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Bank Failures and the Source of Strength Doctrine[1]

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Abstract: This paper examines the determinants of bank failures in the US banking system during the recent financial crisis. The analysis employs a dataset on the financial statements of FDIC-insured commercial banks and their bank holding companies, along with information on bank failures, mergers, and acquisitions. The econometric evidence suggests that failed banks have been characterized by significantly higher loan growth rates, well ahead of the financial crisis, coupled with higher exposures to the mortgage market segment and to funding in the form of brokered deposits. We also find evidence that commercial banks have been less likely to fail, when they belonged to well-capitalized and profitable bank holding companies with lower exposures to short-term funding. Our results provide empirical support for the recent modifications in bank regulation and supervision which introduce countercyclical components for capital buffers and a more comprehensive supervision of consolidated banking groups.

JEL classification: G21; E58; G32.
Keywords: financial crises, bank failures, bank regulation.

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1 Introduction

The global financial crisis triggered by the Lehman collapse on the 15th September 2008 was associated with a financial crash that affected many banking systems world-wide. The authorities in a number of countries responded by rescue operations that involved both system-wide interventions (extended deposit insurance and monetary easing) and individually-targeted bank rescues (asset purchases, debt guarantees, and recapitalizations), see amongst others Gropp et al. (2011), Fahri and Tirole (2012), Philippon and Schnabl (2013). The policy measures were aimed at ensuring the solvency of fragile banks and at restoring confidence in the financial system as a whole (Borio et al. (2010)). By end-2010, the governments of the G10 economies have injected close to $1,285 billion of capital into troubled banks (Brei et al. (2013)).

A few weeks after the Lehman collapse, the US government responded on the 3rd October to the increasing tensions in the banking system by announcing its largest rescue package, the Troubled Asset Relief Program (TARP), allowing the Treasury to purchase up to $700 billion of troubled assets and/or equity in distressed banks (Black and Hazelwood (2012), Bayazitova and Shivdasani (2012), Harris et al. (2013)). Overall, the Treasury injected $257 billion of public funds in 531 bank holding companies, which controlled 826 commercial bank subsidiaries insured by the Federal Deposit Insurance Corporation (FDIC). The Federal Reserve Bank responded earlier to the crisis with both conventional monetary policy (interest rate cuts and liquidity provision through the discount window) and unconventional monetary policy aimed at providing funds to troubled banks and at calming down financial markets. The crisis response increased the Federal Reserve's balance sheet from $900 to 2,200 billion during September and November 2008.

Despite these massive interventions by the authorities, 313 commercial banks, 48 thrift institutions, and 10 bank holding companies have failed during 2008-10 and were placed into receivership by the FDIC involving $712 billion of FDIC-insured assets.[2] The majority of bank failures occurred during the first and second quarter of 2009, mostly affecting the banking sectors of Georgia (55 failures), Florida (40) and Illinois (40). The largest failures in terms of

[2] FDIC-insured institutions include commercial banks and saving institutions that operate in the United States including subsidiaries of foreign deposit-taking institutions. The number does not include the failure of Lehman Brothers – an investment bank – not insured by the FDIC.

assets have been those of Lehman Brothers with close to $600 billion of assets and Washington Mutual Bank, a FDIC-insured thrift institution with $330 billion of assets. Problems in banks with financial difficulties have also been resolved with the aid of other banks, as exemplified by the acquisition of the investment bank Bear Stearns by JP Morgan Chase and Bank of America's acquisitions of Merrill Lynch and Countrywide Financial. In total the US banking system experienced 689 mergers and acquisitions of FDIC-insured institutions during 2008-10 involving $1,400 billion of assets.

Against these backdrops, this paper will investigate the determinants of bank failures that occurred during the recent financial crisis in the United States. In particular, we employ a dataset on the quarterly call reports of some 14,000 commercial banks and 8,400 bank holding companies over the period 1995-2010, complemented with information on mergers, acquisitions and bank failures. Using different measures of bank failure, ranging from outright receivership to acquisitions of undercapitalized banks, we find robust evidence that those banks that later came into serious troubles have been characterized by significantly higher loan growth rates, well ahead of the financial crisis, with higher exposures to the mortgage segment and higher proportions of brokered deposits than banks that later survived. The evidence also points to the importance of short-term determinants of bank failures such as bank capital, non-performing loans, profitability and short-term funding on money markets. A novelty of our paper is that we combine financial information on FDIC-insured commercial banks and their bank holding companies to test whether bank holding companies have been a source of strength to their banking subsidiaries. Once bank holding information are taken into account, we find that commercial banks have been less likely to fail, when they belonged to well-capitalized and profitable bank holding companies with lower exposures to short-term funding. The results therefore seem to suggest that bank holding companies only can turn into a source of strength, when they are, taken on their own, in a sufficiently strong financial position.

The results offer interesting insights to the debate on the regulation of banks and the academic literature on the determinants of bank failures. In response to the global financial crisis, bank regulation has been strengthened with a focus on improving capital adequacy, liquidity positions and the treatment of systemically important financial institutions (BCBS (2010)). The

econometric evidence suggests that weak capital and liquidity positions have been important short-term determinants of bank failures. It thus seems essential that banks will be required to hold higher levels of capital which will increase their loss absorbing capacity in times of financial stress. Similarly, limiting banks over-reliance on short-term funding or requiring banks to align better their liquidity positions on the asset and liability side appears to be a central element in improving existing bank regulation (BCBS (2010), paragraph 40 ff). Our results on the long-term determinants of bank failures, i.e. that failing banks have grown too fast during the economic boom, support the view that an effective regulation has to be complemented by macro-prudential policies that aim at reducing credit pro-cyclicality with the introduction of countercyclical capital requirements (BCBS (2010), paragraph 136 ff, Drehmann et al. (2011)). Finally, with respect to the recent empirical literature on bank failures (Aubuchon and Wheelock (2010), Bhattacharyya and Purnanandam (2011), Jin et al. (2011), Cole and White (2012), DeYoung and Torna (2013)), we shed new insights on the determinants of commercial bank failures by combining the financial statements of commercial bank subsidiaries with those of their ultimate holding companies. The evidence suggests that it is essential to comprehensively evaluate the strength of banking subsidiaries in connection with the financial situation of their holding company.

The paper is structured as follows. The next section overviews the literature on bank failures and discusses our specific contribution. Section 3 presents the data and summary statistics. In Section 4 we present the econometric results on the determinants of bank failures with information on the bank-level, while in Section 5 we discuss the results when in addition information on the holding-level is included. The final section concludes.

2 The empirical literature on bank failures

The early literature on the causes of bank failures and bank distress dates back to the late 1960s (King et al. (2006)). The empirical studies used primarily discriminant analysis on a number of financial ratios based on the seminal work of Altman (1968). In the 1970s, researchers started using discrete-response regression techniques focusing on the prediction of bank failures (Martin (1977), Bovenzi et al. (1983), Lane et al. (1986)) or on changes in supervisory bank ratings (West (1985), Whalen and Thomson (1988)). The studies consistently pointed out some common determinants of bank distress, including capital adequacy, asset quality, liquidity and profitability, results on which an important part of the current early-warning system of US banking supervision is based - the regulatory ratings system CAMELS: **C**apital adequacy, **A**sset quality, **M**anagement quality, **E**arnings, **L**iquidity, **S**ensitivity to market risk (OCC (2007)).

The experience with the distress of many banks during the savings and loan crisis in the late-1980s confirmed that poor banking practices and principal-agent problems on the bank-level are important determinants of bank distress, but it has also proven that regional boom and bust cycles in asset prices, such as in energy or real estate, can push a banking industry into serious troubles (Thomson (1991), Whalen (1991), Cole and Gunther (1995), FDIC (1997), Wheelock and Wilson (2000), Oshinsky and Olin (2006)). Most of the banks that later failed have been characterized by imprudent loan underwriting standards, credit concentrations, high overhead, and imprudent risk management. It also became apparent that new banks and converted mutuals have tended to pursue aggressive growth strategies in the early 1980s, rapidly expanding their loan portfolios to leverage high initial capital positions and to increase earnings per share (FDIC (1997), DeYoung (2003)).

The recent financial crisis of 2008-09 underlined that the traditional determinants of bank insolvency remain highly relevant, however, some new sources of risks emerged related to financial innovation and bank deregulation (Aubuchon and Wheelock (2010), Altunbas et al. (2011), Bhattacharyya and Purnanandam (2011), Jin et al. (2011), Berger et al. (2012), Cole and White (2012), Vazquez and Federico (2012), DeYoung and Torna (2013)). The common evidence suggests that, once again, those banks with poor lending practices, highly concentrated loan books, excessive leverage and reliance on short-term funding have been hardest hit by the

financial stress (Hahm et al. (2011), Huang and Ratnovski (2011), Jin et al. (2011), Cole and White (2012)). The regional pattern of the mortgage crisis has also been important (Aubuchon and Wheelock (2010)). One major lesson of the financial crisis is that banks that appeared well-diversified, operating in the traditional and non-traditional spheres of banking, can quickly turn into problem banks when a systemic shock hits the financial system. At vulnerable banks, the initial shock is amplified by the interaction of liquidity shocks on- and off-balance sheet, fire sales, collapses in asset prices, write-downs, and freezes of interbank and wholesale funding markets (Diamond and Rajan (2011)). There is evidence that not all non-traditional banking activities have been drivers of bank failures. Rather there seem to be particularly risky segments such as stakeholder activities such as investment banking, insurance underwriting and venture capital (DeYoung and Torna (2013)). Our specific contribution to the existing literature is that we enlarge the investigation of bank failure determinants by combining financial information on commercial bank subsidiaries with information on their bank holding companies to test whether holding companies have been a source of strength. Knowing that more than 80% of the US banking system is owned by bank holding companies, we believe that this is an important and largely neglected aspect. A notable exception is the study of Ashcraft (2008) which finds that banks affiliated with a multi-bank holding company, defined as holding companies that own more than one commercial bank, are significantly safer than stand-alone banks and banks affiliated with a one-bank holding company.

3 Description of the dataset

For the current study we have merged three different sources of information: (i) the quarterly *Reports of Condition and Income,* also known as the call reports, submitted by FDIC-insured institutions[3]; (ii) the quarterly or semi-annual reports of bank holding companies; and (iii)

[3] Every national bank, state member bank, and insured non-member bank is required to file consolidated Reports of Condition and Income. The database does not include the Thrift Financial Reports. Indeed, the subsequent analysis could be misleading, if these data were included, as thrift institutions (supervised by the Federal Home Loan Bank Board (FHLBB) and insured/resolved by the Federal Savings and Loans Insurance Corporation (FSLIC)) operated under different regulatory and supervisory schemes.

information on bank failures, mergers and acquisitions. The reporting requirements depend on a bank's size and whether it owns foreign offices.[4] In general, the reports that apply to large banks or banks with foreign offices are more detailed. The financial statements are on a consolidated basis, which implies that headquarters integrate the positions of any majority-owned subsidiary into their financial statement. The bank holding companies of commercial banks have been identified with the information on their top-tier regulatory holding company.[5] As in the case of commercial banks, the reporting requirements differ across small and large bank holding companies (for more details, see Section 5).[6] For example, the financial statement of *Citigroup INC* (the bank holding company) can be matched with the statements of the two national banks *Citibank NA* (60% of the BHC's consolidated assets) and *Citibank South Dakota NA* (10%), the Edge Corporation *Citibank Overseas Investment Corporation* (22%), and two small non-deposit trust companies.

The full sample consists in total of 14,131 commercial banks that operated in the United States during the period 1995-2010, of which 7,257 institutions have been active at end-2010 (see Figure 1). Most of this declining trend in the number of banks can be explained by a process of consolidation in the late 1990s involving more than 6,000 mergers and acquisitions (Figure 1) and $6.7 trillion of assets (Table 1). Acquisition activities have been more frequent in normal times slowing down during the recessions (Jones and Critchfield (2004), Hannan and Pilloff (2009)). As of end-2010, a total of 4,820 bank holding companies controlled 5,607 commercial banks (77% of banks) with $13.1 trillion of assets (85% of the banking system). Taken on their own, bank holding companies owned $3 trillion of unconsolidated assets in, on average, two

[4] The threshold for large banks is $500 million of assets. Foreign offices include international banking facilities, branches, majority-owned subsidiaries, and majority-owned Edge/Agreement subsidiaries.

[5] A top-tier bank holding company is the ultimate domestic parent organization that is not owned by any other domestic bank holding company (Avraham et al. (2012)). US GAAP determines that an ownership applies if the parent company owns more than 50% of the voting stock of the institution, while for supervisory purposes the limit is 25%.

[6] The reports of small bank holding companies, i.e. those with less than $150 million of assets prior to 2006 and $500 million of assets thereafter, are less detailed and unconsolidated only, while large bank holdings report both consolidated and unconsolidated statements.

FDIC-insured commercial banking subsidiaries (the highest number of bank subsidiaries per bank holding company is 20).

[Figure 1 around here]

Over the period 1995-2010, 418 thrifts and commercial banks failed and had to be intervened by a regulatory agency. The majority of bank failures (361 cases) occurred during 2008-10 involving more than $700 billion of total assets (Figure 1 and Table 1). Out of the 361 bank failures associated with the financial crisis, 48 cases involved thrift institutions, 48 stand-alone commercial banks, and 265 commercial bank subsidiaries of bank holding companies.

[Table 1 around here]

The consolidation of the banking sector occurred despite the important increase in the US banking sector's total assets, which tripled during 1995-2010 (from $5 to 15 trillion). Only in 2009, bank assets have fallen explained by a decrease in non-deposit funding associated with the collapse of money markets (Figure 2). Interest-bearing deposits, the major funding source of banks, remained stable with the advent of the financial crisis. There has been an important increase in the liquidity holdings of banks with the onset of the financial crisis in 2008, affirming the difficulty of liquidity circulation on the market and the withholding of liquid funds within banks. On average, banks' equity-to-asset ratio remained beyond 10% over the whole sample, but it did not increase as quickly as total assets, especially during the period 2003-07.

[Figure 2 around here]

The financial crisis had a significant negative impact on bank lending as evidenced by the drop of the annual growth rate of lending from an average of 15% during 2001-07 to 10% during 2008-10 (Table 2, last column). The slowdown in bank lending occurred mainly at large, low-capitalized and BHC-owned banks, while the other banks' lending has been more stable, even counter-cyclical as in the case of well-capitalized banks (Table 2).

[Table 2 around here]

There is a clear pattern that failed banks expanded their loan portfolio at higher rates than banks that later survived in the pre-crisis period (Table 2, columns 7 and 9). Failed banks'

growth rate of lending is unsurprisingly lowest during the crisis with an average of 3.5% compared to 10.6% at banks that survived. More importantly, their loan growth has been by far higher in the pre-crisis period compared to other banks (36.9% annually relative to 13.9% during 2001-07). This pattern eventually points to aggressive and unsustainable lending strategies in the past. There are clear signs of financial vulnerability of failed banks prior to the intervention by the regulator, which has been especially apparent in the concentration of loan books, lower profitability and higher dependence on noncore funding.

[Figure 3 around here]

Figure 3 substantiates our observations by comparing important financial indicators across failed and non-failed banks over time. It highlights that certain risks at failed banks have been apparent several years prior to their insolvency. The capital ratios, non-performing loans and profitability show signs of deterioration only in the run up to the failure, approximately one to two years ahead. For example, the equity ratio drops quickly from an average of 10% of assets, two years prior to failure, to 2% at the time of failure. On the other hand, failed banks' loan growth, exposures to the mortgage market segment and noncore funding (brokered deposits and other borrowed money) have been much higher compared to banks that later survived. The average loan growth of failed banks has consistently outpaced that of the surviving institutions, dropping from 38%, five years and more ahead, to -12% at the time of failure. Moreover, the growth in the loan books of failed banks was more concentrated on the mortgage market segment and increasingly financed with brokered deposits and other borrowed money (Cole and White (2012)). The findings suggest that our econometric specification has to carefully take into account the different timing of the risk indicators by the inclusion of the explanatory variables with different lags.

4 Commercial bank failures

We examine the determinants of bank failures using the pooled Logit estimator. The regression model can be represented as follows:

$$Prob(Y_{it} = 1|X_{it-4}, Z_{it}) = \frac{1}{1+\exp(-\beta X_{it-4} - \gamma Z_{it})},$$

where the subscripts refer to bank *i* in quarter *t*.[7] The dependent variable Y_{it} is an indicator variable that is equal to one, in the quarter during which a bank failed, and zero otherwise. Following Wheelock and Wilson (2000), we employ two definitions of bank failure. According to our first definition, we consider a bank as failing, in the quarter during which it was intervened and closed by the FDIC or a similar regulatory authority. The second failure definition makes two modifications: (i) we include in addition to the failed banks, undercapitalized banks that have been acquired, defining an undercapitalized bank as a bank with a risk-weighted capital ratio of less than 8% or a Tier 1 ratio of less than 4% at the time of acquisition;[8] and (ii) we modify the failure date and define it as the quarter, in which a failed bank became for the first time critically undercapitalized, i.e. when its tangible equity to assets ratio falls below two percent for the first time. The reason for these modifications is that some banks that fulfill the bankruptcy conditions are purchased by other private institutions in the resolution process through a merger and acquisition procedure, while in other cases distressed banks are allowed to remain open, even though they are technically insolvent (Mailath and Mester (1994), Wheelock and Wilson (2000)). The second indicator of bank failures is thus our preferred measure.

The set of explanatory variables includes commercial bank-specific risk indicators taken from the call reports X_{it-4} and macroeconomic variables Z_{it} (discussed below). We have chosen to include the majority of bank-specific variables, lagged by one year, based on the graphical inspection presented before (Figure 3). It appeared that certain indicators (such as profits, capital, and non-performing loans) start dropping one to two years prior to failure, while other balance sheet vulnerabilities have already been apparent well ahead of the crisis (such as the concentration of loan books and their growth rate), see also Bhattacharyya and Purnanandam (2011) and Cole and White (2012). We estimated our model with different lags and specifications and decided to include the early warning indicators in the form of moving averages that cover the period 3-5 years ahead. Finally, we experimented with different sample

[7] We re-estimated the regressions with two other estimators, including the Logit estimator for rare events data (King and Zeng (2001)) and the Logit estimator with random effects. The main results are robust to the choice of these estimators and are available from the authors upon request.

[8] This is in line with the Prompt Corrective Action category of undercapitalized banks, Section 38 of the Federal Deposit Insurance Act.

periods and decided to estimate our model for the period Q1/2006-Q4/2010, as it strikes a balance between pre-crisis and crisis observations. Overall, we capture 317 commercial bank failures out of the total of 361 cases that occurred since 1995.

Discussion of the explanatory variables in vectors X_{it-4} and Z_{it}

Our choice of the explanatory variables is based on the CAMELS framework for banking supervision and the recent empirical literature on the identification of bank risks and the determinants of bank failures during the recent experience with financial distress.

Capital adequacy is measured by the *total risk-based capital ratio*. We prefer this measure of capital to the traditional equity-to-asset ratio, based on the evidence of Figure 3, and the fact that it captures more information about core equity (such as Tier 1 and Tier 2), relating it to risk-weighted assets (Gambacorta and Mistrulli (2004)). The effect of capital regulation and bank risk is ambiguous (Calem and Rob (1999), Borio and Zhu (2008)). In terms of bank failures, however, we expect that higher initial capital levels decrease the probability that a bank fails, since better capitalized banks have a larger buffer stock against unexpected losses, more equity at risk, and therefore they have less risk-taking incentives and a higher loss-absorbing capacity than poorly capitalized banks (Hellmann et al. (2000), Brei and Gadancez (2012)).

As measures for asset quality, we use the *non-performing loan* ratio defined as past due and nonaccrual loans as a fraction of total loans, *other real estate-owned assets* in total assets, the *mortgage* ratio defined by real-estate secured loans in total loans, *bank size* defined by the logarithm of total assets, *past loan growth* measured by the annual growth rate of total loans, *foreign assets* as a fraction of total assets, *asset*- and *mortgage-backed securities* in total assets, *credit commitments* as a ratio of total assets, and off-balance sheet *derivatives* as a ratio over total assets.

Non-performing loans (NPLs) and other real estate-owned (OREO) assets, the latter includes foreclosed real-estate, are intended to capture the quality of a bank's loan book. Higher ratios tend to be an indication of looser lending standards, since a higher fraction of borrowers has not been in the position to repay in time. NPLs and OREO assets are associated with write-downs and capital impairment, and we expect that they increase the probability of failure (Cole and

White (2012)). Mortgages as a fraction of total loans are intended to capture a bank's exposure to the US housing market (Demyanyk and Van Hemert (2011)) and eventual lending concentrations. To gauge the predictive power of concentrated mortgage lending as an early-warning indicator, we include the moving average of the mortgage ratio, 3-5 years ahead, which is in line with Figure 3. We expect that a higher exposure to the mortgage market and a more concentrated loan book are associated with a higher probability of failure (Cole and White (2012)).

Next we include bank size as an explanatory variable. On the one hand, large and systemic institutions are too-big-to-fail, in the sense that governments are likely to rescue a systemic bank in distress due to its importance in the economy. It is thus less likely to observe outright failures of large banks. Rather, governments seem to prefer recapitalizing them, or they opt for other resolution policies including government-assisted mergers, as in the case of Bank of America and Merrill Lynch. On the other hand, implicit bailout guarantees may distort bank incentives, since banks can take on risks without being penalized for it by the market or a closure (Fahri and Tirole (2011), Brei and Gadanecz (2012)). This moral hazard mechanism tends to increase risk-taking incentives making large banks more likely to collapse in response to adverse financial shocks. Finally, larger banks might have been more affected by the financial market turmoil compared to small banks, because smaller banks tend to be less connected with financial markets and more engaged in relationship lending (Gambacorta (2005)). The sign of bank size is therefore undetermined. Foreign assets are included to gauge whether international diversification has been a source of stability for banks. Since the financial crisis was home-made and it did not originate abroad, we expect higher fractions of foreign assets to be negatively related to bank failures, although foreign exposures might be an indication of higher risks, as banks could be subject to informational disadvantages in foreign markets (Ahearne et al. (2004)).

Another variable that captures information about asset quality is a bank's past loan growth, because high growth rates can be an indication of excessive growth strategies associated with looser lending standards (Keeton (1999), Salas and Saurina (2003), Dell'Ariccia and Marquez (2006)). Typically, a failing bank will not have a high loan growth in the run up to its closure, as

regulators impose restrictions on bank activities and asset growth when capital levels decline (OCC (2007)). Rather, excessive growth has been recognized as an effective indicator of potential future problems in banks, as evidenced in Table 2 and Figure 3. We therefore include the moving average of annual loan growth, 3-5 years ahead, and expect it to be positively related with the probability of failure.

Finally, we include indicators for banks' off-balance sheet and securitization activities. Although off-balance sheet exposures have not been a primary cause of bank failures in the 1980s (OCC (2001)), they might have been drivers during the recent bank failure experience. It is not clear whether and which off-balance sheet activities are harmful, since if they are managed properly, then they allow for a transfer of risks to financial markets (Kashyap et al. (2008)). Traditionally, off-balance-sheet risk has originated in loan commitments and letters of credit, because borrowers start drawing down their credit lines when financial conditions deteriorate. The risk inherent in capital market products, such as mortgage-backed securities and derivatives is more difficult to quantify (OCC (2001)). There exists some evidence that securitized assets have not been at the center of recent commercial bank failures. Rather the riskiest tranches of these products have been held on the books of investment banks and major commercial banks (Kashyap et al. (2008), Cole and White (2012)). We capture these types of bank activities by including asset- and mortgage-backed securities (ABS and MBS) that are on-balance sheet (available-for-sale and held-to-maturity), credit commitments, and off-balance sheet derivatives as a ratio over total assets.[9] The relation between these variables and bank failures is ambiguous. Higher fractions of ABS and MBS in total assets might be an indication of higher failure risks, if these assets are mainly risky, non-investment grade tranches. On the other hand, if commercial banks kept the higher graded tranches on their balance sheet, then such asset holdings might reduce the risk of failure. Moreover, higher fractions of securitized assets might be an indication of higher risks, if banks have used securitization to increase profits on the grounds of deteriorating lending standards (Demyanyk and Hasan (2010)). And finally, banks

[9] We measured credit commitments as the sum of unused commitments, financial standby letters of credit, performance standby letters of credit, and commercial and similar letters of credit. As for derivatives we have taken the sum of futures contracts, forward contracts, options and swaps on interest rate, foreign exchange rate, equity and commodity, and credit derivatives.

with higher exposures to credit commitments and off-balance sheet derivatives might have a lower or a higher probability of failure. Again, this depends on the general governance of banks and their risk management practices.

Although management quality is indirectly measured by the indicators on asset quality and capital adequacy, we include three variables that potentially capture information about managerial quality, namely, *bank age, BHC affiliation,* and *managerial efficiency,* the latter being defined by non-interest expense over the sum of net interest income and non-interest income (Oshinsky and Olin (2006)).[10] As for the affiliation of commercial banks to a bank holding company, we include a dummy variable that is equal to one, if a bank is controlled by a bank (or financial) holding company, and zero otherwise. BHC companies might be a source of strength to their commercial bank subsidiaries, nevertheless they might be as well a source of vulnerability (Ashcraft (2008), de Hass and Lelyveld (2014)), an important aspect we will discuss in detail in the next section. Banks that are longer established could have better ties with their competitors, and thus have access to interbank funds in times of stress, or they could have more expertize or a better risk management compared to younger banks. It could also be that newly established banks have been pursuing excessive growth strategies, as experienced prior to the savings and loan crisis in the 1980s (FDIC (1997), DeYoung (2003)). If banks that are longer established have better ties with regulators, and if they are larger than new entrants, then we would expect that they have a higher probability of being rescued. Taken the arguments together, we expect a negative relationship between bank age and the probability of failure. Finally, with regards to our measure for managerial efficiency, we suppose that an important level of non-interest expense relative to net interest income and non-interest income is an indication of cost inefficiency and thus a sign of poor management practices (Spong et al. (1995), Wheelock and Wilson (2000), Oshinsky and Olin (2006)). We expect that more efficient banks have lower default probabilities.

[10] We do not directly use the ratio, because both the lowest and highest values tend to be associated with problem banks. Indeed, the lowest values are reported by banks with a negative sum of net interest income and non-interested income, while the highest values are observed, when net interest income and non-interested income are close to zero. We have chosen to include a dummy variable that is equal to one, when the efficiency ratio in t-4 is positive and lower than the average ratio, and zero otherwise.

As measures for earnings strength, we include the net interest margin (net interest income divided by total assets) and the non-interest margin (non-interest income over assets). Earnings of a bank are essential to absorb loan losses, provide funds for internal growth and to attract investors that supply capital. The retention of earnings can be used to develop and maintain a prudential capital base. Typically, some quarters prior to a failure, bank losses and asset write-downs increase substantially, and we expect that higher profits are associated with a lower probability of failure (Figure 3).

Liquidity risks are measured by two noncore sources of funds, namely *other borrowed money* and *brokered deposits* as a fraction of total assets.[11] A higher exposure to wholesale funds with short maturities, measured here by other borrowed money, makes banks more vulnerable to liquidity shocks than banks that rely more on deposits (Hahm et al. (2011)). It has been proven that deposits tend to be a stable source of funds during financial stress, owing to the inflow of funds from investors who seek a safe haven for their liquid assets (Kashyap et al (2002), Gatev and Strahan (2006)). It should be noted however that there exists recent evidence that deposit inflows can break down at particular institutions (Acharya and Mora (2012)), but it appears that the freeze in wholesale funding markets affected banks the most (Demirgüç-Kunt and Huizinga (2010), Huang and Ratnovski (2011)). We thus expect that a higher ratio is associated with a higher probability of failure. Brokered deposits are intermediated to banks by unaffiliated deposit brokers and they can be a valuable source of funding, when they are properly used. They are however considered as volatile and interest rate sensitive, because such funds are often provided by customers in a search for yield (FDIC (2011)). There is evidence that banks that failed during the recent financial crisis relied heavier on brokered deposits than banks that survived (Cole and White (2012)), and we expect that a higher ratio increases the failure probability. Based on the evidence shown in Figure 3 and knowing that there are regulatory restrictions on brokered deposits at undercapitalized banks, we decided to include the moving average of the brokered deposit ratio, 3-5 years ahead.

[11] Note that we did not include in addition the deposit ratio, because it showed a high negative correlation with brokered deposits and other borrowed money, especially during the financial crisis. This could introduce problems associated with multicolinearity, and we thus focus on these two measures of bank fragility.

Finally, it is important to take into account the local economic conditions, since the boom-and-bust cycle in housing prices varied within the country (Aubuchon and Wheelock (2010)). For instance, the states of Arizona, California, Florida, and Nevada accounted for close to 60% of US residential foreclosures, and as such bank failures might have been more frequent in some states than in others, as evidenced in Figure 4. In particular, we include the state-specific annual growth rate of housing prices, and expect that house prices are negatively related to the probability of failure.[12] We control as well for aggregate financial market conditions, measured by the annual moving average of the financial stress indicator calculated by the Federal Reserve Bank of St. Louis and expect that higher financial stress is associated with a higher probability of bank failures.

[Figure 4 around here]

Results - baseline specification for commercial banks

We report the estimation results of the baseline specification, starting with a parsimonious model (specification 1) which includes a subset of the outlined bank-specific indicators (see Table 4, column 1).[13] We then successively include more explanatory variables. More precisely, specification 2 augments the number of bank-specific variables, and specification 3 includes the macroeconomic indicators and the bank-specific variables, lagged by 3-5 years. In the final specification, we report the estimation results with the same set of explanatory variables as in specification 3, using our second definition of failure which includes in addition undercapitalized banks that have been acquired and which modifies the date of failure, if appropriate (as discussed before).

[12] We experimented as well with state-specific personal income and unemployment rates, to capture that banks might have been harder hit in states where the repayment capacity of borrowers has been subject to a larger adverse shock. It turned out however that these indicators have been highly correlated with house price growth during the crisis and we decided to concentrate on house prices.

[13] Descriptive statistics for the explanatory variables are reported in Table 3. We excluded carefully outliers in the data, by examining the ratios in levels and in growth rates. This method was preferred to a general filter, such as cutting the 1st and 99th percentile of the distribution, in an attempt not to delete important information on failing banks which tend to have extreme observations. We also checked whether there are signs of multicolinearity by analysing the variance inflation factors and the correlation matrix.

[Table 3 around here]

It is important to note that the sample of banks differs across the four specifications due to the fact that the different sets of regressors are not available for all banks. For instance, 17 FDIC-insured banks, among which 3 entities failed (out of 8,344 banks and 317 failures in total), are dropped when the macroeconomic variables are included, because these banks are located in commonwealth jurisdictions (such as Puerto Rico). Moreover, we lose additionally 759 banks of which 48 entities failed, when including the early warning indicators, lagged by 3-5 years. This subset of institutions are banks that have been newly established or that converted to FDIC-insured banks in Q1/2001 or later, knowing that our estimation period is Q1/2006-Q4/2010. Finally, with the modified failure definition, the number of failures increases by 19 cases, explained by crisis-related acquisitions of undercapitalized banks.

The goodness of fit for each specification is, on the one hand, evaluated with the computation of correctly predicted failures and false alarms, the latter representing cases in which our model predicted a failure although nothing happened. This evaluation is made for a specific threshold setting, i.e. bank failures are classified as predicted, if the estimated probability of failure is higher than a particular threshold. In Table 4, we report the number of correctly predicted failures and false alarms obtained with a 10% threshold. The choice of the threshold, however, is subjective and the results are sensitive to the selected threshold. As a result, we also compute the area under the receiver operating characteristic (AUROC) curve to get a better evaluation of the predictive power of the model. The receiver operating characteristic (ROC) curve plots the ratio of correctly predicted failures (true positive rate) against the false alarm rate (false positive rate) for all possible threshold settings. The area under the ROC curve in turn provides a more general summary statistic for the predictive power of each specification, and it bypasses the need for selecting a certain threshold probability. Typically, the AUROC statistic is between 0.5 for random predictions and 1 for perfect predictions.

[Table 4 around here]

The results of specification 1 confirm largely our intuition and are in line with the related literature (see, amongst others, Wheelock and Wilson (2000), King et al. (2006), Jin et al. (2011),

Cole and White (2012), DeYoung and Torna (2013)). Banks that have lower capital ratios, one year ahead of failure, have significantly higher default probabilities. In other words, a 1% higher capital ratio at the average failing bank, one year prior to its failure, decreases the probability of insolvency by 0.855%.[14] This is a purely mechanical relation, since the decision to close a failing bank is, amongst other things, based on the level of capital, which can quickly diminish when the initial capital position is weak and asset write-downs and losses increase. By the same token, banks were more likely to fail when they had higher fractions of non-performing loans, reflecting poorer lending standards prior to the crisis. Note that the coefficient of NPL loans is only marginally significant in specification 1, but it gets highly significant in the remaining specifications. The positive coefficient on the size variable is counter to our expectations, since we would expect that larger banks have a higher probability of being rescued and, thus, a lower probability of failure. As discussed before, there are indications that large banks have been hardest hit by the financial crisis, and it could be that their financial vulnerabilities are correlated with those banks that failed. Other studies also have found a positive coefficient (Jin et al. (2011), DeYoung and Torna (2013)). The remaining variables in specification 1 are significant with the expected signs. Longer established banks, profitable banks, and more efficient banks are less likely to fail, while banks that relied to a higher extent on short-term funding were more likely to fail. Finally, the AUROC statistic is 0.9287 indicating that this small set of short-term predictors is important in explaining bank failures.

The inclusion of the other bank-specific variables in specification 2 does not alter significantly the results. In addition we find evidence that higher fractions of other real estate owned assets tend to increase significantly default probabilities, while higher levels of non-interest income, one-year-ahead, decrease the probability of failure although the effects become insignificant in the subsequent specifications. Therefore, it appears that non-interest income has not been a main driver of commercial bank failures, which is in line with DeYoung and Torna (2013) who find that particular types of both interest and non-interest income have made banks vulnerable.

[14] Note that the estimation results are presented in the form of marginal effects, since the standard Logit coefficients cannot be interpreted in economic terms. The marginal effects are calculated using the average bank-specific characteristics for banks that failed, one year prior to failure.

The asset quality measures on securitization and the off-balance sheet are less significant determinants of bank failures compared to the other variables. There is evidence that banks with higher ratios of ABS and MBS on their balance sheet have had a lower probability of failure, although the significance disappears later on. As mentioned before, commercial banks might have kept higher quality tranches on their balance sheet, selling the riskier ones to investment banks and other types of investors (Kashyap et al. (2008), Bhattacharyya and Purnanandam (2011), Cole and White (2012)). The other coefficients associated with credit commitments, derivatives, foreign assets and the BHC ownership dummy are not significant.

Most of the results appear to be robust to the inclusion of the macroeconomic indicators, and our early warning indicators, lagged by 3-5 years, see specification 3. Drops in property prices increase the failure probability of banks significantly by affecting the collateral of borrowers and their repayment capacity, while financial stress is positively related to bank failures. Quickly growing loan books focused on the mortgage segment and financed by higher fractions of brokered deposits, 3-5 years ahead, are associated with significantly higher failure probabilities (Jin et al. (2011), Cole and White (2012)). The combination of fast loan growth and concentration of loan books on the risky mortgage market segment seem to reflect banks' loose lending standards and aggressive growth strategies in the past. It appears that these activities have been increasingly financed with noncore funding, particularly brokered deposits, making these banks vulnerable to financial shocks on both the asset and liability side (FDIC (2011)). Finally, the main results are robust to the modification of the failure definition (specification 4).

In conclusion, we find that most coefficients are robust across our specifications in terms of magnitude and significance. Important short-term determinants are regulatory capital ratios, non-performing loans, interest income, bank efficiency, and other borrowed money. The major long-term determinants of bank failures are high levels of loan growth, lending concentrations on mortgages, and brokered deposits.

5 Have bank holding companies been a source of strength?

An important part of the US banking system is controlled by bank and financial holding companies (BHC), a legal and organizational form that is unique to the US banking regulation. It appears therefore interesting to investigate whether the financial positions of BHCs had an impact on commercial bank failures, since risks might be either mitigated or amplified by the activities of parent companies (OCC (2007), Ashcraft (2008), Avraham et al. (2012)). For instance, a strong bank holding company might help a banking subsidiary in distress. Indeed, US regulation imposes the source of strength doctrine by which holding companies are supposed to support troubled subsidiary banks, as long as they have, taken on their own, sufficient resources for a rescue (OCC (2001)).

Traditionally, the fields of permissible activities of BHCs have been strongly regulated. Many of these restrictions however have been removed in the late 1990s with the Gramm-Leach-Bliley Act (Omarova and Tahyar (2011), Copeland (2012)). As a result, bank holding companies operate nowadays through a large network of subsidiaries in a variety of market segments, and they combine the traditional banking business with investment banking, insurance and other activities.[15] Bank holding companies are supervised and regulated by the Federal Reserve and are required, similar to their commercial bank subsidiaries, to maintain minimum capital ratios. With a total of 5,607 commercial banks that have been controlled by bank and financial holding companies in 2010 (77% of all banks), and 265 failure experiences on the subsidiary level during 2008-10, the sample of BHC-controlled commercial banks is important and deserves a proper investigation.

Large bank holding companies are required to fill in consolidated and unconsolidated (or parent-only) reports on a quarterly basis, while smaller holdings report only on an unconsolidated basis and semi-annually.[16] In general the reports allow for a comprehensive

[15] The most common industries in which BHCs operate are asset management activities (using trusts, funds and other financial vehicles), credit intermediation, securities trading, management and accounting, health and insurance (Avraham et al. (2012)).

[16] Prior to 2006, the threshold of large bank holdings was $150 million of consolidated assets increasing to $500 million thereafter. For the estimations, we have linearly interpolated the semi-annual reports of small bank holdings to the quarterly frequency.

disaggregation of balance sheets and profits, with a breakdown by the industry in which the holdings' subsidiaries operate (bank, non-bank, and bank holdings).[17] An interesting feature of the bank holding reports is that they allow identifying rescued institutions that received state support during the Troubled Asset Relief Program. This is an important piece of information for our analysis of bank failures, since a bank that has been classified before as non-failed could have actually failed without the assistance of the Treasury, and it is thus important to control for bank rescues in the estimations.

The merging of the financial information of commercial banks and their top-tier holding company reveals that a large part of the US banking system is controlled by BHCs.[18] As of end-2010, 77% of FDIC-insured commercial banks (5,607 institutions), or 85% of the banking system's assets ($13 trillion), have been controlled by 4,820 bank holding companies. Taken on their own, bank holdings owned $3 trillion of unconsolidated assets and controlled, on average, two FDIC-insured banking subsidiaries and an unknown number of non-bank subsidiaries. The median of the relative size of bank holdings (measured by the top-tier BHC's unconsolidated assets over the subsidiary's consolidated assets) is 11%, being highest when a large bank holding owns a small FDIC-insured trust company.[19] During the crisis period of 2008-10, 531 bank holding companies that controlled 826 banks have been rescued and received $257 billion of TARP funds. On average, rescued bank holdings received state support of 24% of unconsolidated assets or 2.5% of consolidated assets.

[17] A caveat is that non-bank subsidiaries are treated in the consolidation, as if they operated on a stand-alone basis (Avraham et al. (2012)). This introduces problems associated with double-counting, since for example a loan granted to another holding's subsidiary will be treated as if it was part of the non-bank subsidiary's balance sheet, even though the positions would net out on a consolidated basis. Moreover, some major non-bank subsidiaries, mainly those that are active in securities trading and insurance, do not file in the FDIC forms and report to other functional regulators (Avraham et al. (2012)).

[18] A top-tier bank holding company is the ultimate domestic parent organization that is not owned by any other domestic bank holding company (Avraham et al. (2012)). US GAAP determines that an ownership applies if the parent company owns more than 50% of the voting stock of the institution, while for supervisory purposes the limit is 25%.

[19] Such as in the case of Bank of America Corporation with $456 billion of unconsolidated assets in 2010 and its subsidiary National Trust Delaware with $3 million of assets.

To control for the financial position of bank holdings, we augment our previous specification by including a vector of bank-holding-specific control variables, B_{it-4}:

$$Prob(Y_{it} = 1|X_{it-4}, Z_{it}, B_{it-4}) = \frac{1}{1 + \exp(-\beta X_{it-4} - \gamma Z_{it} - \delta B_{it-4})}$$

where Y_{it} denotes our indicator variable of bank failures using our second definition, X_{it-4} is the vector of bank-specific variables, and Z_{it} the vector of macroeconomic controls. We estimate the regression with the same set of bank-specific and macroeconomic variables used in the final specification of Table 4. Before turning to the discussion of the estimation results, we discuss briefly the choice and definition of the BHC-specific variables and their expected signs.

Discussion of the BHC-specific explanatory variables in B_{it-4}

As before, we follow the CAMELS framework in choosing our variables, paying attention that we use a parsimonious set of indicators that are not strongly correlated. Given the possibility of double-counting in the consolidated figures, and the fact that small BHCs report parent-only financial statements, we use unconsolidated figures. Another advantage of using unconsolidated information for parent banks is that we already capture information on the subsidiary level by commercial banks' call reports avoiding problems associated with double-counting.

Capital adequacy at the group level is measured by the ratio of unconsolidated BHC *equity capital* over unconsolidated assets. As can be seen at the bottom of Table 3, the average bank holding company finances the major part of its unconsolidated assets with equity with an equity-to-assets ratio of 87.5%. A higher capital buffer at the group level allows a holding company to distribute capital internally with the possibility of recapitalizing subsidiaries in distress without the need of raising capital externally (de Hass and van Lelyveld (2010), Cetorelli and Goldberg (2012)). If a bank holding controls only one banking subsidiary (one-bank BHC), then a given capital buffer should be more likely to be a source of strength to a distressed banking subsidiary. If however a bank holding company controls several bank and non-bank

subsidiaries (multi-bank BHC), then it will depend on the financial situation of the other subsidiaries.[20]

To control for the asset structure of bank holdings, we use the proportion of unconsolidated *equity investments in non-bank subsidiaries* (common and preferred stock) as a proportion of unconsolidated assets. On the one hand, a higher ratio might be an indication of diversification, making a holding company less vulnerable to shocks in the banking sector. On the other hand, it might be an indication of higher vulnerability, especially when holding companies operate in other crisis-prone industries and sectors, such as investment banking and insurance, or they could simply have less expertise in banking.

As a measure for earnings strength at the BHC-level, we include *return on assets* calculated by unconsolidated income over unconsolidated assets, and we expect it to be negatively related to failures, as more profitable BHCs are more likely to be in the position to support distressed banking subsidiaries.

To capture the funding structure of bank holding companies, we include unconsolidated *short-term borrowing* (defined by the sum of commercial papers and other short-term borrowing) and *balances due to other subsidiaries* (non-bank and other bank holdings), both as a ratio over unconsolidated assets. Bank holdings that rely more heavily on funds from money markets are more likely to be a source of vulnerability to bank subsidiaries, since money and wholesale funding markets collapsed in the midst of the crisis (Demirgüç-Kunt and Huizinga (2010), Huang and Ratnovski (2011)). If balances due to other subsidiaries reflect funding from subsidiaries that are engaged in asset management, securities trading, or insurance, a higher reliance on this type of funding might be an indication of higher risks, since these sectors have also been heavily affected by the financial crisis. On the other hand, it might be an indication of lower risks, if these balances originate from less-crisis prone sectors.

Finally, we include information on individual bank rescues associated with the TARP program and expect that bank subsidiaries of rescued bank holdings are less likely to fail. We

[20] Ashcraft (2008) finds that a bank affiliated with a multi-bank holding company is significantly safer than both stand-alone banks and banks affiliated with a one-bank holding company.

experimented with different ratios, using the amount of injected TARP funds as a ratio over assets and decided to work with a *rescue dummy* that is equal to one if a bank holding has been subject to a TARP rescue and zero otherwise. One might argue that it was not the injected amount that mattered to help them survive; rather it might have been the signal that the Treasury is willing to support a particular group, which calmed down investor and depositor uncertainty on the subsidiary level.

Results – augmented by bank holding characteristics

BHC-controlled commercial banks represent a subsample of the whole spectrum of commercial banks in the United States. It is therefore important to first re-estimate the final specification in Table 4 without BHC-specific characteristics to gauge whether the bank failure determinants are different for the sample of BHC-controlled commercial banks, before including the BHC-specific characteristics. The estimation results with bank-specific information only are shown in specification 5 (column 1 of Table 5).

While most coefficients are qualitatively similar in terms of signs and magnitudes, we note that the significance of some variables decreased slightly, as in the case of the early-warning indicators loan growth and mortgage lending, which have been significant on the 1% level in Table 4 and which are now significant on the 5% level. More interestingly, the net interest margin of BHC-owned banking subsidiaries becomes insignificant suggesting that profitability has been a more significant determinant of bank failures in the case of stand-alone banks, while it appears less important in the case of BHC-controlled banks.

[Table 5 around here]

The BHC-specific variables are successively introduced in the remaining specifications of Table 5. The subsequent discussion focuses on the final specification 9, which includes the entire set of bank-specific, holding-specific, and macroeconomic control variables. Note that we had to exclude money borrowed from non-bank subsidiaries, because it was strongly correlated with equity during the estimation period with a correlation is -0.75 introducing colinearity problems between these two variables.

Most of the BHC-specific characteristics turn out to be significant determinants of commercial bank failures and the results appear intuitive. Our measure of capitalization has the expected negative sign. It appears thus that well-capitalized bank holding companies have been a source of strength to their banking subsidiaries. Equity investments of bank holding companies in non-bank subsidiaries do not seem to have been a source of fragility to commercial banks, the associated coefficient is not statistically significant. While the earning measures are insignificant on the subsidiary-level, return on assets on the holding-company-level significantly decrease the probability of commercial bank failures indicating that bank holdings with higher unconsolidated profits, one year ahead, have been a source of strength to their bank subsidiaries. On the funding side, it appears that higher levels of short-term borrowing at the group-level are, as on the subsidiary-level, associated with higher failure risks. The evidence thus suggests that funding shocks can be reinforced, when both banking subsidiaries and holding companies finance large parts of their activities with short-term funds from money markets. Finally, we find evidence that failure probabilities have decreased when a bank holding company received TARP funds and it appears that the US rescue package has circumvented commercial bank collapses, either by recapitalizing banks sufficiently or by decreasing investor uncertainty at those banks that have received public capital injections.

Overall our results highlight the importance of the financial position of bank holding companies in supporting commercial banks to survive. More specifically we provide first evidence that bank holding companies can be both - a source of strength or a source of vulnerability. In other words, if bank holding companies, taken on their own, are profitable, well-capitalized and not funded too much with short-term funds, then they can be a source of strength and support their banking subsidiaries in times of distress.

6 Concluding remarks

This paper examined the determinants of bank failures in the US banking system during the recent financial crisis. The analysis employed a dataset on the financial statements reported by FDIC-insured commercial banks in combination with the financial statements reported by bank holding companies.

Using limited-dependent variable regressions, we find that particular risks at failed banks have been apparent on their balance sheets three to five years ahead of their bankruptcy. More specifically, those banks with higher loan growth, a higher involvement in the mortgage segment and higher reliance on brokered deposits during the economic boom have been more likely to fail several years later. Failed banks have also been characterized by, amongst other things, lower levels of capital, higher dependence on short-term borrowings and higher fractions of non-performing loans one year ahead of their closure. For a subset of commercial banks controlled by bank holding companies, we provide first evidence that banks were less likely to fail when they belonged to well-capitalized and profitable bank holding companies with lower exposures to short-term funding. Along we find that banking subsidiaries of bank holding companies that received public capital have been less likely to fail.

Our results support the recent modifications in bank regulation and supervision that aim at introducing countercyclical capital buffers, improving capital and liquidity requirements, and at evaluating more comprehensively consolidated banking groups.

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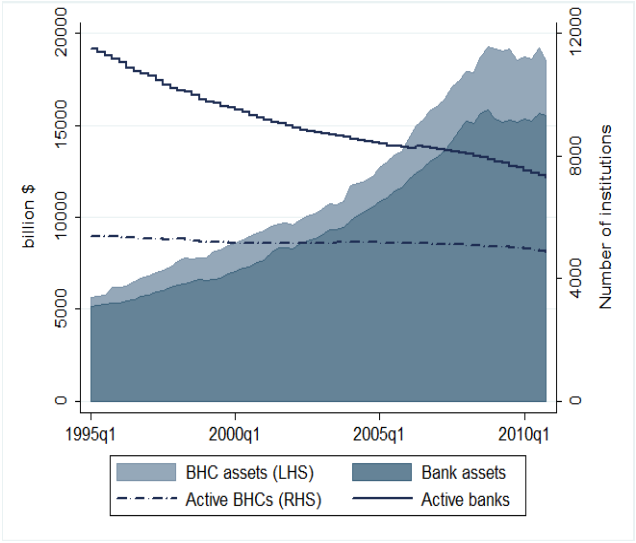
Appendix A

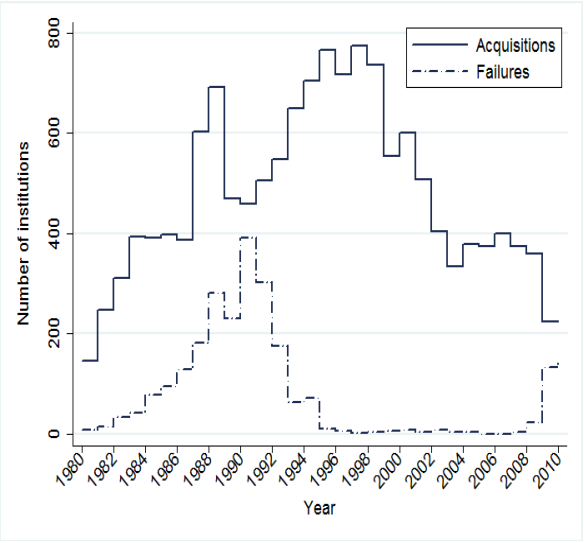
A.1. Figures

Figure 1: Bank assets, failures and acquisitions in the United States

Total assets of banks and BHCs



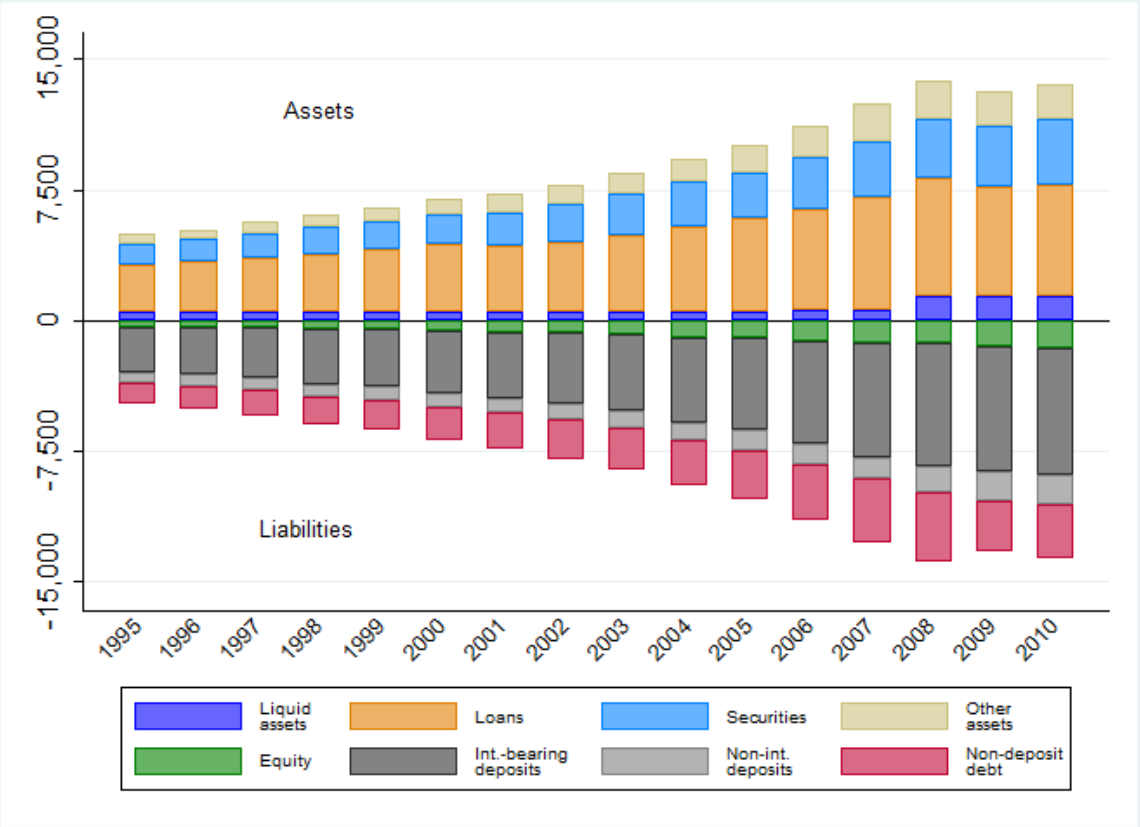
Failed and acquired banks



Note: 'Bank assets' refer to total assets of commercial banks and 'BHC assets' to total unconsolidated assets of bank holding companies (BHCs). 'Active banks' indicate the number of active commercial banks in a given quarter and 'Active BHCs' the number of active BHCs. The number of failures and acquisitions only take into account commercial banks and not thrift institutions.

Sources: Call reports of commercial banks and bank holding companies; Federal Reserve Bank of Chicago M&A database; authors' own calculations.

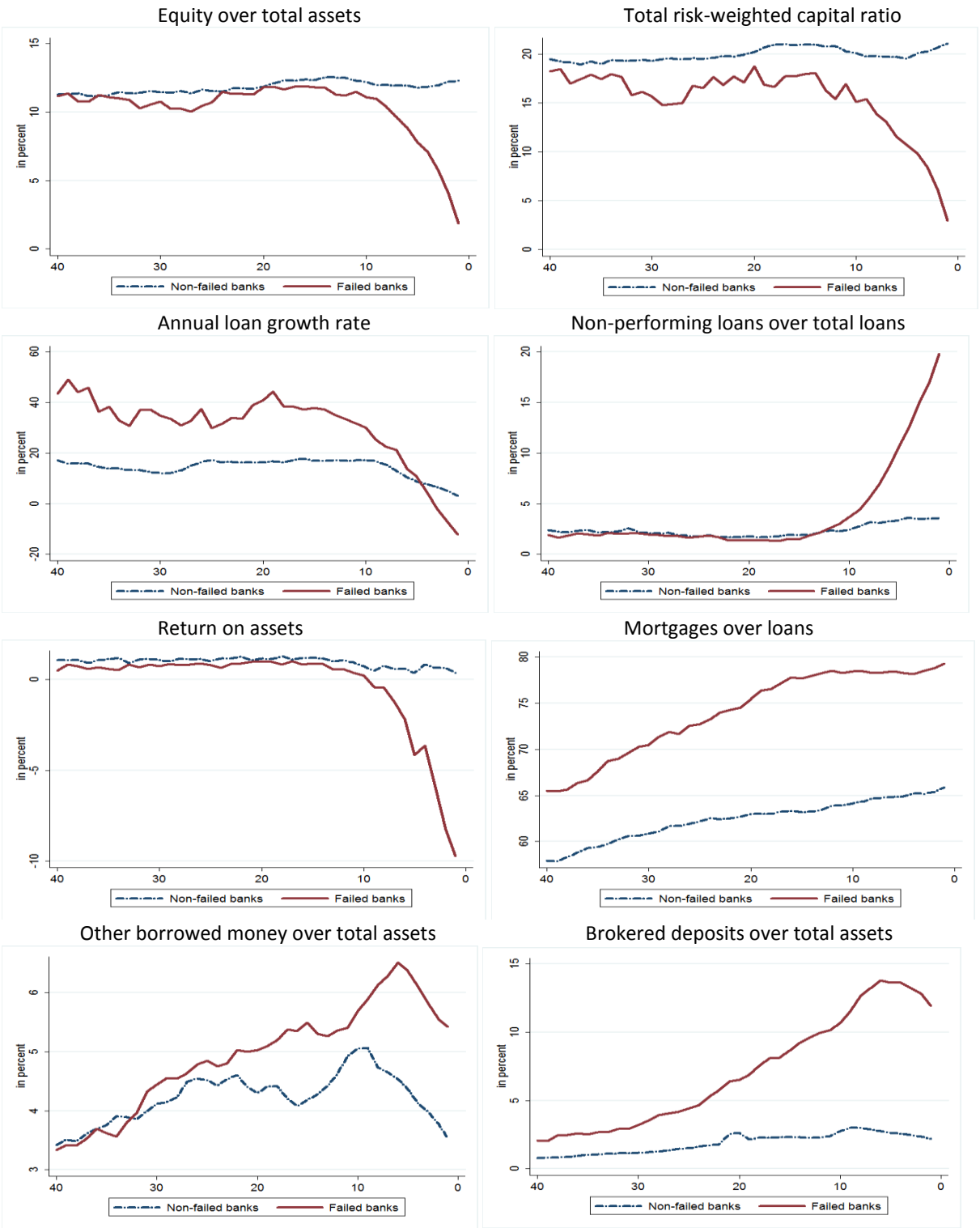
Figure 2: Balance sheets of commercial banks



Note: In billion $. 'Liquid assets' refer to cash and balances due from depository institutions, 'loans' to loans and leases net of unearned income and allowances, 'securities' to the sum of hold-to-maturity & available-for-sale securities and trading assets, 'equity' to the sum of preferred & common stock and surplus, and 'non-deposit debt' to federal funds purchased, trading liabilities, other borrowed money, subordinated debt, and other liabilities. The total volume of assets and liabilities is lower than that shown in the Figure 1, because foreign banks' agencies and branches, and entities that are only engaged in international banking operations are excluded, due to reporting limitations for other balance sheet categories than total assets.

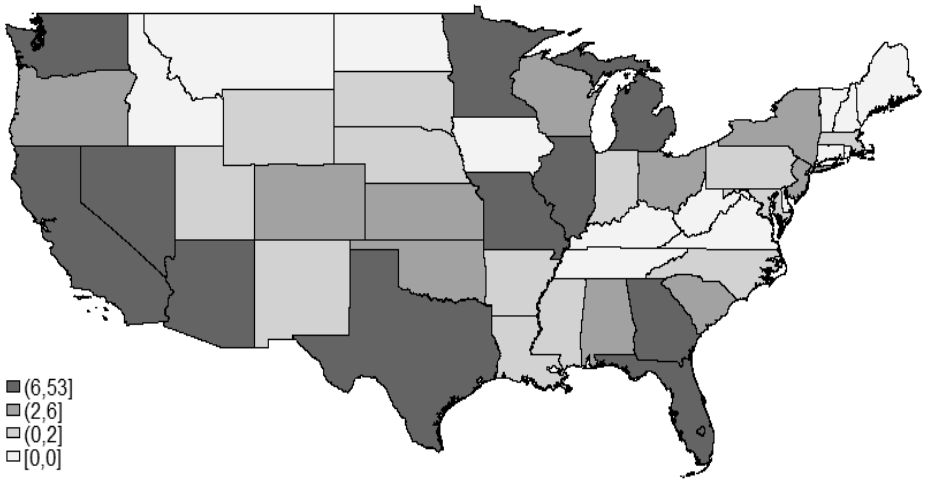
Sources: Call reports of commercial banks; authors' own calculations.

Figure 3: Trends at failed and surviving banks



Note: Unweighted averages, in percentage points. Failed banks refer to commercial banks that have been closed by the FDIC during 2008-10, and non-failed banks to acquired and surviving institutions. Values on the horizontal axis indicate the number of quarters prior to a bank failure, while in the case of non-failed banks, t=0 is Q4/2010 for active banks, or the quarter of acquisition for banks that have been taken over.
Sources: Call reports of commercial banks; Federal Reserve Bank of Chicago M&A database; authors' own calculations.

Figure 4: Commercial bank failures during 2007-2010 by state



Note: The different colors are related to the number of bank failures in a particular state. There are 4 categories: 0 failures, 1-2 failures, 3-6 failures and 7-53 failures. The highest number of failures has occurred in Georgia (53), followed by Florida (40) and Illinois (40).

Sources: Federal Reserve Bank of Chicago M&A database; authors' own calculations.

A.2. Tables

Table 1: Failures and acquisitions of commercial banks and thrift institutions

	Failures		***Acquisitions***	
	Number of institutions	*Involved assets (billion $)*	*Number of institutions*	*Involved assets (billion $)*
		2008-10		
All banks	**361**	**712.01**	**689**	
Commercial banks	313	227.53	636	1,253.89
- Stand-alone banks	48	15.46	60	11.97
- BHC-owned banks	265	212.07	576	1,241.92
Thrifts	48	484.48	53	n.a.
		2001-07		
All banks	**26**	**8.48**	**2335**	
Commercial banks	22	4.18	2089	2,856.33
- Stand-alone banks	11	2.32	333	200.90
- BHC-owned banks	11	1.86	1756	2,655.43
Thrifts	4	4.30	246	n.a.
		1995-2000		
All banks	**31**		**3680**	
Commercial banks	26	2.67	3240	2,570.09
- Stand-alone banks	15	2.05	431	61.55
- BHC-owned banks	11	0.62	2809	2,508.54
Thrifts	5	n.a.	440	n.a.

Note: 'Failures' refer to bank closures that were resolved by a regulator (FDIC, RTC, NCUA, or another regulatory agency) and 'acquisitions' to bank mergers or acquisitions (including acquisitions of 40-100% of assets and splits). 'Number of institutions' indicates the number of events in a particular period, and 'involved assets' the sum of total assets of involved banks measured at the date of the event or in Q4/2007 in the case of thrifts. Commercial banks refer to national, non-member, state member and state saving banks regulated by the Federal Reserve System, FDIC, and OCC. Thrifts refer to federal saving banks, savings and loan associations and credit unions regulated by the Office of Thrift Supervision and National Credit Union Administration. 'Stand-alone banks' indicates that banks are not controlled by a bank holding company and 'BHC-owned banks' to banks that are controlled by a bank holding company.

Sources: Call reports of commercial banks and bank holding companies; Federal Reserve Bank of Chicago M&A database; thrift reports for 2007; authors' own calculations.

Table 2: Summary statistics for the financial statements of commercial banks

	Large	*Small*	*High capitalized*	*Low capitalized*	*Stand-alone*	*BHC-owned*	*Failed*	*Acquired (2008-2010)*	*Other*	*Total*
Number of banks	2086	2086	2086	2086	1577	6767	313	612	6792	8344
Number of BHC-owned banks	1839	1549	1254	1914	0	6767	265	560	5463	6767
Assets at end-2010 (bil. USD)	11600	84	1496	6639	388	11910	228	1228	12297	12297
Percentage of all assets	94.33	0.68	12.16	53.99	3.16	96.85	1.85	9.98	100	100
Age at end-2010 (in years)	72.86	79.44	51.53	80.08	59.25	73.56	37.35	59.12	70.72	70.72
Annual loan growth (2008-2010, in %)	7.86	10.36	26.30	4.53	20.71	7.78	3.55	8.20	10.61	10.30
Annual loan growth (2001-2007, in %)	18.08	8.76	24.70	10.94	22.08	13.08	36.86	16.50	13.87	14.97
Annual loan growth (1995-2000, in %)	22.10	9.69	14.42	16.18	18.39	15.40	34.17	19.40	14.87	16.19
				Ratios (averages 1995-2010)						
Total risk-weighted capital ratio (in %)	16.03	22.40	32.38	13.09	25.30	17.01	16.09	18.36	19.18	18.93
Equity over total assets (in %)	10.18	12.36	17.46	8.05	13.47	10.50	10.36	11.01	11.29	11.20
Loans over total assets (in %)	65.38	57.33	55.81	65.51	58.85	63.19	69.87	62.51	61.80	62.17
Mortgages over total loans (in %)	69.55	52.41	59.93	65.47	65.55	62.28	73.20	64.89	62.36	63.05
Concentration of loans (HHI), (0=diversified, 1=concentrated)	0.61	0.45	0.56	0.54	0.60	0.52	0.64	0.56	0.53	0.54
Non-performing loans over total loans (in %)	2.27	2.79	2.65	2.31	2.60	2.45	4.58	2.13	2.47	2.48
ABS & MBS over total assets (in %)	8.23	4.93	5.67	7.10	6.09	6.41	5.25	7.46	6.31	6.34
Deposits over total assets (in %)	79.85	84.47	77.79	84.65	82.14	83.18	82.14	82.36	83.00	82.93
Loans over deposits (in %)	85.45	69.22	76.30	78.42	73.60	77.60	87.57	82.80	75.66	76.65
Brokered deposits over total assets (in %)	2.93	1.01	2.51	1.70	1.80	1.89	6.55	1.93	1.71	1.87
Other borrowed money over total assets (in %)	5.55	1.79	2.56	4.26	2.76	3.69	4.61	3.54	3.42	3.47
Credit commitments over total assets (in %)	30.84	9.63	44.85	11.41	34.11	14.33	16.43	15.15	19.33	19.00
Derivatives over total assets (in %)	12.44	0.10	5.41	6.87	0.58	4.21	1.58	3.42	3.56	3.36
Net interest income over total assets (in %)	3.81	3.95	3.89	3.88	3.88	3.87	3.92	3.85	3.87	3.88
Non-interest income over total assets (in %)	1.26	0.92	1.53	0.94	1.05	0.95	0.89	1.11	0.97	0.98
Return on assets (in %)	0.96	0.84	0.69	0.92	0.64	0.94	-0.19	0.82	0.91	0.87

Note: Unweighted averages are shown, in percentage points where applicable. The sample covers 8,344 commercial banks covered in specification 1 of Table 4. A 'small' bank has a size that is in the first quartile of bank size, measured by total assets, while a 'large' bank has a size that is in the fourth quartile of bank size. The same distinction applies to 'low capitalized' and 'high capitalized' banks measured by equity over total assets. 'Stand-alone banks' refer to banks that are not controlled by a bank holding company and 'BHC-owned banks' to banks that are controlled by a bank holding company. 'Failed banks' refer to banks that have been closed by a regulator in 2008-10, 'acquired banks' to banks that have been acquired in 2008-10, and "other banks" are the surviving banks that have been active during 2008-10. Total assets and age of failed and acquired banks have been calculated at the time of event. Averages for NPL loans are for the period 2001-2010.

Sources: Call reports of commercial banks and bank holding companies; Federal Reserve Bank of Chicago M&A database; authors' own calculations.

Table 3: Descriptive statistics for the regression variables

Panel A: Commercial bank variables

Variable	Definition	Obs.	Mean	Median	Std. Dev.	Min	Max
Regulatory capital $_{t-4}$	Total risk-weighted capital ratio (in %)	146292	17.82	14.38	14.72	0	489.11
Non-performing loans $_{t-4}$	Ratio of non-performing loans over total loans (in %)	146292	2.38	1.57	3.03	0	100
Other real estate owned $_{t-4}$	Ratio of other real estate owned over total assets (in %)	146292	0.26	0.01	0.66	0	26.33
Size $_{t-4}$	Natural logarithm of total assets in thousands of dollars	146292	11.89	11.75	1.33	7.71	21.29
Mortgages $_{t-12/t-19}$	Mortgages over total loans, moving average from t-12 to t-19 quarters (in %)	132515	65.41	68.07	19.28	0	100
Loan growth $_{t-12/t-19}$	Annual growth rate of total loans, moving average from t-12 to t-19 quarters (in %)	132515	11.60	7.73	19.65	-68.77	420.10
ABS&MBS $_{t-4}$	Ratio of ABS and MBS to total assets (in %)	146292	6.35	2.95	8.83	0	82.16
Foreign assets $_{t-4}$	Ratio of foreign assets to total assets (in %)	146292	0.16	0	2.25	0	84.18
Credit commitments $_{t-4}$	Ratio of credit commitments over total assets (in %)	146292	23.10	10.11	468.77	0	41575.29
Derivatives $_{t-4}$	Ratio of off-balance sheet derivatives over total assets (in %)	146292	4.27	0	215.35	0	47773.66
Managerial efficiency $_{t-4}$	Dummy that equals to 1, if non-interest expenses over net interest income and non-interest income are positive and lower than the sample mean, 0 otherwise	146292	0.56	1	0.50	0	1
Age $_{t}$	Age of the institution (in years)	146292	69.16	78.5	43.46	1	226.75
BHC dummy $_{t}$	Dummy that equals to 1 if a bank is owned or controlled by a bank holding company	146292	0.81	1	0.39	0	1
Net interest margin $_{t-4}$	Annualized ratio of net interest income over total assets (in %)	146292	3.69	3.64	1.19	-145.59	67.70
Non-interest income $_{t-4}$	Annualized ratio of non-interest income over total assets (in %)	146292	0.92	0.6	4.46	-253.42	371.60
Other borrowed money $_{t-4}$	Ratio of other borrowed money over total assets (in %)	146292	4.64	2.31	6.29	0	86.83
Brokered deposits $_{t-12/t-19}$	Total brokered deposits over total assets, moving average from t-12 to t-19 quarters (in %)	132515	1.81	0	5.40	0	88.35
House price growth $_{t}$	Annual growth rate of average house prices, by state (in %)	132515	-0.40	0.14	6.02	-28.19	21.41
Financial stress $_{t/t-3}$	Financial stress indicator, moving average from t to t-3 quarters (index)	132515	0.48	0.17	1.44	-1.12	3.23

Panel B: Bank holding company variables

Variable	Definition	Obs	Mean	Median	Std. Dev.	Min	Max
Equity over assets $_{t-4}$	Ratio of unconsolidated equity over unconsolidated assets (in %)	105369	87.50	95.75	15.43	0.04	100
Rescue dummy $_{t}$	Dummy that equals to 1, if the bank holding company received TARP funds, 0 otherwise	105369	0.04	0	0.19	0	1
Equity invested in non-banks $_{t-4}$	Unconsolidated equity investments in non-bank subsidiaries over unconsolidated assets (in %)	105369	1.08	0	4.17	0	88.95

Return on assets $_{t-4}$	Annualized unconsolidated net income over unconsolidated assets (in %)	105369	7.16	8.45	14.45	-395.99	297.40
Short-term borrowing $_{t-4}$	Unconsolidated short-term borrowing over unconsolidated assets (in %)	105369	1.27	0	4.61	0	79.19
Money borrowed from non-banks $_{t-4}$	Unconsolidated balances due to non-bank subsidiaries over unconsolidated assets (in %)	105369	7.15	0	12.23	0	99.04

Note: In percentage points where applicable.

Sources: Call reports of commercial banks and bank holding companies; Financial stress indicator - Federal Reserve Bank of St. Louis; Housing prices - Federal Housing Finance Association; authors' own calculations.

Table 4: Baseline estimations – probability of failure

	Specification 1 ***Failure definition 1***		***Specification 2*** ***Failure definition 1***		***Specification 3*** ***Failure definition 1***		***Specification 4*** ***Failure definition 2***	
	Marginal effect	*Std. error*	*Marginal effect*	*Std. error*	*Marginal effect*	*Std. error*	*Marginal effect*	*Std. error*
				C: capital adequacy				
Regulatory capital $_{t-4}$	-0.972***	0.110	-0.855***	0.185	-0.867***	0.202	-0.640***	0.132
				A: asset quality				
Non-performing loans $_{t-4}$	0.210	0.151	0.193**	0.095	0.388***	0.098	0.307***	0.070
Size $_{t-4}$	0.004***	0.001	0.006***	0.002	0.004**	0.002	0.003**	0.001
Other real estate owned $_{t-4}$			0.297***	0.115	0.135	0.104	0.104	0.080
Mortgages $_{t-12/t-19}$					0.035**	0.016	0.031***	0.012
Loan growth $_{t-12/t-19}$					0.012**	0.005	0.010***	0.004
ABS&MBS $_{t-4}$			-0.059**	0.027	0.005	0.022	-0.007	0.017
Foreign assets $_{t-4}$			-0.056	0.115	0.022	0.085	-0.004	0.076
Credit commitments $_{t-4}$			-0.006	0.008	-0.003	0.008	-0.002	0.006
Derivatives $_{t-4}$			-0.026	0.021	-0.038	0.033	-0.018	0.020
				M: management				
Managerial efficiency $_{t-4}$	-0.025***	0.005	-0.023***	0.005	-0.010**	0.005	-0.008**	0.004
Age $_{t}$	-0.0002***	0.000	-0.0002***	0.000	-0.0001**	0.000	-0.0001**	0.000
BHC dummy $_{t}$			0.001	0.004	0.005	0.004	0.002	0.003
				E: earnings				
Net interest margin $_{t-4}$	-0.144***	0.038	-0.134***	0.039	-0.097***	0.036	-0.072***	0.027
Non-interest income $_{t-4}$			-0.044***	0.013	-0.015	0.044	0.001	0.047
				L: liquidity				
Other borrowed money $_{t-4}$	0.049***	0.019	0.063***	0.021	0.066**	0.026	0.044**	0.019
Brokered deposits $_{t-12/t-19}$					0.058***	0.021	0.036**	0.014
				S: sensitivity to markets and the economy				
House price growth $_{t}$					-0.110***	0.038	-0.094***	0.028
Financial stress $_{t/t-3}$					0.006***	0.002	0.005***	0.001
Observations	146292		146292		132515		132417	
Pseudo R^2	0.28		0.29		0.37		0.35	
AUROC	0.9287		0.9317		0.9534		0.9466	
Banks	8344		8344		7568		7562	
Bank failures	317		317		266		285	
Correctly predicted failures	60		58		74		81	
False alarms	95		95		85		85	
- among which rescued banks	9		7		5		5	

Note: The estimation period is Q1/2006-Q4/2010. The probability of failure has been estimated with the pooled Logit estimator with robust standard errors clustered at the bank level. Marginal effects are shown, evaluated for the average failed bank one year prior to closure, which had the following average characteristics (in decimals, where applicable): regulatory capital=0.107, non-performing loans=0.106, other real estate owned=0.018, size=12.435, mortgages=0.779, loan growth=0.307, ABS&MBS=0.053, foreign assets=0.001, credit commitments=0.123, derivatives=0.011, managerial efficiency=0, age=38.945, BHC dummy=0, net interest margin=0.029, non-interest income=0.008, other borrowed money=0.064, brokered deposits=0.082, house price growth=-0.055, financial stress=1.204. Standard errors of the marginal effects are computed by the delta method. Note that the dummy variables are set to zero. 'Failure definition 1' refers to the estimations in which the dependent variable is equal to 1 in the quarter during which a bank failed and zero otherwise. 'Failure definition 2' indicates that the dependent variable is equal to 1 in the quarter during which the tangible equity ratio of a failed bank has fallen for the first time below 2% or when an undercapitalized bank was acquired and zero otherwise. 'AUROC' refers to the area under the receiver operating characteristic, 'correctly predicted failures' to the number of bank failures that have been predicted with a probability of at least 10%, and 'false alarms' to the number of instances during which the model predicted a failure with at least 10%, although the bank survived. 'Rescued banks' are banks that received TARP funds. ***, ** and * indicate significance at the 1%, 5% and 10% level.

Table 5: Estimation results with information on bank holding companies

	Specification 5		Specification 6		Specification 7		Specification 8		Specification 9	
	Marginal effect	Std. error	Marginal effect	Std. error	Marginal effect	Std. error	Marginal effect	Std. error	Marginal effect	Std. Error
Commercial bank characteristics										
Regulatory capital $_{t-4}$	-0.795***	0.110	-0.785***	0.115	-0.711***	0.118	-0.714***	0.119	-0.715***	0.118
Non-performing loans $_{t-4}$	0.313***	0.062	0.341***	0.065	0.363***	0.067	0.370***	0.069	0.367***	0.067
Other real estate owned $_{t-4}$	0.012	0.084	-0.006	0.095	-0.060	0.102	-0.044	0.103	-0.046	0.102
Size $_{t-4}$	0.004***	0.001	0.006***	0.001	0.006***	0.002	0.006***	0.002	0.006***	0.002
Mortgages $_{t-12/t-19}$	0.033**	0.013	0.031**	0.014	0.039**	0.017	0.040**	0.017	0.040**	0.017
Loan growth $_{t-12/t-19}$	0.009**	0.004	0.014***	0.004	0.015***	0.006	0.016***	0.006	0.016***	0.006
ABS&MBS $_{t-4}$	-0.023	0.023	-0.030	0.026	-0.047	0.033	-0.044	0.034	-0.046	0.034
Foreign assets $_{t-4}$	0.013	0.070	0.023	0.076	0.030	0.085	0.036	0.080	0.032	0.087
Credit commitments $_{t-4}$	-0.023	0.020	-0.027	0.021	-0.024	0.024	-0.023	0.025	-0.024	0.024
Derivatives $_{t-4}$	-0.005	0.009	-0.007	0.011	-0.007	0.011	-0.006	0.010	-0.008	0.011
Managerial efficiency $_{t-4}$	-0.007**	0.003	-0.006*	0.004	-0.005	0.004	-0.005	0.004	-0.005	0.004
Age $_{t}$	-0.0001**	0.000	-0.0001**	0.000	-0.0001**	0.000	-0.0001*	0.000	-0.0001**	0.000
Net interest margin $_{t-4}$	-0.007	0.162	-0.044	0.118	-0.077	0.059	-0.075	0.068	-0.071	0.079
Non-interest income $_{t-4}$	-0.034	0.078	-0.019	0.103	0.050	0.103	0.060	0.098	0.053	0.102
Other borrowed money $_{t-4}$	0.048**	0.023	0.040	0.025	0.044	0.029	0.043	0.030	0.046	0.029
Brokered deposits $_{t-12/t-19}$	0.039***	0.014	0.029*	0.015	0.039**	0.018	0.038**	0.018	0.038**	0.018
Bank holding characteristics										
Equity over assets $_{t-4}$			-0.037***	0.007	-0.040***	0.009	-0.018	0.017	-0.034***	0.010
Rescue dummy $_{t}$			-0.040***	0.012	-0.049***	0.015	-0.049***	0.015	-0.050***	0.015
Equity invested in non-banks $_{t-4}$					0.023	0.026	0.023	0.026	0.025	0.026
Return on assets $_{t-4}$					-0.023***	0.005	-0.023***	0.005	-0.023***	0.005
Short-term borrowing $_{t-4}$							0.052**	0.025	0.036*	0.020
Money borrowed from non-banks $_{t-4}$							0.022	0.019		
Macroeconomic conditions										
House prices growth $_{t}$	-0.100***	0.025	-0.103***	0.026	-0.127***	0.031	-0.130***	0.032	-0.129***	0.032
Financial stress $_{t/t-3}$	0.005***	0.001	0.006***	0.001	0.008***	0.002	0.008***	0.002	0.008***	0.002
Observations	105369		105369		105369		105369		105369	
Pseudo R^2	0.35		0.37		0.38		0.38		0.38	
AUROC	0.9512		0.9539		0.9564		0.9568		0.9567	
Banks	6196		6196		6196		6196		6196	
Bank failures	240		240		240		240		240	
Correctly predicted failures	71		81		89		91		92	
False alarms	70		68		79		77		77	
- among which rescued banks	4		1		3		3		3	

Note: The estimation period is Q1/2006-Q4/2010. The probability of failure has been estimated with the pooled Logit estimator with robust standard errors clustered at the bank level. Marginal effects are shown, evaluated for the average failed bank one year prior to closure, which had the following average characteristics (in percent (decimals), where applicable): regulatory capital=0.110, non-performing loans=0.095, other real estate owned=0.015, size=12.310, mortgages=0.761, loan growth=0.291, ABS&MBS=0.049, foreign assets=0.001, credit commitments=0.144, derivatives=0.014, managerial efficiency=0, age=39.264, net interest margin=0.032, non-interest income=0.009, other borrowed money=0.06, brokered deposits=0.076, equity over assets=0.714, rescue dummy=0, equity invested in non-banks=0.018, return on assets=-0.114, short-term borrowing=0.050, money borrowed from non-banks=0.169, house price growth=-0.055, financial stress=1.146. Standard errors of the marginal effects are computed by the delta method. Note that we have set the dummy variables to zero. The estimations are based on 'Failure definition 2' which treats a bank as failed in the quarter during which the tangible equity ratio of a failed bank has fallen for the first time below 2% or when an undercapitalized bank was acquired. 'AUROC' refers to the

area under the receiver operating characteristic, 'correctly predicted failures' to the number of bank failures that have been predicted with a probability of at least 10%, and 'false alarms' to the number of instances during which the model predicted a failure with at least 10%, although the bank survived. 'Rescued banks' are banks that received TARP funds. ***, ** and * indicate significance at the 1%, 5% and 10% level.