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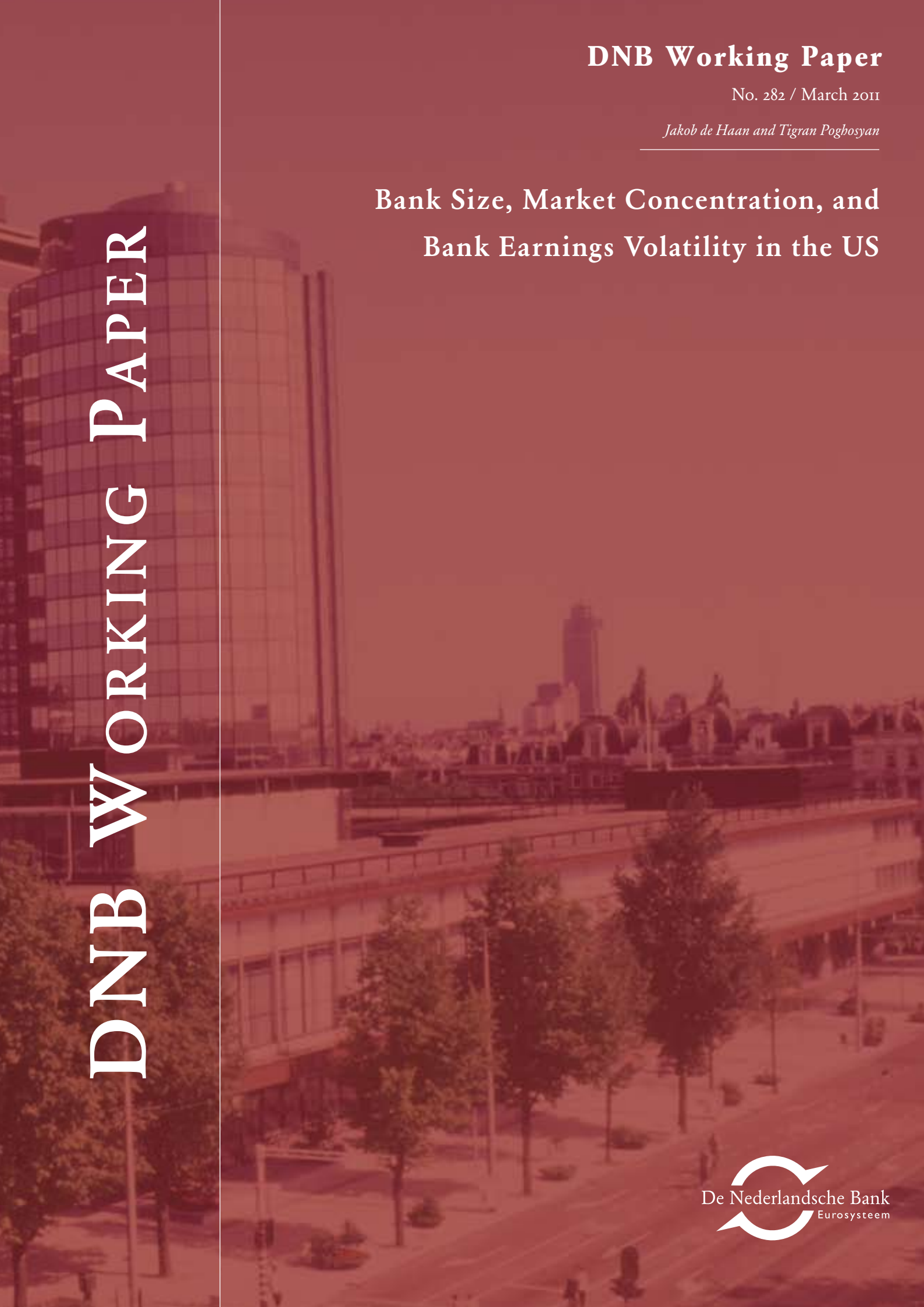

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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Bank Size, Market Concentration, and Bank Earnings Volatility in the US

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Abstract

We examine whether bank earnings volatility depends on bank size and the degree of concentration in the banking sector. Using quarterly data for non-investment banks in the United States for the period 2004Q1-2009Q4 and controlling for the quality of management, leverage, and diversification, we find that bank size reduces return volatility. The negative impact of bank size on bank earnings volatility decreases (in absolute terms) with market concentration. We also find that larger banks located in concentrated markets have experienced higher volatility during the recent financial crisis.

JEL Classifications: *G21, G32, L25*

Keywords: *Bank Earnings Volatility, Bank Size, Market Concentration, Financial Crises*

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1. Introduction

The global financial crisis has sparkled an intense debate about the structure of the banking industry in which several economists and policymakers pose that many banks have grown too big and that the banking system has become too concentrated. For instance, Buiter (2009) argues:

> "The real issue is size. … A complex but small business is no threat to systemic stability; neither is a highly international but small business. Size is the core of the problem; the other dimensions (interconnectedness, complexity and international linkages) only matter (and indeed worsen the instability problem) if the institution in question is big. ….Large banks can be broken up in a variety of ways (vertically, that is, by activities or products) or horizontally, that is, by splitting a given activity or the supply of a given product of service among several independent legal entities. The crisis and contraction are delivering the opposite outcome. There are fewer banks and market concentration is increasing everywhere."[1]

However, critics of proposals to break up banks have pointed out that the presence of many small banks is no guarantee that crises do not occur as the Savings and Loans crisis in the U.S. has shown. If many small banks behave very similar and therefore get into financial distress at the same time, together they may also be too important to fail. Furthermore, large banks may be more stable than small banks thereby contributing to financial stability. The present paper addresses the latter argument.

Although it is often implicitly assumed that small and large banks behave differently, there is only limited evidence available on differences in behavior of small and large banks (see section 2 for a further discussion). We address the following questions: (i) does bank size affect earnings volatility? (ii) does market concentration affect earnings volatility? (iii) is the effect of bank size on bank earnings volatility conditioned by the degree of concentration in the banking sector?

The reason for focusing on earnings volatility is that more volatile earnings may lead to uncertainty about the level of equity capital and can result in a deterioration of banks' soundness (Couto, 2002). Previous studies (e.g., Albertazzi

[1] The number of banks operating in the U.S. has declined sharply since 1990, primarily due to mergers and acquisitions. A key factor driving these structural changes was deregulation allowing banks to establish branch networks that span numerous local areas within a state and, in some cases, across state lines and throughout the U.S. However, Hannan and Prager (2009) point out that this has not resulted in any notable increase in the concentration of local banking markets. The average Herfindahl–Hirschman index (HHI) actually declined for both metropolitan statistical areas and rural counties between 1990 and 2007.

and Gamabacorta, 2009) suggest that excess volatility in bank earnings can result in unstable capital structures.

Our approach is to examine whether size and market concentration affect earnings volatility, controlling for reasons that banks may have differences in earnings volatility. First, there may be differences in bank efficiency that may be related to bank size. We use the ratio of bank total non-interest costs to total non-interest revenues to proxy the efficiency of bank operations (Shezhad et al., 2010). In addition, large banks may be more diversified than small banks (Stever, 2007). To control for this, we follow Stiroh (2004) and include the share of non-interest income in total income of banks as explanatory variable. Large banks may also be 'too big to fail' and therefore may be inclined to take more risks. We control for this by including leverage. Also market concentration is a potentially important determinant of profitability (Berger et al., 2005; Beck et al., 2006). We therefore also investigate whether banks' earnings volatility is affected by market concentration, both directly and indirectly, by a possible conditioning effect of size on volatility.

Using quarterly data on all commercial, savings, and cooperative banks in the United States for the period 2004Q1-2009Q4, we find that that bank size decreases return volatility. The negative impact of bank size on bank earnings volatility reduces when market concentration rises.

Finally, we analyze whether the recent financial crisis has affected the relationship between bank size, market concentration, and earnings volatility.[2] We find that larger banks located in more concentrated markets have experienced higher volatility during the crisis than before the crisis, but had still lower earnings volatility than small banks.

The paper is structured as follows. Section 2 offers a selective review of the literature on the relationship between bank performance, bank size, and market concentration and outlines how our paper is related to previous studies. Section 3 develops the model, while Section 4 describes the data. Section 5 presents the main empirical results. Section 6 offers a sensitivity analysis. Section 7 concludes.

[2] Afonso et al. (2010) report that in the immediate aftermath of Lehman's bankruptcy there were sharp differences between large and small banks in their access to interbank credit: large banks show reduced amounts of daily borrowing after Lehman and borrowed from fewer counterparties. In contrast, smaller banks were able to increase the amount borrowed from the interbank market and even managed to add lending counterparties during the crisis.

2. Literature review

Why are big banks different from small banks? According to DeYoung et al. (2004), deregulation and technological change have transformed the U.S. banking industry into two primary size-based groups. The first group consists of large banking institutions, characterized by the use of ‘‘hard’’ information, impersonal relationships, low unit costs, and standardized loans, while the second group is made up of small banks, characterized by the use of ‘‘soft’’ information, relationship development, higher unit costs, and non-standardized loans. Small banks are a primary source of financing for small business firms, which are an important engine of economic growth. Controlling for market concentration and a variety of other factors that might influence yields, Carter and McNulty (2005) find an inverse relationship between bank size and the net return on small business lending, suggesting that smaller banks are better at making these types of loans. Berger et al. (2005) report similar results. Using the Federal Reserve's 1993 National Survey of Small Business Finance (NSSBF), which covers the financing practices of a stratified random sample of firms, they find that small banks have superior ability to allocate capital to risky borrowers; small banks are better in collecting and acting on 'soft' information. According to Berger et al. (2005), large banks are less willing to lend to firms on which they have limited information. On the other hand, Stever (2007) argues that small banks are riskier because of their limited ability to diversify. His data refer to U.S. bank holding companies between 1986-2003. Stever (2007) reports that small banks have fewer opportunities to diversify, which forces them to either pick borrowers whose assets have relatively low credit risk or to make loans that are backed by more collateral. This lower diversification, in turn, may result in higher earnings volatility.

However, scant empirical evidence suggests otherwise (Stiroh, 2006b). De Young and Roland (2001) report that fee-based activities are associated with increased earnings volatility. Likewise, Stiroh (2004) finds that a greater reliance on non-interest income is associated with more volatile returns. According to De Young and Roland (2001), this volatility reflects the low switching cost of fee-based activities compared to relationship lending, higher operating leverage due to greater reliance on fixed inputs like labor, and higher financial leverage due to low capital requirements. Finally, Stiroh (2006b) shows that activities that generate non-interest income make returns more volatile. As pointed out by Stiroh (2006a), the intuition is that a shift into new activities affects the portfolio variance by changing the weights

on the components and by introducing a diversifying covariance. Apparently, the higher weight on relatively volatile non-interest activities outweighs the diversification benefits.

Our paper differs from previous studies like those of Carter and McNulty (2005), Berger et al. (2005) and Stever (2007) as we focus on the relationship between bank size and total earnings volatility, irrespective of the borrower.

A paper that comes close to ours is Fayman (2009). Using similar data as the current paper, Fayman (2009) reports that there are some notable differences between factors that affect the profitability of large and small banks. For example, large banks rely on non-interest related sources of profitability, while small banks are more significantly impacted by levels of default risk. In contrast to Fayman, we do not classify banks in two categories but include size as explanatory variable in our model for profit variability. Furthermore, we do not focus on the level of earnings, but on earnings volatility.

Previously, Boyd and Runkle (1993) have analyzed the relationship between bank size and earnings volatility.[3] They report an inverse and significant relationship between size and the standard deviation of the rate of return on assets (ROA) using data for 122 U.S. banking holding companies over the period 1971-1990. However, their sample is restricted to firms that are large by industry standards and whose shares are listed and actively traded, while we use data on all commercial, savings, and cooperative banks in the United States for the period Q1.2004-Q4.2009. In contrast to the results of Boyd and Runkle (1993), Stiroh (2004) reports that the standard deviation of the return on equity (ROE) is not related to bank size.

Finally, some papers have analyzed how market concentration affects bank profitability and fragility. As pointed out by Beck et al. (2006), there are contrasting theoretical views concerning the impact of concentration on the fragility of the banking sector. Two arguments have been put forward in support of the view that concentration will reduce fragility.[4] First, concentrated banking systems may enhance market power and boost bank profits (Porter, 1979). As high profits provide a ‘‘buffer’’ against adverse shocks and increase the charter or franchise value of the bank, thereby diminishing incentives for bank owners and managers to take excessive

[3] Stiroh (2004) also reports that the standard deviation of the return on equity (ROE) is not related to bank size.
[4] This part of the paper heavily draws on Beck et al. (2006).

risk, they reduce banking sector fragility. Second, it is probably easier to monitor a few banks in a concentrated banking system than it is to monitor many banks in a diffuse banking system. Consequently, supervision of banks will be more effective and fragility will be less pronounced in a concentrated banking system.

In contrast, some authors argue that a more concentrated banking structure enhances bank fragility. First, according to Boyd and De Nicolo (2005) the argument that market power in banking boosts profits ignores the potential impact of banks' market power on firm behavior. Due to the higher interest rates that banks can charge due to their market power, firms are induced to assume greater risk, which, in turn, may lead to more bank fragility. Second, advocates of the ‘‘concentration–fragility’’ view argue that as there are fewer banks in concentrated systems, they will be ‘‘too important to fail’’. Due to (implicit) government guarantees, banks in concentrated systems have an incentive to assume greater risk which increases banking system fragility.

Most empirical evidence lends support to the view that concentration increases banking sector fragility. The analysis of De Nicolo et al. (2004), which is based on data for some 100 banks over the period 1993-2000 and z-scores as proxy for riskiness, suggests that more concentrated banking sectors are more fragile. Boyd and De Nicolo (2005) report that in concentrated markets banks have an incentive to become more risky, which, in turn, may lead to higher earnings variability notably so during a financial crisis. Beck et al. (2006) examine the impact of concentration and regulation on the likelihood of a systemic banking crisis. Using data for 69 countries from 1980 to 1997, these authors find that crises are less likely in economies with more concentrated banking systems even after controlling for differences in commercial bank regulatory policies, national institutions affecting competition, macroeconomic conditions, and shocks to the economy. Likewise, Schaeck et al. (2009) report that concentration decreases the probability of a systematic crisis. Their analysis is based on 31 systemic banking crises in 45 countries.

Recently, Hannan and Prager (2009) have estimated profit models for small banks operating in only one U.S. market, distinguishing between rural and urban banking markets. The authors find that effect of size differs across both markets. Whereas the estimated coefficient of size is negative and highly significant in the equation explaining ROA in rural markets, it is positive and significant in the equation explaining ROA in urban markets. Also the effect of concentration differs.

In contrast to rural markets, in urban markets there is no significant relationship between market concentration and small single-market bank profits. Different from Hannan and Prager (2009), the present paper includes all banks in the analysis and uses states as geographical units. Unlike the country-level measure, the state-level measure of market concentration better captures regional concentration of U.S. bank operations. As highlighted in Meyer and Yeager (2001), despite the legislation removing restrictions on interstate banking in mid-1990s (i.e., the Riegle-Neal Banking and Branching Efficiency Act of 1994), the vast majority of the U.S. banks still remain small and geographically concentrated. They successfully compete with large banks in small-business lending, where they have a comparative advantage in acquiring and monitoring soft information from local clients. According to Yeager (2004), 61 percent of all U.S. banks have operated within a county in 2001, which is even smaller geographical entity than a state.

3. Model specification

The dependent variable is bank earnings volatility. It is proxied by the variation in banks' return on assets (ROA). As a robustness check, we also employ the variation in return on equity (ROE) as a proxy for earnings volatility. Earnings volatility for bank *i* is defined as the standard deviation of its ROA (ROE) calculated over the last four quarters. As a robustness check, we also take the standard deviation of ROA (ROE) over the last eight quarters to calculate volatility.

Arithmetically, the earnings volatility for bank *i* in state *s* in year *t* can be expressed as:

$$Volatility_{i,s,t} = \sqrt{\frac{1}{T+1}(\sum_{t=1}^{t-T}(ROA_{i,s,t} - \frac{1}{T+1}\sum_{t=1}^{t-T} ROA_{i,s,t}))^2}, \quad (1)$$
$$T = (4,8)$$

where *i*, *s*, and *t* indices denote bank, state, and time, respectively. The model specification is as follows:

$$Volatility_{i,s,t} = \alpha_{i,s,t} + \beta_1 Concentration_{s,t} + \beta_2 Size_{i,s,t} + \beta_3 Concentration_{s,t} * Size_{i,s,t} + \gamma_1 X_{s,t} + \varepsilon_{i,s,t} \quad (2)$$

where *Concentration* is our proxy for bank concentration in state *s* in year *t*; *Size* indicates a proxy for bank size of bank *i* in state *s* at time *t*; *X* is a vector of bank-

specific control variables. The interaction of concentration and size is included to examine whether concentration conditions the impact of size. The model also includes a vector of state fixed effects to control for state-specific macroeconomic developments and a vector of time fixed effects to control for systemic factors affecting all banks simultaneously (like the level of interest rates).

Our modeling approach is as follows: We control for the various reasons put forward in the literature why the earnings volatility of big and small banks may be different and then we test whether size still plays a role in explaining earnings volatility. First, we control for efficiency as bigger banks may have better management and therefore be more efficient. Following previous studies (see, e.g., Poghosyan and De Haan, 2010; Shezhad et al., 2010), we use the ratio of bank total non-interest costs to total non-interest revenues to proxy the efficiency of bank operations, where a higher ratio implies less efficiency. Second, big banks may take more risks because they know that they will be rescued if they get into financial troubles ('too big too fail'). According to Boyd and Runkle (1993), regulatory treatment of banks is asymmetric by size. Larger banks typically enjoy an implicit government guarantee that stems from their systemic importance. As a result, they are better shielded against external shocks and can expand their leverage above prudential limits. To control for this, we include the banks' leverage. Finally, big banks may have better opportunities to diversify than small banks. According to Stever (2007), small banks have fewer opportunities to diversify forcing them to either pick borrowers whose assets have relatively low credit risk or to make loans that are backed by more collateral. This lower diversification may result in higher earnings volatility. On the other hand, as discussed in the previous section, most previous studies suggest that a lower share of non-interest income in total revenues, which is our measure for diversification, decreases earnings volatility.

Brambor et al. (2006) argue that in interactive models with multiplicative terms simple t-statistics do not provide substantial information and should be complemented by inference based on the significance of marginal effects. More specifically, one needs to take the derivative of the model with respect to the variable of interest (in our case: concentration) and evaluate the significance of its effect using a function of standard errors of individual coefficients. The significance of the variables of interest is determined using confidence intervals based on Aiken and West (1991) standard errors.

4. Data description and analysis

Bank balance sheet and income statement data are taken from the Reports on Condition and Income (the "Call Report") collected by federal bank regulators. We use quarterly data on all commercial, savings, and cooperative banks in the United States for the period 2004.Q1-2009.Q4. Table A1 in the appendix shows the distribution of banks across states.

We use the following regressors:

- *Bank size*. We use a relative measure of bank size. It is calculated as the number of standard deviations the log total assets of bank *i* located in state *s* at time period *t* deviates from the mean log assets of all banks located in state *s* at time *t*.
- *Market concentration*. We use the Herfindahl-Hirshman index of market concentration (ranging from 0 to 10,000) to measure market concentration at the state level in period *t*. The index is calculated using bank total assets as inputs.
- *Cost-to-income ratio*. Following previous studies (see, e.g., Poghosyan and De Haan, 2010), we use the ratio of bank total non-interest costs to total non-interest revenues to proxy the efficiency of bank operations, where a higher ratio implies less efficiency.
- *Leverage*. Leverage is calculated as the ratio of bank total assets to total equity.
- *Diversification.* Following Stiroh (2004), we include the share of non-interest income in total income of banks to control for diversification.
- *Bank type*. We introduce dummy variables to distinguish between three types of banks in our sample: commercial, savings, and cooperative. Investment banks are not included in our sample.
- *Time and state fixed effects*. We augment the model by state and time specific fixed effects to account for the impact of macroeconomic developments on bank return volatility.

Table 1 provides summary statistics of our dependent and main explanatory variables. Table A2 in the appendix provides the definition of all variables, the data sources, and the expected sign of the explanatory variables, while Table A3 shows the correlation

matrix. The low correlation of the explanatory variables suggests that multicollinearity is not a problem in our estimations.

Table 1 here

5. Results

The estimations are performed using the fixed effects panel estimator, which was found to be superior to the random effects estimator based on the Hausman test. Table 2 shows the main results. Columns (1) and (2) refer to ROE volatility measured over a four-quarters and eight-quarters period, respectively, while columns (3) and (4) measure ROA volatility over a four-quarters and eight-quarter period, respectively.

Table 2 here

Our findings can be summarized as follows. First, relative bank size has a negative effect on return volatility.[5] This result is in contrast to the findings of Stiroh (2004), but confirms the results of Boyd and Runkle (1993). In section 6 we will analyze whether this relationship is different before and during the recent financial crisis. We will also examine whether our findings are robust if we use absolute instead of relative size.

Second, the coefficient of market concentration is generally insignificant. This finding does not provide support for the "concentration-fragility" view (Boyd and De Nicolo, 2005), according to which a high level of concentration makes banking systems riskier. However, as will be explained below, a proper analysis of the influence of concentration requires that interaction effects be taken into account.

Third, higher leveraged banks face higher return volatility. This finding signifies the importance of regulating bank capital (Basel II) as a safeguard against excessive risk taking. Fourth, banks with a relatively higher ratio of costs to income face higher return volatility. This finding suggests that less efficient banks are more vulnerable to risk. Finally, banks having a higher share of non-interest revenues in total revenues have higher volatile earnings. This finding is in line with the results of previous studies.

[5] This result remains if we exclude very large banks (total assets more than 1 billion $) from the sample. Results are available on request.

The above discussion was based on simple t-statistics describing the significance of individual variables in explaining return volatility. For a more precise analysis, we follow Brambor et al. (2006) and show the impact of size on return volatility, conditional on market concentration. Figure 1 shows the impact of bank size on earnings volatility conditional on market concentration. The graphs on the upper panel display the marginal effect of bank size at different levels of market concentration measuring ROE volatility over four and eight quarters, respectively, while the graphs on the lower panel display the marginal effect of bank size at different levels of market concentration measuring ROA volatility over four and eight quarters, respectively. The dashed lines present the 95 percent confidence intervals.

Figure 1 here

Figure 1 suggests that the negative impact of bank size on bank earnings volatility decreases (in absolute terms) with market concentration.

6. Sensitivity analysis

6.1 Alternative size variable

As a first sensitivity check we use the logarithm of total assets to measure of bank size. The estimation results reported in Table 3 confirm that our results are robust to this alternative definition of bank size. The impact of bank size remains negative and significant across different specifications. The impact of other variables is also very similar compared to the results reported in Table 2.

Table 3 here

6.2 Attrition

Some banks drop out of our sample due to M&A or failure. In order to check whether attrition affects our result, we have re-estimated Table 2, restricting the sample to only those banks that are present throughout the whole sample period. As a result, the number of banks drops to about 5,4000. The estimation results as reported in Table 4 suggest that our findings are robust to the attrition effect.

Table 4 here

6.3 The impact of the crisis

We examine whether the financial crisis has affected our findings. Our *crisis* variable is measured as a dummy that takes the value of one after the collapse of Lehman Brothers in September 2008 and is zero otherwise.[6] To identify the individual and collective impact of bank size, market concentration, and the financial crisis on earnings volatility, we introduce interaction terms with these variables:

$$\begin{aligned} Volatility_{i,s,t} = {} & \alpha_{i,s,t} + \beta_1 Crisis_t + \beta_2 Concentration_{s,t} + \beta_3 Size_{i,s,t} + \\ & \beta_4 Crisis_t * Size_{i,s,t} + \beta_5 Crisis_t * Concentration_{s,t} + \beta_6 Size_{i,s,t} * Concentration_{s,t} + \\ & \beta_7 Crisis_t * Size_{i,s,t} * Concentration_{s,t} + \gamma_1 X_{s,t} + \varepsilon_{i,s,t} \end{aligned} \quad (3)$$

Table 5 shows that the global financial crisis has significantly increased the return volatility of banks. The crisis hit larger banks more seriously than small banks as shown by the positive interaction term size-crisis. For the case of ROA, the impact of the crisis was higher in more concentrated markets, but the magnitude is relatively low (positive interaction term concentration-crisis). All in all, larger banks located in more concentrated markets have experienced higher volatility during the crisis (positive interaction term concentration-size-crisis), but again, the impact is relatively small.

Table 5 here

Figure 2 shows the impact of size conditional on market concentration before and during the crisis. The first part of the figure shows the marginal effect of bank size at different levels of market concentration before the crisis and the second part of the figure shows the marginal effect of bank size at different levels of market concentration during the crisis. The graphs in Figure 2 show that smaller banks face higher earnings volatility during the financial crisis, since both upper and lower lines of the confidence interval are negative (except for very high levels of market concentration and the ROE measure of earnings volatility). Moreover, the confidence

[6] We have also applied August 2007 as the starting point of the crisis; the results (available on request) were similar to those reported in the paper.

bands in the crisis period are much tighter than in the pre-crisis period, suggesting that the relationship between bank size and market concentration has become more pronounced during the crisis.

Figure 2 here

6.4 Using the Sharpe ratio

We have also redone Table 2 using the Sharp ratio (calculated as the ratio of ROA (ROE) to their four- and eight-quarter rolling standard deviation) as dependent variable. The reason is that, so far, we have neglected the well-known relationship between risk and return. Table 6 shows the results. Since bank earnings variability appears in the denominator of the Sharp ratio, one would expect that coefficients would revert signs. Table 6 shows that this is indeed the case for most coefficients. We find that larger banks earn higher return per unit of volatility, less efficient banks exhibit lower return-volatility ratio, and banks having a higher share of non-interest revenues in total revenues have a lower Sharp ratio. The concentration-size interaction term also reverses sign, suggesting that the marginal effect of bank size on return-volatility ratio is declining with the increase in market concentration, which could be due to the positive impact of market concentration on return volatility reported above. The only significant coefficient that does not change sign is leverage. This implies that even though more leveraged banks have more volatile earnings, the increase in earnings driven by expanding leverage more than offsets the increase in their volatility, resulting in an increasing return-volatility ratio.

Table 6 here

6.5 Using the Z-score

Finally, we have redone Table 2 using the Z-score (calculated as the sum of the average ROA and the average equity to assets ratio divided by the standard deviation of ROA) as dependent variable. The Z-score, originally proposed by Boyd and Runkle (1993), measures the number of standard deviations a return realization has to fall in order to deplete equity, under the assumption of normality of bank returns. Thus, a higher Z-score implies a lower likelihood of bank insolvency, since a bank's distance from default lengthens.

Table 7 shows that larger banks are less risky, in line with our earlier finding that larger banks incur lower earnings volatility. In addition, we find that the riskiness of larger banks increases with higher market concentration (negative interaction term of size and market concentration), which is also in line with our previous results. Finally, as expected, we find that less efficient banks and banks earning a higher share of income from non-traditional activities (fee income, securities trading, etc) are also riskier. Taken together, these results confirm our earlier findings.

Table 7 here

7. Conclusions

The global financial crisis has brought the issue of "too-big-to-fail" back on the agenda of policymakers. Against this background, this paper analyzes the relationship between bank size and earnings volatility in the U.S. banking industry for the period 2004Q1-2009Q4. Our approach is to examine whether size affects earnings volatility, controlling for reasons that banks may have differences in earnings volatility. For instance, differences in bank efficiency may be related to bank size. In addition, large banks may be more diversified than small banks. Large banks may also be 'too big to fail' and therefore may be inclined to take more risks. We control for this by including leverage. As market concentration has been found to affect profitability, we also investigate whether banks earnings volatility is affected by market concentration, both directly and indirectly, by a possible conditioning effect of size on volatility.

We find that larger banks have lower earnings volatility compared to smaller banks. This inverse relationship has become stronger during the recent financial crisis. Our main result is robust to different definitions of variables used in the estimations. The negative relationship between bank size and earnings volatility holds when ROA volatility is used as dependent variable instead of ROE volatility. Similarly, using absolute bank size (proxied by the logarithm of total assets) instead of relative bank size does not lead to qualitatively different results. The negative impact of bank size on bank earnings volatility reduces when market concentration rises.

Our results suggest that despite all the criticism on big banks, their stable earnings contribute to financial stability. Further analysis is therefore needed to decide whether trimming big banks will really enhance financial stability.

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Appendix

Table A1. Number of banks in each state			
State	*Number of Banks*	*Country*	*Number of Banks*
Alabama	161	Montana	80
Alaska	6	Nebraska	250
Arizona	65	Nevada	39
Arkansas	164	New Hampshire	27
California	311	New Jersey	113
Colorado	171	New Mexico	49
Connecticut	48	New York	171
Delaware	29	North Carolina	109
Dist of Columbia	6	North Dakota	99
Florida	321	Ohio	205
Georgia	368	Oklahoma	268
Hawaii	6	Oregon	41
Idaho	17	Pennsylvania	226
Illinois	709	Rhode Island	12
Indiana	144	South Carolina	88
Iowa	389	South Dakota	86
Kansas	357	Tennessee	203
Kentucky	212	Texas	700
Louisiana	143	Utah	38
Maine	29	Vermont	17
Maryland	72	Virginia	138
Massachusetts	175	Washington	102
Michigan	163	West Virginia	67
Minnesota	459	Wisconsin	286
Mississippi	96	Wyoming	67
Missouri	351	**Total**	**8453**

Table A2. Data sources and expected signs			
Variable	Definition	Expected Sign	Data Source
Dependent Variables			
ROA Volatility	4 or 8 quarter standard deviation of Return on Assets		Call Reports
ROE Volatility	4 or 8 quarter standard deviation of Return on Equity		Call Reports
Explanatory Variables			
Bank Size	The number of standard deviations above or below mean logarithmic bank size in a state	Negative/Positive	Call Reports
Market Concentration	Herfindahl index at state level based on bank assets	Negative/Positive	Call Reports
Cost/Income	Non-interest cost as a share in bank non-interest income	Positive	Call Reports
Leverage	Total Assets/ Equity Ratio	Negative	Call Reports
Diversification	Non-interest income as a share in total bank income	Negative/Positive	Call Reports
Savings Bank	Dummy which takes a value of 1 for savings banks and zero otherwise	Negative/Positive	Call Reports
Cooperative Bank	Dummy which takes a value of 1 for investment banks and zero otherwise	Negative/Positive	Call Reports
Commercial Bank	Dummy which takes a value of 1 for commercial banks and zero otherwise	Negative/Positive	Call Reports

Table A3. Correlation matrix

	ROA Volatility, 4q	*ROE Volatility, 4q*	*ROA Volatility, 8q*	*ROE Volatility, 8q*	*Bank Size*	*Bank Relative Size*	*Market Concentration*	*Cost/Income*	*Leverage*	*Diversification*
ROA Volatility, 4q	1.0000									
ROE Volatility, 4q	0.4798	1.0000								
ROA Volatility, 8q	0.6655	0.2996	1.0000							
ROE Volatility, 8q	0.3837	0.7501	0.4203	1.0000						
Bank Size	-0.0574	-0.0021	-0.0639	-0.0076	1.0000					
Bank Relative Size	-0.0718	-0.0129	-0.0784	-0.0192	0.8801	1.0000				
Market Concentration	0.0083	0.0006	0.0075	-0.0023	0.1245	-0.0093	1.0000			
Cost/Income	0.0170	0.0104	0.0203	0.0101	-0.0935	-0.1093	-0.0042	1.0000		
Leverage	-0.0221	0.0554	-0.0503	0.0519	0.2052	0.2263	-0.0067	-0.0234	1.0000	
Diversification	0.0047	-0.0034	-0.0003	-0.0039	0.1346	0.1361	-0.0140	0.1978	0.0659	1.0000

Table 1. Summary statistics					
Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*	*Observations*
ROA Volatility, 4 quarters *(Bank Level)*	0.0012	0.0021	0.0000	0.1111	138920
ROE Volatility, 4 quarters *(Bank Level)*	0.0120	0.0617	0.0000	11.6573	138920
ROA Volatility, 8 quarters *(Bank Level)*	0.0013	0.0025	0.0000	0.5233	136711
ROE Volatility, 8 quarters *(Bank Level)*	0.0132	0.0595	0.0004	8.2458	136711
ROA Sharp Ratio, 4 quarters *(Bank Level)*	6.1955	8.7265	-45.5309	738.5195	138920
ROE Sharp Ratio, 4 quarters *(Bank Level)*	6.2127	9.2941	-30.2030	1062.2300	138920
ROA Sharp Ratio, 8 quarters *(Bank Level)*	4.5495	4.5860	-11.6673	70.8598	136711
ROE Sharp Ratio, 8 quarters *(Bank Level)*	4.5066	4.5207	-18.6660	69.8662	136711
Z-Score, 4 quarters (*Bank Level*)	260.7251	319.1257	0.2482	21930.85	138920
Z-Score, 8 quarters (*Bank Level*)	185.4295	157.9898	0.2237	2319.648	136711
Bank Size *(Bank Level)*	11.8648	1.1962	8.6920	20.5204	139562
Bank Relative Size *(Bank Level)*	0.0163	0.8446	-1.9355	3.1531	139562
Market Concentration *(State level)*	1231.4	1433.0	75.7	9570.5	139562
Cost/Income *(Bank Level)*	2.1360	2.5243	0.6214	19.4138	139562
Leverage *(Bank Level)*	10.0418	2.5645	2.4204	17.7611	139562
Diversification *(Bank Level)*	0.0560	0.0475	0.0000	0.3240	139562

Table 2. Empirical results					
		ROE		ROA	
		[1]	[2]	[3]	[4]
		Four quarters	Eight quarters	Four quarters	Eight quarters
Size	Coefficient	-0.0181***	-0.0181***	-0.0013***	-0.0013***
	Standard Error (Robust)	(0.002)	(0.001)	(0.000)	(0.000)
Market concentration	Coefficient	-0.0007	0.0011	0.0001	0.0002*
	Standard Error (Robust)	(0.004)	(0.004)	(0.000)	(0.000)
Interaction: Concentration-Size	Coefficient	0.0179***	0.0160***	0.0007***	0.0007***
	Standard Error (Robust)	(0.005)	(0.004)	(0.000)	(0.000)
Cost to income ratio	Coefficient	0.0008***	0.0006***	0.0001***	0.0000***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	Coefficient	0.0050***	0.0038***	0.0002***	0.0001***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Diversification	Coefficient	0.0423***	0.0319***	0.0045***	0.0032***
	Standard Error (Robust)	(0.008)	(0.008)	(0.000)	(0.000)
Constant	Coefficient	-0.0321***	-0.0167**	-0.0004*	0.0002
	Standard Error (Robust)	(0.008)	(0.007)	(0.000)	(0.000)
Time fixed effects		Yes	Yes	Yes	Yes
State fixed effects		Yes	Yes	Yes	Yes
Bank type fixed effects		Yes	Yes	Yes	Yes
Number of Observations		138920	136711	138920	136711
Number of Banks		8408	8353	8408	8353
R-squared		0.017	0.015	0.065	0.063
*Notes: Estimations are performed using the fixed effects estimator. ***, **, and * denote significance at 10, 5, and 1 percent confidence levels, respectively.*					

Table 3. Robustness check: Alternative size variable					
		ROE		ROA	
		[1]	[2]	[3]	[4]
		Four quarters	Eight quarters	Four quarters	Eight quarters
Size	Coefficient	-0.0205***	-0.0214***	-0.0015***	-0.0015***
	Standard Error (Robust)	(0.001)	(0.001)	(0.000)	(0.000)
Market concentration	Coefficient	-0.0007	0.0009	0.0001	0.0002*
	Standard Error (Robust)	(0.004)	(0.004)	(0.000)	(0.000)
Interaction: Concentration-Size	Coefficient	0.0254***	0.0241***	0.0013***	0.0012***
	Standard Error (Robust)	(0.005)	(0.005)	(0.000)	(0.000)
Cost to income ratio	Coefficient	0.0007***	0.0005***	0.0001***	0.0000***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	Coefficient	0.0051***	0.0039***	0.0002***	0.0001***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Diversification	Coefficient	0.0382***	0.0276***	0.0042***	0.0029***
	Standard Error (Robust)	(0.009)	(0.008)	(0.000)	(0.000)
Constant	Coefficient	0.2048***	0.2313***	0.0166***	0.0171***
	Standard Error (Robust)	(0.018)	(0.016)	(0.001)	(0.000)
Time fixed effects		Yes	Yes	Yes	Yes
State fixed effects		Yes	Yes	Yes	Yes
Bank type fixed effects		Yes	Yes	Yes	Yes
Number of Observations		138920	136711	138920	136711
Number of Banks		8408	8353	8408	8353
R-squared		0.018	0.016	0.069	0.068
*Notes: Estimations are performed using the fixed effects estimator. ***, **, and * denote significance at 10, 5, and 1 percent confidence levels, respectively.*					

Table 4. Robustness check: controlling for attrition					
		ROE		ROA	
		[1]	[2]	[3]	[4]
		Four quarters	Eight quarters	Four quarters	Eight quarters
Size	Coefficient	-0.0155***	-0.0166***	-0.0008***	-0.0008***
	Standard Error (Robust)	(0.002)	(0.002)	(0.000)	(0.000)
Market concentration	Coefficient	0.0001	0.0031	0.0002	0.0003***
	Standard Error (Robust)	(0.006)	(0.005)	(0.000)	(0.000)
Interaction: Concentration-Size	Coefficient	0.0169**	0.0154**	0.0011***	0.0008***
	Standard Error (Robust)	(0.007)	(0.006)	(0.000)	(0.000)
Cost to income ratio	Coefficient	0.0009***	0.0005***	0.0001***	0.0001***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	Coefficient	0.0051***	0.0037***	0.0002***	0.0001***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Diversification	Coefficient	0.0420***	0.0324***	0.0043***	0.0035***
	Standard Error (Robust)	(0.012)	(0.010)	(0.000)	(0.000)
Constant	Coefficient	-0.0034	0.0230	0.0058***	0.0064***
	Standard Error (Robust)	(0.018)	(0.016)	(0.000)	(0.000)
Time fixed effects		Yes	Yes	Yes	Yes
State fixed effects		Yes	Yes	Yes	Yes
Bank type fixed effects		Yes	Yes	Yes	Yes
Number of Observations		101456	101456	101456	101456
Number of Banks		5282	5282	5282	5282
R-squared		0.011	0.011	0.062	0.076
*Notes: Estimations are performed using the fixed effects estimator. ***, **, and * denote significance at 10, 5, and 1 percent confidence levels, respectively.*					

Table 5. Robustness check: including financial crisis variable					
		ROE		ROA	
		[1]	[2]	[3]	[4]
		Four quarters	Eight quarters	Four quarters	Eight quarters
Size	Coefficient	-0.0210***	-0.0209***	-0.0015***	-0.0015***
	Standard Error (Robust)	(0.002)	(0.001)	(0.000)	(0.000)
Market concentration	Coefficient	-0.0014	0.0002	-0.0000	0.0000
	Standard Error (Robust)	(0.004)	(0.004)	(0.000)	(0.000)
Interaction: Concentration-Size	Coefficient	0.0143***	0.0114**	0.0004**	0.0003**
	Standard Error (Robust)	(0.005)	(0.005)	(0.000)	(0.000)
Cost to income ratio	Coefficient	0.0007***	0.0005***	0.0001***	0.0000***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	Coefficient	0.0051***	0.0039***	0.0002***	0.0001***
	Standard Error (Robust)	(0.000)	(0.000)	(0.000)	(0.000)
Diversification	Coefficient	0.0404***	0.0301***	0.0044***	0.0031***
	Standard Error (Robust)	(0.008)	(0.008)	(0.000)	(0.000)
Crisis	Coefficient	-0.0010	-0.0008	-0.0003***	-0.0002***
	Standard Error (Robust)	(0.002)	(0.001)	(0.000)	(0.000)
Interaction: Size-Crisis	Coefficient	0.0044***	0.0039***	0.0003***	0.0003***
	Standard Error (Robust)	(0.001)	(0.001)	(0.000)	(0.000)
Interaction: Concentration-Crisis	Coefficient	0.0020	0.0026	0.0004***	0.0004***
	Standard Error (Robust)	(0.003)	(0.002)	(0.000)	(0.000)
Interaction: Concentration-Size-Crisis	Coefficient	0.0056	0.0074**	0.0005***	0.0006***
	Standard Error (Robust)	(0.004)	(0.003)	(0.000)	(0.000)
Constant	Coefficient	-0.0498***	-0.0284***	-0.0018***	-0.0006***
	Standard Error (Robust)	(0.008)	(0.007)	(0.000)	(0.000)
Time fixed effects		Yes	Yes	Yes	Yes
State fixed effects		Yes	Yes	Yes	Yes
Bank type fixed effects		Yes	Yes	Yes	Yes
Number of Observations		138920	136711	138920	136711
Number of Banks		8408	8353	8408	8353
R-squared		0.018	0.016	0.071	0.071
*Notes: Estimations are performed using the fixed effects estimator. ***, **, and * denote significance at 10, 5, and 1 percent confidence levels, respectively. Control variables not shown.*					

Table 6. Robustness check: Sharpe ratio as dependent variable					
		ROE		ROA	
		[1]	[2]	[3]	[4]
		Four quarters	Eight quarters	Four quarters	Eight quarters
Size	Coefficient	0.4700***	0.9146***	0.4905***	1.0352***
	Standard Error (Robust)	(0.070)	(0.164)	(0.071)	(0.179)
Market concentration	Coefficient	-0.1328	0.6546	0.0218	-0.4364
	Standard Error (Robust)	(0.203)	(0.491)	(0.206)	(0.538)
Interaction: Concentration-Size	Coefficient	-2.5273***	-3.5492***	-2.2802***	-4.0928***
	Standard Error (Robust)	(0.254)	(0.607)	(0.257)	(0.664)
Cost to income ratio	Coefficient	-0.0987***	-0.1811***	-0.1040***	-0.1800***
	Standard Error (Robust)	(0.007)	(0.016)	(0.007)	(0.018)
Leverage	Coefficient	0.0622***	0.0680***	0.0052**	0.1555***
	Standard Error (Robust)	(0.008)	(0.019)	(0.002)	(0.020)
Diversification	Coefficient	-5.3391***	-9.1024***	-5.7727***	-9.7366***
	Standard Error (Robust)	(0.434)	(1.047)	(0.439)	(1.146)
Constant	Coefficient	-2.7117***	-5.3112**	-2.5855***	-8.1028***
	Standard Error (Robust)	(0.916)	(2.192)	(0.928)	(2.397)
Time fixed effects		Yes	Yes	Yes	Yes
State fixed effects		Yes	Yes	Yes	Yes
Bank type fixed effects		Yes	Yes	Yes	Yes
Number of Observations		138920	136711	138920	136711
Number of Banks		8408	8353	8408	8353
R-squared		0.122	0.060	0.121	0.052

*Notes: Estimations are performed using the fixed effects estimator. ***, **, and * denote significance at 10, 5, and 1 percent confidence levels, respectively. Control variables not shown.*

Table 7. Robustness check: Z-score as dependent variable			
		ROA	
		[1]	[2]
		Four quarters	Eight quarters
Size	Coefficient	27.9225***	12.3706***
	Standard Error (Robust)	(6.043)	(2.498)
Market concentration	Coefficient	-3.2562	-5.2835
	Standard Error (Robust)	(18.742)	(7.394)
Interaction: Concentration-Size	Coefficient	-105.6826***	-57.3470***
	Standard Error (Robust)	(23.143)	(9.251)
Cost to income ratio	Coefficient	-4.4623***	-2.7034***
	Standard Error (Robust)	(0.625)	(0.249)
Diversification	Coefficient	-337.8176***	-184.9225***
	Standard Error (Robust)	(39.931)	(15.786)
Constant	Coefficient	-124.9026	-44.0873
	Standard Error (Robust)	(81.636)	(34.199)
Time fixed effects		Yes	Yes
State fixed effects		Yes	Yes
Bank type fixed effects		Yes	Yes
Number of Observations		138920	136711
Number of Banks		0.034	0.079
R-squared		0.032	0.079
*Notes: Estimations are performed using the fixed effects estimator. ***, **, and * denote significance at 10, 5, and 1 percent confidence levels, respectively. Control variables not shown.*			

Figure 1. Marginal effect of bank size on bank earnings volatility

The figure shows the marginal impact of bank size on bank earnings volatility and corresponds to our main results as given in Table 2. The graphs on the upper panel display the marginal effect of bank size at different levels of market concentration measuring ROE volatility over four and eight quarters, respectively, while the graphs on the lower panel display the marginal effect of bank size at different levels of market concentration measuring ROA volatility over four and eight quarters, respectively.

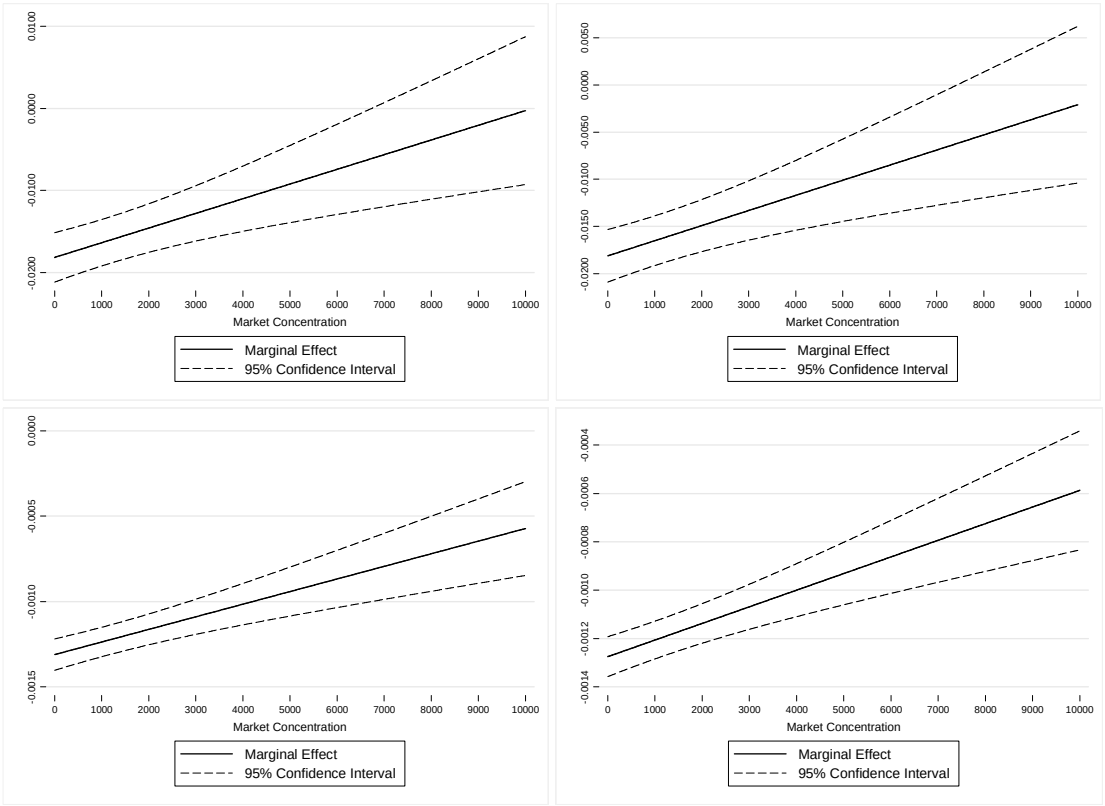


Figure 2. Marginal effect of bank size on bank earnings volatility:
before and during the crisis

The figure shows the marginal impact of bank size on bank earnings volatility in the pre-crisis period (*Crisis*=0) and corresponds to our main results as given in Table 5. The graphs on the upper panel display the marginal effect of bank size at different levels of market concentration measuring ROE volatility over four and eight quarters, respectively, while the graphs on the lower panel display the marginal effect of bank size at different levels of market concentration measuring ROA volatility over four and eight quarters, respectively.

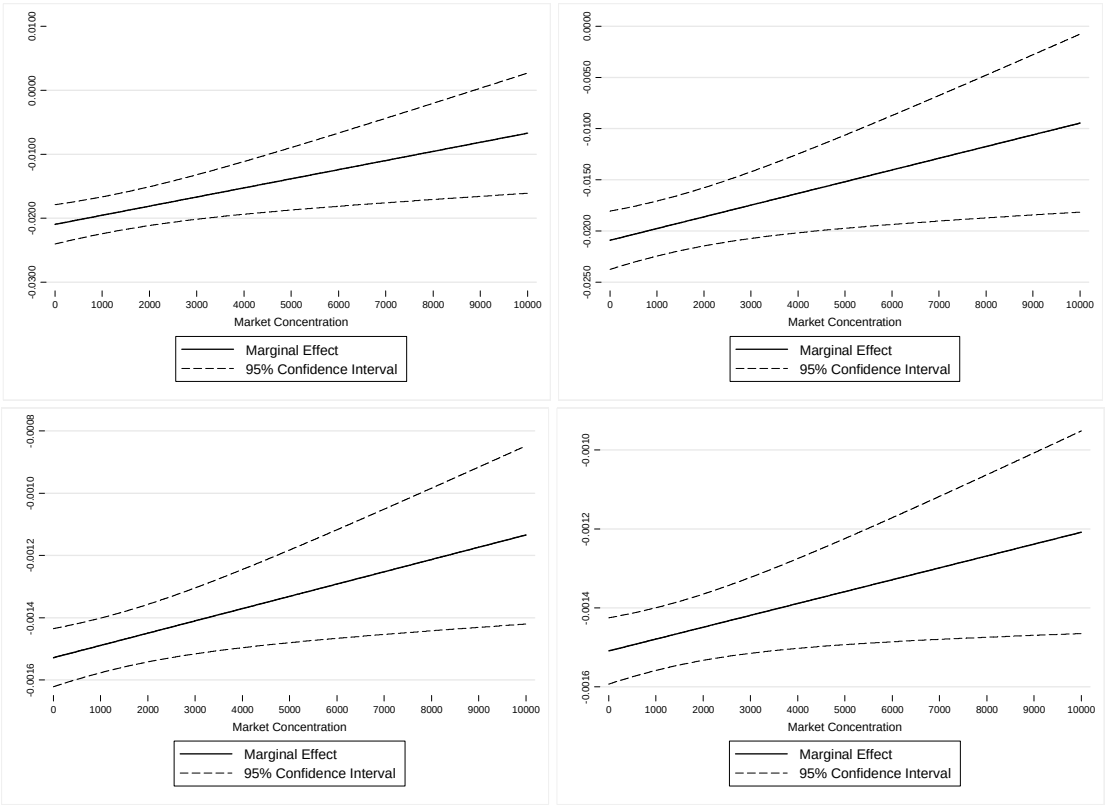


Figure 2 (c-ed). Marginal effect of bank size on bank earnings volatility:
before and during the crisis

The figure shows the marginal impact of bank size on bank earnings volatility in the crisis period (*Crisis*=1) and corresponds to our main results as given in Table 5. The graphs on the upper panel display the marginal effect of bank size at different levels of market concentration measuring ROE volatility over four and eight quarters, respectively, while the graphs on the lower panel display the marginal effect of bank size at different levels of market concentration measuring ROA volatility over four and eight quarters, respectively.

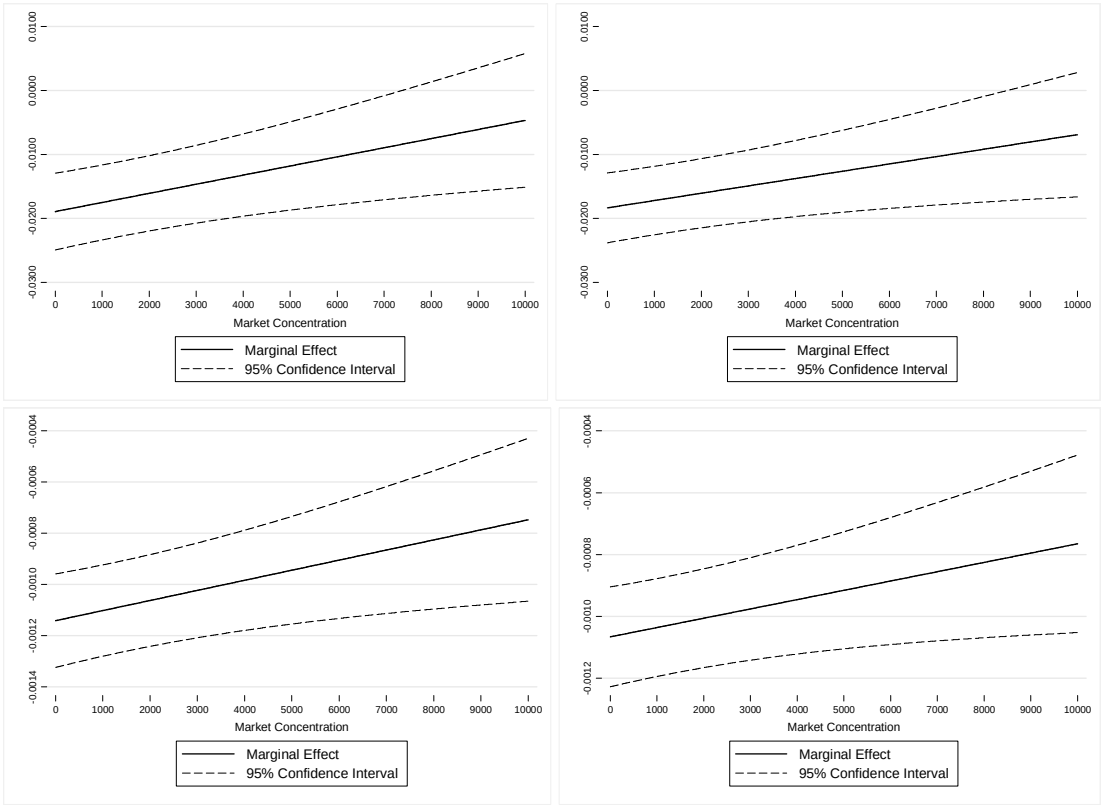


Figure 3. Marginal effect of bank size on bank Sharp Ratio:
before and during the crisis

The figure shows the marginal impact of bank size on bank Sharp Ratio in the pre-crisis period (*Crisis*=0) and corresponds to our main results as given in Table 6. The graphs on the upper panel display the marginal effect of bank size at different levels of market concentration measuring ROE Sharp Ratio over four and eight quarters, respectively, while the graphs on the lower panel display the marginal effect of bank size at different levels of market concentration measuring ROA Sharp Ratio over four and eight quarters, respectively.

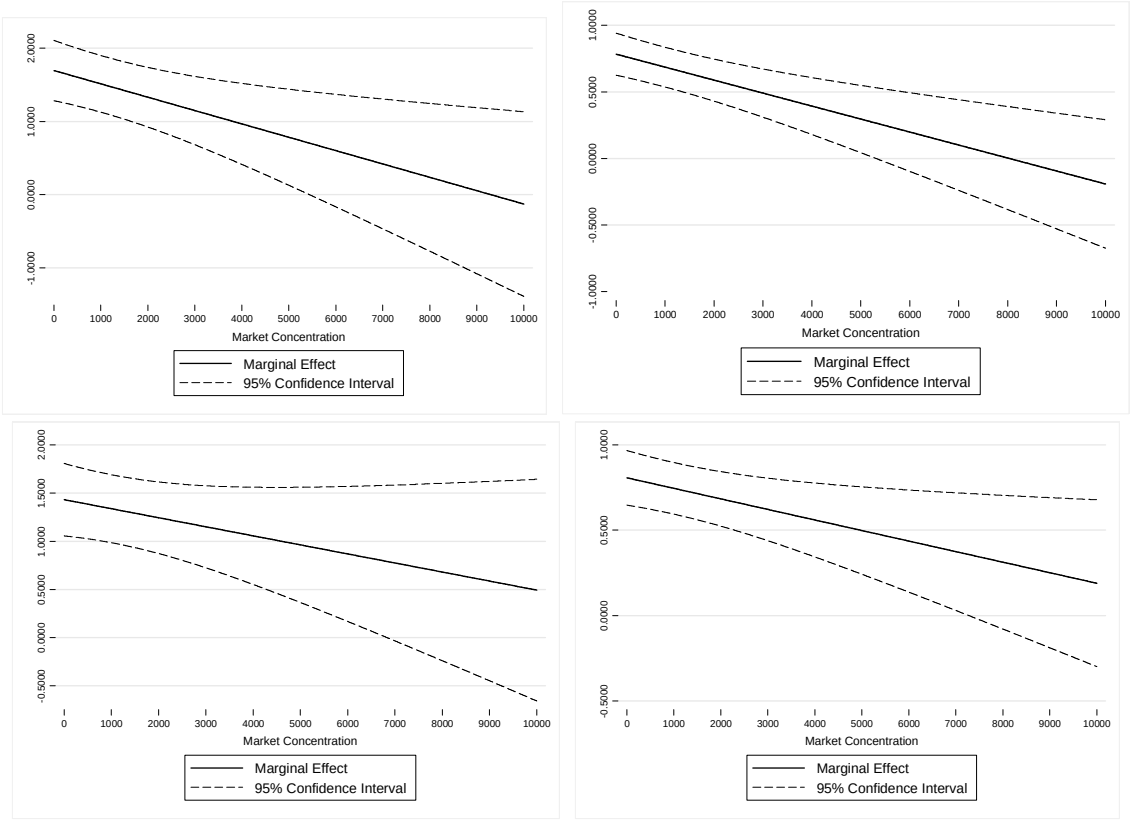
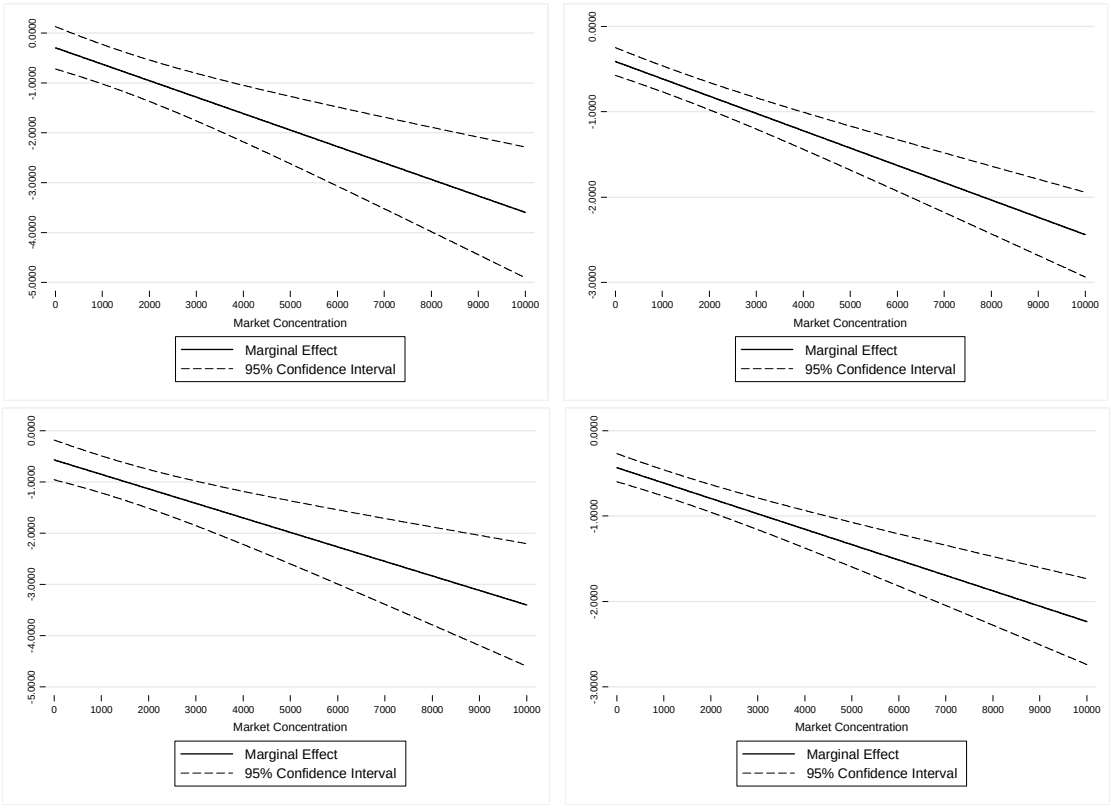


Figure 3 (c-ed). Marginal effect of bank size on bank Sharp Ratio:
before and during the crisis

The figure shows the marginal impact of bank size on bank Sharp Ratio in the crisis period (*Crisis*=1) and corresponds to our main results as given in Table 6. The graphs on the upper panel display the marginal effect of bank size at different levels of market concentration measuring ROE Sharp Ratio over four and eight quarters, respectively, while the graphs on the lower panel display the marginal effect of bank size at different levels of market concentration measuring ROA Sharp Ratio over four and eight quarters, respectively.



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