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Competition and Bank Risk
The Role of Securitization and Bank Capital

by Yener Altunbas, David Marques-Ibanez, Michiel van Leuvensteijn, and Tianshu Zhao

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Abstract

We examine how bank competition in the run-up to the 2007–2009 crisis affects banks' systemic risk during the crisis. We then investigate whether this effect is influenced by two key bank characteristics: securitization and bank capital. Using a sample of the largest listed banks from 15 countries, we find that greater market power at the bank level and higher competition at the industry level lead to higher realized systemic risk. The results suggest that the use of securitization exacerbates the effects of market power on the systemic dimension of bank risk, while capitalization partially mitigates its impact.

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Contents

I. Introduction 4

II. Theoretical background and literature review.....5
A. Bank market power, industry competition and systemic risk 5
B. Capitalization, securitization and systemic risk 7

III. Data and Model.....9

IV. Results, robustness tests and additional analysis.....13

V. Conclusion 17

References.....18

Tables

1: Definitions, data sources and the description of main variables.....26
2: Sample distribution across countries 28
3: Descriptive Statistics.....29
4: Impact of bank level market power (Lerner) and industry competition on systemic risk ...30
5: Estimated results via IV approach 31
6: Estimated results using alternative measurements of capitalization.....32
7: Estimated results using alternative measurement of bank risk 33
8: Estimated results using alternative measurement of competition at the country level.....34
9: Estimated results for banks involved/ not involved in Merger and Acquisition in the 35
10: Estimated results for U.S. banks in the sample.....36
11: Estimated results with additional bank-specific control variables during the pre-crisis ...37
12: Estimated results for mortgage backed securitization 38
13: Estimated results for non-mortgage backed securitization.....39

Appendices.....22

I. INTRODUCTION

The effect of competition on the stability of the banking system has been a subject of intense academic debate. Interestingly, this literature tends to focus on the standalone or idiosyncratic risk of banks, rather than on the systemic dimension (Carletti, 2008; Allen and Carletti, 2013). Following the global 2007–2009 financial crisis, there has been intensified interest in systemic fragility, and macro-prudential regulation, which warrants a deeper understanding of the impact of competition on the systemic dimension of bank risk (Leroy and Lucotte, 2017). In this paper, we first examine the impact of bank competition on systemic bank risk. In a second step, we consider how the two major changes in the banking system taking place in the run-up to the crisis (i.e. capital regulation and financial innovation) impact on the relationship between competition and systemic bank risk through their influence on the behavior of individual banks (Crockett, 2002).

We test the effect of bank-specific market power and industry-level competition on banks' systemic risk using an international sample of financial institutions composed of the largest, listed, banks from the United States, Denmark, Sweden, United Kingdom, and 11 Eurozone countries.[2] Our empirical setting is supported by previous literature that emphasizes the role of banks as producers of information on borrowers. In such a framework, the impact of market competition on bank risk works via the intensity of screening and monitoring of borrowers (Caminal and Matutes, 1997; 2002).

Following this literature, we distinguish between market power at the individual bank level and competition at the banking industry level. Higher market power allows *individual banks* to utilize their higher borrowers' switching costs to improve loan repayment rates while maintaining their borrowers' base. Higher bank-specific market power can thus substitute for costly screening and monitoring, and encourage more aggressive lending strategies. As such, higher market power increases banks' exposure to common shocks to the economy and leads to higher systemic risk.

Regarding competition at the *banking industry* level, more competitive banking markets reduce the value of information production and increase its relative associated costs. This lowers the incentives of all banks to generate costly information to attract business from competitors. Hence banks operating in credit markets with high levels of competition exhibit more lax screening and monitoring, eventually resulting in high levels of systemic risk.

This paper adds to the existing literature in several ways. First, we investigate the distinct impact of bank market power and banking industry competition on systemic risk. Second, we emphasize the time dimension of this relationship, as the credit risk taken by banks in the upswing of a financial cycle usually materializes at a later stage, when the financial cycle turns. Third, we investigate the effect of two key variables (i.e. securitization and capitalization) on the market power-systemic risk relationship. This is motivated by an

[2] Namely: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain.

interest in identifying the roles that capitalization and securitization play in shaping banks' incentives to screen and monitor borrowers in the provision of bank credit.

We find that higher market power of individual banks and more competitive market conditions in the pre-crisis period lead to higher bank systemic risk during the crisis. Securitization amplifies, while capitalization mitigates, partially, the effects of market power on the systemic dimension of bank risk. These empirical results are statistically and economically significant. Our estimations suggest that the difference in systemic risk between a monopolist bank and a price taker is about 34 percent. One standard deviation of capitalization will mitigate the difference between a monopolist bank and a price taker by about 62 percent, and one standard deviation of securitization increases the difference between a monopolist bank and a price taker by around 94 percent.

Our findings are robust to the use of different measures of bank risk, competition, and capitalization, as well as additional controls accounting for bank-specific characteristics. Findings are also robust to the use of Instrumental Variables.

Our results are related to the literature emphasizing the effects of competition on the intensity of screening and monitoring services and how bank capital and securitization could strengthen or weaken this relationship. The financial crisis has shown that it is necessary to take a more detailed look at how changes to the banking system (such as securitization or enhanced solvency regulations) alter the behavior of banks. Our findings suggest that regulators should pay close attention to how these changes interact with competition in banking markets. The finding that capitalization does not fully counterbalance the impact of securitization on the market power-systemic risk relationship implies that capital adequacy requirements might need to be supplemented with additional supervisory tools to strengthen banks' incentives to screen and monitor their borrowers more intensively.

The remainder of this paper is organized as follows. Section II provides a discussion of the theoretical framework and reviews the relevant literature. Section III sets out the empirical model, data sources and identification strategy. Section IV provides the empirical results, robustness tests and further identification analyses via the separate estimation of non-mortgage and mortgage securitization. The paper's conclusions are presented in Section V.

II. THEORETICAL BACKGROUND AND LITERATURE REVIEW

A. Bank market power, industry competition and systemic risk

Banks' role in screening and monitoring investment projects make them important for the efficient allocation of capital in the economy (Caminal and Matutes, 2002). Crucially this key role also influences the relationship between competition and risk-taking (Carletti, 2008). Arguably, from a competitive perspective, banks' role as producers of proprietary credit information helps them, first, to retain existing borrowers, since it increases the threat of adverse selection problems for rivals trying to poach customers from their borrower base (Hauswald and Marquez, 2006). Second, it enables banks to poach borrowers from competitors more easily as it reduces the threat of adverse selection created by their rivals.

Bank-specific market power and competitive conditions at the industry level can have different impacts on the incentives of banks to screen and monitor existing and new borrowers and thus be expected to have different effects on systemic risk. In this respect, a bank with greater market power engages less in gathering proprietary information on existing borrowers, as these borrowers face higher switching costs if their main bank has higher market power (Boot and Thakor, 2000). Therefore, market power can be utilized by banks to enforce financial contracts and maintain their existing market share (Qian and Strahan, 2007).[3] Given these effects of market power, banks with higher market power are more likely to expose themselves to excessive lending, characterized by more lax lending standards, and to eventually exhibit higher levels of realized risks (Caminal and Matutes, 1997; 2002)[4][5].

At the industry level, a more competitive banking sector results in higher systemic bank risk. Higher competition implies lower average market power, which suggests that borrowers will shop around to obtain credit, and banks are more likely to face unknown new borrowers when attempting to expand their market share. This worsens the quality of information on borrowers and increases the costs associated with a given standard of information quality. As a result, banks find it profitable to reduce their information production to undercut competitors and increase market share (Dell'Ariccia and Marquez, 2006). This leads to an industry-wide higher lending growth supplied with minimal levels of screening. Consequently, a more competitive banking system implies an increase in banks' systemic risk (Bolt and Tieman, 2004).

The literature on the herding behavior of banks also models the impact of competition on the systematic risk of banks. A higher level of herding leads to an increase in systemic risk, as banks contribute more to common shocks and are more exposed to their effects (Rajan, 1994). Some of this literature emphasizes that bank herding can result from information contagion (Acharya and Yorulmazer, 2008). In this setting, the returns on bank loans comprise systematic and idiosyncratic components, and the failure of one bank transmits adverse information about the systematic component. That is, individual bank failure generates a negative externality in the cost of loanable funds and expected profit for surviving banks. The impact is greater when bank loan returns have less commonality, so banks herd undertaking correlated investments to minimize the impact of such information contagion on the negative externality.

[3] While market power allows the bank to appropriate a higher proportion of information rents due to banks' engagement in screening and monitoring, charging information rents will discourage the demand for bank credit, implying a negative impact on bank profitability.

[4] This channel is in sharp contrast with the positive impact of market power on the average riskiness of the pool of applicants (Allen and Gale, 2004) and the negative relationship between franchise value and risk taking (Keeley, 1990).

[5] Excessive lending, characterised by lower levels of screening and monitoring, exposes banks to overinvestment with existing borrowers. Since investment is subject to decreasing returns to scale and multiplicative uncertainty, banks become more vulnerable to shocks to the economy.

Competition in the banking industry influences banks' incentives to herd and, therefore, the systemic dimension of bank risk. The direction of this effect is, however, uncertain. On one hand, banks operating in a less competitive market may herd more, since the need to engage in differentiated investment to soften price competition is weaker (Acharya and Yorulmazer, 2008). On the other hand, they might herd less if lower competition supports their franchise value, such that bank owners favor individual rather than collective survival (Acharya, 2009).

Also, the impact of competition on bank herding could be increased due to considerations of managerial reputation and career concern (Rajan, 1994). Industry competition encourages bank managers to outperform and outgrow their competitors, with such banks driving each other into strong credit expansions, characterized by lax lending standards (Rötheli, 2001). This competition-induced herding behavior renders the banking system systemically riskier,[6] and predicts a positive relationship between higher competition at the industry level and systemic risk.

B. Capitalization, securitization and systemic risk

In general, well-capitalized banks tend to choose a more prudent loan portfolio as capital attenuates the excessive incentives towards risk-taking induced by limited liability and deposit insurance (e.g. Freixas and Rochet, 2008; Acharya et al., 2011). Higher capital levels, therefore, strengthen incentives to screen and monitor borrowers (Beck et al., 2017), encouraging banks to apply stricter lending standards to existing borrowers and be less aggressive in competing for new borrowers (Brander and Lewis, 1986; Bolt and Tieman, 2004).

Higher capital also implies lower herding incentives for banks. Well-capitalized banks face less asymmetric information problems when raising loanable funds (Gambacorta and Mistrulli, 2004; Repullo, 2004) and have a higher probability of survival (Berger and Bouwman, 2013). Well-capitalized banks are therefore less vulnerable to information contagion risks and prefer surviving individually to surviving jointly (Acharya and Yorulmazer, 2008). Following this literature, therefore, well-capitalized banks are expected to empirically exhibit lower levels of systemic risk.

In contrast, other studies suggest that higher capitalization might induce bank risk. The rationale is that higher capital leads to lower returns per unit of capital so that banks may invest in riskier assets to compensate for lower returns (Calem and Rob, 1999). Structurally, there seems to be a trade-off between banks' incentives to preserve capital, reducing risk taking, and their incentives to boost short-term returns to capital, incurring higher risks (Hellmann et al., 2000). Such a trade-off is expected to be smaller for banks with greater market power since they enjoy a higher level of franchise value (Agoraki et al., 2011) and, therefore, prioritize long-term survival rather than short-term profits.

[6] This effect is particularly pronounced when expectation of the occurrence of the normal state in the long-run is much higher than expectation of the adverse state, and managers have short-term concerns (Rajan, 1994). While the performance of the bank consists of systematic and idiosyncratic components, the labor market for bank managers appears more likely to associate better performance with managers' ability in the normal rather than adverse state (Thakor, 2016).

Regarding the impact of securitization on bank risk, some pre-crisis theories suggest that securitization may make banks more resilient to negative shocks and, consequently, reduces systemic risk. This is because the pooling of loans and tranching of securities create lower-risk and more liquid securities for investors, reducing the average cost of loanable funds. This allows banks to lower the cost of credit, which, in turn, reduces adverse selection and moral hazard problems (DeMarzo, 2004).

By allowing banks to convert illiquid, hard-to-sell loans into marketable securities, securitization can also decrease the sensitivity of bank lending to the availability of deposits, which may make the supply of credit more stable for borrowers and strengthen their incentives to honor loan obligations. In addition, securitization provides banks with opportunities to quickly redeploy loanable resources to more profitable business opportunities (Greenspan, 2005). More recent work, on the other hand, tends to find that securitization increases systemic risk by making banks more vulnerable to market sentiment and economic shocks (Loutskina, 2011; Laeven et al., 2016). Also, securitization has transformed the traditional role of banks in credit markets from "buying and holding" to "buying and selling". This increases the distance between the originator of loans and the bearer of their default risk so that banks have lower incentives to carefully screen and monitor the borrowers of securitized loans (Rajan, et al., 2015; Maddaloni and Peydró, 2011). This effect is likely to be more pronounced if banks use securitization as a tool for risk transfer (Boot and Ratnovski, 2016).[7]

An assessment of the channels through which capitalization and securitization affect systemic bank risk (as detailed above) provide valuable insights for the formulation of the empirical tests used in this paper to analyses the relationship between market power and systemic risk. The empirical tests are important for a better understanding of the main driving forces behind the relationship. The literature on the impact of competition on banks' incentives to collect and process proprietary information on their existing and potential borrowers implies that higher capitalization, due to its effect strengthening incentives for banks to screen and monitor borrowers, *mitigates* the impact of market power on systemic risk. Higher securitization, on the other hand, because of its influence in lowering screening standards and reducing the monitoring of borrowers, *exacerbates* the impact of market power on systemic risk. In contrast, the literature on the herding behavior of banks suggests higher capitalization can either strengthen or offset the impact of market power on systemic risk, due to the higher survival rate and lower level of limited liability of well capitalized banks. This literature, however, provides no evidence of the impact of securitization on the market power-systemic risk relationship.

[7] Empirical evidence on the impact of business diversification (from traditional to higher reliance on securitization as a source of income) on banks' soundness and profitability suggest very limited impact during good times (Apergis, 2014).The impact seems to diminish with the increase in the scale of securitization (Fiordelisi and Marques-Ibanez, 2013; Boot and Ratnovski, 2016).

III. DATA AND MODEL

A major challenge of the empirical literature analyzing the relationship between competition and risk concerns *when* to time the measurement of the variable accounting for bank risk (Beck, 2008), as there is an important lag between the period in which risk-taking takes place and materialization of losses arising from these risks.

This paper exploits the realization of bank risk during the 2007–2009 crisis. This choice corresponds to the notion that the problem of risk-taking of banks originated during the period leading up the financial crisis (Ruckes, 2004). We assess whether the ex-ante cross-sectional variability in bank-specific market power and competitive conditions at the industry level prior to the crisis are related to the ex-post materialization of bank risk during the crisis. Our approach assumes that, to a large extent, the measurement of risk can only be gauged when an extreme event, such as a crisis, occurs. Indeed, when the focus is on the systemic component of bank risk, it is reasonable to expect it would mostly be realized in the event of a banking crisis (Rajan, 2006).

The initial dataset used in the study consists of more than 1,100 listed banks from 15 countries: 11 Eurozone countries, Denmark, Sweden, the UK, and the United States. It is a highly representative sample that covers around three-quarters of the total aggregate balance sheet of banks operating in these countries. We focus on the parent company of all listed banking groups headquartered in those countries. [8]

Our main specification aims to assess the impact of bank-specific market power and industry competition in the run-up to the crisis (i.e. 2003Q4 to 2007Q3, the pre-crisis period) on bank systemic risk during the crisis (i.e. 2007Q4 to 2009Q4):

$$Risk_{i,k,post} = constant + \alpha * Lerner_{i,k,pre} + \beta * CAPITALIZATION_{i,k,pre} + \gamma * SECURITIZATION_{i,k,pre} + \tau * CONTROL_{i,k,pre} + b * Lerner_{k,pre} + \varepsilon_{i,k,post} \quad (1)$$

Where *i* refers to each single bank, *k* refers to the country, *pre* refers to the pre-crisis period (2003Q4 to 2007Q3) and *post* refers to the crisis period (2007Q4 to 2009Q4).

The measurement of realized bank risk has limitations (Hansen, 2012), so for each bank we calculate three alternative measures of risk ($Risk_{i,k,post}$). Measuring bank risk via indicators that incorporate stock prices is common in recent literature that analyses crisis periods (Bisias et al., 2012). All three measures therefore incorporate input signals derived from stock market prices, aiming to capture the systemic dimension of bank risk.

[8] For a full description of the characteristics of the database and variable definitions, see Altunbas et al. (2011) and Table 1.

In our analysis, a measure of systemic risk exposure is first estimated for each bank using the Marginal Expected Shortfall (*MES*) (Acharya et al., 2012). This step is based on the view that a shortage of capital for an individual bank becomes more hazardous for the whole economy if it happens when other institutions are also undercapitalized. Following previous work, we collect our stock market data from Datastream for the 2007Q4 to 2009Q4 period and compute the average daily stock return of each bank on days when the country's banking sector stock price index experiences its lowest (5 percent of daily) returns (DeJonghe, 2010). A higher *absolute value* of *MES* is associated with a higher level of systemic risk. We use *MES* as our preferred measure of risk in our empirical estimation as it is closer to the concept of systemic risk although in the robustness tests we use the other two measures.

Our second measurement of bank risk is bank *beta*. This measures systematic risk or the average responsiveness of each bank's stock market prices to movements in the overall stock market using a simple capital asset pricing model. Bank-specific *beta* accommodates the idea that the more susceptible a bank is to market upheavals, the more it can contribute to the severity of a crisis. To ensure comparability in our cross-country sample, we use the broad stock market index for each country, available from Datastream. For each bank *i*, separate regressions are run to derive *beta*-bank-quarter estimations, using its daily data for each quarter in the period from 2007Q4 to 2009Q4. For each individual bank, the average *beta* over the whole crisis period is then calculated. A larger estimated bank-specific *beta* indicates a higher level of bank risk.

Our third measure of bank risk is the expected default frequency (*EDF*) computed by Moody's KMV. The measurement is built on Merton's model (Merton, 1974). The *EDF* value,[9] expressed as a one-year ahead probability of default of individual banks, is calculated by combining banks' financial statements, stock market information and a proprietary default database. Because of the systemic nature of banking, the default of an individual bank is expected to have adverse effects on other financial and non-financial institutions. For each bank, its average *EDF* for the 2007Q4 to 2009Q4 period is calculated. A higher *EDF* indicates a higher likelihood of bank default in one year's time.

Market power at the bank level (i.e. $Lerner_{i,k,pre}$) is accounted for by means of a bank-specific *Lerner index*, adjusted for the price elasticity of loan demand. The yearly financial statements of individual banks in our sample for the period 2000-2007 (sourced from Bankscope) are used to make separate estimations of the translog cost function for each country and derive the bank-specific *Lerner index* for each bank. A higher value for the

[9] Compared to other measures of expected bank risk, the KMV methodology has various advantages. First, it is not based on ratings, which might be biased indicators of corporate risk due to conflicts of interest. Second, unlike measures of default risks derived exclusively from accounting information—such as Z-scores—, *EDF* is not a backward-looking indicator. Third, despite their simplifying assumptions, *EDF* estimations of default risk show strong robustness to model misspecifications (Jessen and Lando, 2015). Finally, during the recent financial crisis, compared to other measures of default risk, the *EDF* has performed relatively well as a predictor of firms' risk on a cross-sectional perspective. That is, the relative positions of firms ranked according to their *EDF* levels in the year before the crisis were good predictors of rank ordering of default risk during the crisis (Munves et al., 2009).

Lerner index suggests a higher degree of market power of the bank in question (Van Leuvensteijn et al., 2011).

To calculate the degree of banking competition in each country during the pre-crisis period (i.e. $Lerner_{k,pre}$), all the bank-specific Lerner values for that country are averaged. A higher *Lerner index* at the country level indicates a lower degree of competition. As an alternative, competition as perceived by banks is estimated via their responses to national bank lending surveys, in which banks are regularly asked to report their views on changes in competition in their country.

Bank capital ($CAPITALIZATION_{i,k,pre}$) is measured using the average ratio of Tier I capital to total risk weighted assets during the pre-crisis period (2003Q4 to 2007Q3), based on consolidated quarterly financial statements from Bloomberg. Tier I, higher-quality (i.e. core) capital is expected to be more effective in safeguarding bank solvency than broader measures of bank capital (Demirguc-Kunt et al., 2010). The analysis also uses the average ratio of the sum of Tier I and II capital to risk weighted assets (*Total capital ratio*) and Tier I capital to total assets (*Core capital leverage ratio*) during the pre-crisis period (2003Q4 to 2007Q3) as robustness checks.

The securitization variable ($SECURITIZATION_{i,k,pre}$) is measured by computing the average of quarterly accumulated securitization flows over total assets prior to the crisis (2003Q4 to 2007Q3). Securitization data are originally obtained from Bondware, a commercial database compiled by Dealogic, and calculated by aggregating the data for each quarter for each bank's individual deal-by-deal issuance. The sample includes mortgage-backed securities (*MBS*), funded public asset-backed securities (*ABS*), as well as cash-flow (balance-sheet) collateralized debt obligations (*CDOs*) issued by euro-area originators. The securitized loans included in the sample involve a transfer of funding from market investors to originators so that pure synthetic structures (such as synthetic CDOs, in which there is only transfer of credit risk) are not included. Whenever possible we filter for private label transactions only.

Finally, as regards control variables ($CONTROL_{i,k,pre}$), a vector of bank-specific variables is introduced. These variables are extracted from the quarterly consolidated balance sheet of banks, obtained from Bloomberg for the 2003Q4 to 2007Q3 period. Size (*Size*) is measured by the natural logarithm of total assets, excessive loan growth (*Excess loan growth*) is measured by the difference between the loan growth of an individual bank and the average of all banks in the country, and deposit funding (*Deposit funding*) is measured as the ratio of retail deposits to total assets. Selection of the bank-specific control variables is motivated by the existing literature, which identifies bank size, loan growth rate and funding structure as important drivers of bank risk (Altunbas et al., 2017).[10]

[10] The analysis does not follow the literature that uses the ratio of non-interest income to total income (and/or that of other earning assets to total earning assets) as the measurement of the business mix (or diversification of business activities) since the authors believe their measurement of securitization is a better measurement to serve this end. Nevertheless, we control for non-interest income divided by total income (other earning assets divided by total earning assets) as an additional robustness check.

Regarding *Size*, there is evidence to suggest that, due to too-big-to-fail considerations, supervisors may be more lenient in disciplining the excessive risk-taking of large banks (Laeven and Levine, 2007). With respect to *Excess loan growth*, a higher growth rate imposes a direct challenge to the screening ability of banks. More directly, excessive loan growth damages banks' abilities to maintain certain lending standards, leading to higher credit risk (Jimenez et al., 2013; Altunbas et al., 2017). By controlling for loan growth, it is also possible to better focus on the impact of competition on changes in information production in the provision of bank credit. In fact, the expansion of credit need not be coupled with higher bank systemic risk if the incentives for banks to screen and monitor remain unchanged during credit expansion (Dell' Ariccia et al., 2014). The *deposit funding* control variable aims to capture the vulnerability of the bank to liquidity shocks because of funding structure (Huang and Ratnovski, 2008).

As a further robustness check, the degree of banking competition is replaced at the country level by country-fixed effects. This aims to account for all the country factors (including economic conditions, safety net, supervision and regulation, and features of the banking industry) which could influence the risk-taking of individual banks.[11] An additional estimation that specifically accounts for economic growth is also included. This is calculated as the average of quarterly changes in real GDP (*GDP growth*) at the country level during the pre-crisis period.

As stated previously, we also examine the impact of capitalization and securitization on the relationship between market power and systemic risk.[12] For this purpose, Model (1) is modified by the addition of the interactions of $CAPITALIZATION_{i,k,pre}$ and $SECURITIZATION_{i,k,pre}$ with $Lerner_{i,k,pre}$:

$$Risk_{i,k,post} = constant + \alpha * Lerner_{i,k,pre} + \beta * CAPITALIZATION_{i,k,pre} + \gamma * SECURITIZATION_{i,k,pre} + \varphi * CAPITALIZATION_{i,k,pre} * Lerner_{i.k,pre} + \varphi * SECURITIZATION_{i,k,pre} * Lerner_{i.k,pre} + \tau * CONTROL_{i,k,pre} + b * Lerner_{k,pre} + \varepsilon_{i,k,post} \quad (2)$$

[11] To save space, results with country-fixed effects are not presented in the paper, but are available on request.

[12] Capitalization and securitization variables are de-meaned using the respective sample means. The estimated α, therefore, indicates the impact of market power on the systemic risk of banks if they were to have capitalization and securitization values equalling their sample mean.

The statistical sources and a brief description of the variables used are provided in Table 1. Table 2 provides descriptive statistics and Table 3 shows the distribution of banks by country. The detailed information regarding the estimation of the Marginal Expected Shortfall (*MES*), bank-specific *beta* and *Lerner index* are presented in Appendices A, B, and C, respectively.

IV. RESULTS, ROBUSTNESS TESTS AND ADDITIONAL ANALYSIS

Both the baseline Models (1) and Model (2) are estimated using Ordinary Least Squares (OLS). The results are first presented using *MES* as the measure of systemic risk, the *Lerner index* as the measure of bank-specific market power and competition at industry level, and the ratio of Tier I capital to total risk weighted assets as capitalization. The estimated results of Model (1) are presented in Table 4 (Columns 1 and 2). They show that higher levels of competition (i.e. lower levels of $Lerner_{k,pre}$) in the banking industry in the pre-crisis period lead to higher systemic risk during the crisis. At the individual level, bank-specific market power (i.e. higher levels of $Lerner_{i,k,pre}$) positively contributes to systemic risk (*MES*). Both results are statistically significant. Regarding the economic significance, the difference in the systemic risk between a monopolist bank and a bank which is a price taker is 1.11 (see Table 4, Column 1), which is 34.3 percent of the sample mean of *MES*.

Table 4 results also suggest that well-capitalized banks ($CAPITALIZATION_{k,pre}$) in the pre-crisis period have a lower level of systemic risk during the crisis. The finding is consistent with the effect of capital in mitigating the adverse incentives for banks to exploit their limited liability and safety net arrangements. Higher levels of securitization activity in the pre-crisis period ($SECURITIZATION_{i,k,pre}$) is negatively related to systemic risk. Hence, there is no evidence that banks that are more active in securitization markets take more risks. As far as control variables are concerned, in line with previous work (Altunbas et al., 2017), we find larger bank size (*Size*), higher loan growth compared to other banks in the same country (*Excess loan growth*), and lower share of deposit funding (*Deposit funding*) relate to higher systemic risk during the crisis.

Column 2 (Table 4) shows the results of re-estimating Model (1) by replacing the competitiveness conditions at the industry level with the real average GDP growth rate at the country level (*GDP growth*). None of the estimated coefficients are qualitatively different from those in the baseline Model 1 (Column 1, Table 4).

Turning to the augmented model (Model 2), which includes the two interactions of bank market power with capitalization and securitization respectively, results indicate that the interaction with capitalization is negative while that with securitization is positive, and both terms are significant at the 10 percent level. These findings suggest that higher capitalization reduces the impact of market power on the systemic risk faced by a bank, while higher levels of securitization exacerbate the effect. These results are economically significant. One standard deviation of capitalization will mitigate the difference in *MES* between a monopolist bank and a price taker by 62.0 percent, and one standard deviation of securitization increases the difference in *MES* between a monopolist bank and a price taker by 93.9 percent. While capitalization appears to weaken the positive relationship between bank market power and

systemic risk, its effect does not seem to be strong enough to counterbalance the effect of securitization. As seen, the estimated impact of bank market power on systemic risk remains statistically significantly positive for banks where the value of capitalization and securitization equals the sample mean. This would, therefore, suggest that exclusive reliance on capitalization for the stability of the banking system is questionable.

The impact of capitalization and securitization on the relationship between market power and bank systemic risk can be connected with previous literature highlighting the role of the credit screening and monitoring behavior of banks in driving the impact of market power on bank systemic risk. With respect to capitalization, better capitalized banks tend to internalize a larger proportion of the downside cost of skipping screening and monitoring. Hence higher capitalization leads to stronger incentives to invest in information on borrowers' credit risk and to set stricter lending standards for granting new loans. This mitigates the potential effect of market power on systemic risk.

Turning to securitization, as emphasized in Section II, acquisition of proprietary information about borrowers of securitized banks is particularly costly as this type of information cannot be credibly communicated to outside investors. While a traditional bank with higher market power may be inclined to take higher aggregate risks, the scope to generate risk might be more restricted when securitization is not available. The attempt of banks to scale up securitization may compromise their willingness to acquire proprietary information *ex ante*, since the price an outside investor offers for a securitized loan is not able to incorporate proprietary information that banks produce (Parlour and Plantin, 2008). A higher level of securitization could therefore further undermine banks' fundamental relationship with borrowers, and intensify the positive relationship between bank-specific market power and systemic risk.

The results of re-estimating Model (2) by replacing banking industry competition with real GDP growth rate at the country level (*GDP growth*) are reported in Column 4 of Table 4. These estimates replicate our previous findings with regard to the impact of capitalization and securitization on the market power-systemic risk relationship.

The time dimension of our empirical design, namely the analysis of how bank-specific market power *prior* to the crisis period impacts on systemic risk *during* the crisis, should ease concerns about reverse causality. However, the relationships identified so far could be biased by the omission of variables which correlate with bank-specific market power in the pre-crisis period, particularly if they are persistent up to the crisis. For example, sound banks with a reputation for stricter risk management probably have a higher lending rate to marginal cost margin because of a lower lemon discounts on their funding costs (Chen et al., 2017). More broadly, banks with an overall better reputation may be less subject to declines in their share prices during the crisis period due to uncertainty about banks' practices. Also, banks with more shareholder-friendly boards might price their lending in a way that generates more value for shareholders before a crisis, but is related to larger declines in value during crisis periods (Beltratti and Stulz, 2012).

To assuage concerns about these types of potential endogeneity, Models (1) and (2) are run with instrumental variables, using instruments for bank-specific market power in the pre-crisis period constructed from the average size, excess loan growth rate, deposit funding, securitization and capitalization of other banks in the same country for the 2003Q4 to 2007Q3 period (Laeven and Levine, 2009). Table 5 summarizes the results of these instrumental variable estimations (IV). The Kleibergen-Paap rk Wald F statistic rejects the null hypothesis for weak instruments at the 5 percent level. The Hansen *J* statistic suggests that the instruments are coherent with each other and confirms the validity of the instruments as a group (at the 10 percent level).[13] All in all, the results estimated with IV are in line with our main findings and also show that the positive relationship between bank-specific market power and systemic risk decreases with capitalization, and increases with securitization.

Our main estimations are further replicated by replacing the proxy for capitalization (Tier I capital to risk-weighted assets) with two alternative measures of bank capital: first, a capital to total assets ratio (i.e. *Total capital ratio*); second, a core capital to total assets ratio (i.e. *Core capital ratio*) (see Table 6). The aim is to assess the robustness of our results to any distortion that might be derived from the use of risk-weighted measures of total assets as opposed to simpler leverage ratios.

The estimations are also repeated using two alternative measures of bank risk: an indicator of systematic risk, as proxied by a bank-specific *beta*, and a structural measure, as indicated by the expected default frequency of each individual bank (*EDF*) (see Table 7).

An alternative measure of bank competition at the country level is also employed. This measure is the average percentage of banks reporting a tightening in credit conditions due to changes in bank competition in the period from 2003Q4 to 2007Q3, based on data collected in the quarterly Bank Lending Survey conducted by the European Central Bank, and Senior Loan Officer Surveys of other national central banks (i.e. *BLS*) (see Table 8).

Information is also collected on Mergers and Acquisitions[14] and the sample separated into those banks involved (and not involved) in Mergers and Acquisition (M&A) in the pre-crisis period (see Table 9). The motivation is that banks involved in M& might have different business and market strategies, and therefore different risk profiles that might affect our crisis estimations. Also, banks involved in M&As need to integrate the financial reporting of the acquirer and targets, thereby introducing noise into the information content of our control variables.

[13] We also run separate estimations of Models (1) and (2) with instruments used as additional control variables, none of which appears to be statistically significant. Therefore, the exclusion restriction of our instruments should not be a matter for concern.

[14] The source is the Thomson Reuters - SDC Platinum database.

Furthermore, it is necessary to investigate whether the results are sensitive to examining subsamples of banks and we show that our results also hold when only US banks are included (see Table 10). In addition, our main results are robust to the inclusion of additional bank-specific variables, including those accounting for diversification (non-interest income to total income, other earning assets to total assets), profitability (net income to total assets) and asset quality (loan loss provisions to total loans) (see Table 11).

Our results suggest that bank-specific market power and banking competition at the country level prior to the crisis exerts a significant impact on bank systemic risk during the crisis. As suggested by previous literature, we argue that competition directly impacts on banks' incentives to collect and process proprietary information on their actual and potential borrowers. We also propose that bank capitalization incentivizes banks to produce private information on borrowers and constrains risk taking, mitigating the impact of higher market power on systemic risk. In contrast, we find that securitization negatively affects banks' incentives to screen and monitor borrowers, exacerbating the impact of higher market power on systemic risk.

While the evidence appears quite robust, it is not possible to unequivocally conclude that bank investment in information gathering, to enhance the screening and monitoring of borrowers, is the sole driver of our results. To further understand the findings, it is necessary to investigate whether the impact of securitization on bank systemic risk differs according to the type of securitization adopted by banks, distinguishing between mortgage and non-mortgage securitization. The former is usually based on "harder" and more quantifiable information, such as borrowers' income or real estate values, as opposed to non-mortgage loans, in which "softer" proprietary information plays a more significant role and is costlier for the bank to acquire and process (Stein, 2002). If we are correct in our contention that our empirical findings can be largely explained by banks' incentives to produce costly proprietary information about their borrowers, it is expected that the impact of securitization, in intensifying the positive relationship between bank-specific market power and systemic risk, should be mainly driven by non-mortgage securitization.

To confirm this, we re-estimate the Model (2) to consider each type of securitization separately. The empirical results (see Tables 12 and 13) suggest that non-mortgage securitization is the main driver behind the overall impact of securitization on the relationship between market power and systemic risk. Regarding the impact of securitization on systemic risk *per se*, both types of securitization appear to be negatively related to systemic risk. Therefore, securitization by itself does not appear to increase systemic risk, which is in line with some previous research (Albertazzi et al., 2015). In countries which did not experience a housing bubble[15] (see in Column (2) of Table 13), mortgage-back securitization even appears to mitigate the positive relationship between bank-specific market power and systemic risk.

[15] Countries in our sample experiencing a housing bubble are the US, UK, Spain, and Ireland.

V. CONCLUSION

This paper examines how bank competition, both bank and industry levels, in the run up to the 2007-2009 crisis, impacts on bank systemic risk during the crisis. It also investigates the extent to which capitalization and securitization affect the relationship between market power and systemic risk, particularly with regard to their role in shaping banks' incentives to screen and monitor borrowers in the provision of credit. In this respect, our empirical study, which uses a sample of the largest listed banks of the US, UK, Sweden, Denmark and 11 Eurozone countries, builds on previous empirical and theoretical literature.

Our results show that bank-specific market power in the pre-crisis period leads to higher systemic risk during the crisis and that a higher level of competition at the industry level is associated with a higher level of bank systemic risk during the crisis. The positive relationship between market power and systemic risk decreases with capitalization but increases with securitization. Furthermore, bank capital does not fully counterbalance the effect of securitization on the relationship between market power and systemic risk. The results are robust to a number of tests, including different measures of systemic risk, competition, and capitalization, as well as inclusion of additional bank-specific characteristics and additional estimations using instrumental variables.

From our results, it follows that banking supervisors and macro-prudential regulators should collaborate closely with competition authorities to prevent the build-up of large systemic risks. The findings also suggest that bank capital alone is not sufficient to offset the adverse impact of competition and securitization on banks' systemic risks. In particular, the higher capital requirements in Basel III may need to be supplemented with additional regulatory tools, which can incentivize banks to increase screening and tighten lending standards for certain borrowers to mitigate the creation of systemic risks.

References

Acharya, V. V. (2009). A theory of systemic risk and design of prudential bank regulation. *Journal of Financial Stability*, 5(3), 224–255.

Acharya, V., Engle, R. and Richardson, M. (2012). Capital shortfall: A new approach to ranking and regulating systemic risks. *American Economic Review*, 102(3), 59–64.

Acharya, V. V., Sundaram, R. K., and John, K. (2011). Cross-country variations in capital structures: The role of bankruptcy codes. *Journal of Financial Intermediation*, 20(1), 25–54.

Acharya, V. V., and Yorulmazer, T. (2008). Information contagion and bank herding. *Journal of Money, Credit and Banking*, 40(1), 215–231.

Agoraki, M. E. K., Delis, M. D., and Pasiouras, F. (2011). Regulations, competition and bank risk-taking in transition countries. *Journal of Financial Stability*, 7(1), 38–48.

Albertazzi, U., Eramo, G., Gambacorta, L., and Salleo, C. (2015). Asymmetric information in securitization: An empirical assessment. *Journal of Monetary Economics*, 71(C), 33–49.

Allen, F., and Carletti, E. (2013). What is systemic risk? *Journal of Money, Credit and Banking*, 45(s1), 121–127.

Allen, F., and Gale, D. (2004). Competition and financial stability. *Journal of Money, Credit and Banking*, 36(3), 453–480.

Altunbas, Y., Manganelli, S., and Marques-Ibanez, D. (2011). Bank risk during the financial crisis: do business models matter? European Central Bank Working Paper Series 1394.

Altunbas, Y., Gambacorta, L., and Marques-Ibanez, D. (2014). Does Monetary Policy Affect Bank Risk? *International Journal of Central Banking*, 10(1), 95–136.

Altunbas, Y., Manganelli, S., and Marques-Ibanez, D. (2017). Realized bank risk during the great recession. *Journal of Financial Intermediation*, 32, 29–44.

Angelini, P. and Cetorelli, N. (2003). The effects of regulatory reform on competition in the banking industry. *Journal of Money, Credit and Banking*, 35(5), 663–684.

Apergis, N. (2014). The long-term role of non-traditional banking in profitability and risk profiles: Evidence from a panel of US banking institutions. *Journal of International Money and Finance*, 45, 61–73.

Appelbaum, E. (1982). The estimation of the degree of oligopoly power. *Journal of Econometrics*, 19 (23), 287–299.

Balla E., Ergen, I., and Migueis, M. (2014). Tail dependence and indicators of systemic risk for large US depositories. *Journal of Financial Stability*, 15, 195–209.

Beck, T. (2008). Bank competition and financial stability: friends or foes? World Bank Policy Research Working Paper Series 4656.

Beck, T., De Jonghe, O., and Mulier, K. (2017). "Bank sectoral concentration and (systemic) risk: Evidence from a worldwide sample of banks", Center for Economic Policy Research, Discussion Paper 12009.

Beltratti, A., and Stulz, R. M. (2012). The credit crisis around the globe: Why did some banks perform better? *Journal of Financial Economics*, 105(1), 1–17.

Berger, A. N., and Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? *Journal of Banking and Finance*, 21(7), 895–947.

Berger, A. N., and Bouwman, C. H. (2013). How does capital affect bank performance during financial crises? *Journal of Financial Economics*, 109(1), 146–176.

Bisias, D., Flood, M., Lo, A. W., and Valavanis, S. (2012). A survey of systemic risk analytics. *Annual Review of Financial Economics*, 4(1), 255–296.

Bolt, W., and Tieman, A. F. (2004). Banking competition, risk and regulation. *Scandinavian Journal of Economics*, 106(4), 783–804.

Boot, A. W., and Ratnovski, L. (2016). Banking and trading. *Review of Finance*, 20(6), 2219–2246.

Boot, A. W., and Thakor, A. V. (2000). Can relationship banking survive competition? *Journal of Finance*, 55(2), 679–713.

Brander, J. A., and Lewis, T. R. (1986). Oligopoly and financial structure: The limited liability effect. *American Economic Review*, 956–970.

Calem, P., and Rob, R. (1999). The impact of capital-based regulation on bank risk-taking. *Journal of Financial Intermediation*, 8(4), 317–352.

Caminal, R., and Matutes, C. (1997). Can competition in the credit market be excessive? Center for Economic Policy Research, Discussion Paper 1725.

Caminal, R., and Matutes, C. (2002), Market power and banking failures, *International Journal of Industrial Organization*, 20(9), 1341–1361.

Carletti, E. (2008). Competition and regulation in banking. *Handbook of Financial Intermediation and Banking*, 126(5), 449–482.

Chen, Z., Liu, F. H., Opong, K., and Zhou, M. (2017). Short-term safety or long-term failure? Empirical evidence of the impact of securitization on bank risk. *Journal of International Money and Finance*, 72, 48–74.

Corts, K. (1999). Conduct parameters and the measurement of market power. Journal of Econometrics, 88, 227–250.

Crockett, A. (2002). Market discipline and financial stability. *Journal of Banking and Finance*, 26(5), 977–987.

De Jonghe, O. (2010). Back to the basics in banking? A micro-analysis of banking system stability. *Journal of Financial Intermediation*, 19(3), 387–417.

Dell'Ariccia, G., Laeven, L., and Marquez, R. (2014). Real interest rates, leverage, and bank risk-taking. *Journal of Economic Theory*, 149, 65–99.

Dell'Ariccia, G., and Marquez, R. (2006). Lending booms and lending standards. *Journal of Finance*, 61(5), 2511–2546.

DeMarzo, P. M. (2004). The pooling and tranching of securities: A model of informed intermediation. *Review of Financial Studies*, 18(1), 1–35.

Demirgüç-Kunt, A., and Huizinga, H. (2010). Bank activity and funding strategies: The impact on risk and returns. *Journal of Financial Economics*, 98(3), 626–650.

Fiordelisi, F., and Marques-Ibanez, D. (2013). Is bank default risk systematic? *Journal of Banking and Finance*, 37(6), 2000–2010.

Freixas, X., and Rochet, J. C. (2008). *Microeconomics of banking*. MIT Press.

Gambacorta, L., and Mistrulli, P. E. (2004). Does bank capital affect lending behavior? *Journal of Financial Intermediation*, 13(4), 436–457.

Genesove, D., and Mullin, W.P. (1998). Testing static oligopoly models: conduct and cost in the sugar industry, 1890-1914. *Rand Journal of Economics*, 29, 355–377.

Greenspan, A. (2005). *Risk Transfer and Financial Stability*, Federal Reserve Bank of Chicago, Chicago IL.

Hansen, L. P. (2012). *Challenges in identifying and measuring systemic risk*, National Bureau of Economic Research Working Paper 18505.

Hauswald, R., and Marquez, R. (2006). Competition and strategic information acquisition in credit markets. *Review of Financial Studies*, 19(3), 967–1000.

Hellmann, T. F., Murdock, K. C., and Stiglitz, J. E. (2000). Liberalization, moral hazard in banking, and prudential regulation: Are capital requirements enough? *American Economic Review*, 90(1), 147–165.

Huang, R., and Ratnovski, L. (2011). The dark side of bank wholesale funding. *Journal of Financial Intermediation*, 20(2), 248–263.

Jiménez, G., Lopez, J. A., and Saurina, J. (2013). How does competition affect bank risk-taking? *Journal of Financial Stability*, 9(2), 185–195.

Jessen, C., and Lando, D. (2015). Robustness of distance-to-default. *Journal of Banking and Finance*, 50, 493–505.

Keeley, M. C. (1990). Deposit insurance, risk, and market power in banking. *American Economic Review*, 80(5), 1183–1200.

Laeven, L., Ratnovski, L., and Tong, H. (2016). Bank size, capital, and systemic risk: Some international evidence. *Journal of Banking and Finance*, 69, 25–34.

Laeven, L., and Levine, R. (2007). Is there a diversification discount in financial conglomerates? *Journal of Financial Economics*, 85(2), 331–367.

Laeven, L., and Levine, R. (2009). Bank governance, regulation and risk taking. *Journal of Financial Economics*, 93(2), 259–275.

Leroy, A., and Lucotte, Y. (2017). Is there a competition-stability trade-off in European banking? *Journal of International Financial Markets, Institutions and Money*, 46, 199–215.

Loutskina, E. (2011). The role of securitization in bank liquidity and funding management. *Journal of Financial Economics*, 100(3), 663–684.

Maddaloni, A., and Peydró, J. L. (2011). Bank risk-taking, securitization, supervision, and low interest rates: Evidence from the Euro-area and the US lending standards. *Review of Financial Studies*, 24(6), 2121–2165.

Merton, R.C. (1974). On the pricing of corporate debt: The risk structure of interest rates, *Journal of Finance*, 29 (2), 449–470.

Munves, D., Hamilton, D., and Gökbayrak, O. (2009). The Performance of EDFs since the Start of the Credit Crisis, *Moody's Analytics* (June).

Parlour, C. A., and Plantin, G. (2008). Loan sales and relationship banking. *Journal of Finance*, 63(3), 1291–1314.

Qian, J., and Strahan, P. E. (2007). How laws and institutions shape financial contracts: The case of bank loans. *Journal of Finance*, 62(6), 2803–2834.

Rajan, R. G. (1994). Why bank credit policies fluctuate: A theory and some evidence. *Quarterly Journal of Economics*, 109(2), 399–441.

Rajan, R. G. (2006). Has finance made the world riskier? *European Financial Management*, 12(4), 499–533.

Rajan, U., Seru, A., and Vig, V. (2015). The failure of models that predict failure: Distance, incentives, and defaults. *Journal of Financial Economics*, 115(2), 237–260.

Repullo, R. (2004). Capital requirements, market power, and risk-taking in banking. *Journal of Financial Intermediation*, 13(2), 156–182.

Rötheli, T. F. (2001). Competition, herd behavior, and credit cycles: evidence from major Swiss Banks. *Journal of Economics and Business*, 53(6), 585–592.

Ruckes, M. (2004). Bank competition and credit standards. *Review of Financial Studies*, 17(4), 1073–1102.

Stein, J. C. (2002). Information production and capital allocation: Decentralized versus hierarchical firms. *Journal of Finance*, 57(5), 1891–1921.

Thakor, A. V. (2016). The highs and the lows: A theory of credit risk assessment and pricing through the business cycle. *Journal of Financial Intermediation*, 25, 1–29.

Van Leuvensteijn, M., Bikker, J. A., Van Rixtel, A. A., and Sørensen, C. K. (2011). A new approach to measuring competition in the loan markets of the euro area. *Applied Economics*, 43(23), 3155–3167.

Appendix A: Marginal expected shortfall (*MES*)

The measure of marginal expected shortfall (*MES*) used in this paper is based on the expected capital shortfall framework, as in Acharya et al. (2012). *MES* estimates the average bank returns on days when the banking market as a whole is in the tail of the loss distribution of its returns:

$$MES_{ti} = 1/T \sum_1^T (R_{i,k,t} \ | R_{m,k,t} < \Gamma) \quad \text{(A.1)}$$

$R_{,i,k,t}$ is the stock returns of bank *i* in country *k* at time *t*, and $R_{m,k,t}$ is the banking stock market index in country *k* at time *t* . A systemic event is defined as a drop of the market index below a threshold Γ, over a given time horizon. Following Acharya et al. (2012), we adopt the standard risk level of 5percent, and take the 5percent of worst days for the banking sector index ($R_{m,k,t}$) during the crisis period (2007Q4-2009Q4). The average returns of each of individual bank ($R_{,i,k,t}$) are then computed for these days. Daily stock returns for individual banks and countries' banking sectors are gathered from Datastream.

Appendix B: Bank-specific *beta*

Our second measure of bank risk, i.e. bank-specific *beta*, describes the average stock market reaction of each bank to movements in the overall stock market index. It is constructed using a simple capital asset pricing model, based on the following equation:

$$R_{i,k,t} = \beta_{i,k,t} * R_{m,k,t} + \varepsilon_{i,k,t} \quad \text{(B.1)}$$

where $R_{i,k,t}$ represents the daily excess stock returns for each bank *i* in country *k* at time *t*; $R_{m,k,t}$ is the daily excess stock market returns for the broad stock market index *m* for country *k.* We take the 10-year government bond yield as the risk-free rate of interest for the country concerned. The term $\varepsilon_{i,k,t}$ is the error term. To ensure comparability, we use the broad stock market index for each country available from Datastream. For each bank *i*, the $\beta_{i,k,t}$ is estimated by running regressions on daily data for every quarter *q* from 2007Q4 to 2009Q4. The average *beta* for each bank during this crisis period is then calculated.

Appendix C: Calculating the elasticity adjusted *Lerner Index*

To derive measures for bank-specific market power and the degree of competition at the industry level, the following steps are adopted. We include banks which satisfy the following conditions: total assets, loans, deposits, equity and other non-interest income are positive; the net income to total assets ratio is below 20 percent; personnel expenses to total assets and other expenses-to-assets ratios are between 0.05percent and 5percent; and finally, the equity-to-assets ratio is higher than 1percent. We first estimate a translog cost function (*TCF*) for each country, using the financial statements of individual banks for the period 2000 –2007. We then calculate the bank-specific *Lerner index* using the difference between the average price of loans and marginal cost of loans, derived from the *TCF*, divided by the average price of loans. We further adjust the bank-specific *Lerner index*, allowing for the price elasticity of loan demand for the overall market. Toward this end, we simultaneously estimate the TCF

and the supply equation. Finally, the *Lerner index* at the industry level is computed by averaging the elasticity-adjusted bank-specific *Lerner indices* of banks in each country.

The *TCF* function assumes that the technology of an individual bank can be described by one multiproduct production function. A dual cost function can be derived from such a production function, taking output levels and factor prices as exogenous. The *TCF* is a second-order Taylor expansion around the mean of a generic dual cost function. Translog is a flexible functional form that is proven to be an effective tool in explaining multiproduct bank services.

Following Van Leuvensteijn et al. (2011), we specify the *TCF* as:

$$lnc_{it} = \alpha_0 + \sum_{t=1}^{T-1} \gamma_t d_t + \sum_{j=1}^{K} \delta_j lnx_{ijt} + \sum_{j=1}^{K} \sum_{k=1}^{K} \epsilon_{jk} lnx_{ijt} lnx_{ikt} + v_{it} \qquad \text{(C.1)}$$

where the dependent variable c_{it} reflects the production costs of bank i ($i = 1, .., N$) in year t ($t = 1, .., T$); d_t represents year dummies. The explanatory variables x_{ikt} represent three groups of variables ($k = 1, .., K$). The first group consists of (K_1) bank output components, such as loans, securities and other services (proxied by other income). The second group consists of (K_2) input prices, such as wage rates, deposit rates (as price of funding) and the price of other expenses (proxied as the ratio of other expenses to fixed assets). The third group (K_3) consists of the equity ratio, which is treated as the quasi-fixed input factor in line with Berger and Mester (1997). $v_{it}$is the error term.

The *TCF* is estimated separately for each of our 15 sample countries. We apply linear homogeneity in the input prices and cost-exhaustion and also the symmetry restrictions before the estimation. The marginal costs of loans for bank i at time t are obtained by differentiating the *TCF* with respect to loans:

$$mc_{ilt} = \frac{c_{it}}{x_{ilt}} \left(\delta_1 + 2\epsilon_{1l} lnx_{ilt} + \sum_{k=1 \ldots K; k \neq l} \epsilon_{1k} lnx_{ikt} \right) \qquad \text{(C.3)}$$

The *Lerner index* for bank i is defined as:

$$L_{it} = \frac{p_{it} - mc_{ilt}}{p_{it}} \qquad \text{(C.4)}$$

where p_{it} denotes the average price of loans for bank i at time t, which is measured as total interest income divided by total loans, while mc_{ilt} are marginal costs of loans derived via Equation (C.3).

However, this traditional *Lerner index* cannot distinguish markets that have high margins due to inelastic demand for the market as a whole from that because market participants face lower degree of competition or perhaps collusive (Corts, 1999). To overcome this problem, the elasticity-adjusted *Lerner index* has been developed (Genesove and Mullin, 1998; Corts, 1999). More precisely, this measure normalises the *Lerner index* for the price elasticity of

demand for the overall market in order to derive the competitiveness pressure faced by individual banks. To estimate the elasticity-adjusted *Lerner index* we follow Angelini and Cetorelli (2003):

Bank *i* solves the following profit-maximising problem:

$$\max_{q_i} \Pi = p(Q)q_i - C(q_i, w_i) \qquad \text{(C.5)}$$

where $= \sum_i q_i$, the total amount of bank loans in loan market as a whole and q_i is the loan provided by bank *i*. $C(q_i, w_i)$ is the cost function of bank *i*, and w_i represents the vector of factor input prices. The corresponding supply function (first-order condition) is:

$$p_i = C'(q_i, w_i) - \frac{\Theta_i}{\varepsilon} \qquad \text{(C.6)}$$

where Θ_i is the conjectural elasticity of total loans of the industry with respect to loans of bank *i*, $\Theta_i = \frac{dQ/dq_i}{Q/q_i}$ and involves both the bank's loans share and its conjectural variation. $\varepsilon = \frac{dQ/dp}{Q} < 0$ and is market demand semi-elasticity to the price. In a perfectly competitive market, Θ_i equals zero for all banks, while in a monopoly market Θ_i equals one. Appelbaum (1982) suggests that it is sufficient to estimate the ratio $\lambda_i = \frac{\Theta_i}{\varepsilon}$ if the goal is to evaluate price-marginal cost margin of a particular firm in the industry which depends on both the elasticity of market demand and the degree of competition, measured by conjectural variation. The elasticity-adjusted *Lerner index*, the relative mark-up of price over marginal cost, will then be defined as $L_e = \frac{\lambda}{p}$, where *p* is the average price of loans in the industry.

Substituting the marginal costs Equation (C.3) into the supply Equation (C.6), we obtain:

$$p_{it} = \frac{c_{it}}{x_{ilt}}\left(\delta_1 + 2\epsilon_{1l} lnx_{ilt} + \sum_{k=1\ldots K; k\neq l} \epsilon_{1k} lnx_{ikt}\right) + \sum_{t=1\ldots T-1} \lambda_t d_t + \varepsilon_{it} \qquad \text{(C.7)}$$

where d_t is a year dummy and ε_{it} *i*s the error term. To identify λ_t and the elasticity-adjusted *Lerner index*, we simultaneously estimate the *TCF* (C.2) and the supply equation (C.7). We impose linear homogeneity in the input prices, cost-exhaustion in input shares, and the symmetry restrictions on *TCF* and cross-equation restrictions. The elasticity-adjusted *Lerner index*, $L_{e,it}$, is then equal to:

$$L_{e,it} = \mu_t \frac{p_{it} - mc_{ilt}}{p_{it}} \quad \text{(C.8)}$$

μ_t equals to λ_t /(p_{avg} –mc_{avg}). The elasticity-adjusted *Lerner index* thus equals to the *Lerner index* of each bank for each year times this yearly parameter to correct for the price elasticity of demand for the whole market, where p_{it} denotes the price of loans for bank *i* at time *t*, measured as total interest income divided by total loans, while mc_{ilt} are the marginal costs of loans derived via Equation (C.3). The elasticity adjusted *Lerner index* for our sample banks is calculated by the average yearly *Lerner index* of the bank during the pre-crisis period. The yearly elasticity adjusted *Lerner index* for the industry, L_t, is computed by averaging the individual L_{it} in each country for each year *t*.

Table 1: Definitions, data sources and the description of main variables

Variable	Source	Description
Panel A: Bank risk variables		
Marginal expected shortfall (MES)	Datastream and authors' calculation following Acharya et al., (2012).	Marginal expected shortfall (*MES*), as in Acharya et al. (2012), using α*=5percent*, calculated for the crisis period (2007Q4 - 2009Q4), based on individual banks' and countries' banking sector daily stock market returns.
Bank-specific beta	Datastream and authors' calculations.	Average of the quarterly non-overlapping *betas* in a capital asset pricing model, constructed using daily excess stock returns for each bank *i* on the broad market index of country *j*, calculated during the crisis period (2007Q4 - 2009Q4).
Expected default frequency (EDF)	Moody's KMV.	One-year ahead probability of default, computed by Moody's KMV, building on Merton's (1974) model to price corporate bond debt. The *EDF* value, expressed as a percentage, is calculated by combining banks' financial statements with stock market information and a proprietary default database. We calculate the average of quarterly data during the crisis period (2007Q4 - 2009Q4).
Panel B: Bank competition variables		
Lerner (firm level)	Authors' calculations (see appendix C for details).	The elasticity adjusted Lerner index of banks in the pre-crisis period. The marginal costs of loans are derived from the Translog Cost Function (TCF) estimated by country for the period 2000-2007. For each bank for each year the Lerner index is then calculated as the difference between the average charged interest rate on loans and the estimated marginal cost of loans divided by the average interest rate charged by the bank. The Lerner index of the bank is the average of yearly bank-specific Lerner index values over the period 2000-2007.The Lerner index is then adjusted for price elasticity of demand.
Lerner (industry level)	Author's calculation.	The elasticity adjusted Lerner index for the industry in the pre-crisis period. This is computed by the average of yearly *Lerner index* for the country over the period 2000-2007. The yearly *Lerner index* for the country is the average of individual banks' elasticity adjusted *Lerner index* values for each year over the period 2000-2007.
BLS	Bank Lending Survey of the European Central Bank and Senior Loan Officer Surveys from other national central banks. See (Altunbas et al., 2014).	Competition as measured by the average percentages of banks reporting a tightening in credit conditions due to competition in surveys during the pre-crisis period (2003Q4 to 2007Q3).
Panel C: Balance sheet variables		
Size	Bloomberg.	Average of the logarithm of total assets (USD millions) during the pre-crisis period (2003Q4 to 2007Q3).
Capitalization (percent)	Bloomberg.	Average of the quarterly ratios of tier I capital to risk-weighted assets during the pre-crisis period (2003Q4 to 2007Q3).
Total capital ratio (percent)	Bloomberg.	Average of the quarterly ratios of total capital (Tier I and Tier II) to risk-weighted assets during the pre-crisis period (2003Q4 to 2007Q3).
Core capital ratio (percent)	Bloomberg.	Average of the quarterly ratio of tier I capital to total assets during the pre-crisis period (2003Q4 to 2007Q3).
Securitization (percent)	DCM Analytics Dealogic.	Average of the quarterly ratios of total securitization to total assets during the pre-crisis period (2003Q4 to 2007Q3).
Non-mortgage backed securitization (percent)	DCM Analytics Dealogic.	Average of the quarterly ratios of total non-mortgage backed securitization flow to total assets of each originating bank during the pre-crisis period (2003Q4 to 2007Q3).
Mortgage backed securitization (percent)	DCM Analytics Dealogic.	Average of the quarterly ratios of total mortgage backed securitization flow to total assets of each originating bank

Variable	Source	Description
		during the pre-crisis period (2003Q4 to 2007Q3).
Deposit funding (percent)	Bloomberg.	Average of the quarterly ratios of customer deposits to total assets during the pre-crisis period (2003Q4 to 2007Q3).
Excessive loan growth	Bloomberg and authors' calculations.	Average of the quarterly differences between the individual bank lending growth and the average loan growth of all banks in each country during the pre-crisis period (2003Q4 to 2007Q3).
Other earning assets ratio (percent)	Bloomberg.	Average of the quarterly ratios of other earning assets to total assets during the pre-crisis period (2003Q4 to 2007Q3).
Profitability (percent)	Bloomberg.	Average of the quarterly ratios of net income to total assets during the pre-crisis period (2003Q4 to 2007Q3).
Asset quality (percent)	Bloomberg.	Average of the quarterly ratios of total loan loss provisions to total loans during the pre-crisis period (2003Q4 to 2007Q3).
Non-Interest Income (percent)	Bloomberg.	Average of the quarterly ratios of non-interest income to total income during the pre-crisis period (2003Q4 to 2007Q3).
Panel D: Other Control variables		
Housing bubble dummy	Authors' calculations.	Binary variable which takes the value of 1 if observation is from the USA, UK, Spain, Portugal and Ireland, and 0 otherwise.
GDP growth	Bank for International Settlements.	Average of quarterly changes in real GDP during the pre-crisis period (2003Q4 to 2007Q3).

Note: This table presents the names of the variables employed in our empirical analysis, indicates the data sources and gives a brief description of each variable. More detailed information, plus all publicly available data, are available upon request.

Table 2: Sample distribution across countries

Country	Number of banks: Systemic risk/bank-specific beta	Number of banks: *EDF*
Eurozone countries		
Austria (AT)	8	8
Belgium (BE)	3	3
Germany (DE)	19	19
Spain (ES)	11	11
Finland (FI)	2	
France (FR)	17	18
Greece (GR)	13	13
Ireland (IE)	3	3
Italy (IT)	20	20
The Netherlands (NL)	2	2
Portugal (PT)	5	5
Non-Eurozone countries		
Denmark (DK)	31	31
Sweden (SE)	4	4
United Kingdom (GB)	6	6
United States (US)	402	402
Total	**546**	**545**

Note: This table provides information regarding the distribution of the sample banks in each of our 15 sample countries.

Table 3: Descriptive Statistics

Variables	N	Average	Median	Standard Deviation	Q1	Q3
Panel A: Bank Risk						
Marginal expected shortfall (MES)	495	3.222	2.912	2.611	1.174	5.093
Bank-specific beta	495	0.691	0.457	0.599	0.158	1.272
Expected default frequency (EDF)	495	0.910	0.320	2.220	0.130	0.790
Panel B: Bank competition variables						
Lerner (firm level)	495	0.778	0.765	0.091	0.721	0.833
Lerner (industry level)	495	0.793	0.757	0.070	0.746	0.865
BLS	495	-27.154	-25.000	22.504	-40.000	-10.000
Panel C: Balance Sheet Variables						
Size	495	7.290	6.620	2.070	5.870	8.200
Capitalization (percent)	495	9.630	8.820	5.620	7.310	10.910
Total capital ratio (percent)	495	13.730	12.830	3.240	11.690	14.640
Core capital ratio (percent)	495	4.720	4.530	2.490	3.080	6.000
Securitization (percent)	495	0.100	0.011	0.840	0.001	0.239
Non-mortgage backed securitization (percent)	495	0.047	0.012	0.091	0.002	0.048
Mortgage backed securitization (percent)	495	0.057	0.015	0.079	0.003	0.094
Deposit funding (percent)	495	71.411	75.124	13.988	66.317	81.100
Excessive loan growth	495	6.270	5.750	2.330	4.720	7.470
Other earning assets ratio (percent)	495	26.372	23.592	13.980	17.587	32.178
Profitability (percent)	495	0.970	0.960	0.950	0.650	1.260
Asset quality (percent)	495	1.200	1.130	1.823	0.844	1.342
Non-Interest Income (percent)	495	20.01	16.53	14.24	10.98	24.79
Panel D: Other Control Variables						
Housing bubble dummy	495	0.830	1.000	0.370	1.000	1.000
GDP growth	495	1.143	1.157	0.654	0.876	1.539

Note: The average *MES* over the post-crisis period (2007Q4-2009Q4) was 3.22 percent, which is in line with the marginal expected shortfall (*MES*) of 2.094, reported for US banks in Balla et al. (2014, p. 201).

Table 4: Impact of bank level market power (*Lerner*) and industry competition on systemic risk and the impact of capitalization and securitization on this relationship

Variable	***Systemic risk***	***Systemic risk***	***Systemic risk***	***Systemic risk***
	(1)	(2)	(3)	(4)
Lerner (firm level)	1.1071**	1.8536***	1.3075**	1.1162**
	(0.4750)	(0.6989)	(0.6243)	(0.5257)
Securitization	−0.7781***	−0.7773**	−0.7513***	−0.7153**
	(0.2174)	(0.3111)	(0.2019)	(0.3418)
Capitalization	−0.1262**	−0.1419***	−0.1363***	−0.1181***
	(0.0543)	(0.0518)	(0.0484)	(0.0370)
Size	0.4644***	0.5614***	0.5686***	0.6359***
	(0.1779)	(0.1985)	(0.1010)	(0.0862)
Excessive loan growth	0.4076**	0.3597*	0.2968*	0.2671
	(0.1638)	(0.1859)	(0.1683)	(0.1730)
Deposit funding	−0.0342*	−0.0484***	−0.0406***	−0.0515***
	(0.0176)	(0.0172)	(0.0154)	(0.0184)
Macro-Economic variables				
Lerner (industry level)	−0.1027***		−0.0924***	
	(0.0248)		(0.0329)	
GDP growth		2.3427**		3.0223***
		(0.9376)		(1.1343)
Competition interactions				
*Capitalization * Lerner (firm level)*			−0.0845***	−0.0941***
			(0.0143)	(0.0101)
*Securitization * Lerner (firm level)*			0.7054***	0.6986***
			(0.2281)	(0.2204)
Constant	−4.3572**	−7.2602***	4.0853*	−6.8198***
	(2.1327)	(2.0288)	(2.1932)	(2.1142)
No. of observations	495	495	495	495
R^2	0.380	0.382	0.399	0.418

Note: This table provides the estimated results of Model (1) and Model (2). Systemic risk is measured by the *MES*. Columns (1)-(2) show the estimated results of Model (1). Column (1) shows the effect of bank balance sheet variables, *Lerner (firm level)* and *Lerner (industry level)* on systemic risk. Column (2) replaces *Lerner (industry level)* with real *GDP* growth. Columns (3)-(4) introduce the interaction terms of *Securitization* and *Capitalization* with bank-specific market power and present the estimated results of Model (2). The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 5: Estimated results via IV approach

Variable	***Systemic risk***	***Systemic risk***	***Systemic risk***	***Systemic risk***
	(1)	(2)	(3)	(4)
Lerner (firm level)	2.9082**	2.5658**	2.7888**	2.7477**
	(1.4695)	(1.2918)	(1.4086)	(1.3092)
Securitization	−0.9291***	−0.7338***	−0.6955***	−0.6677***
	(0.2523)	(0.2715)	(0.2088)	(0.2695)
Capitalization	−0.0586**	−0.1967**	−0.1603*	−0.1536*
	(0.0288)	(0.0766)	(0.0850)	(0.0794)
Size	0.5437***	0.5197***	0.5479***	0.6754***
	(0.1541)	(0.1754)	(0.1667)	(0.1516)
Excessive loan growth	0.3083**	0.3878**	0.3038**	0.2244*
	(0.1322)	(0.1528)	(0.1421)	(0.1351)
Deposit funding	−0.0479**	−0.0479***	−0.0403**	−0.0487***
	(0.0199)	(0.0165)	(0.0195)	(0.0162)
Macro-Economic variables				
Lerner (industry level)	−0.1066***		−0.0937***	
	(0.0255)		(0.0244)	
GDP growth		2.4449***		3.4920***
		(0.5070)		(0.4701)
Competition interactions				
*Capitalization * Lerner (firm level)*			−0.0746*	−0.0944***
			(0.0406)	(0.0360)
*Securitization * Lerner (firm level)*			0.7371***	0.7658***
			(0.2486)	(0.2293)
Constant	4.1756**	−7.8448***	2.9956*	−8.7299***
	(2.0616)	(1.3193)	(1.7888)	(1.2488)
*Capitalization * Lerner (firm level)*			-0.0746*	-0.0944***
			(0.0406)	(0.0360)
*Securitization * Lerner (firm level)*			0.7371***	0.7658***
			(0.2486)	(0.2293)
Constant	4.1756**	-7.8448***	2.9956*	-8.7299***
	(2.0616)	(1.3193)	(1.7888)	(1.2488)
No. of observations	495	495	495	495
Weak identification test				
Kleibergen-Paap rk Wald F statistic	23.881	23.703	20.173	24.285
Stock-Yogo weak ID test critical values at 5percent level	19.28	19.28	19.28	19.28
Overidentification test				
Hansen J statistic	3.012	5.636	8.853	7.677
(P-value)	0.5559	0.3433	0.1151	0.1041
R^2	0.381	0.380	0.397	0.411

Note: The table contains the estimated results of Model (1) (Columns (1)-(2)) and Model (2) (Column (3)-(4)) using the IV approach. Systemic risk is measured by the *MES*. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Columns (1) and (2) present the estimated results of Model (1). Column (1) shows the effect of bank balance sheet variables and *Lerner (firm level)* and *Lerner (industry level)* on systemic risk. Column (2) replaces *Lerner (industry level)* with real *GDP growth*. Columns (3) and (4) introduce the interaction terms of securitization and capitalization with bank-specific market power and show the estimated results of Model (2). The instruments used for bank-specific market power are: *Size, Excessive loan growth, Deposit funding, Capitalization, Securitization* of other banks in the

same country during the pre-crisis period in the estimation of Model (1) and also include the product of capitalization of other banks in the same country during the pre-crisis period, the bank-specific *Lerner index* during the pre-crisis period, and the product of securitization of other banks in the same country during the pre-crisis and bank-specific *Lerner index* during the pre-crisis period in the estimation of Model (2). Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of other variables can be found in Table 1.

Table 6: Estimated results using alternative measurements of capitalization

Variable	***Systemic risk***	***Systemic risk***	***Systemic risk***	***Systemic risk***
	(1)	(2)	(3)	(4)
Lerner (firm level)	1.3209***	2.1687***	2.0240***	1.7420***
	(0.4685)	(0.4772)	(0.4085)	(0.3329)
Securitization	−0.7666***	−0.8255***	−0.8403***	−0.8040***
	(0.2171)	(0.2169)	(0.2222)	(0.1826)
Total capital ratio	−0.1284**		−0.1496**	
	(0.0544)		(0.0619)	
Core capital ratio		−0.1439***		−0.0961*
		(0.0554)		(0.0540)
Size	0.4500**	0.4917***	0.6296***	0.7145***
	(0.1863)	(0.1743)	(0.0976)	(0.0995)
Excessive loan growth	0.4130**	0.3804**	0.2536	0.1810
	(0.1706)	(0.1632)	(0.1720)	(0.1693)
Deposit funding	−0.0363**	−0.0354**	−0.0348**	−0.0322*
	(0.0172)	(0.0166)	(0.0155)	(0.0165)
Macro-Economic variables				
Lerner (industry level)	−0.1060***	−0.1042***	−0.0932***	−0.0899***
	(0.0233)	(0.0234)	(0.0315)	(0.0286)
Competition interactions				
*Total capital ratio*Lerner (firm level)*			−0.0519***	
			(0.0084)	
*Core capital ratio*Lerner (firm level)*				−0.1210***
				(0.0181)
*Securitization * Lerner (firm level)*			0.6457***	0.8250***
			(0.1879)	(0.2129)
Constant	4.5446**	3.6873*	3.1239	2.7278
	(2.0792)	(2.0484)	(2.3664)	(2.1299)
No. of observations	495	495	495	495
R^2	0.376	0.378	0.395	0.400

Note: The table contains the estimated results of Model (1) and Model (2) using total capital ratio and core capital ratio as alternative measurements of the capitalization of banks in the pre-crisis period. Systemic risk is measured by the *MES*. Columns (1)-(2) present the estimated results of Model (1). Column (1) shows the results of using total capital ratio as the measurement of capitalization; Column (2) shows the results using core capital ratio as the measurement. Columns (3)-(4) introduce the interaction terms of securitization and capitalization with bank-specific market power and provide the estimated results of Model (2). Column (3) shows the results using total capital ratio as the measurement of capitalization and Column (4) shows the results using core capital ratio as the measurement. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 7: Estimated results using alternative measurement of bank risk

Variable	***Bank-specific beta***	***EDF***
	(1)	(2)
Lerner (firm level)	0.4675^{***}	5.5974^{***}
	(0.1320)	(0.1371)
Securitization	-0.2189^{***}	-1.2587^{*}
	(0.0825)	(0.6646)
Capitalization	-0.0776^{***}	-0.0545^{***}
	(0.0106)	(0.0061)
Size	0.0922^{***}	-0.1965^{***}
	(0.0269)	(0.0305)
Excessive loan growth	0.1492^{***}	-0.1436^{***}
	(0.0421)	(0.0143)
Deposit funding	-0.0108^{***}	-0.0098^{**}
	(0.0018)	(0.0039)
Macro-Economic variables		
Lerner (industry level)	-0.0209^{**}	-0.0134^{*}
	(0.0090)	(0.0073)
Competition interactions		
*Capitalization * Lerner (firm level)*	-0.0114^{***}	-0.1744^{***}
	(0.0025)	(0.0092)
*Securitization * Lerner (firm level)*	0.1640^{**}	1.2876^{*}
	(0.0675)	(0.7268)
Constant	0.4592	2.6905^{***}
	(0.5533)	(0.5967)
No. of observations	495	495
R^2	0.519	0.066

Note: This table provides the estimated results of Model (2). Systemic risk is measured by bank-specific *beta* (Column (1)) and *EDF* (Column (2)), respectively. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 8: Estimated results using alternative measurement of competition at the country level

Variable	***Systemic risk***	***Systemic risk***
	(1)	(2)
Lerner (firm level)	2.1774^{***}	2.1091^{***}
	(0.3994)	(0.7182)
Securitization	0.2019^{**}	-0.5564^{***}
	(0.0936)	(0.1771)
Capitalization	-0.0822^{***}	-0.0654^{*}
	(0.0094)	(0.0389)
Size	1.1842^{***}	0.6331^{***}
	(0.0708)	(0.0806)
Excessive loan growth	0.0960	0.2706^{*}
	(0.0816)	(0.1502)
Deposit funding	-0.0293^{**}	-0.0302^{*}
	(0.0116)	(0.0159)
Macro-Economic variables		
BLS	-0.0628^{***}	-0.0209^{**}
	(0.0025)	(0.0090)
Competition interactions		
*Capitalization * Lerner (firm level)*		-0.0556^{***}
		(0.0094)
*Securitization * Lerner(firm level)*		0.5176^{***}
		(0.1619)
Constant	-11.1850^{***}	-5.3942^{***}
	(0.6131)	(1.4620)
No. of observations	495	495
R^2	0.454	0.404

Note: This table provides the estimated results of Model (1) and Model (2). Systemic risk is measured by the *MES*. The results use the answers in Bank Lending Surveys (*BLS*) from each country to the question of whether banks report a tightening (or loosening) of credit conditions due to competition during the pre-crisis period as the measurement of competition. Column (1) reports the estimated results of Model (1). Columns (2) introduces the interaction terms of securitization and capitalization with bank-specific market power and provides the estimated results of Model (2). The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 9: Estimated results for banks involved/ not involved in Merger and Acquisition in the pre-crisis period

	MandA Involved	*MandA Non-involved*	*MandA Involved*	*MandA Non-involved*
Variable	*Systemic risk*	*Systemic risk*	*Systemic risk*	*Systemic risk*
	(1)	(2)	(3)	(4)
Lerner (firm level)	2.8102**	0.9581***	2.8652**	1.3552***
	(1.2811)	(0.3032)	(1.3086)	(0.4979)
Securitization	−0.6626**	−0.6971**	−0.7273**	−0.7458***
	(0.2654)	(0.2709)	(0.2852)	(0.2547)
Capitalization	−0.0671**	−0.0314**	−0.1610**	−0.0277*
	(0.0282)	(0.0152)	(0.0679)	(0.0151)
Size	0.5449	0.7511***	0.7583**	0.7992***
	(0.3731)	(0.1276)	(0.3425)	(0.1014)
Excessive loan growth	-0.0004	0.3679***	-0.1212	0.3063***
	(0.4507)	(0.0430)	(0.4291)	(0.0482)
Deposit funding	0.0036	−0.0782***	0.0130	−0.0728***
	(0.0146)	(0.0113)	(0.0142)	(0.0112)
Macro-Economic variables				
Lerner (industry level)	−0.1071**	−0.0977***	−0.0909**	−0.0888***
	(0.0446)	(0.0261)	(0.0406)	(0.0264)
Competition interactions				
*Capitalization * Lerner (firm level)*			−0.1225***	−0.0898***
			(0.0267)	(0.0196)
*Securitization * Lerner (firm level)*			1.2758***	0.3801**
			(0.3777)	(0.1802)
Constant	6.0070*	3.0903	3.9195	1.9840
	(3.3494)	(1.9118)	(2.8390)	(2.0543)
No. of observations	193	302	193	302
R^2	0.363	0.385	0.440	0.390

Note: This table provides the estimated results of Model (1) and Model (2) for banks involved in Merger and Acquisition (Columns (1) and (3)) and those not involved (Columns (2) and (4)) in the pre-crisis period. Systemic risk is measured by the *MES*. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. Robust standard errors are in parentheses. The definition of variables can be found in Table 1. The information regarding Merger and Acquisition is gathered from the Thomson Reuters - SDC Platinum database.

Table 10: Estimated results for U.S. banks in the sample

Variable	*MES*	*Bank-specific beta*	*EDF*	*MES*	*Bank-specific beta*	*EDF*
	(1)	(2)	(3)	(4)	(5)	(6)
Lerner (firm level)	2.9766*	0.6389*	2.9752***	2.8090**	0.5733**	2.5936**
	(1.7860)	(0.3349)	(0.6470)	(1.3535)	(0.2632)	(1.1968)
Securitization	−0.6453**	−0.4358**	−0.3544**	−0.5715***	−0.6611***	−0.6226*
	(0.2828)	(0.2154)	(0.1674)	(0.1626)	(0.0823)	(0.3573)
Capitalization	−0.0478**	−0.0237**	−0.0586**	−0.0205*	−0.0154*	−0.0808***
	(0.0232)	(0.0092)	(0.0241)	(0.0122)	(0.0088)	(0.0204)
Size	1.1379***	0.3182***	0.1738	0.9907***	0.2184***	0.2185
	(0.1954)	(0.0499)	(0.1755)	(0.1357)	(0.0438)	(0.1648)
Excessive loan growth	0.2352*	0.0857**	0.2581*	0.2756***	0.1190***	0.3984***
	(0.1388)	(0.0387)	(0.1440)	(0.0907)	(0.0252)	(0.1380)
Deposit funding	−0.0503**	−0.0517***	−0.0522**	−0.0525***	−0.0578**	-0.0187
	(0.0234)	(0.0152)	(0.0209)	(0.0154)	(0.0239)	(0.0191)
Competition interactions						
*Capitalization * Lerner (firm level)*				−0.0458**	−0.0296***	−0.1219***
				(0.0203)	(0.0079)	(0.0336)
*Securitization * Lerner (firm level)*				0.2922**	0.3377***	0.5737*
				(0.1181)	(0.0133)	(0.3101)
Constant	−7.4066***	−2.3678***	0.7044	−6.7387***	−1.8564***	-0.0723
	(1.3144)	(0.2893)	(0.9154)	(1.0551)	(0.3390)	(0.9450)
No. of observations	370					
R^2	0.423	0.621	0.125	0.411	0.580	0.148

Note: This table provides the estimated results of Model (1) (Columns (1)-(3)) and Model (2) (Columns (4)-(6)) for U.S banks. Columns (1)-(3) shows the effect of bank balance sheet variables and *Lerner (firm level)*. Columns (4)-(6) introduce the interaction terms of securitization and capitalization with bank-specific market power. Systemic risk is measured by the *MES* in Columns (1) and (3), by *bank-specific beta* in Columns (2) and (4), and by *EDF* in Columns (3) and (6). The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 11: Estimated results with additional bank-specific control variables during the pre-crisis period

Variable	*Systemic risk*	*Systemic risk*	*Systemic risk*	*Systemic risk*
	(1)	(2)	(3)	(4)
Lerner (firm level)	2.2937***	1.6754***	1.9724***	2.0682***
	(0.8283)	(0.5989)	(0.4850)	(0.7229)
Securitization	−0.9080***	−0.8427***	−0.7347***	−1.3577***
	(0.1341)	(0.1748)	(0.2183)	(0.3393)
Capitalization	−0.0110**	−0.1552**	−0.1063*	−0.0594*
	(0.0056)	(0.0627)	(0.0587)	(0.0357)
Size	0.6407***	0.6816***	0.7379***	0.8626***
	(0.1525)	(0.1057)	(0.1196)	(0.1246)
Excessive loan growth	0.2276	0.2176	0.1371	0.1736*
	(0.1998)	(0.1647)	(0.1864)	(0.0948)
Deposit funding	−0.0332**	−0.0319*	−0.0308**	−0.0348***
	(0.0153)	(0.0179)	(0.0149)	(0.0106)
Additional bank variables				
Non-Interest Income	-0.0018			
	(0.0056)			
Other earning assets ratio		-0.0087	-0.0045	-0.0042
		(0.0057)	(0.0048)	(0.0044)
Profitability			0.6541***	0.3964***
			(0.1092)	(0.1363)
Asset quality				0.5517***
				(0.0728)
Macro-Economic variables				
Lerner (industry level)	−0.0910***	−0.0789**	−0.0949***	−0.0912**
	(0.0250)	(0.0333)	(0.0268)	(0.0397)
Competition interactions				
*Capitalization * Lerner (firm level)*	−0.2545***	−0.0399***	−0.0601***	−0.0798***
	(0.0310)	(0.0151)	(0.0122)	(0.0160)
*Securitization * Lerner (firm level)*	0.7562***	0.8039**	0.7150***	0.4965***
	(0.1992)	(0.2025)	(0.1985)	(0.1646)
Constant	3.1293**	2.2087	2.7157	1.1761
	(1.5296)	(2.4027)	(1.9477)	(3.2193)
No. of observations	495	495	495	495
R^2	0.449	0.396	0.409	0.447

Note: This table provides the estimated results of Model (2), with additional bank-specific control variables in the pre-crisis period. Systemic risk is measured by the *MES*. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 12: Estimated results for mortgage backed securitization

Variable	***Systemic risk***	***Systemic risk***
	(1)	(2)
Lerner (firm level)	2.7997^{***}	2.7071^{**}
	(0.9072)	(1.2171)
Mortgage backed securitization	-0.0236^{**}	-0.0234^{*}
	(0.0115)	(0.0127)
Capitalization	-0.1572^{***}	-0.1341^{***}
	(0.0569)	(0.0483)
Size	0.6275^{***}	0.5672^{***}
	(0.1130)	(0.1261)
Real Estate loan growth	0.2355	0.2870
	(0.1995)	(0.1957)
Deposit funding	-0.0415^{**}	-0.0432^{**}
	(0.0199)	(0.0183)
Macro-Economic variables		
Lerner (industry level)	-0.0768^{**}	-0.0896^{**}
	(0.0351)	(0.0380)
Competition interactions		
*Capitalization*Lerner*	-0.0499^{***}	-0.0440^{***}
	(0.0102)	(0.0170)
*Mortgage backed securitization * Lerner*	0.3615	-0.0398^{***}
	(0.3953)	(0.0151)
*Mortgage backed securitization * Lerner * Housing bubble*		0.4253^{***}
		(0.1591)
Constant	1.3667	2.6486
	(2.5053)	(2.4747)
No. of observations	495	495
R^2	0.387	0.384

Note: The table contains the estimated results of Model (2) for mortgage backed securitization only. Systemic risk is measured by the *MES*. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.

Table 13: Estimated results for non-mortgage backed securitization

Variable	***Systemic risk***	***Systemic risk***
	(1)	(2)
Lerner (firm level)	1.4151***	2.0794***
	(0.5026)	(0.6277)
Non-mortgage backed securitization	−0.9062***	−0.8381***
	(0.2710)	(0.2319)
Capitalization	−0.1162**	−0.1467**
	(0.0548)	(0.0577)
Size	0.4540***	0.6151***
	(0.1725)	(0.0953)
Excessive loan growth	0.4128**	0.2670
	(0.1622)	(0.1710)
Deposit funding	−0.0336*	−0.0385**
	(0.0178)	(0.0153)
Macro-Economic variables		
Lerner (industry level)	−0.1041***	−0.0940***
	(0.0241)	(0.0309)
Competition interactions		
*Capitalization * Lerner (firm level)*		−0.0561***
		(0.0074)
*Non-mortgage backed securitization * Lerner (firm level)*		0.5259**
		(0.2246)
Constant	4.2287**	3.2142
	(2.1574)	(2.1400)
No. of observations	495	495
R^2	0.384	0.396

Note: The table contains the estimated results of Model 1 (Column (1)) and Model 2 (Column (2)) for non-mortgage backed securitization only. Systemic risk is measured by the *MES*. The dependent variable is calculated during the crisis period (2007Q4 to 2009Q4). Regressors are calculated as averages of quarterly data for individual banks during the pre-crisis period (2003Q4 to 2007Q3) unless otherwise indicated. Robust standard errors are in parentheses. *, ** and *** indicate statistical significance at the 10percent, 5percent and 1percent levels, respectively. The definition of variables can be found in Table 1.