based on their 1-year ahead expected default frequencies at this time
Control variables			
Profitability	*roa*	Bloomberg	Ratio of net income to total assets * 100 during the pre-crisis period (2003Q4 to 2007Q3)
GDP growth	*gdp*	Bank for International Settlements	Quarterly changes in real GDP during the pre-crisis period (2003Q4 to 2007Q3)
House prices	*hp*	Bank for International Settlements	Quarterly changes in real housing prices during the pre-crisis period (2003Q4 to 2007Q3) demeaned from their long-term historical averages (prior 20 years)
Stock market	*sm*	Datastream	Quarterly changes on the broadbroad stock market indices for non-financial corporations calculated by Datastream during the pre-crisis period (2003Q4 to 2007Q3) de-meaned from their long-term historical averages (prior 20 years)
Corporate governance	*cgov*	Authors' calculation - Thomson Reuters	Summing of the squared percentage of shares controlled by each shareholder
Regulation	*regu*	World Bank	Barth, Caprio and Levine (2004). Based on surveys (for 2000, 2003 and 2008) sent to national bank regulatory and supervisory authorities - we focus on regulations that inhibit a bank's ability to engage in securities underwriting, brokering and all aspects of the mutual fund industry, and calculate average values for all these categories
Competition	*comp*	Federal Reserve Board, Eurosystem and Sveriges Riksbank	Obtained from the answers to bank lending surveys submitted by credit officers who report on whether credit standards have been affected by a perceived increase in competition and, thus, loosened (i.e. a negative impact). The results of these surveys provide national averages for each quarter. Our analysis is based on average changes for the pre-crisis period (2003Q4 to 2007Q3)

Table II
Summary Statistics

This table presents the summary statistics of the variables used in our paper (see Section III and Table I for further details). Unless stated otherwise, descriptive statistics are derived from the average values calculated on the basis of quarterly data for the pre-crisis or the crisis period. Variables accounting for bank risk are calculated from the average values for each bank during the crisis period (2007Q4 to 2009Q4) except for the variable accounting for central bank liquidity. This is constructed as the average of just the period of full allotment of liquidity provision by the European Central Bank (from 2008Q4 to 2009Q4) to avoid any distortions arising from changes in the operational framework. The variables accounting for capital structure, asset structure and securitization, funding structure, loan growth and income, profitability and corporate governance are calculated from the averages of quarterly data for individual banks for the pre-crisis period (2003Q4 to 2007Q3). GDP growth, house prices, the stock market and competition are calculated from the country averages for quarterly data for the pre-crisis period already mentioned. The regulation variable is calculated from the average values for each country derived from the latest available surveys (i.e. for 2000, 2003 and 2008). The *Alpha_edf* and *Beta_edf* variables related to managerial performance are calculated from the averages for individual banks for the pre-crisis and crisis periods.

Variables	N	Average	Median	Standard Deviation	Minimum	Maximum
Panel A: Bank risk						
Financial support	1,138	0.2	0.0	0.4	0.0	1.0
Systematic risk	510	0.7	0.5	0.6	-0.3	2.3
Expected default frequency	614	1.0	0.3	2.3	0.0	27.8
Central bank liquidity	83	3.4	1.2	6.3	0.0	46.9
Panel B: Other variables						
Capital structures						
Tier I capital	1,088	10.1	9.0	5.4	1.4	49.6
Undercapitalised	1,088	0.5	0.0	1.4	0.0	6.0
Asset structure and securitization						
Size	1,115	6.9	6.4	2.2	-1.8	14.0
Loans to total assets	1,081	64.3	68.1	17.5	0.0	97.6
Securitization	1,138	0.1	0.0	0.8	0.0	19.7
Funding structure						
Short-term market funding	1,112	19.4	16.7	14.1	1.0	90.0
Deposit funding	1,076	8.9	5.0	11.0	0.0	70.0
Loan growth and Income						
Excessive loan growth	886	6.2	5.8	2.3	-2.1	13.3
Non-interest income	1,057	17.9	15.2	12.1	0.2	78.7
Managerial performance						
Market-to-book	1,070	1.2	1.1	0.3	0.1	4.0
High_risk ex post	614	0.2	0.0	0.4	0.0	1.0
Low_risk ex post	614	0.3	0.0	0.4	0.0	1.0
Alpha_edf	595	0.0	0.0	0.1	-0.4	2.1
Beta_edf	595	0.0	0.0	0.1	-0.4	1.2
Control variables						
Profitability	1,106	1.0	0.9	1.0	-6.2	10.0
GDP growth	1,138	1.3	1.3	0.2	0.6	2.1
House prices	1,138	1.2	1.3	0.6	-1.6	2.4
Stock market	1,138	1.5	1.4	0.6	-0.2	5.6
Regulation	1,138	10.5	11.2	1.6	5.0	11.2
Competition	1,138	-59.3	-70.9	23.4	-70.9	1.1
Corporate Governance	791	6.8	1.7	13.4	0.0	100.0

Table III

Effects of bank business models on bank risk: probit estimates for the probability of receiving public financial support

This table presents the effects of bank business models and other variables on bank risk using our main specification (see Section III for further details and Table I for variable definitions). It provides the probit estimates for the probability of a bank receiving financial support from the government (*resc)*. This variable is constructed on the basis of information collected on the public rescue of banks via capital injections, the issuance of guaranteed bonds or other government-sponsored programmes. The variables accounting for bank risk (in this case, *resc)* are calculated for the crisis period (2007Q3 to 2009Q4). Variables accounting for bank capital structure, asset structure and securitization, funding structure, loan growth and income, and profitability are calculated from the averages of quarterly data for individual banks for the pre-crisis period (2003Q4 to 2007Q4). GDP growth, house prices, the stock market and competition are calculated from the country averages of quarterly data for the pre-crisis period already mentioned. The *Alpha_edf* and *Beta_edf* variables accounting for managerial performance are calculated from the averages for individual banks for the pre-crisis and crisis periods. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels respectively.

		(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Capital structure	Tier I capital	-0.0448 ***	-0.0699 ***	-0.0743 ***	-0.0781 ***	-0.0891 ***	-0.0896 ***	-0.0925 ***	-0.1021 ***
		(0.008)	(0.006)	(0.004)	(0.030)	(0.003)	(0.002)	(0.004)	(0.017)
	Undercapitalized		-0.1401 ***	-0.1329 ***	-0.1354 ***	-0.0691 ***	-0.1576 ***	-0.1699 ***	-0.1006 ***
			(0.021)	(0.016)	(0.031)	(0.023)	(0.008)	(0.016)	(0.039)
Asset structure and securitization	Size	0.1144 ***	0.1382 ***	0.1337 ***	0.1309 **	0.1677 ***	0.0942 ***	0.0934 ***	0.1306 ***
		(0.007)	(0.003)	(0.002)	(0.061)	(0.003)	(0.017)	(0.016)	(0.011)
	Loans to total assets	0.0182 ***	0.0158 ***	0.0149 ***	0.0145 **	0.0115 ***	0.0073	0.0064 **	0.0043
		(0.003)	(0.004)	(0.005)	(0.006)	(0.002)	(0.005)	(0.003)	(0.011)
	Securitization	-0.0408 ***	-0.0348 ***	-0.0352 ***	-0.0584 ***	-0.0794 ***	-0.3904 ***	-0.4780 ***	-0.3784 ***
		(0.004)	(0.002)	(0.002)	(0.013)	(0.022)	(0.079)	(0.079)	(0.005)
Funding structure	Short-term market funding	0.0267 ***	0.0241 ***	0.0236 ***	0.0227 ***	0.0143 ***	0.0107 **	0.0103 ***	0.0046
		(0.004)	(0.004)	(0.005)	(0.008)	(0.001)	(0.005)	(0.003)	(0.004)
	Deposit funding	-0.0379 ***	-0.0347 ***	-0.0342 ***	-0.0327 ***	-0.0251 ***	-0.0381 ***	-0.0331 ***	-0.0237 ***
		(0.003)	(0.004)	(0.004)	(0.006)	(0.001)	(0.008)	(0.008)	(0.001)
Loan growth and income	Excessive loan growth	0.1330 ***	0.1302 ***	0.1281 ***	0.1324 **	0.1323 ***	0.1581 ***	0.1658 ***	0.1500 **
		(0.023)	(0.021)	(0.022)	(0.055)	(0.004)	(0.030)	(0.029)	(0.063)
	Non-interest income	-0.0108 ***	-0.0116 ***	-0.0124 ***	-0.0093 **	-0.0119 ***	-0.0071 ***	-0.0057 ***	-0.0064 *
		(0.002)	(0.001)	(0.001)	(0.004)	(0.003)	(0.002)	(0.001)	(0.004)
Managerial performance	Alpha_edf						-0.3630	-0.5593	-0.3874
							(0.603)	(0.814)	(0.629)
	Beta_edf						1.1741 ***	0.9601 ***	0.1307
							(0.066)	(0.012)	(0.250)
Control variables	Profitability			0.0957 *	0.0433	-0.0273	0.1541 *	0.0780	0.0209
				(0.058)	(0.214)	(0.048)	(0.080)	(0.064)	(0.080)
	GDP growth				0.8208 ***	1.0193 **		0.8623 ***	1.1356 ***
					(0.221)	(0.516)		(0.033)	(0.206)
	House prices					0.5140 *			0.3965 ***
						(0.267)			(0.081)
	Stock market					-0.3927 ***			-0.3951 ***
						(0.024)			(0.016)
	Intercept	-3.1363 ***	-2.8028 ***	-2.7321 ***	-3.7687 ***	-3.8629 ***	-1.7960 ***	-2.8625 ***	-3.0009 **
		(0.307)	(0.391)	(0.446)	(0.266)	(0.489)	(0.616)	(0.518)	(1.376)
	No. of observations	852	852	852	863	838	547	546	547
	Pseudo R2	0.0995	0.1113	0.1121	0.1195	0.1394	0.1283	0.138	0.1621
	Percent true positives/negatives	51.72/76.15	54.84/76.53	59.02/76.81	56.14/76.43	57.97/77.08	58.33/75.05	60.00/75.26	54.41/75.05
	Percent correctly classified	74.51	75.0	75.55	75.09	75.55	73.22	73.59	72.5
	Hosmer–Lemeshow test	7.05	4.44	1.44	6.21	7.46	12.39	5.74	9.69
	Hosmer–Lemeshow test p-value	0.5312	0.8155	0.9937	0.6233	0.4874	0.1347	0.6759	0.2874

Table IV
The effects of bank business models on bank risk: OLS estimates for systematic risk

This table presents the effects of bank business models and other variables on bank risk using our main specification (see Section III for further details and Table I for variable definitions). It provides the OLS estimates for bank distress, measured as individual bank systematic risk during the crisis period (*risk)*. This variable is calculated as the average of the non-overlapping quarterly beta in a capital asset pricing model calculated for each bank quarterly using daily stock market data for the crisis period (2007Q4 to 2009Q4). The variables accounting for bank capital structure, asset structure and securitization, funding structure, loan growth and income, and profitability are calculated from the averages of quarterly data for individual banks for the pre-crisis period (2003Q4 to 2007Q4). GDP growth, house prices, the stock market and competition are calculated from the country averages of quarterly data for the pre-crisis period already mentioned. The *Alpha_edf* and *Beta_edf* variables accounting for managerial performance are calculated from the averages for individual banks for the pre-crisis and crisis periods. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels respectively.

		(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Capital structure	Tier I capital	0.0040	-0.0097	-0.0233 ***	-0.0207 ***	-0.0160 **	-0.0156 ***	-0.0220 **	-0.0209 **
		(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.001)	(0.010)	(0.010)
	Undercapitalized		-0.0811 ***	-0.0733 ***	-0.0740 ***	-0.0487 ***	-0.0815 ***	-0.0875 ***	-0.0568 ***
			(0.017)	(0.017)	(0.017)	(0.018)	(0.008)	(0.019)	(0.020)
Asset structure and securitization	Size	0.1039 ***	0.1090 ***	0.1114 ***	0.1041 ***	0.1327 ***	0.1784 ***	0.1605 ***	0.1714 ***
		(0.031)	(0.032)	(0.033)	(0.036)	(0.036)	(0.020)	(0.032)	(0.035)
	Loans to total assets	0.0083 ***	0.0061 ***	0.0058 **	0.0053 **	0.0057 **	0.0033 ***	0.0001	-0.0009
		(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.000)	(0.004)	(0.004)
	Securitization	-0.2073 ***	-0.2076 ***	-0.1885 ***	-0.2055 ***	-0.1359 **	-0.1653 ***	-0.1687 ***	-0.0984 *
		(0.057)	(0.054)	(0.055)	(0.063)	(0.061)	(0.023)	(0.059)	(0.060)
Funding structure	Short-term market funding	0.0119 ***	0.0097 ***	0.0102 ***	0.0097 ***	0.0087 ***	0.0079 ***	0.0046	0.0023
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.000)	(0.004)	(0.004)
	Deposit funding	-0.0217 ***	-0.0201 ***	-0.0191 ***	-0.0179 ***	-0.0149 ***	-0.0195 ***	-0.0189 ***	-0.0153 ***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.003)	(0.003)
Loan growth and income	Excessive loan growth	0.1560 ***	0.1597 ***	0.1554 ***	0.1597 ***	0.1405 ***	0.1052 ***	0.1170 ***	0.1091 ***
		(0.026)	(0.027)	(0.028)	(0.030)	(0.028)	(0.009)	(0.029)	(0.028)
	Non-interest income	-0.0050 ***	-0.0043 **	-0.0064 ***	-0.0053 **	-0.0043 *	-0.0059 ***	-0.0051 **	-0.0042
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.000)	(0.003)	(0.003)
Managerial performance	Alpha_edf						-1.7663 ***	-2.2279 ***	-2.2953 ***
							(0.026)	(0.695)	(0.692)
	Beta_edf						0.7409 ***	0.5753	0.5553
							(0.007)	(0.414)	(0.364)
Control variables	Profitability			0.1824 ***	0.1705 ***	0.0978 **	0.1607 ***	0.2268 ***	0.1993 ***
				(0.049)	(0.049)	(0.048)	(0.003)	(0.058)	(0.061)
	GDP growth				0.2198 **	0.2770 ***		0.1724	0.2487 **
					(0.110)	(0.104)		(0.109)	(0.104)
	House price					0.1554 ***			0.1456 ***
						(0.040)			(0.043)
	Stock market					-0.1101 ***			-0.1236 ***
						(0.036)			(0.042)
	Intercept	-1.6053 ***	-1.3420 ***	-1.3931 ***	-1.6561 ***	-1.8555 ***	-1.4259 ***	-1.3668 ***	-1.4105 ***
		(0.252)	(0.257)	(0.276)	(0.300)	(0.331)	(0.118)	(0.354)	(0.390)
	No. of observations	483	483	483	483	486	364	358	358
	R2	0.4953	0.5172	0.532	0.5352	0.5548	0.584	0.5839	0.6043

Table V
The effects of bank business models on bank risk: OLS estimates for central bank liquidity

This table presents the effects of bank business models and other variables on bank risk using our main specification (see Section III for further details and Table I for variable definitions). It provides the OLS estimates for bank distress measured as the total liquidity received by each institution from the central bank (*bid)*. This variable is calculated as the ratio of the total liquidity received from the Eurosystem during the crisis-period (2007Q4 to 2009Q4) to total assets * 100. The variables accounting for bank capital structure, asset structure and securitization, funding structure, loan growth and income, and profitability are calculated from the averages of quarterly data for individual banks for the pre-crisis period (2003Q4 to 2007Q4). GDP growth, is calculated from the country averages of quarterly data for the pre-crisis period already mentioned. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels respectively.

		(I)	(II)	(III)	(IV)	(V)	(VI)
Capital structure	Tier I capital	-0.1771 ***	-0.1814 ***	-0.2978 ***	-0.3308 ***	-0.2718 **	-0.2423 ***
		(0.062)	(0.053)	(0.026)	(0.043)	(0.119)	(0.017)
	Undercapitalized		-0.0097	-0.0131	-0.1115 ***	0.0122	-0.2273 ***
			(0.020)	(0.016)	(0.005)	(0.179)	(0.038)
Asset structure and securitization	Size	-0.2985 ***	-0.2979 ***	-0.5000 ***	-0.5844 ***	0.0778	-1.6089 ***
		(0.025)	(0.023)	(0.042)	(0.042)	(1.070)	(0.040)
	Loans to total assets	0.0779 ***	0.0781 ***	0.0559 ***	0.0695 ***	0.0642	-0.0395 ***
		(0.004)	(0.004)	(0.001)	(0.004)	(0.046)	(0.011)
	Securitisation	-0.6003 ***	-0.6012 ***	-0.4397 ***	-0.9080 ***	-0.6080	-0.4731 *
		(0.140)	(0.143)	(0.085)	(0.096)	(0.525)	(0.255)
Funding structure	Short-term market funding	0.1485 ***	0.1483 ***	0.1366 ***	0.1403 ***	0.0937 **	0.0186 ***
		(0.005)	(0.006)	(0.006)	(0.009)	(0.044)	(0.004)
	Deposit funding	-0.0759 ***	-0.0759 ***	-0.0621 ***	-0.0628 ***	-0.0198	-0.0355 **
		(0.014)	(0.014)	(0.012)	(0.017)	(0.021)	(0.018)
Loan growth and income	Excessive loan growth	0.4462 ***	0.4453 ***	0.6182 ***	0.7737 ***	-0.2190	1.4540 ***
		(0.006)	(0.008)	(0.015)	(0.022)	(0.940)	(0.032)
	Non-interest income	-0.2356 ***	-0.2350 ***	-0.2698 ***	-0.2574 ***	-0.2000 ***	-0.2594 ***
		(0.002)	(0.001)	(0.005)	(0.010)	(0.043)	(0.014)
Managerial performance	Alpha_edf					1.9940	-27.6183 ***
						(7.431)	(4.738)
	Beta_edf					7.6373 ***	1.6826 **
						(2.831)	(0.779)
Control variables	Return on assets			2.0872 ***	0.7259		3.4926 ***
				(0.245)	(0.732)		(0.158)
	GDP growth				1.6483 ***		
					(0.487)		
	Intercept	2.9410 ***	2.9702 ***	4.7210 ***	2.5345 ***	6.4676	15.1652 ***
		(0.201)	(0.143)	(0.109)	(0.906)	(5.440)	(0.472)
	No. of observations	72	72	72	72	66	66
	R^2	0.6406	0.6406	0.6632	0.6763	0.5109	0.7061

Table VI

The effects of bank business models on bank risk: robustness tests

This table presents the effects of bank business models and other variables on bank risk using our main specification (see Section III for further details and Table I for variable definitions). Columns I to III provide the probit estimates for the probability of a bank receiving financial support from the government (*resc)*. This variable is constructed on the basis of information collected on the public rescue of banks via capital injections, the issuance of guaranteed bonds or other government-sponsored programmes during the crisis period (2007Q3 to 2009Q4). Columns IV to VIII present the OLS estimates for bank distress, measured as individual bank systematic risk during the period of crisis (*risk)*. This variable is calculated as the average of the non-overlapping quarterly beta in a capital asset pricing model calculated for each bank quarterly using daily stock market data for the crisis period specified. The variables accounting for bank capital structure, asset structure and securitization, funding structure, loan growth and income, profitability and also corporate governance are calculated from the averages of quarterly data for individual banks for the pre-crisis period (2003Q4 to 2007Q4). GDP growth, house prices, the stock market, competition and regulation are calculated from the country averages of quarterly data for the pre-crisis period already mentioned. The *Alpha_edf* and *Beta_edf* variables accounting for managerial performance are calculated from the averages for individual banks for the pre-crisis and crisis periods. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels respectively.

		Probit estimates			OLS estimates		
		(I)	(II)	(III)	(IV)	(V)	(VI)
Capital structure	Tier I capital	-0.1049 ***	-0.1024 ***	-0.1000 ***	-0.0141 ***	-0.0015	-0.0023
		(0.007)	(0.029)	(0.031)	(0.001)	(0.010)	(0.010)
	Undercapitalized	-0.2108 ***	-0.0321	-0.0154	-0.0552 ***	-0.0419 **	-0.0278 *
		(0.033)	(0.032)	(0.038)	(0.007)	(0.016)	(0.016)
Asset structure and securitization	Size	0.0643	0.2203 **	0.1974 ***	0.0959 ***	0.1272 ***	0.1474 ***
		(0.091)	(0.103)	(0.077)	(0.013)	(0.049)	(0.048)
	Loan to total assets	0.0075 ***	0.0006	0.0006	-0.0047 ***	-0.0013	-0.0004
		(0.001)	(0.015)	(0.014)	(0.000)	(0.004)	(0.004)
	Securitisation	-0.4666 ***	-0.3673 ***	-0.3532 ***	-0.1884 ***	-0.0602	-0.0010
		(0.086)	(0.009)	(0.040)	(0.031)	(0.038)	(0.039)
Funding structure	Short-term market funding	0.0077 ***	-0.0041 *	-0.0034 ***	0.0009 **	0.0016	0.0013
		(0.001)	(0.002)	(0.001)	(0.000)	(0.004)	(0.004)
	Deposit funding	-0.0350 ***	-0.0216 ***	-0.0167 ***	-0.0163 ***	-0.0114 ***	-0.0107 ***
		(0.002)	(0.002)	(0.004)	(0.001)	(0.004)	(0.004)
Loan growth and income	Excessive loan growth	0.2407 ***	0.0957 ***	0.1107 ***	0.1620 ***	0.1209 ***	0.1106 ***
		(0.071)	(0.007)	(0.017)	(0.002)	(0.041)	(0.039)
	Non-interest income	-0.0044 ***	-0.0058 ***	-0.0081 ***	-0.0039 ***	0.0035	0.0040
		(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
Managerial performance	Alpha_edf	-1.5150 ***	-0.2606	1.0869	-2.0789 ***	-2.3482 ***	-2.2903 ***
		(0.517)	(0.373)	(1.358)	(0.076)	(0.657)	(0.634)
	Beta_edf	1.1697 **	0.1205	0.4466 ***	2.3684 ***	0.8383 *	0.7647 *
		(0.577)	(0.533)	(0.173)	(0.146)	(0.467)	(0.433)
Control variables	Return on assets	0.0087	0.0541	-0.0115	0.2832 ***	0.0740	0.0324
		(0.012)	(0.169)	(0.124)	(0.011)	(0.064)	(0.064)
	GDP growth		0.5974 **	0.3928 ***		0.1829 *	0.1625
			(0.257)	(0.119)		(0.103)	(0.106)
	House price			0.5598 ***			0.1704 ***
				(0.121)			(0.040)
	Stock market			0.0489			-0.0314
				(0.084)			(0.046)
Robustness	Governance	-0.0221 ***			-0.0022 ***		
		(0.003)			(0.000)		
	Regulation		-0.1669 ***	-0.2214 ***		0.0531 **	0.0234
			(0.032)	(0.035)		(0.023)	(0.023)
	Competition		-0.0367 ***	-0.0344 **		-0.0034 ***	-0.0046 ***
			(0.014)	(0.015)		(0.001)	(0.002)
	Intercept	-1.6029 ***	-2.9540	-2.5741	-0.7255 ***	-2.0381 ***	-2.0409 ***
		(0.159)	(2.375)	(2.312)	(0.046)	(0.414)	(0.404)
	No. of observations	438	537	531	291	365	365
	Pseudo R^2	0.1621	0.1815	0.1802	0.5823	0.5519	0.5697
	Percent true positives/negatives	65.35/75.37	58.21/75.52	61.04/76.69			
	Percent correctly classified	73.06	73.41	74.5			
	Hosmer–Lemeshow test	8	8.78	8.7			
	Hosmer–Lemeshow test p-value	0.4338	0.3608	0.3683			

Table VII
The distributional effects of bank business models on bank risk: quantile estimates for systematic risk

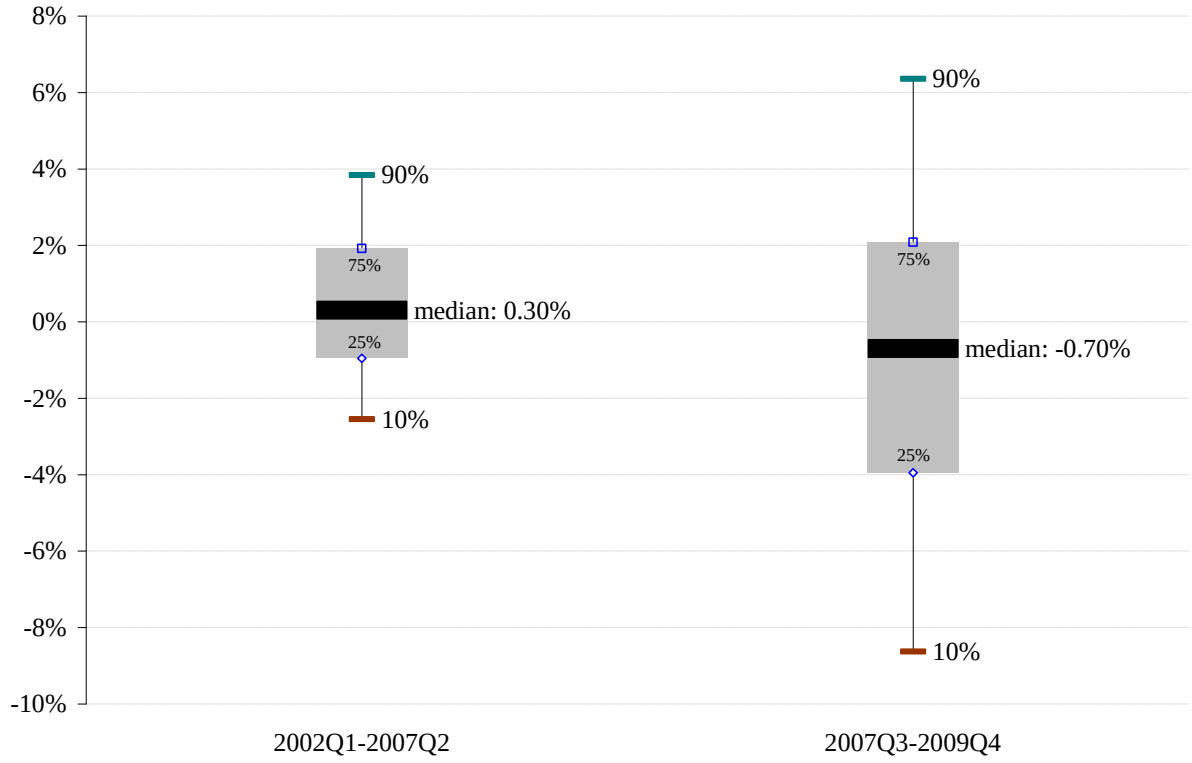
This table presents the distributional dependence between the bank business model and other variables relating to bank risk using our simplified specification (see Section IV.C for a more detailed explanation of our application of regression quantiles and Table I for variable definitions). It provides the quantile regression estimates for bank distress, measured as individual bank systematic risk during the crisis period (*risk)*. This variable is calculated as the average of the non-overlapping quarterly beta in a capital asset pricing model calculated for each bank quarterly using daily stock market data for the crisis period (2007Q4 to 2009Q4). The variables accounting for bank capital structure, asset structure and securitization, funding structure, loan growth and income, and profitability are calculated from the averages of quarterly data for individual banks for the pre-crisis period (2003Q4 to 2007Q4). GDP growth, house prices, the stock market, and competition are calculated from the country averages of quarterly data for the pre-crisis period already mentioned. The *Alpha_edf* and *Beta_edf* variables accounting for managerial performance are calculated from the averages for individual banks for the pre-crisis and crisis periods. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels respectively. The equality test applied is the F-test where the null hypothesis is that the estimated slope coefficients for each variable are not statistically different across all the different quantile estimates. The p-value for this test is given below the equality test value.

		Q10	Q25	Q50	Q75	Q90	Equality Test[1]
Capital structure	Tier I capital	0.0075	-0.0017	-0.0056	-0.0138 *	-0.0055	1.1300
		(0.005)	(0.004)	(0.010)	(0.008)	(0.013)	***0.340***
	Undercapitalized	-0.0459 ***	-0.0438 ***	-0.0491 **	-0.0571 ***	-0.0467 **	0.5300
		(0.015)	(0.011)	(0.022)	(0.018)	(0.024)	***0.711***
Asset structure and securitization	Size	0.1516 ***	0.1619 ***	0.1158 **	0.1086 **	0.0653	0.3200
		(0.031)	(0.021)	(0.050)	(0.042)	(0.064)	***0.867***
	Loans to total assets	0.0005	0.0006	0.0046	0.0089 ***	0.0097 *	5.8200
		(0.003)	(0.002)	(0.004)	(0.003)	(0.005)	***0.016***
	Securitisation	0.0478	0.0331	-0.0729	-0.1192 **	-0.1742 ***	6.0100
		(0.029)	(0.031)	(0.081)	(0.053)	(0.041)	***0.015***
Funding structure	Short-term market funding	0.0029	0.0058 ***	0.0103 **	0.0138 ***	0.0111 **	4.6600
		(0.003)	(0.002)	(0.004)	(0.004)	(0.005)	***0.031***
	Deposit funding	-0.0158 ***	-0.0159 ***	-0.0191 ***	-0.0289 ***	-0.0335 ***	3.9500
		(0.004)	(0.002)	(0.004)	(0.003)	(0.004)	***0.004***
Loan growth, income and profitability	Excessive loan growth	0.0371 *	0.0621 ***	0.1385 ***	0.1284 ***	0.2054 ***	6.5400
		(0.022)	(0.017)	(0.044)	(0.038)	(0.059)	***0.011***
	Non-interest income	0.0012	-0.0052 ***	-0.0079 **	-0.0063 **	-0.0002	2.3700
		(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	***0.125***
	Return on assets	0.1038 **	0.2390 ***	0.2597 ***	0.0869 *	0.1012 **	2.6600
		(0.041)	(0.027)	(0.057)	(0.049)	(0.050)	***0.104***
	Intercept	-1.3269 ***	-1.3913 ***	-1.4986 ***	-0.9853 ***	-1.1544 **	
		(0.296)	(0.192)	(0.416)	(0.357)	(0.537)	
	No. of observations	503	503	503	503	503	
	Pseudo R^2						

Figure 1

Box plot distribution of the stock market returns of individual banks

The diagram below shows the cross-sectional distribution of stock market returns for the listed European and US banks included in our sample. It is based on data for monthly stock market prices obtained from Datastream for the period 2003Q4 to 2009Q4. The 10%, 25%, 50%, 75% and 90% quantiles of the distribution of average stock market returns for the pre-crisis (2003Q4 to 2007Q3) and crisis (2007Q4 to 2009Q4) periods are presented. This "box plot" consists of a "box" that moves from the first to the third quartile (Q1 to Q3). Within the box itself, the thick horizontal line represents the median. The area below the bottom whisker moves from the 25% to the 10% quantile, while the area above the top whisker moves from the 75% to the 90% quantile of the distribution.



Source: Constructed from data obtained from Datastream.

Figure 2

Main hypotheses relating to alpha creation (fake versus real alpha)

Figure 2 provides a graphical illustration of the variables accounting for management performance – *alpha_edf* and *beta_edf* (see Section III.C for further details and Table I for variable definitions). Above the Y axis are those banks whose average one-year ahead expected default frequency (*edf*) belongs to the upper quartile of the cross-sectional distribution of this variable which covers all banks in the crisis period (i.e. 2007Q4 to 2009Q4), while those with an average one-year ahead *edf* belonging to the lower quartile of the cross-sectional distribution are to be found below this axis. The X axis separates those banks with an above average market-to-book value in the pre-crisis period (i.e. 2003Q4 to 2007Q3) from those with one that is below average. The former are to be found on the right-hand side of the X axis and the latter on the left-hand-side.

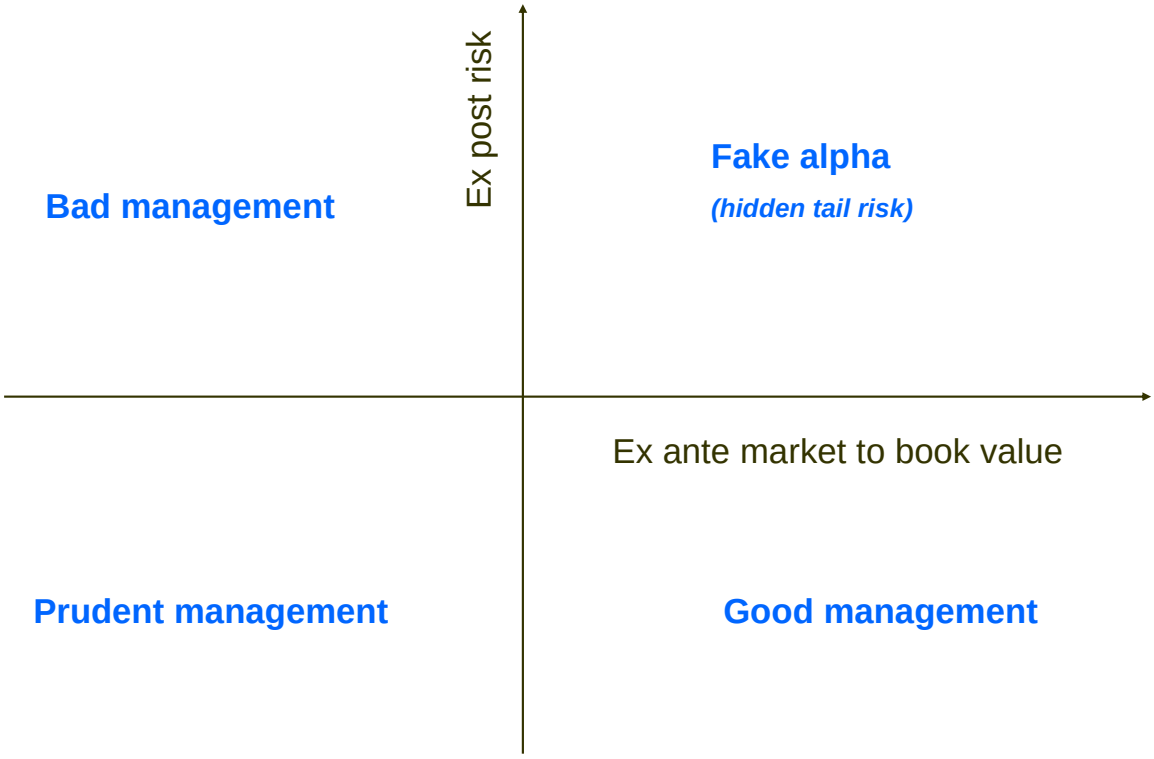


Figure 3
The distributional effects of bank size on bank risk: quantile estimates of the size coefficient related to systematic risk

The black line in Figure 3 plots the projected estimates of the OLS coefficient of bank size on distress. Bank distress is measured as the individual bank systematic risk during the crisis period (*risk)*. This variable is calculated as the average of the non-overlapping quarterly beta in a capital asset pricing model calculated for each bank quarterly using daily stock market data for the crisis period (2007Q4 to 2009Q4). It also presents the 25% and 75% projected estimates of the quantile coefficients for the distributional dependence of bank size on bank distress. See Table VII for the detailed quantile regression results; Table I for variable definitions and Section IV.C for a more detailed explanation of our quantile regression estimation.

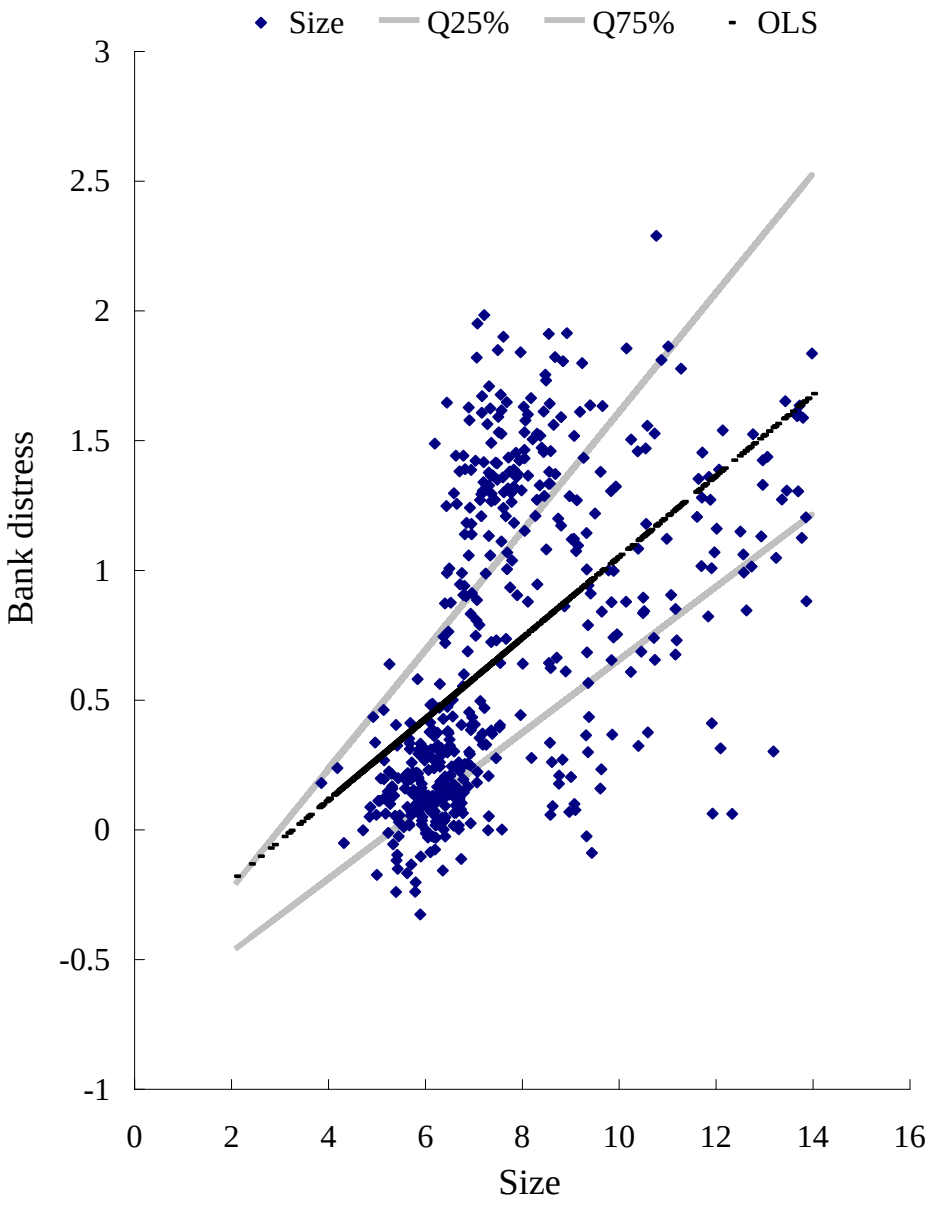
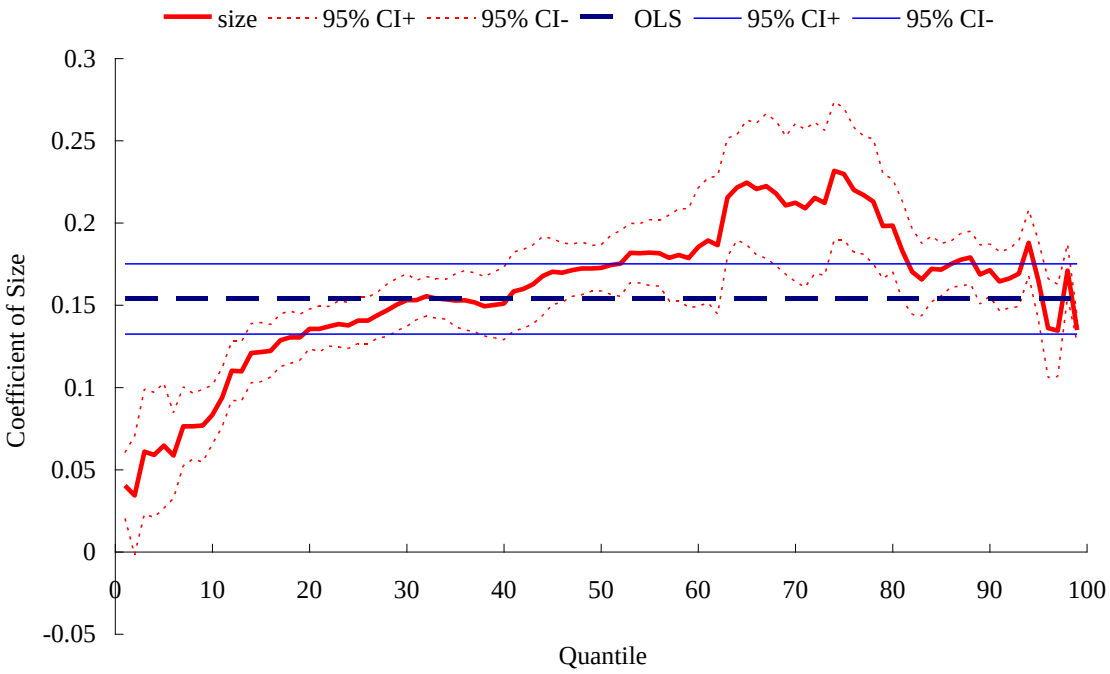


Figure 4
The distributional effects of bank size on bank risk: quantile estimates of the size coefficient related to systematic risk

The dotted line in Figure 4 plots the OLS coefficient of bank size on distress – including the 95% confidence intervals. In addition, it presents the different quantile regression estimates – including the 95% confidence intervals – for the coefficients associated with the impact of the size variable on bank distress, which is measured as individual bank systematic risk during the crisis period (*risk)*. This variable is calculated as the average of the non-overlapping quarterly beta in a capital asset pricing model calculated for each bank quarterly using daily stock market data for the crisis period (2007Q4 to 2009Q4). See Table VII for the detailed quantile regression results; Table I for variable definitions and Section IV.C for a more detailed explanation of our quantile regression estimation.



Source: Constructed from data obtained from Datastream.