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CEO Risk-Taking Incentives and Bank Failure during the 2007-2010 Financial Crisis [*]

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Abstract

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Keywords: executive compensation; risk-taking incentives; leverage; risk shifting; bank governance; financial crisis.

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February 27, 2015

Abstract

We propose a simple measure of the risk-taking incentives of the CEOs of highly levered financial institutions, levered delta, which captures the incentives to take on risk generated by CEOs' stock holdings. Using this measure, we find that stronger CEO risk-taking incentives prior to the 2007–2010 financial crisis are associated with a higher probability of bank failure during the crisis. We find no evidence that risk-taking incentives or bank failure are related to corporate governance failures. However, CEOs' risk-taking incentives appear to be aligned with shareholders' incentives to shift risk to other claim holders.

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> *We're going to examine the ways in which the means and manner of executive compensation have contributed to a reckless culture and quarter-by-quarter mentality that in turn have wrought havoc in our financial system.* Remarks by President Barack Obama on Executive Compensation with Secretary Geithner. September 4, 2009 (Obama, 2009).

There is a widespread view (illustrated by the above quote) that bankers' compensation was responsible for creating the incentives to take on risk that led to the latest financial crisis. This view of executive compensation has guided numerous proposals to regulate pay at financial institutions.[1] Moreover, the perception that executive compensation created excessive risk-taking incentives has often been accompanied by the belief that those incentives were the consequence of corporate governance failures, which created a misalignment between executives' incentives and shareholder interests.[2]

However, despite the attention devoted to executive pay by regulators, extant research does not provide much support for the hypothesis that CEO compensation in the run-up to the crisis is responsible for the high levels of risk of some financial institutions. Notably, Fahlenbrach and Stulz (2011) find no significant relation between the most commonly used measure of the risk-taking incentives generated by executive compensation (Guay, 1999's *option vega*) and bank performance during the crisis.[3] Cheng et al. (2014) also put forth an alternative explanation of the relation between CEO compensation and bank risk, in which banks' exogenously given riskiness determines the (optimal) CEO compensation, and not the other way around, and find results consistent with their proposed explanation. Moreover, Fahlenbrach and Stulz (2011) find that firms whose CEOs had their incentives better aligned with shareholders' interests had worse performance during the crisis, and Cheng et al. (2014) report that firms whose CEOs were less likely to be entrenched were riskier. Therefore, the authors of both papers conclude that the misalignment of the incentives of shareholders and managers of financial institutions is unlikely to have contributed to the financial crisis.

In this paper, we re-examine the question as to whether the incentives to take on risk created by CEO compensation are associated with bank risk and investigate whether the risk-taking incentives of bank CEOs are aligned with those of shareholders.

[1] Section 956 of the 2010 Dodd-Frank Act requires that the banking agencies regulate compensation arrangements at large financial institutions to discourage inappropriate risk taking, and, in 2011, the agencies proposed a rule to regulate pay in financial institutions. Outside of the US, regulatory action has been intense as well. The Committee of European Banking Supervisors issued in 2010 a set of *Guidelines on Remuneration Policies and Practices*, and the European Union approved directives CRD III (in 2010) and CRD IV (in 2013) to regulate compensation at financial institutions (see Murphy, 2013, for a description and a critical assessment of these reforms). In the UK, the Financial Services Authority issued in 2009, and amended in 2010, the so called Remuneration Code. At the multinational level, the Financial Stability Forum issued the *Principles for Sound Compensation Practices* in 2009.

[2] For example, in 2009, SEC Chairman Mary L. Schapiro stated: "I believe that many of the problems leading to our economic crisis can be laid at the door of poor corporate governance. Too many boards failed in their primary function of diligently overseeing management. As a result, too many managers took on too much risk and made decisions that were too focused on the short-term." (Schapiro, 2009)

[3] We note, however, that Gande and Kalpathy (2011) report that that same measure computed prior to the crisis is positively associated with the amount of Federal assistance during the crisis.

Regarding the first question, we consider the absence of a relation between CEO risk-taking incentives and bank risk somewhat puzzling. As economists, we expect individuals, including CEOs, to respond to incentives. Moreover, it seems likely that the CEOs of large complex financial institutions had ample room to alter their firms' riskiness in response to those incentives. Thus, we propose and test the hypothesis that the solution to this apparent puzzle is that standard measures of the risk-taking incentives generated by executive compensation, which focus solely on the incentives generated by stock options, do not capture a potentially large component of the incentives to take on risk for bank CEOs, namely the incentives generated by their stock holdings (an argument also made by Chesney et al., 2012). Indeed, because of limited liability, equity holders have the incentive to shift risk to debtholders and other claim holders (Jensen and Meckling, 1976; Galai and Masulis, 1976), and this incentive is especially strong for the equity holders of highly levered firms, such as large US financial institutions. Now, the incentives to take on risk embedded in stock holdings will have a small impact on a CEO's risk-taking incentives if the CEO owns few shares or, more generally, if his wealth responds little to changes in the stock value. Therefore, we propose a measure of the incentives to take on risk generated by equity, *levered delta* (LD), which we define as the product of leverage and the CEO's exposure to the firm's equity value (*delta*). This measure captures in the simplest way possible the hypotheses that risk-taking incentives will be increasing in leverage and that the impact of leverage on CEO risk-taking incentives will be greater the greater the CEO's exposure to the firm's equity value.

In addition to the incentives generated by stock and option holdings, other components of executive compensation arrangements can also generate risk-taking incentives, which are not captured by standard incentive measures. For example, termination payments, which reduce the downside risk for CEOs, may increase CEOs' incentives to take on risk. In the opposite direction, executives' holdings of debt-like claims, such as unsecured pension benefits or deferred compensation, may reduce risk-taking incentives by aligning CEOs' incentives with those of debtholders (Jensen and Meckling, 1976; Edmans and Liu, 2011). Thus, we also consider these other measures of CEOs' risk-taking incentives.

We also study the relation between shareholders and CEOs' risk-taking incentives and bank risk. The results by Fahlenbrach and Stulz (2011) and Cheng et al. (2014) that riskier financial institutions are characterized by a better alignment between the interests of shareholders and managers suggest, on the one hand, that corporate governance failures are unlikely to be responsible for high levels of risk taking and, on the other hand, that bank shareholders have strong incentives to induce executives to take on risk. Following up on these results, we investigate whether corporate governance failures can explain our measure of CEO risk-taking incentives (LD) or whether, to the contrary, the strength of CEOs' risk-taking incentives responds to the strength of shareholders' risk-taking incentives, as measured by bank leverage. Standard arguments suggest that shareholders' incentives to take on risk at the expense of other claim holders will be increasing in firm leverage and, therefore, that the shareholders of more levered firms will give their CEOs stronger risk-taking incentives. However, if shareholders ultimately bear the cost of this risk shifting in the form of a higher cost of debt, the shareholders of more levered firms may structure executive compensation so as to limit risk shifting (Jensen and Meckling, 1976; John and John, 1993). In such case, there need not be a positive relation between leverage and risk-taking incentives.

To investigate the relation between CEO risk-taking incentives prior to the financial crisis and bank risk, we use bank failure during the crisis period (2007–2010) as the measure of bank risk. We measure risk ex post to capture the tail risk that is unlikely to be captured by standard risk measures, such as stock return volatility, systematic risk, or idiosyncratic risk, if they are computed prior to the crisis (as in Cheng et al., 2014 or DeYoung et al., 2013). Moreover, measures that infer bank risk from the market value of securities (such as the buy-and-hold returns employed by Fahlenbrach and Stulz, 2011) capture the part of firm risk that is borne by the holders of those securities, but may not incorporate the risks borne by other stakeholders, such as the taxpayers who bail out a bank's security holders. To partly address this limitation, we use an encompassing definition of bank failure during the 2007-2010 financial crisis that includes not only bank closures but also acquisitions of distressed banks with the intervention of supervisors. As a case in point, Bear Stearns did not default, yet it was acquired by J.P. Morgan, with the intervention and assistance of the Federal Reserve, for $10 per share, when the previous closing price had been $30, and when just two weeks earlier the stock had traded at $85.88. Our measure considers Bear Stearns as a failed financial institution.

We estimate the relation between risk-taking incentives measured in year 2006 and bank failure in the period 2007-2010 for a sample of large US financial institutions and find that, whereas there is no significant relation between bank failure and risk-taking incentives measured as option vega (in line with the findings of Fahlenbrach and Stulz, 2011), there is a statistically and economically significant relation between LD and bank failure. At the same time, if we control for LD, no other measure of incentives (such as the size of termination payments or the manager's holdings of inside debt) is significantly associated with bank failure.

Therefore, our results are consistent with the hypothesis that the incentives generated by CEOs' holdings of stock and options had an impact on bank risk. However, we do not have an exogenous source of variation in compensation incentives that would allow us to identify the causal effect of these incentives on risk. Therefore, our results could well reflect the fact that it is optimal for riskier firms to give their CEOs compensation contracts with larger LD or be due to the correlation of LD with omitted variables related to risk or risk-taking incentives. Although we cannot rule out these possibilities, we consider different omitted variables that could be driving the results and include proxies for these variables as controls in our regressions. Thus, we consider that the relation between LD and bank failure is due to the correlation of our incentive measure with the strength of other unmeasured incentives (such as those stemming from the threat of replacement or career concerns) or with firm or CEO characteristics potentially correlated with greater risk taking. The relation between risk-taking incentives, as measured by LD, and bank failure survives the inclusion of these controls. We also find no support for the alternative explanations that our incentive measure is simply measuring risk and not risk-taking incentives, or that bank failure captures persistently poor performance instead of risk. Finally, we also check that our results are robust to changes in the definition of the sample, the criteria we use to identify bank failure, different specifications, alternative risk measures, and an alternative measure of risk-taking incentives provided by Chesney et al. (2012).

We find no significant relation between standard measures of the alignment between the incentives of managers and shareholders, such as board size or independence, Gompers et al. (2003)'s *Governance index*, or Bebchuk et al. (2009)'s *Entrenchment index*, and either bank failure or risk-taking incentives, in line with the results of Cheng et al. (2014) and Chesney et al. (2012). However, if we use banks' lagged leverage as a measure of shareholders' incentives to shift risk to debtholders (as in John et al., 2010), we find that it has a positive relation with LD. Moreover, in contrast to the results by John et al. (2010), we find no evidence in our sample that the shareholders of more levered firms structured the compensation of their CEOs so as to achieve a lower pay-performance sensitivity. Therefore, our results do not lend support to the hypothesis that improving shareholders' ability to monitor and discipline managers would have substantially reduced bank risk. If anything, our results suggest that a better alignment between CEO incentives and shareholder interests would have resulted in stronger risk-taking incentives in the more levered financial institutions.

In addition to the work by Fahlenbrach and Stulz (2011) and Cheng et al. (2014), several articles have analyzed the relation between CEO compensation and bank risk in the wake of the financial crisis. In the paper most closely related to ours, Chesney et al. (2012) propose a measure of the sensitivity of the value of CEOs' equity holdings to the volatility of the firm's assets (*asset volatility vega*) derived from a model in which equity is a call option on the firm's assets and stock options are an option on that option.[4] Chesney et al. (2012) find evidence generally consistent with a positive relation between asset volatility vega in the years prior to the crisis and bank write-downs (which they use as an ex post measure of risk) during the crisis. As a robustness check, we compute asset volatility vega for the firms in our sample and find that it is very highly correlated with LD. Moreover, using asset volatility vega as a measure of risk-taking incentives leads to results very similar to those obtained with LD. DeYoung et al. (2013) analyze the relation between both risk and business policies likely to be related to bank risk and one-year lagged CEO incentives (measured by delta and option vega). In contrast to Fahlenbrach and Stulz (2011), DeYoung et al. (2013) do find a relation between option vega and both bank risk and bank policies for a sample of U.S. commercial banks,

[4]Anderson and Core (2013) propose alternative measures of risk-taking incentives that aim to capture the incentives embedded in stock, options, and debt-like claims held by CEOs.

but they measure risk prior to the financial crisis. Gande and Kalpathy (2011) show that option vega before the crisis is positively associated with the amount of U.S. Federal Reserve emergency loans provided to banks, which they use as an ex post measure of bank risk. Bhagat and Bolton (2014) examine the net payoff obtained by the CEOs of 14 of the largest US financial institutions during the period from 2000 to 2008, as well as CEOs' trades of their own stock during the same period, and conclude that CEO compensation in those firms generated incentives for excessive risk taking. John et al. (2010) study the relation between the pay-performance sensitivity of bank CEOs, leverage, and several measures of outside monitoring and find that pay-performance sensitivity is positively associated with outside monitoring and negatively associated with bank leverage. Finally, Bebchuk and Spamann (2010) and Bebchuk et al. (2010) analyze case studies of executive compensation at large U.S. financial institutions and propose compensation reforms.[5]

Our article contributes to the literature analyzing executive compensation and risk taking in banks in three ways. First, we propose a simple measure of CEO risk-taking incentives that captures the incentives generated by CEOs' portfolios of both stock and stock options, and we show that this measure is positively associated with bank risk. Second, we use an ex post measure of bank risk, bank failure during the crisis, that aims to capture the full extent of bank risk taking prior to the crisis. And thirdly, we find that shareholder incentives to take on risk are positively related to CEO risk-taking incentives.

1 Sample selection

We select all firms with 4-digit SIC codes between 6000 and 6300 covered by the compensation database Execucomp in year 2006. Of the 167 firms so selected, we keep all firms with SIC codes 6020 (*Commercial Banks*), 6035 (*Savings Institutions, Federally Chartered*), and 6036 (*Savings Institutions, Not Federally Chartered*)—a total of 114 firms—and we exclude firms with SIC codes 6111 (*Federal Credit Agencies*) and 6282 (*Investment Advice*). To determine the inclusion of the 41 firms in the remaining SIC codes, we search the National Information Center of the Federal Financial Institutions Examination Council (FFIEC) to verify each firm's institution type in year 2006.[6] We keep a firm in the sample if it is identified as any type of regulated institution.[7] We also keep in the sample those firms listed as primary dealers by the New York Fed.[8] This process yields a base sample of 130 firms in 2006, from which we drop five firms because there

[5]There are few earlier studies of the relation between CEO compensation and bank risk taking, notably Houston and James (1995) and John and Qian (2003). Laeven and Levine (2009) and Erkens et al. (2012) also analyze the relation between bank governance and bank risk for international samples of large financial institutions.

[6]These firms have SIC codes: 6099 (*Functions Rel. To Dep. Bkg.*), 6141 (*Personal Credit Institutions*), 6153 (*Short-Term Business Credit*), 6159 (*Misc. Business Credit Instn.*), 6162 (*Mortgage Bankers & Loan Corr.*), 6172 (*Finance Lessors*), 6199 (*Finance Services*), 6200 (*Security & Commodity Brokers*), 6211 (*Security Brokers & Dealers*). We access the National Information Center of the FFIEC at `http://www.ffiec.gov/nicpubweb/nicweb/SearchForm.aspx`.

[7]The classes of regulated institutions are: financial holding company, bank holding company, savings and loans holding company, federal savings bank, national bank, state member bank, FDIC-insured non-member bank, federal savings association.

[8]`http://www.newyorkfed.org/newsevents/news/markets/2006/an060915p.html`

is not enough information to compute LD.[9] Therefore, our final sample has 125 firms. For transparency, we report our final sample in Appendix B.[10] In Section 8, we also check the robustness of our results to different sample selection criteria.

Since we obtain compensation data from Execucomp, our sample is composed of relatively large, publicly traded financial institutions. The sample contains all large bank and financial holding companies whose main activity is commercial banking, which range from holding companies with national presence (such as Bank of America or Wells Fargo) to regional bank holding companies (Fifth Third Bancorp., National City Corp. or Regions Financial Corp.), or companies operating mainly in one or two states (such as Anchor Bancorp Wisconsin Inc. or Tompkins Financial Corp.). The sample also contains the five largest investment banks (Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, and Morgan Stanley) and several holding companies (such as American Express Co. and Charles Schwab) that have bank subsidiaries and are federally regulated.[11]

We obtain accounting information from Compustat Fundamentals and market data from CRSP. Panel A in Table 1 displays summary statistics for the firms in our sample, whereas Panel B displays the same statistics for the universe of firms in Compustat with SIC codes between 6000 and 6050. The financial institutions in our sample are significantly larger, irrespectively of whether size is measured by market capitalization or total assets: The average market capitalization in year 2006 is \$15.7 billion (median \$2 billion) and the average total asset value is \$103.8 billion (median \$11.5 billion) for the firms in our sample, whereas the same values in the Compustat universe of banks are \$4.4 billion (median \$0.2 billion) and \$41.4 billion (median \$1 billion), respectively. Average leverage is lower and average ROA higher in our sample than in the Compustat universe of banks.

2 Risk and bank failure

Our measure of risk taking in the years preceding the crisis is bank failure during the crisis period. To date the crisis, we follow the time-lines provided by the New York Fed (which dates the beginning of the "financial turmoil" in June 2007, when Bear Stearns pledged \$3.2 billion to aid one of its hedge funds)[12] and the Saint Louis Fed (which dates the beginning of the financial crisis in February 2007, coinciding with Freddie Mac's announcement that it would no longer buy the riskiest subprime mortgages and mortgage-related securities)[13]

[9] We drop Center Financial Corp., with SIC 6036, because it does not match with *Compustat Fundamentals*. We drop Raymond James Financial Corp., Bankunited Financial Corp., Glacier Bancorp Inc., and Guaranty Financial Group Inc. because there is not enough information to compute our measures of risk-taking incentives.

[10] Our sample selection procedure is analogous to the one employed by Fahlenbrach and Stulz (2011), except that we exclude Federal Credit Agencies. Thus, for example, Fannie Mae is not in our sample.

[11] Although we often refer to the firms in our sample as banks, they are really holding companies with bank subsidiaries.

[12] `http://www.ny.frb.org/research/global_economy/Crisis_Timeline.pdf`.

[13] `http://timeline.stlouisfed.org/index.cfm?p=timeline`.

and define 2007 to be the first year of the financial crisis.

Because of the potentially systemic importance of many of the banks in our sample, regulators may be expected to intervene to bail out a bank at risk of insolvency or to encourage sound banks to acquire financially distressed banks so as to avoid actual default. Identifying bank failure with default would, thus, not capture the instances of financial distress in which the regulators' intervention averts bank failure. Even in the midst of a financial crisis, outright default of large financial institutions is too rare to allow for a precise estimation of the coefficients of interest. Moreover, using default as a measure of failure could bias the estimates if different banks have different probabilities of being bailed out. In particular, the CEOs of those banks more likely to be bailed out may take on greater risk in the anticipation of a bailout. If regulators would not allow these banks to default, one would incorrectly attribute a low level of risk taking to banks with a large risk exposure. Therefore, we define bank failure so as to encompass both institutions that default and those that are acquired by other financial institutions with the support or intervention of regulators.

More precisely, we first identify which firms are delisted in the period 2007-2010 by analyzing the series of monthly returns in the CRSP stock database. This process yields a set of 31 delisted firms. However, firms may delist for reasons other than bankruptcy or financial distress. For example, firms may go private, merge, or be acquired for strategic reasons even if they are sound. To determine whether firms were delisted because of financial distress, we take the following steps:

1. We check the FDIC webpage for information about banks that become inactive during the crisis period.[14] However, the FDIC provides information about active and inactive banks but not holding companies (which are our unit of observation). Therefore, we first identify the main banking subsidiary of each holding company from the organization's structure provided by the FFIEC. The FDIC indicates if a bank is inactive because it was put into receivership, or because it was merged (with or without financial assistance by the regulator). If the FDIC indicates that the firm was closed or there was a merger with financial assistance by the Fed or the FDIC we consider the firm failed. We unambiguously identify 9 firms as failed in this step.

2. *Merger discount.* Following the procedure used by Fahlenbrach et al. (2012), we use the SDC Platinum database to identify mergers and check whether firms not classified as failed in the previous steps are acquired with a discount in the crisis period. In particular, we identify three firms acquired with significant discounts (with one-day, one-week and one-month negative premiums of above 30%). We also consider as failed a firm (Mellon) acquired with a one-day small discount of 6%, as well as a

[14] `http://www2.fdic.gov/idasp/main.asp`.

firm (Countrywide) that is acquired with a one-day positive premium of 40%, but with one-week and one-month discounts of 18% and 28%, respectively.

3. For those delisted firms that we do not classify as failed in the previous steps, we search the PROQUEST database using the company name and the following keywords: *failed, bankrupt, intervened, closed.* The PROQUEST search identifies one firm as failed (Lehman Brothers, which is identified from its Chapter 11 petition filing).

4. We finally perform the same search on the internet (using standard search engines). This broader internet search indicates that one firm is acquired with substantial regulatory pressure (Merrill Lynch), another one with TARP aid given to the acquiring institution (National City Corp), and another one after a large amount of TARP bailout money is given to the target institution (Provident Bankshares).[15]

The procedure identifies 19 firms in the sample as failed. For transparency, we provide the list of failed firms as well as the reason why they are identified as such in Appendix C. Since the last three steps involve some judgment on our part, in Section 8 we consider the robustness of our results to alternative classifications of the firms identified as failed in these steps.

As discussed in the introduction, using bank failure as a measure of risk helps us avoid some limitations of alternative risk measures. However, bank failure is not without problems. First, as an ex post measure of realized risk, bank failure contains a significant amount of measurement error: Whether a bank fails is determined not only by ex ante decisions that determine the level of risk, but also by luck. This measurement error will push up the standard error of our estimates. Second, our measure of bank risk captures the exposure to risks that have negative realizations during the financial crisis. It is possible that those banks more likely to fail conditionally on the events that led to the financial crisis were not riskier ex ante. Third, with our definition of failure we capture instances in which a firm's financial condition is so weak that it is forced to disappear as an independent entity (either because of bankruptcy or forced merger). However, we may consider as healthy systemically important financial institutions that managed to survive only thanks to massive public aid (such as Citigroup or Bank of America). Since this misclassification may bias our results, in Section 8 we evaluate the robustness of the results to classifying as failed (or excluding from the sample) some institutions that survived as separate entities only because they receive extremely large amounts of

[15]In the case of Merrill Lynch, there were sustained rumors that the Federal Reserve had pressured Bank of America to carry out the acquisition and Congressional hearings were held in 2009 to determine, among other things, whether the Government or the Federal Reserve had pressured or threatened Bank of America's management to acquire Merrill Lynch (see, e.g., Story and Becker, 2009). National City Corp was acquired after being one of the few qualified banks that was denied TARP help. On the contrary, the acquirer (PNC) received TARP money a few weeks before the purchase of National City was announced, a move that was widely interpreted as a push by supervisors to force National City to agree to be acquired (see, e.g., Fitzpatrick et al., 2008). Finally, Provident Bankshares Corp. received $151 million from TARP to prop up capital on Nov. 14, 2008. One month later, M&T and Provident Bankshares Corp. announced that the former would acquire the latter for $401 million.

public funding. Finally, as a binary variable, our measure is coarse, since it makes no distinctions within the groups of failed or surviving banks. In Section 8 we also evaluate the relation between bank failure and other risk measures and check the robustness of our results to the use of alternative risk measures.

3 Risk-taking incentives from stock and option holdings

Compensation will create incentives to take on risk if increasing risk increases the expected utility of the CEO's compensation. Since the CEOs in our sample hold large portfolios of stock and stock options, their risk-taking incentives will be largely determined by how risk influences the expected utility of those portfolios.

Executive stock options are call options on the firm's stock. Because of the convexity of the relation between the value of the underlying stock and the payoff from exercising the option, a basic result in asset pricing is that the value of a call option is increasing in the volatility of the underlying. Because of this result, (Guay, 1999) proposed to use the *option vega* of an executive's wealth as the measure of the executive's risk-taking incentives. Option vega approximates the change in the CEO's wealth that would follow from a 0.01 change in the volatility of stock returns. If the CEO holds n_i options of option grant i (where different option grants differ in their strike price and maturity), the CEO's option vega is:

$$\textit{option vega} = \sum_i n_i \frac{\partial O_i}{\partial \sigma_S} \times 0.01, \tag{1}$$

where O_i is the Black-Scholes value (often adjusted for dividends) of option i and σ_S the volatility of stock returns. Since Guay (1999)'s contribution, most papers analyzing CEOs' risk-taking incentives measure these incentives by means of option vega (e.g., Knopf et al., 2002; Coles et al., 2006; Brockman et al., 2010; Fahlenbrach and Stulz, 2011).

However, this measure of risk-taking incentives does not account for the incentives to take on risk generated by executives' stock holdings. Indeed, a long line of work in corporate finance, starting with Jensen and Meckling (1976) and Galai and Masulis (1976), has highlighted that leverage creates incentives for shareholders to take on risk. This is so because any increase in firm value above the amount owed to debtholders is fully appropriated by shareholders, so shareholders' gains from upside risk are not capped. At the same time, limited liability implies that shareholders' losses are limited to their initial investment. In fact, the payoff to a shareholder of a levered firm is similar to the payoff of a call option on the firm's assets with a strike price equal to the face value of the firm's debt (Black and Scholes, 1973; Merton, 1973). Thus, standard valuation models imply that the value of the equity of a levered firm is increasing in the volatility of the firm's asset value (the underlying asset). Moreover, these models also yield the result that the sensitivity of the value of an in-the-money call option increases as the option gets closer to the money (that is, as the strike price and the value of the underlying get closer). For the case of equity, this means that the sensitivity of equity value to asset volatility increases as the value of the firm's assets and the face value of debt get closer, or, in other words, as leverage increases. Figure 1 illustrates this point. For a firm with low leverage (whose equity is deep in the money), such as firm A, the mean-preserving spread depicted in the Figure does not change the expected equity payoff. However, for a highly levered firm, such as firm B, the same mean-preserving spread increases the payoff to equity holders if asset returns are high, but does not reduce the payoff if returns are low, thereby increasing equity holders' expected payoff. Thus, whereas the risk-taking incentives stemming from equity may be low for firms with low leverage, they may be substantial for highly levered firms, such as large US financial institutions.[16] Because shareholders' incentives to take on risk are increasing in the firm's leverage, we use leverage as a measure of shareholders' risk-taking incentives (as, for example, John et al., 2010).

Now, a CEO's incentives to take on risk will depend not only on the firm's leverage, which determines the impact of the volatility of firm value on the firm's equity value, but also on the size of his equity holdings, which determines how much the executive's wealth is influenced by changes in the firm's equity value. Since, in addition to stock, CEOs often hold substantial amounts of options, we measure the exposure of a CEO's wealth to changes in equity value by means of delta, which we define, as it is customary in the executive compensation literature, as the approximate change in CEO wealth associated with a 1% change in the stock price (see, e.g., Brockman et al., 2010):

$$delta = \Delta_S + \Delta_O = \left[n_S \left(\frac{S}{100} \right) \right] + \left[\sum_i n_i \frac{\partial O^i}{\partial S} \left(\frac{S}{100} \right) \right], \tag{2}$$

where Δ_S and Δ_O denote the delta from stocks and options, respectively, n_S denotes the number of shares of the firm's stock held by the CEO, S the stock price, and i, n^i, and O^i are the identifier of the option grant, the number of options of grant i, and the value of the options of grant i, respectively. A CEO's delta, thus, depends on the CEO's holdings of the firm stock and options, as well as on the sensitivity of the option holdings to changes in the stock price. In Appendix A, we describe how we compute delta and option vega.

To incorporate both the sensitivity of equity value to changes in firm risk (as proxied by leverage) and the sensitivity of the CEO's wealth to changes in equity value (as measured by delta), we define our measure

[16] Guay (1999) proposes an approximation to the sensitivity of equity value to volatility and finds that this sensitivity is generally very small for a sample of US CEOs in 1993, consistently with a generally small leverage in that sample. Because of this result, subsequent work on risk-taking incentives has ignored the incentives stemming from stock holdings and has focused solely on option vega.

of risk-taking incentives, which we label *levered delta* (LD), simply as the product of firm leverage and delta:

$$LD = delta \times leverage. \tag{3}$$

Since we do not observe the firm's market value, we measure leverage (following Fahlenbrach et al., 2012) as the quasi-market value of leverage, computed as the ratio of the quasi-market value of the firm (measured as the book value of assets minus book value of equity plus market value of equity) divided by the market value of equity.

We define LD as the product of delta and leverage because this is the simplest measure that ensures both that LD is increasing in leverage and that the impact of leverage on the CEO's risk-taking incentives is increasing in the CEO's exposure to the firm's equity value. An alternative route to obtain a measure of the risk-taking incentives generated by CEOs' holdings of stock and options, followed by Chesney et al. (2012), is to derive the measure from a structural valuation model. We discuss the relation between the two approaches in Section 8.

As Figure 1 illustrates, the expected payoff of a call option at expiration is increasing in the volatility of the underlying asset. However, a higher volatility need not increase the expected utility of a risk averse individual who cannot freely trade or hedge the option, because the higher volatility increases the risk of the executive's wealth. (Lambert et al., 1991; Guay, 1999; Ingersoll, 2006). Moreover, the CEO's risk premium will tend to be higher the larger the exposure of the CEO's wealth to changes in the firm's stock, that is, the larger the CEO's delta. Since the restricted stock and executive stock options that are part of executives' compensation packages are typically subject to vesting restrictions, not tradeable, and there are limitations to executives' ability to hedge their exposure to their firms' equity value, several articles propose using delta as a measure of the sensitivity of the risk premium to changes in stock volatility (Guay, 1999; Knopf et al., 2002; Coles et al., 2006; Brockman et al., 2010). Taking into account delta when measuring incentives is especially important in our case, since for low leverage levels, increases in delta (and, thus, in LD) will have a small impact on risk-taking incentives, whereas, at the same time, they will increase the CEO's exposure to the firm's risky stock. Therefore, we use delta, in combination with LD, as a measure of the disincentives to increase risk stemming from executives' nondiversifiable exposure to their firms' equity risk.

Panel A in Table 2 provides descriptive statistics of the incentive measures computed in year 2006.[17]

[17] We note that we compute the incentive measures differently for seven firms because of data availability or management changes. In three firms (First Niagara, Goldman Sachs, and UnionBanCal Corporation), the CEO retires in 2006. Since retirement years are highly atypical, for these firms we compute the incentive measures in year 2005. Starting December 15, 2006, SEC disclosure rules require firms to report disaggregated information of option grants awarded to CEOs. This disaggregated information allows us to compute the risk incentive measures directly as described in Appendix A. However, a few firms in our sample had an earlier fiscal year end, so that they did not have to comply with the new disclosure requirement until the next fiscal year (2007). For such firms (Bear Stearns, Goldman Sachs, Lehman Brothers, Morgan Stanley, and Washington Federal Savings) we use the one year approximation technique described in Core and Guay (2002).

The incentive measures display substantial dispersion, with standard deviations at least twice as large as the mean and with the 90th percentile being ten times as large as the median and about a hundred times larger than the 10th percentile. Panel B in Table 2 displays the correlations between LD, delta, and option vega. Although LD is positively correlated with option vega, the correlation is relatively low. Therefore, LD and vega measure different things in our sample. Delta has a positive correlation with both option vega and LD, and the strong correlation between delta and LD indicates that the variation in LD does not simply reflect variation in leverage.

4 Risk-taking incentives and failure

4.1 Empirical strategy

To estimate the relation between risk-taking incentives prior to the financial crisis and bank failure during the crisis we measure CEO risk-taking incentives in year 2006. This choice of measurement period is determined by several requirements. We require the period to be sufficiently close to the crisis to be able to potentially attribute to the compensation incentives in the measurement period an impact on the probability of failure during the crisis. We also require that the incentive measurement period not be a crisis year for two reasons. First, to the extent that bank failure was motivated by actions taken by banks in the years prior to the crisis, the measurement of incentives would take place after the actions they were supposed to incentivize. Second, we would like to avoid capturing reverse causality: Measuring incentives during the crisis could capture the reaction of CEOs' compensation packages to negative realizations of uncertainty during the crisis. The period 2003–2006 satisfies these two requirements. However, the choice of year 2006 as the measurement period also maximizes the availability and quality of the compensation data, because a new set of compensation disclosure requirements became effective in this year. Thus, before year 2006, the information on pension benefits and termination payments is very limited, and the information regarding executive stock options improves in 2006. Moreover, other studies have used 2006 as their measurement period (notably, Fahlenbrach and Stulz, 2011), which makes it easier to compare our results with theirs.

Although we have a panel with firm and compensation data, by construction we have a single cross section of the dependent variable (failure). Therefore, our empirical specifications are cross-sectional regressions with failure during the crisis as the dependent variable and incentives measured in 2006 as the explanatory variable of interest. The use of bank failure during the financial crisis as the dependent variable rules out the use of fixed firm or CEO effects to control for time-invariant unobserved heterogeneity.

Since we would like to capture the potential effect of risk-taking incentives on the likelihood of failure, we cannot include as controls in our regressions measures of risk taking that could be the result of those incentives. To clarify this point, suppose that the credit risk of a bank's loan portfolio were the only variable determining bank risk. In this case, even if compensation fully determined CEOs' incentives to take on risk (through the choice of riskiness of the loan portfolio), we would observe no effect of compensation on bank risk if we controlled for the credit risk of the loan portfolio in our regressions. In Section 5 we, nonetheless, investigate the effect of including leverage, as a measure of bank risk, in the estimating equations. The small size of our sample significantly limits the power of the tests and further constrains our choice of control variables in the estimating equations. Thus, we opt for parsimonious specifications and include independent variables only if there are a priori reasons to expect them to be related to both risk-taking incentives and the probability of bank failure. In Section 5 we discuss our choice of regressors in the multivariate specifications. Here we emphasize that the goal of our analysis is not to accurately predict bank failure but to estimate the relation between pre-crisis incentives and bank failure during the crisis.

Our main specification throughout the paper is the linear probability model:

$$failed_i = \alpha + \beta w_{i,2006} + \delta \Delta_{i,2006} + \mathbf{x}_{i,2006}\gamma + \varepsilon_i, \quad (4)$$

where $failed_i$ is a dummy variable equal to one if the firm fails in the period from 2007 to 2010, w is a measure of risk-taking incentives (option vega or LD), Δ is the CEO's delta, and $\mathbf{x}_{i,2006}$ is a vector of controls, which may include lagged values. Linear probability models have the advantage of easy interpretability, yet are necessarily misspecified because they do not restrict probabilities to lie between zero and one. The small size of our sample, however, makes estimation of nonlinear models (such as probit or logit models) imprecise.[18] Therefore, we focus on the results from linear probability models, although in Section 8 we also evaluate the robustness of our results to both non-linear transformations of the incentive measures and non-linear specifications of the estimating equation.

It is important to note that the risk-taking incentive measures are likely to be quite noisy approximations to the true risk-taking incentives implied by CEOs' holdings of stock and options. Therefore, even if the measurement error is unrelated to the underlying incentives, the coefficients on the risk-taking incentive measures will tend to be biased towards zero because of attenuation bias.

4.2 Univariate results

In Panel C of Table 2, we compare the means and medians of the incentive measures in the subsamples of failed and surviving financial institutions. The mean LD among failed banks is almost four times larger

[18]The small sample size also recommends against alternative specifications, such as duration models.

than among surviving banks and the difference is statistically significant at the 1% level. At the same time, although failed banks exhibit a higher option vega, the difference in mean option vega between failed and surviving banks is smaller and not statistically significant at the 10% significance level. We obtain similar results if we compare the medians of the two subsamples. Therefore, the comparison of the subsamples of failed and surviving banks shows that the measure of risk-taking incentives matters: Whereas failed banks have substantially higher risk-taking incentives as measured by LD, the difference is small and not statistically significant if measured by option vega.

In Table 3 we report estimated coefficients of the simple linear probability model (4) without controls. The univariate results show that a change of one standard deviation in LD is associated with about a 0.10 (ten percentage points) increase in the probability of failure, and the estimated coefficient is statistically significant at the 1% level. Increasing levered delta from its median to the 90th percentile would increase the probability of failure by 0.09. Therefore, increases in risk-taking incentives, when measured by LD, are associated with a statistically and economically significant change in the probability of failure.

If we measure incentives by means of option vega, however, the estimated coefficient is smaller (a one standard deviation change in option vega is associated with a 0.03 increase in the probability of failure) and not statistically significant at conventional significance levels. Therefore, with a different risk measure and a somewhat different sample, our results replicate those of Fahlenbrach and Stulz (2011), who find no statistically significant relation between option vega and bank risk taking. Fahlenbrach and Stulz (2011) find a positive and statistically significant coefficient for delta. In column 3 of Table 3, we also report a positive coefficient for delta in a univariate specification, although it is not statistically significant at conventional significance levels. In light of our results, a plausible interpretation of Fahlenbrach and Stulz's positive coefficient for delta is that it is due to the positive correlation between delta and the risk-taking incentives not captured by option vega. In fact, when we estimate the baseline linear probability model (4) with LD and delta as regressors, the coefficient for delta becomes negative and the coefficient for LD increases substantially, and both estimates are significantly different from zero at the one percent level. Although the negative coefficient for delta implies that increasing delta would reduce the probability of failure for low enough levels of leverage, the leverage of the firms in the sample is sufficiently high to guarantee that the predicted marginal effect of delta is positive for all but seven firms.

The results in Table 3 are consistent with a causal effect of CEO compensation on bank risk. However, there are, obviously, alternative plausible explanations for the results. In particular, LD may be correlated with bank or CEO characteristics that either make banks inherently more risky or provide CEOs other incentives to take on risk. In the next section, we propose and evaluate the plausibility of several alternative explanations for the univariate results. Hereafter, we focus on LD as the measure of CEOs' risk-taking incentives stemming from the CEOs' stock and option holdings, although in Section 8 we also consider an alternative measure.

5 Alternative explanations

5.1 Other sources of incentives

The positive relation between LD and the probability of failure could be due to the correlation between LD and other, more relevant, determinants of CEOs' risk choices. First, the implicit incentives created by the threat of replacement could be more powerful in determining CEOs' risk choices than concerns about the sensitivity of current wealth to firm risk. These implicit incentives will arise if banks pay CEOs more than their reservation value and bank risk affects the probability of termination (as in standard efficiency wage models). Whether the threat of replacement provides incentives to increase or decrease risk will hinge on the determinants of CEO replacement. If CEOs are replaced only when firm performance is dismal, then the threat of termination may, in general, provide incentives to reduce risk, since CEOs will seek to lower the probability of negative tail risk (see, e.g., Eckbo and Thorburn, 2003). On the other hand, if continuation as CEO requires being at the top of the distribution of performance, then the threat of replacement may provide incentives for taking on risk, since moderately poor performance would have similar implications as extremely poor performance, whereas the CEO would benefit from very strong performance. In the former case, our results could be explained by the presence of weaker termination incentives in firms with higher LD; in the latter case, by a positive correlation between LD and termination incentives. In either case, if termination incentives dominated those provided by CEOs' equity portfolios, controlling for termination incentives would significantly reduce the estimated coefficient for LD. Although we cannot measure the sign and the magnitude of the effect of termination incentives on risk taking at each firm in our sample, there are several measures that are likely to be correlated with the strength of those incentives. First, the incentives stemming from the threat of replacement are, other things equal, likely to be stronger for CEOs with a higher total pay, to the extent that at least part of the pay premium reflects quasirents and not merely compensation for unobserved general skills, which would also increase their reservation value. Second, termination incentives are also likely to be stronger for younger CEOs, since the number of periods in which these CEOs may earn rents if they are not replaced is higher. Therefore, including total pay and CEO age in the estimating equation is likely to capture at least part of the effect of termination incentives on risk taking. Golden parachutes (which are termination payments associated with a change in control of the firm, such as a takeover or a merger) or more general severance pay may also affect a CEO's termination incentives. Other things equal, more generous termination payments reduce the CEO's downside risk and, thus, increase his risk-taking incentives. Therefore, if termination payments were positively related to LD, they could explain our univariate results. Termination payments could also be set in place in firms at which there is an inherently higher risk of CEO replacement or a higher sensitivity of replacement decisions to firm performance. If either of these two factors is associated both with firms' inherent riskiness and with LD, this association could help explain our univariate results.

CEOs may also have incentives to take or hedge risks to affect the perception that investors have of their ability, since this perception is likely to have a significant impact on their career prospects (DeMarzo and Duffie, 1995; Breeden and Viswanathan, 1998). Again, the sign of the relation between the strength of these career concerns and CEOs' incentives to take on risk is not clear a priori. However, irrespectively of the sign of this relation, the career concerns of older CEOs are likely be weaker because more information about their abilities has already accumulated and because there are fewer years left in which they may benefit from a higher perceived ability. Therefore, age may act as a proxy for the strength of career concerns.

Finally, whereas LD and delta measure the incentives to take on risk stemming from CEOs' equity portfolios, there are other components of CEO compensation that may also influence CEOs' risk-taking incentives. As emphasized by Sundaram and Yermack (2007), Edmans and Liu (2011), and Anderson and Core (2013), defined benefit pension plans and deferred compensation are similar to debt claims. Such debt-like claims (known as inside debt) provide incentives to take on (or limit) risk similar to those of debtholders. Again, our univariate results could be due to the fact that LD is negatively correlated with incentives stemming from inside debt. Therefore, we include inside debt as a control in our regressions, which we define, following Cassell et al. (2012), as the sum of the present value of accumulated pension benefits from all pension plans and the total aggregate balance in deferred compensation plans of the CEO.

5.2 Matching, risk, and compensation

Our univariate results could also be explained by the fact that high LD contracts are the least costly contracts to compensate the CEOs of inherently riskier firms or those CEOs who are more likely to engage in risky practices.

In standard principal-agent models, the performance sensitivity of pay should be, other things equal, negatively correlated with firm riskiness, since the cost of linking pay to performance (in terms of a higher risk premium that has to be paid to the CEO) is higher for firms with more volatile performance.[19] However, if riskier firms were matched with more risk-tolerant CEOs, in equilibrium riskier firms could offer contracts

[19]See Prendergast (2002) for a discussion of the standard models and the empirical evidence relative to the relation between risk and incentives.

with greater pay-performance sensitivity (Ackerberg and Botticini, 2002). Cheng et al. (2014) also consider the possibility that firms that are inherently riskier (which would make a low sensitivity of pay to performance optimal) are also firms in which the marginal return of CEO effort is higher (which would make a high pay-performance sensitivity optimal). If the relation between riskiness and the marginal productivity of CEO effort is positive and strong enough, the CEOs of riskier firms will not have significantly lower deltas and could even have higher deltas (and, as a result, higher values of LD in highly levered firms).

Larger banks could be inherently risky (because of, say, their complexity) or more likely to engage in certain risky practices (because, for example, the existence of a too-big-to-fail implicit guarantee). At the same time, a well known regularity in executive compensation is that CEO pay is increasing in firm size. To the extent that a larger total pay also implies a larger equity pay (because, say, fixed pay is limited by legal or reputational constraints), firm size could be, somewhat mechanically, positively correlated with LD.[20] Including size in our regressions could control for the impact of size on both riskiness and LD. As we discuss in Section 4.1, however, we do not want to include controls that may be themselves measures of bank riskiness. Since risky expansion policies in the years prior to the crisis may have influenced bank size as of 2006 (Fahlenbrach et al., 2012), we measure firm size in year 2003 (although we note that measuring size in 2006 does not affect our results).

Finally, there may be CEO characteristics that determine CEOs' risk choices or risk tolerance, and different compensation contracts may attract CEOs of different characteristics or be optimal given different risk-relevant CEO characteristics. For example, it is plausible that firms with more risk tolerant CEOs will have stronger incentives and higher risk as a result of CEO choices (see, e.g., Dittmann and Maug, 2007). We do not have a measure for CEOs' risk aversion. However, we can control for variables that are likely to be correlated with it. First, CEO age may be correlated with CEOs' risk aversion, CEOs' estimates of the risk of different policies (for example, older CEOs may have lived through previous crises, like the savings and loans crisis, in positions of responsibility), or CEO overconfidence. Similarly, if CEOs' risk aversion decreases with their wealth, a measure of CEOs' wealth may also allow us to partly control for differences in risk aversion. Therefore, we also control for CEO wealth (other than the wealth in the form of their own firm's equity) in our regressions, using the measure of non-firm wealth provided by Dittmann and Maug (2007).[21]

[20] Size could have the opposite effect of reducing the probability of failure if larger banks were more diversified, had more skilled managers, if there were economies of scale in risk management, or if, despite the potentially perverse incentives they create, the net effect of too-big-to-fail guarantees on the probability of failure were negative. However, given that there is a positive correlation between incentive measures and size in our sample, if the correlation between size and failure probability had a negative sign, then it would not explain our univariate results.

[21] We thank the authors for providing their data online at `http://people.few.eur.nl/dittmann/data.htm`.

5.3 Risk-taking incentives or risk?

By construction, LD is increasing in firm leverage (as long as delta is positive) and will, thus, be positively correlated with firm leverage unless the correlation between delta and leverage is negative and sufficiently strong. At the same time, leverage may be interpreted as a measure of firm risk. Therefore, an alternative explanation of our results is that LD does not measure risk-taking incentives but, instead, firm risk itself. In such a case, our results would just imply that the value of some increasing function of firm risk is associated with a higher probability of failure.

To the extent that a higher risk of failure increases risk shifting incentives, distinguishing the effect of an exogenous increase in firm risk from the effect of the increase in risk generated by the stronger risk shifting incentives is difficult. However, as a crude way to evaluate the possibility that LD simply measures bank leverage, one can control for leverage in the regressions. If the relation between LD and failure is due to the fact that the former is simply a proxy for leverage, then controlling for leverage should make the coefficient for LD vanish. Since the relation between leverage and the probability of failure may be nonlinear, we also include leverage squared in the regressions. However, as we discuss in Section 4.1, if CEOs have the ability to determine leverage and leverage is an important determinant of risk, controlling for leverage could make the estimated coefficient of incentives vanish, even if risk-taking incentives fully determined leverage and, thus, risk. The substantial correlation between leverage and LD, together with our small sample size, may also render the estimates less precise.

5.4 Risk vs. poor management

Another possible interpretation of our results is that failure is not measuring risk taking but, rather, poor management. Thus, the univariate results could be due to the fact that firms with worse prospects or less able managers may have provided their CEOs stronger incentives for effort prior to the crisis. If these incentives did not succeed in improving banks' prospects, banks with stronger incentives prior to the crisis (which, through a higher delta, could plausibly translate into higher LD) may have had a higher probability of failure. Alternatively, LD may be negatively correlated with CEOs' incentives to exert effort or make sound decisions (although a priori it is not clear why this should be so). To account for this possibility we also include firm performance prior to the crisis (measured by either ROA or stock returns) as a control in the regressions.

Table 4 displays the sign of the relation between different variables and the probability of failure predicted by the explanations discussed in this section. For a proposed explanation to potentially explain the positive relation between LD and bank failure, the sign of the relation between LD and the variables that have to do with that explanation should be the same as the predicted sign of the relation between those variables and failure. As a way of evaluating the plausibility of the different explanations, in Table 4 we display in boldface the predicted signs that are equal both i) to the sign of the difference in the corresponding variable between the subsamples of failed and surviving firms, and ii) to the sign of the sample correlation between that variable and LD.[22]

5.5 Results

In Panels A and B of Table 6, we report the results of estimating our linear probability model including the different control variables discussed above. The first noteworthy result is that the coefficients for LD and delta remain highly statistically significant and with the same signs as in the specification without controls: Greater risk-taking incentives, as measured by LD, are associated with a higher probability of failure during the crisis. Moreover, including controls other than termination payments does not affect the magnitude of the estimated coefficients for LD and delta. The magnitude of the coefficients increases if severance pay or golden parachutes are included as controls. However, the change is not due to the inclusion of these controls, but to the fact that there are a few firms for which information on termination payments is not available.[23] It turns out that the companies with no information on termination payments include four of the five investment banks (which have very large values of LD and delta). In Section 8 we analyze the influence that these observations may have on our results.

The second implication of the results in Table 6 is that, with the exception of leverage, none of the proposed controls has an estimated coefficient different from zero at conventional significance levels. Moreover, the estimated coefficients are generally of small magnitude. We highlight that the estimated coefficients for both ROA and stock returns in the period from 2004 to 2006 are positive. The sign and statistical significance of these coefficients (as well as the, unreported, positive correlation between LD and both ROA and pre-crisis stock returns) do not support the hypothesis that a high LD is associated with persistent underperformance or that this persistent underperformance can explain bank failure during the crisis.

Although the coefficients of both leverage and leverage squared are statistically significant, including these variables in the regression barely affects the estimated coefficients for LD and delta. Therefore, the relation between the probability of failure and LD is not simply due to the linear correlation between LD and leverage. Thus, either the relation between leverage and the probability of failure is nonlinear in a way that is captured by LD (and not by a quadratic function of leverage), or the interaction between leverage

[22] In the Online Appendix, we report the correlations between the different variables and between them and LD, as well as the results of tests of the difference in means and medians between the subsamples of failed and surviving firms.

[23] In unreported results, we run the specification in column 1 of Panel A (with only size as a control) for the subsample of firms with information on severance pay, and we obtain a coefficient identical to the ones reported in columns 6-8 of Panel A.

and CEO compensation has a positive relation with risk beyond the direct impact of leverage on risk.

6 Bank governance

According to managerial power theories of CEO pay, the CEOs of poorly governed banks are likely to be paid more. If higher pay is not accompanied by changes in compensation structure, the CEOs of poorly governed firms will have larger equity holdings and, thus, other things equal, stronger risk-taking incentives if their firms are highly levered. Moreover, according to some managerial power theories of CEO pay, poorly governed firms may structure CEO compensation so as to camouflage the level of that compensation. In particular, poorly governed firms may make greater use of equity compensation, especially stock options, because these forms of compensation can be justified as providing incentives to the manager and because the cost to the firm of these compensation vehicles may be easier to conceal or undervalue (Bebchuk and Fried, 2004). Therefore, LD (which increases with the size of a CEO's stock and option holdings) may be higher for the CEOs of poorly governed firms. At the same time, the CEOs of poorly governed banks may make riskier choices for reasons unrelated to the risk-taking incentives captured by LD. For example, entrenched CEOs may be less likely to be replaced if the bank performs poorly. Therefore, these CEOs may not suffer much from downside risk and benefit as much as other CEOs from upside risk, which would make risky strategies more attractive for more entrenched CEOs. Worse governed firms may also have poorer risk management systems, which may allow for the excessive accumulation of risk.[24]

To investigate the impact of bank governance on the probability of bank failure, we consider several standard measures of the quality of corporate governance: board independence (measured as the percentage of directors who are independent); board size (since larger boards have often been described as less effective); the Governance index of Gompers et al. (2003); and the Entrenchment index of Bebchuk et al. (2009). The latter two indices attempt to measure the degree of managerial entrenchment, with higher values of the indices denoting greater managerial entrenchment. We compute board independence and board size using information from RiskMetrics, BoardEx, and proxy statements. We obtain the data for the Governance index from Andrew Metrick's webpage,[25] and the data for the Entrenchment index from Lucian Bebchuk's webpage.[26]

Table 7 displays summary statistics of the governance variables. Boards are relatively large (which is

[24] We note that poor governance may also decrease firm risk. For example, less entrenched managers may need to achieve stellar performance to keep their job (which would increase risk incentives), whereas more powerful managers may be able to remain at their post with mediocre performance. To the extent that entrenched managers earn greater rents, they may also be less inclined to follow policies that increase the probability of default, since default (or regulator intervention to replace the management team) would imply the loss of those rents. In any case, what matters for the argument is that governance may be associated with firm risk through channels other than the incentives measured by LD.

[25] `http://faculty.som.yale.edu/andrewmetrick/data.html.`

[26] `http://www.law.harvard.edu/faculty/bebchuk/data.shtml.`

consistent with the size and complexity of the banks in the sample), and there is not a large heterogeneity in board independence. Otherwise, the levels and variation in the governance indices are similar to those reported in previous articles (Gompers et al. (2003), Bebchuk et al. (2009)).

We first check whether including standard governance measures as controls affects the size or sign of the coefficients of the incentive measures. As we report in Table 8, the estimated coefficient for LD and its standard error are largely unchanged with respect to the benchmark specification with only firm size as control. Moreover, none of the coefficients associated with the governance variables are statistically significant at conventional levels. The magnitude of the estimated coefficients is also relatively small, with one standard deviation changes in the variables associated with changes in the probability of failure between 0.008 and 0.035 for all variables and specifications. The results, thus, suggest that, controlling for compensation incentives, bank governance quality is not associated with banks' probability of failure.

Despite the above results, governance quality could still be responsible for firms' risk choices if it determined the risk-taking incentives embedded in CEO pay. To evaluate this possibility, we regress our measures of incentives on different governance variables. The results, reported in Table 8, show that only board size has a statistically significant relation with LD. The coefficient is negative, which indicates that larger boards, often perceived as less effective, are associated with weaker risk-taking incentives.[27] Whereas the coefficients for the Governance index and the Entrenchment index suggest that worse governance (in the sense of greater management entrenchment) is associated with weaker incentives, the coefficient for board independence suggests that greater board independence (often interpreted as a sign of better governance) is associated with weaker incentives. However, these coefficients are estimated very imprecisely, so our sample does not provide clear evidence that managerial entrenchment or board independence are related to risk-taking incentives.

In summary, standard measures of the quality of corporate governance do little to explain bank risk, and only board size has a statistically significant relation with CEOs' risk-taking incentives, with an estimated coefficient that suggests that CEO risk-taking incentives are stronger in firms with smaller boards. Our results are, thus, broadly in line with the ones by Cheng et al. (2014) and Chesney et al. (2012), who find no discernible relation between governance variables and bank risk or incentives. Since CEO risk-taking incentives in 2006 may be the result of past governance quality instead of the governance quality in 2006, in unreported results we also run the regressions reported in Table 8 with the governance variables measured in 2003 (2004 in the case of the indices, because of data availability) and find similar results, with only board size having a discernible impact on LD.[28]

[27] Yermack (1996) and Eisenberg et al. (1998) find performance to be decreasing in board size, but Coles et al. (2008) show that performance is positively associated with board size for complex firms. However, these results should be interpreted with caution because of potentially large unresolved endogeneity problems.

[28] In unreported results, we also find that there is no significant relation between any of the governance variables and failure in specifications that omit the incentive variables LD and delta.

7 Shareholder incentives, CEO incentives, and bank risk

Managers' incentives to take on risk may be determined not by the wedge between managers' and shareholders' interests but, instead, by the incentives that shareholders themselves have to encourage risk taking. In fact, because of a combination of limited liability, very high leverage, and implicit government guarantees, bank shareholders may have an incentive to increase the risk of bank assets at the expense of depositors and debtholders. As we discuss in Section 3, bank leverage may serve as a possible measure of shareholders' incentives to shift risk to other claim holders (see also John et al., 2010). Because leverage in 2006 may reflect to a larger extent the results of CEOs' risk-taking incentives than shareholder incentives at the time of setting CEO compensation, and because LD is, by construction, an increasing function of leverage in 2006, we use leverage in 2003 as a measure of shareholders' incentives to take on risk and estimate the relation between this measure and LD.

Of course, by definition, the partial derivative of LD with respect to leverage is non-negative and equal to delta. So, to the extent that there is some persistence in leverage, one would expect that, keeping delta constant, LD (measured in 2006) would increase with year 2003's leverage. However, if the shareholders of more levered firms managed their CEO's compensation to achieve a lower delta (that is, if delta is not kept constant as leverage changes), the relation between LD and leverage could be flat or even negative.[29] Indeed, if debt markets accurately reflected bank risk, excessive risk would be borne by shareholders through higher interest rates for the firm's debt (Jensen and Meckling, 1976). Therefore, it may be in the interest of those firms whose shareholders have stronger incentives to shift risk to debtholders to design CEO compensation of their managers so as to limit the managers' incentives to take risk. It follows from this argument that the CEOs of more levered banks will have lower pay-performance sensitivity (John and John, 1993). Therefore, if shareholders bore the costs of higher default risk, then there need not be a positive correlation between leverage and LD. However, because of deposit insurance, implicit government guarantees, or lack of sophistication by depositors, the interest rates on banks' debt and deposits may not reflect bank riskiness. In such case, those banks whose shareholders have greater incentives to take on risk may also provide stronger risk-taking incentives to their CEOs.

In Table 9, we report the results of estimating regressions of LD and delta (measured in 2006) on leverage and firm size (both measured in 2003). As the table shows, LD is increasing in leverage and the size of the coefficient is significant (a one standard deviation increase in leverage is associated with one half standard deviation of LD). At the same time, the relation between delta and leverage is positive, although the estimated coefficient is not statistically significant at conventional significance levels. To further explore

[29] Let L denote leverage and $\Delta(L)$ denote the CEO's delta as a function of L. Then, $LD(L) = \Delta(L)L$ and $LD'(L) = \Delta'(L)L + \Delta(L)$. Therefore, if $\Delta'(L) < 0$, it can be the case that $L > L'$ and $LD(L) \leq LD(L')$.

the relation between lagged leverage and delta, we also regress each of delta's two components, the delta from stock (Δ_S) and the delta from options (Δ_O)—as defined in equation (2) and measured in 2006—on bank size and leverage, measured in 2003. Again, the relation between lagged leverage and either component of delta is not statistically significant and small in magnitude. Therefore, it does not appear as if more levered banks adjust the sensitivity to performance of their CEOs' wealth. This result is in contrast to the finding reported by John et al. (2010) of a negative relation between pay-performance sensitivity and leverage for a sample of bank holding companies in the period from 1993 to 2007. John et al. (2010) employ a different definition of pay-performance sensitivity, namely the estimated relation between the dollar value of CEO total compensation (which includes both total pay and the changes in the value of the CEO's stock and option holdings) and the dollar return to shareholders. To check whether the difference between their results and ours is due to the different definition of pay performance sensitivity, we employ a measure of pay performance sensitivity closer to the one used by John et al. (2010). In particular, we define $\Delta_\$$ as the change in the dollar value of the CEO's portfolio of stock and options associated with a change of \$1,000 in the firm's market capitalization.[30] However, as Table 9 shows, this measure also has a positive, yet not statistically significant relation with leverage. Therefore, the difference between John et al. (2010)'s results and ours may be due either to their more inclusive definition of CEO wealth or to their different sample (of about 70 bank holding companies per year) and sample period. In fact, they report a relation between leverage and delta that is mostly negative for the years 1993-2002, but mostly positive for the years 2003-2006.

8 Robustness checks

8.1 Alternative measure of risk-taking incentives

We propose LD as a simple measure of the risk-taking incentives implicit in CEOs' holdings of stock and options. Chesney et al. (2012) and Anderson and Core (2013) propose alternative measures of CEO risk-taking incentives that also incorporate the risk-taking incentives implied by CEOs' stock holdings. Here, we focus on Chesney et al.'s measure, because the measure proposed by Anderson and Core (2013) may be problematic for highly levered firms, such as the banks in our sample. Chesney et al. propose a stylized structural model of equity as a call option on the firm's assets (as in Black and Scholes, 1973, and Merton, 1973) and derive the value of stock and options and their derivatives with respect to firm volatility in closed form. In the baseline case in which the CEO holds n_O identical options and n_S shares, their measure of

[30] Formally, we define $\Delta_\$ = \frac{dW}{dS}\frac{1{,}000}{N}$, where W is the value of the executive's portfolio of stocks and options, S the stock price, and N the number of equity shares. Since market capitalization is $N \times S$, a change in the stock price of $\frac{1{,}000}{N}$ would lead to a change of \$1,000 in market capitalization.

risk-taking incentives (*asset volatility vega* or AVV) is defined as:

$$AVV = n_O \frac{dO}{d\sigma_v} 0.01 + n_S \frac{dS}{d\sigma_v} 0.01, \tag{5}$$

where S is the stock price (as a call on firm value) and O is the value of the option (obtained as the value of an option on another option), and the derivatives are taken with respect to the volatility of firm value, σ_v.

To check the robustness of our results to the use of an alternative measure of risk-taking incentives that also takes into account the risk-taking incentives of equity, we compute AVV for all firms in the sample in year 2006, following Chesney et al. (2012). (We briefly describe the methodology in Appendix A, but refer to the article by Chesney et al., 2012, for the details.) In Panel A of Table 10, we report the correlation of AVV with LD, delta, and option vega. Two results are especially noteworthy. The first one is the very strong and positive correlation between LD and AVV (0.85). Despite their very different definitions, in our sample, most of the action in AVV is captured by our simple measure LD. At the same time, AVV has a low correlation with option vega, similar to the one between LD and option vega. Therefore AVV and LD, on the one hand, and option vega, on the other hand, appear to measure different things. In Panel B of Table 10, we replicate the main multivariate specifications reported in Table 6, with AVV replacing LD as the measure of risk-taking incentives. The results are very similar both in terms of magnitude (for example, a one standard deviation—10.38—increase in AVV would increase the probability of failure by 0.11) and statistical significance.

8.2 Alternative risk measures

For the reasons discussed in Section 2, we use bank failure during the crisis as the measure of risk-taking prior to the crisis. Since our measure is different from those used in prior research and conditions our empirical strategy, in this section we study the relation between bank failure during the crisis and alternative risk measures and check the robustness of our results to the use of these alternative measures.

We consider as alternative risk measures the volatility of stock returns and the market beta of the firm's stock (as in Cheng et al., 2014, or DeYoung et al., 2013) and the buy-and-hold returns of the firm's stock (as in Fahlenbrach and Stulz, 2011). We first check whether higher levels of volatility or beta computed prior to the crisis are associated with the incidence of bank failure. As Table 11 shows, there is no significant difference in volatility or beta prior to the crisis between banks that would fail during the crisis and those that would survive. In unreported regressions, we also estimate univariate linear probability and probit models of the probability of failure with these risk measures (computed prior to the crisis) as the explanatory variable and find that they contribute very little to explaining failure during the crisis. We also consider the possibility that changes in these variables in the run-up to the crisis may be associated with failure. However, as we report in Table 11, changes in the risk measures prior to the crisis explain very little of the variation in bank failure. Therefore, our results indicate that ex ante measures of volatility or beta capture little of the exposure to the kind of bank risk that realized during the crisis and that led to the failure of a significant fraction of the financial institutions in our sample.

However, when measured during the crisis period, all risk measures are strongly associated with bank failure. Banks that eventually fail have significantly lower buy-and-hold returns in the period from July 1, 2007, to December 31, 2008 (which is the period employed by Fahlenbrach and Stulz, 2011). Not surprisingly, given the strong correlation between buy-and-hold returns, volatility, and beta, the latter two measures are also strongly correlated with failure. Further, as we show in Table 11, the signs and statistical significance of the coefficients are the same for all risk measures. Therefore, the difference between our results and those of Fahlenbrach and Stulz (2011), who use buy-and-hold returns, or Cheng et al. (2014), who use volatility and beta, appears to be due to the different measure of risk-taking incentives and not to the measure of bank risk.

8.3 Sample selection

The diversity of activities carried out by large financial institutions makes it difficult to determine unambiguous sample selection criteria. For this reason and for the sake of comparability, we also conduct our analysis with the sample of financial institutions used by Fahlenbrach and Stulz (2011). Fahlenbrach and Stulz's sample contains only 98 firms and is not a proper subset of our sample. For example, Fahlenbrach and Stulz include federal credit agencies, such as Fannie Mae, while we do not do so.[31] As Column 1 in Table 12 shows, the results are largely unchanged if we use this alternative sample of financial institutions. There are, however, two differences. First, whereas in our sample the coefficient for delta is not statistically significant in the univariate specification, it becomes statistically significant for the Fahlenbrach and Stulz's sample, in line with their results. The second difference is that the coefficients for delta and LD are not statistically significant when estimated jointly in Fahlenbrach and Stulz's sample. However, both differences can be explained by the extremely high (0.91) correlation between LD and delta in their sample.

[31] Moreover, we seem to have compensation information for a larger number of firms from Fahlenbrach and Stulz (2011)'s sample than Fahlenbrach and Stulz. This difference could be explained by the fact that we use a later version of the compensation database.

8.4 Failed institutions

Some of the steps of the procedure that we use to identify firms as failed require the use of some judgement and soft information. In particular, as we discuss in Section 2, we consider two firms as failed (Mellon Financial and Countrywide Financial) that were acquired during the crisis but do not clearly meet our merger discount requirements. We also consider three firms as failed (Merrill Lynch, National City Corp and Provident Bankshares) on the basis of information obtained from the media. Column 2 in Table 12 shows that results are largely unchanged if we consider that none of these five firms fail during the crisis. In unreported results, we also consider each of the two groups separately, and the results are identical.

8.5 Investment banks

Our sample contains three primary dealers (Bear Stearns, Goldman Sachs and Merrill Lynch) that supervisors do not identify as a regulated institution, but that we include because of their systemic importance. Moreover, our sample also contains Lehman Brothers and Morgan Stanley, which the National Information Center of the FFIEC identifies as regulated institutions. To investigate whether our results are driven by the inclusion of the five largest investment banks, we estimate the baseline regressions excluding them from the sample. As column 4 in Table 12 shows, the coefficients for the incentive variables remain highly statistically significant and increase in magnitude, because, as we explain below, some of the investment banks have very large values of the incentive variables. We find similar (unreported) results if we exclude only the investment banks not identified as regulated institutions or if we include a dummy for the investment banks (rather than excluding them from the sample).

8.6 Too big to fail institutions

We identify as failed those firms that either close or are acquired with the intervention of regulators. However, some financial institutions may be too large for regulators to either allow them to fail or to be able to find a suitable acquirer. These financial institutions may, thus, not be part of our list of failed institutions, even if they took on large risks ex ante and experienced strongly negative outcomes as a result of those risks. This possibility may bias our estimates towards zero if the risk-taking incentives of too-big-to-fail (or be acquired) institutions are strong and if these firms took on large risks. On the other hand, it may lead us to overestimate the relation between risk-taking incentives and bank risk if large banks take on large risks yet opt for compensation arrangements with low values of LD.

We take two approaches to evaluate the potential biases generated by too-big-to-fail institutions. First, following Fahlenbrach et al. (2012), we consider Citigroup and Bank of America as failed, given the massive amount of aid they received from the government. As column 3 of Table 12 shows, considering these banks as failed does not alter our results. Second, we identify the banks in the sample that could be considered both too-big-to-fail and "too-big-to-be-acquired," which we label TBTBA banks. There is obviously no official list of TBTBA firms, so we consider the robustness of our results to different definitions. Our first definition identifies as TBTBA those firms larger than the largest failed institution in our sample (with size measured either as market capitalization or total assets in 2006).[32] The other two definitions use the Financial Stability Board's lists of systemically important financial institutions (created in 2011) and global systemically important banks (created in 2012). Our second definition considers as TBTBA all the U.S. institutions on the 2011 list. The 2012 list divides the systemically important financial institutions into five buckets, according to their level of systemic importance, with bucket five (one) containing the institutions with the greatest (smallest) systemic importance. Finally, our third definition defines as TBTBA only those firms on the 2011 list that are in buckets two to five (the ones with the greatest systemic importance) of the 2012 list.[33] To evaluate the potential biases introduced by TBTBA institutions, we include a dummy variable for these firms in our regressions and run the regressions excluding the TBTBA firms from the sample. For the sake of brevity, we report in columns 5-6 of Table 12 only the results obtained when we exclude TBTBA banks, defined in terms of market capitalization or according to the 2011 list of systemically important institutions, from the sample. The results, which are essentially identical if we apply the other definitions or include dummies instead of excluding banks from the sample, show that our results are not affected by the presence of TBTBA institutions.

8.7 Extreme values and specification

A possible concern about our results, especially given the small size of our sample, is that they may be influenced by the presence of firms with extreme values of the incentive measures. In fact, some firms, such as Bear Stearns, have very large values of LD. The presence of firms with very large values of LD in the group of failed banks may lead to a positive estimated coefficient even if there is no positive relationship between LD and failure. However, since the dependent variable lies between zero and one, the presence of banks with very large values of LD among the banks with a value of one for the dependent variable may have the opposite effect of biasing the estimated coefficient towards zero. To check the robustness of our results

[32] If size is measured by total assets, the largest failed institution is Merrill Lynch and the TBTBA institutions are Morgan Stanley, J.P. Morgan Chase, Bank of America, and Citigroup. If size is measured by market capitalization in 2006, the largest failed institution is Wachovia and the TBTBA institutions are Wells Fargo, J.P. Morgan Chase, Bank of America, and Citigroup.

[33] The 2011 and 2012 lists contain the same eight US financial institutions: Bank of America, Bank of New York Mellon, Citigroup, Goldman Sachs, J.P. Morgan Chase, Morgan Stanley, State Street, and Wells Fargo. Buckets two to five contain all these banks except for State Street and Wells Fargo. Further restricting the list to buckets three to five would leave only Citigroup and J.P. Morgan Chase as TBTBA. The list can be accessed at the Financial Stability Board's website: `https://www.financialstabilityboard.org/list/fsb_pa/tid_174/index.htm`.

to the presence of firms with very high values of the incentive measures (LD and delta), we winsorize them at the 2% level and re-estimate the baseline univariate and bivariate regressions. As column 1 of Panel B in Table 12 shows, the estimated coefficients remain statistically significant and are of similar magnitude.

A related concern is that the linear model given by expression (4) is necessarily misspecified, since the dependent variable is bounded between zero and one. Although this misspecification may not be severe in some cases, it may create substantial bias if, as it is the case with LD, the explanatory variable of interest has a skewed distribution.[34] Therefore, we also consider the robustness of our results to different specifications that are nonlinear in LD. The first specification is a simple log linear model, in which we replace LD and delta by the natural logarithm of one plus the corresponding variable (we add one because of the presence of firms with zero or close to zero values for the incentive measures). This specification allows for a concave relation between the incentive measures and the probability of failure and, at the same time, can be estimated by OLS. The estimated coefficients, which we report in Column 2 of Panel B in Table 12, are highly statistically significant. In columns 3 to 6 of Panel B in Table 12 we also report estimated marginal effects (evaluated at the sample means of the explanatory variables) of probit and logit models. To better compare the results with those from the linear probability model, we note that, for the univariate specification, an increase of one standard deviation in LD (starting from the mean) is associated with changes in the probability of failure of 0.09 (probit) and 0.08 (logit), very similar to the 0.10 change of the linear specification.[35]

The fact that our main results are largely robust to different specifications, the use of different subsamples, different definitions of failure, and different risk measures suggests that our results are not an artifact of the particular sample used in this paper, which could be a significant concern given the small sample size.

9 Conclusion

In this paper, we analyze the relation between the risk-taking incentives created by executive compensation and bank risk and study the potential determinants of those incentives.

Since financial institutions are highly levered, we propose a measure of the risk-taking incentives generated by CEO compensation, levered delta (LD), which incorporates the incentives generated by the option-like nature of the stock of levered institutions. We define LD as the product of leverage and the sensitivity of the CEO's wealth to changes in the firm's stock price (delta).

[34] However, we note that our linear probability model generates almost no predicted values of the probability of failure outside of the unit interval. Thus, for the univariate specification in column 1 of Table 3—with only LD as independent variable—all predicted probabilities lie between 0 and 1, and for both the bivariate specification in column 4 of Table 3—with LD and delta—and the specification with all controls in column 8 of Table 6 only one predicted value lies outside the unit interval.

[35] In columns 3 to 6 of Panel B in Table 12, we report robust standard errors rather than the standard errors implied by the probit and logit models. However, the use of robust standard errors in probit or logit models is contentious. The estimated probit and logit standard errors are smaller than the ones reported in the table and lead to coefficients for LD that are significant at the 5% level in all specifications.

To measure bank risk taking in the period prior to the 2007-2010 financial crisis we identify those banks that failed during the crisis. Because of the potential for government intervention to facilitate the acquisition of distressed banks by sounder financial institutions, we propose a definition of bank failure that identifies as failed not only those financial institutions that went bankrupt or were forced into receivership, but also those that were acquired with the assistance or intervention of supervisors. This ex post measure of bank risk aims to sidestep the limitations of standard risk measures measured prior to the crisis, which may not have been that informative about the actual risks taken by banks in the run-up to the crisis, as well as to measure the full risk borne by banks, and not only the part borne by bank shareholders.

For our sample of large US financial institutions, we show that the risk-taking incentives implied by LD are associated with a higher probability of failure during the financial crisis. We propose and investigate different potential explanations for these results and interpret our findings as supporting two alternative explanations. The first explanation is that the risk-taking incentives measured by LD did have an impact on CEOs' risk choices prior to the crisis. The second explanation is that inherently riskier banks found it optimal to compensate their CEOs in ways that led to high values of LD. Further theoretical and empirical work is needed to distinguish between the two alternatives. On the theory side, it may be useful to derive the optimal compensation contract for bank CEOs under different assumptions of the roles played by bank executives, boards of directors, and shareholders in determining and monitoring compensation decisions and risk choices. The implications of these models could then be taken to the data to shed light on the actual mechanism that links compensation and bank risk. The very different results obtained with option vega and levered delta also suggest that more attention should be paid to deriving measures of risk-taking incentives. On the empirical side, finding credible sources of exogenous variation in incentives remains the main challenge to be addressed to be able to propose policy recommendations regarding the compensation of bank executives.

We show that standard measures of governance quality do not help explain bank failure or the level of risk-taking incentives. In contrast, CEOs' risk-taking incentives are positively related to shareholders' incentives to shift risk to debtholders. These results suggest that either compensation incentives are designed to align CEOs' incentives with those of shareholders or, at least, that compensation policies are not set so as to counteract the risk-taking incentives embedded in banks' equity. In contrast to the theoretical prediction of John and John (1993) that more levered firms would structure CEO compensation so as to limit CEOs' incentives to take on risk, we find the CEOs' pay-performance sensitivity to be largely unrelated to bank leverage (which implies stronger risk-taking incentives for the CEOs of more levered banks). A possible interpretation of our results is that, contrary to the shareholders in John and John (1993)'s model, bank shareholders may not fully internalize the costs that risk shifting imposes to debtholders.

Our results have several implications for bank regulation. First, in contrast to the results of prior studies, our findings are consistent with compensation being a source of risk-taking incentives for bank executives. However, we lack an exogenous source of variation in incentives that would allow us to identify their causal effect on bank risk. Therefore, whether regulating executive compensation would have an impact on bank risk remains an open question. We emphasize as well that, even if we provide evidence that is consistent with a role for compensation incentives in determining bank risk, our results are largely orthogonal to the question as to whether CEOs' risk-taking incentives or bank risk prior to financial crisis were excessive. In line with previous studies, we find no support for the proposition that improving bank governance by, say, limiting managerial entrenchment or increasing board independence, would significantly reduce risk-taking incentives or bank risk. However, our results are silent regarding some governance failures specific to banks, which have also received attention from regulators, such as the financial background of directors, the quality of the risk management systems, or the relevance in the organization of the executives in charge of risk management.

References

Ackerberg, D. A. and M. Botticini (2002). Endogenous matching and the empirical determinants of contract form. *Journal of Political Economy 110*(3), 564–591.

Anderson, J. D. and J. E. Core (2013). Managerial incentives to increase firm volatility provided by debt, stock, and options. *Working Paper, MIT*.

Bebchuk, L., A. Cohen, and A. Ferrell (2009). What matters in corporate governance? *Review of Financial Studies 22*(2), 783–827.

Bebchuk, L., A. Cohen, and H. Spamann (2010). The wages of failure: Executive compensation at Bear Stearns and Lehman 2000-2008. *Yale Journal on Regulation 27*(1), 257–282.

Bebchuk, L. and H. Spamann (2010). Regulating bankers pay. *Georgetown Law Journal 98*(2), 247–287.

Bebchuk, L. A. and J. M. Fried (2004). *Pay without performance.* Harvard University Press Cambridge, MA.

Bhagat, S. and B. Bolton (2014). Financial crisis and bank executive incentive compensation. *Journal of Corporate Finance 25*, 313–341.

Black, F. and M. Scholes (1973). The pricing of options and corporate liabilities. *Journal of Political Economy 81*(3), 637–654.

Breeden, D. and S. Viswanathan (1998). Why do firms hedge? An asymmetric information model. *Fuqua School of Business, Working Paper*.

Brockman, P., X. Martin, and E. Unlu (2010). Executive compensation and the maturity structure of corporate debt. *The Journal of Finance 65*(3), 1123–1161.

Cassell, C. A., S. X. Huang, J. Manuel Sanchez, and M. D. Stuart (2012). Seeking safety: The relation between CEO inside debt holdings and the riskiness of firm investment and financial policies. *Journal of Financial Economics 103*(3), 588–610.

Cheng, H., H. Hong, and J. Scheinkman (2014). Yesterday's heroes: Compensation and creative risk-taking. *The Journal of Finance (forthcoming)*.

Chesney, M., J. Stromberg, and A. Wagner (2012). Risk-taking incentives, governance, and losses in the financial crisis. *Swiss Finance Institute Research Paper No. 10-18*.

Coles, J., N. Daniel, and L. Naveen (2006). Managerial incentives and risk-taking. *Journal of Financial Economics 79*(2), 431–468.

Coles, J. L., N. D. Daniel, and L. Naveen (2008). Boards: Does one size fit all? *Journal of Financial Economics 87*(2), 329–356.

Coles, J. L., N. D. Daniel, and L. Naveen (2013). Calculation of compensation incentives and firm-related wealth using Execucomp: Data, program, and explanation. *Working paper*. Available at http://papers.ssrn.com/abstract=2296381.

Core, J. and W. Guay (2002). Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. *Journal of Accounting Research 40*(3), 613–630.

DeMarzo, P. M. and D. Duffie (1995). Corporate incentives for hedging and hedge accounting. *Review of Financial Studies 8*(3), 743–771.

DeYoung, R., E. Y. Peng, and M. Yan (2013). Executive compensation and business policy choices at US commercial banks. *Journal of Financial and Quantitative Analysis 48*(1), 165–196.

Dittmann, I. and E. Maug (2007). Lower salaries and no options? On the optimal structure of executive pay. *The Journal of Finance 62*(1), 303–343.

Eckbo, B. E. and K. S. Thorburn (2003). Control benefits and CEO discipline in automatic bankruptcy auctions. *Journal of Financial Economics 69*(1), 227–258.

Edmans, A. and Q. Liu (2011). Inside debt. *Review of Finance 15*(1), 75–102.

Eisenberg, T., S. Sundgren, and M. T. Wells (1998). Larger board size and decreasing firm value in small firms. *Journal of Financial Economics 48*(1), 35–54.

Erkens, D. H., M. Hung, and P. Matos (2012). Corporate governance in the 2007–2008 financial crisis: Evidence from financial institutions worldwide. *Journal of Corporate Finance 18*(2), 389–411.

Fahlenbrach, R., R. Prilmeier, and R. M. Stulz (2012). This time is the same: Using bank performance in 1998 to explain bank performance during the recent financial crisis. *The Journal of Finance 67*(6), 2139–2185.

Fahlenbrach, R. and R. Stulz (2011). Bank CEO incentives and the credit crisis. *Journal of Financial Economics 99*(1), 11–26.

Fitzpatrick, D., D. Enrich, and D. Paletta (2008). PNC Buys National City in Bank Shakeout. *Wall Street Journal*.

Galai, D. and R. W. Masulis (1976). The option pricing model and the risk factor of stock. *Journal of Financial economics 3*(1), 53–81.

Gande, A. and S. Kalpathy (2011). CEO compensation at financial firms. *SMU Working Paper*.

Gompers, P., J. Ishii, and A. Metrick (2003). Corporate governance and equity prices. *The Quarterly Journal of Economics 118*(1), 107–156.

Guay, W. (1999). The sensitivity of CEO wealth to equity risk: an analysis of the magnitude and determinants. *Journal of Financial Economics 53*(1), 43–71.

Houston, J. and C. James (1995). CEO compensation and bank risk. Is compensation in banking structured to promote risk taking? *Journal of Monetary Economics 36*(2), 405–431.

Ingersoll, J. E. (2006). The subjective and objective evaluation of incentive stock options. *The Journal of Business 79*(2), 453–487.

Jensen, M. and W. Meckling (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics 3*(4), 305–360.

John, K., H. Mehran, and Y. Qian (2010). Outside monitoring and CEO compensation in the banking industry. *Journal of Corporate Finance 16*(4), 383–399.

John, K. and Y. Qian (2003). Incentive features in CEO compensation in the banking industry. *Economic Policy Review 9*(1).

John, T. A. and K. John (1993). Top-management compensation and capital structure. *The Journal of Finance 48*(3), 949–974.

Knopf, J. D., J. Nam, and J. H. Thornton Jr (2002). The volatility and price sensitivities of managerial stock option portfolios and corporate hedging. *The Journal of Finance 57*(2), 801813.

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

Lambert, R. A., D. F. Larcker, and R. E. Verrecchia (1991). Portfolio considerations in valuing executive compensation. *Journal of Accounting Research*, 129–149.

Merton, R. C. (1973). Theory of rational option pricing. *Bell Journal of Economics 4*(1), 141–183.

Murphy, K. J. (2013). Regulating banking bonuses in the European Union: a case study in unintended consequences. *European Financial Management 19*(4), 631–657.

Obama, B. (2009, Sep). Remarks by President Barack Obama on executive compensation with Secretary Geithner.

Prendergast, C. (2002). The tenuous trade-off between risk and incentives. *The Journal of Political Economy 110*(5), 1071–1102.

Schapiro, M. L. (2009). Speech by SEC Chairman: Address to Transatlantic Corporate Governance Dialogue 2009 Conference.

Story, L. and J. Becker (2009, June 12). Bank chief tells of U.S. pressure to buy Merrill Lynch. *The New York Times*.

Sundaram, R. and D. Yermack (2007). Pay me later: Inside debt and its role in managerial compensation. *The Journal of Finance 62*(4), 1551–1588.

Yermack, D. (1996). Higher market valuation of companies with a small board of directors. *Journal of Financial Economics 40*(2), 185–211.

Table 1: Firm characteristics: summary statistics. S.d. denotes standard deviation and p10, p50, and p90 correspond to percentiles 10, 50, and 90, respectively. *Market cap.* is the firm's market capitalization computed as total common equity multiplied by the price of the stock at the close of the calendar year. *Total assets* is the book value of the total assets of the firm. Market cap. and total assets are measured in billions of dollars. *Leverage* is the quasi-market value of leverage, computed as book value of assets minus book value of equity plus market value of equity, divided by the market value of equity. *ROA* is the ratio of operating income before depreciation over total assets at the end of the previous year. All variables are measured in 2006. *Panel A* displays summary statistics for our sample. The number of firms in the sample is 125. *Panel B* displays summary statistics for the entire population of firms available in Compustat for year 2006 with SIC codes between 6000 and 6050.

Panel A. Firms in the sample

	Mean	S.d.	p10	p50	p90
Market cap.	15.73	39.57	0.62	2.04	31.49
Total assets	103.85	284.27	2.85	11.52	199.95
Leverage	6.36	2.85	3.93	5.64	9.33
ROA	0.03	0.01	0.02	0.03	0.05

Panel B. Compustat population (SIC codes 6000–6050)

	Count	Mean	S.d.	p10	p50	p90
Market cap.	747	4.40	18.92	0.04	0.17	4.50
Total assets	778	41.37	203.17	0.28	1.01	20.86
Leverage	746	7.28	3.19	4.31	6.52	10.97
ROA	759	0.02	0.03	0.01	0.02	0.04

Table 2: Incentive measures in year 2006: summary statistics. *LD* is the product of *leverage* and *delta*, where *leverage* is the quasi-market value of leverage, as defined in Table 1, and *delta* is the change in the value of the CEO's portfolio of stock and options (measured in $ million) associated with a 1% change in the price of the stock of the firm. *Option vega* is the change in the value of the CEO's option portfolio (measured in $ million) associated with a change of 0.01 in the standard deviation of the price of the stock. All variables are measured in 2006. *Panel A* contains summary statistics. *Panel B* contains correlation coefficients. *Panel C* contains the means and medians of the incentive variables for the subsamples of failed and surviving institutions. Asterisks in the mean and median columns of the group of failed institutions represent statistically significant differences according to the t-test of means and the rank-sum test for differences in medians, respectively. *, ** and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively. The number of firms in the sample is 125.

Panel A. Incentive measures

	Mean	S.d.	p10	p50	p90
LD	8.89	22.29	0.23	2.02	22.09
Option vega	0.32	0.55	0.00	0.08	0.90
Delta	1.34	4.24	0.04	0.37	2.97

Panel B. Pairwise correlations between incentive measures

	LD	Option vega	Delta
LD	1		
Option vega	0.2575	1	
Delta	0.7175	0.2329	1

Panel C. Differences in means and medians between failed and surviving banks

	Surviving		Failed	
	Mean	Median	Mean	Median
LD	6.34	1.72	23.06***	9.36*
Option vega	0.30	0.07	0.46	0.15
Delta	1.23	0.30	2.00	1.03*
N	106		19	

Table 3: Risk-taking incentives and bank failure. The table presents estimated coefficients of different specifications of a linear probability model with *failed* as the dependent variable. *Failed* is a dummy variable equal to 1 if the firm fails in the period from 2007 to 2010. *LD* is the product of *leverage* and *delta*, where *leverage* is the quasi-market value of leverage as defined in Table 1, and *delta* is the change in the value of the CEO's equity portfolio (measured in $ million) associated with a 1% change in the price of the stock of the firm. *Option vega* is the change in the value of the CEO's portfolio of options (measured in $ million) associated with a change of 0.01 in the standard deviation of the stock price. *LD, option vega*, and *delta* are measured in year 2006. *, ** and *** represent significance levels at 10%, 5%, and 1%, respectively. Robust standard errors are reported in parentheses.

	(1)	(2)	(3)	(4)	(5)
LD	0.004***			0.007***	
	(0.002)			(0.002)	
Option vega		0.065			0.059
		(0.067)			(0.069)
Delta			0.006	−0.023***	0.004
			(0.009)	(0.005)	(0.008)
N	125	127	125	125	125
R^2	0.073	0.011	0.004	0.107	0.012

Table 4: Alternative explanations. Each row corresponds to a possible explanation for the results in Table 3. Each cell displays the expected sign of the relation between the variable corresponding to the cell's column and failure, according to the explanation corresponding to the cell's row. A proposed explanation may explain the results in Table 3 if the sign of the relation between a variable related to that explanation and LD is the same as the sign reported in the corresponding cell. We display a sign in boldface if the sample correlation between the corresponding variable and LD has the same sign as the difference in the average value of the variable between the subsamples of failed and surviving banks and this sign is equal to the predicted sign in the table. For example, according to the "risk aversion" explanation, CEO wealth would have a positive relation with probability of bank failure, so we place a + sign in the corresponding cell. Since the sample correlation between CEO wealth and LD is positive, we display the **+** sign in boldface.

	CEO pay	Age	Term. payments	Inside debt	Size	Wealth	Leverage	Pre-crisis returns
Termination incentives	**+**/−	**+**/−	**+**					
Career concerns		**+**/−						
Debt-like incentives	−			−				
Size	**+**				**+**			
CEO risk aversion		−				**+**		
LD measures risk							**+**	
Poor management								−

Table 5: Alternative explanations: summary statistics of relevant variables in year 2006. *Firm size (2003)* is the log of total assets at the end of year 2003. *Total pay* is the total compensation received by the CEO. It comprises salary, bonus, other annual payments, restricted stock grants, long term incentive plan (LTIP) payouts, other compensation, and the value of option grants. *CEO age* denotes the CEO's age in years. *G. parachute* and *severance pay* are the contingent payments upon termination with and without a change in control, respectively, as in year 2006's proxy statements. *Inside debt* (Cassell et al., 2012) is the sum of the present value of accumulated pension benefits from all pension plans and the total aggregate balance in deferred compensation plans of the CEO at the end of 2006, as reported in Execucomp. *Non-firm wealth* is the non-firm wealth of the CEO, as defined by Dittmann and Maug (2007). *Leverage* is the quasi-market value of leverage, computed as book value of assets minus book value of equity plus market value of equity, divided by market value of equity. *ROA* is the ratio of operating income before depreciation over total assets at the end of the previous year. *Returns (avg.)* is the average annual stock return in the period 2002-2006. All compensation variables are measured in millions of dollars. All variables are measured in 2006 unless stated otherwise.

	Count	Mean	S.d.	p10	p50	p90
	count	*mean*	*sd*	*p10*	*p50*	*p90*
Firm size (2003)	128	9.45	1.68	7.65	9.14	12.07
Total pay	125	6.89	10.37	0.66	2.20	20.37
CEO age	128	57.51	6.66	49.00	58.00	65.00
Severance pay	119	6.27	13.23	0.00	0.63	18.40
G. parachute	119	12.31	19.74	0.00	4.88	39.22
Inside Debt	118	8.69	15.50	0.00	3.40	26.96
Non-firm wealth	120	33.81	95.22	0.52	6.61	73.95
Leverage	128	6.36	2.85	3.93	5.64	9.33
ROA (avg.)	129	0.03	0.01	0.02	0.03	0.04
Returns (avg.)	121	0.11	0.10	0.02	0.10	0.23

Table 6: Risk-taking incentives and bank failure: multivariate results. The table presents estimated coefficients of different specifications of a linear probability model with *failed* as the dependent variable. *Failed* is a dummy variable equal to 1 if the firm fails in the period from 2007 to 2010. *LD* is the product of *leverage* and *delta*, where *leverage* is the quasi-market value of leverage as defined in Table 1, and *delta* is the change in the value of the CEO's equity portfolio (measured in $ million) associated with a 1% change in the price of the firm's stock. *Leverage*^{2} is leverage squared. All other variables are as defined in Table 5. All variables are measured in year 2006 unless stated otherwise. Robust standard errors are reported in parentheses.

Panel A. Firm characteristics, CEO characteristics, and other incentives

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LD	0.007***	0.005***	0.007***	0.033***	0.033***	0.032***	0.006***	0.031**
	(0.002)	(0.002)	(0.002)	(0.008)	(0.008)	(0.008)	(0.002)	(0.014)
Delta	−0.022***	−0.019***	−0.022***	−0.096***	−0.094***	−0.093***	−0.022***	−0.088**
	(0.005)	(0.005)	(0.005)	(0.022)	(0.022)	(0.023)	(0.006)	(0.040)
Firm size (2003)	0.011		0.011	−0.025	−0.024	−0.019	0.017	−0.020
	(0.021)		(0.021)	(0.022)	(0.024)	(0.026)	(0.024)	(0.030)
Total pay		0.006						0.002
		(0.005)						(0.011)
CEO age			−0.004					−0.002
			(0.005)					(0.006)
Severance pay				0.001				0.001
				(0.003)				(0.004)
G. parachute					0.000			0.000
					(0.002)			(0.003)
Inside debt						−0.001		−0.001
						(0.002)		(0.002)
Non-firm wealth							0.000	−0.000
							(0.001)	(0.001)
N	125	123	125	118	118	117	118	109
R^2	0.109	0.124	0.115	0.166	0.165	0.164	0.111	0.151

Panel B. Risk and pre-crisis performance

	(1)	(2)	(3)
LD	0.006***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)
Delta	−0.012**	−0.022***	−0.022***
	(0.006)	(0.004)	(0.005)
Firm size (2003)	−0.004	0.005	0.015
	(0.022)	(0.021)	(0.023)
Leverage	0.113**		
	(0.049)		
Leverage^2	−0.005**		
	(0.002)		
ROA (avg.)		4.625	
		(3.742)	
Return (avg.)			0.152
			(0.314)
N	125	125	121
R^2	0.174	0.128	0.112

Table 7: Governance variables in year 2006: summary statistics. *G-index* is the Governance index defined by Gompers et al (2003). *E-index* is the Entrenchment index, as defined by Bebchuck et al. (2009). *Board size* is the number of members of the board of directors. *Independence* is the number of independent directors divided by board size. All variables are measured in year 2006.

	Count	Mean	S.d.	p10	median	p90
G-index	106	9.98	2.79	7.00	10.00	13.00
E-index	106	2.93	1.32	1.00	3.00	4.00
Independence	124	0.72	0.13	0.55	0.75	0.87
Board size	124	12.50	3.11	9.00	12.00	17.00

Table 8: Governance, risk-taking incentives, and bank failure. *Panel A* displays estimated coefficients of different specifications of a linear probability model with *failed* as the dependent variable. *Failed* is a dummy variable equal to 1 if the firm fails in the period from 2007 to 2010. *LD* is the product of *leverage* and *delta*, where *leverage* is the quasi-market value of leverage as defined in Table 1, and *delta* is the change in the value of the CEO's equity portfolio (measured in $ million) associated with a 1% change in the price of the stock of the firm. *G-index* is the Governance index defined by Gompers et al (2003). *E-index* is the Entrenchment index, as defined by Bebchuck et al. (2009). *Board size* is the number of members of the board of directors. *Independence* is the number of independent directors divided by board size. All variables are measured in year 2006, except *Firm size (2003)*, which is the natural logarithm of total assets as of year 2003. *Panel B* displays estimated coefficients of different specifications of a linear model with LD as the dependent variable. *, ** and *** represent significance levels at 10%, 5%, and 1%, respectively. Robust standard errors are reported in parentheses.

Panel A. Governance, risk-taking incentives, and bank failure

	(1)	(2)	(3)	(4)	(5)
LD	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Delta	−0.023***	−0.022***	−0.023***	−0.022***	−0.024***
	(0.005)	(0.005)	(0.006)	(0.004)	(0.006)
Firm size (2003)	0.015	0.012	0.017	0.023	0.019
	(0.025)	(0.027)	(0.021)	(0.021)	(0.025)
G-index	0.010				0.011
	(0.011)				(0.011)
E-index		−0.013			
		(0.026)			
Independence			0.065		0.141
			(0.264)		(0.321)
Board size				−0.011	−0.009
				(0.011)	(0.012)
N	105	105	121	121	104
R^2	0.126	0.122	0.121	0.129	0.133

Panel B. Governance and risk-taking incentives

	(1)	(2)	(3)	(4)	(5)
Firm size (2003)	6.406***	5.737***	5.797***	6.394***	7.139***
	(1.781)	(1.358)	(1.487)	(1.662)	(1.853)
G-index	−0.286				−0.366
	(0.470)				(0.586)
E-index		−3.119			
		(2.495)			
Independence			−24.236		−34.496
			(34.426)		(41.261)
Board size				−1.333***	−1.556***
				(0.387)	(0.480)
N	105	105	121	121	104
R^2	0.187	0.213	0.210	0.225	0.254

Table 9: Shareholder risk-taking incentives and CEO risk-taking incentives. The table shows results from regressions in which the dependent variable is the variable indicated in the column heading and the explanatory variables are *Firm size (2003)*, which is the natural logarithm of total assets as of year 2003, and *leverage (2003)*, which is the quasi-market value of leverage as of year 2003. *LD* is the product of *leverage* and *delta*, where *delta* is the change in the value of the CEO's equity portfolio (measured in $ million) associated with a 1% change in the price of the stock of the firm. Δ_S is the delta from stock holdings, and Δ_O the delta from option holdings, as defined in equation (2). $\Delta_\$$ is the change in the value of the CEO's equity portfolio (measured in $ million) associated with a $1,000 change in the firm's market capitalization. All dependent variables are measured in year 2006. *, ** and *** represent significance levels at 10%, 5%, and 1%, respectively. Robust standard errors are reported in parentheses.

	LD	Delta	Δ_S	Δ_O
Firm size (2003)	3.661***	0.703***	0.395	0.288***
	(1.037)	(0.255)	(0.250)	(0.053)
Leverage (2003)	4.329**	0.021	0.054	−0.037
	(2.015)	(0.221)	(0.211)	(0.027)
N	124	124	123	122
R^2	0.438	0.080	0.031	0.312

Table 10: Risk-taking incentives and bank failure: alternative measure of risk-taking incentives. The table replicates Table 6 with Chesney et al. (2012)'s *asset volatility vega* (AVV) as the measure of risk-taking incentives. AVV is the change in the value of the CEOs portfolio of stocks and options associated with a 0.01 change in the standard deviation of the value of the assets of the firm, as defined and computed by Chesney et al. (2012). The table presents estimated coefficients of different specifications of a linear probability model with *failed* as the dependent variable. *Failed* is a dummy variable equal to 1 if the firm fails in the period from 2007 to 2010. *Delta* is the change in the value of the CEO's equity portfolio (measured in $ million) associated with a 1% change in the price of the stock of the firm. All other variables are as defined in Table 5. All variables are measured in year 2006, unless stated otherwise. Robust standard errors are reported in parentheses.

Panel A. Correlation table

	AVV	LD	Delta	Option vega
AVV	1	0.8472	0.2499	0.1604

Panel B. Multivariate results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AVV	0.010***	0.008***	0.011***	0.061***	0.061***	0.061***	0.009***	0.051*
	(0.003)	(0.003)	(0.003)	(0.020)	(0.020)	(0.020)	(0.002)	(0.030)
Delta	−0.003	−0.004*	−0.001	−0.005	−0.003	−0.004	−0.004	−0.002
	(0.002)	(0.002)	(0.002)	(0.006)	(0.003)	(0.003)	(0.005)	(0.013)
Firm size (2003)	0.016		0.016	−0.016	−0.014	−0.014	0.020	−0.019
	(0.021)		(0.021)	(0.022)	(0.024)	(0.026)	(0.023)	(0.030)
Total pay		0.006						0.004
		(0.005)						(0.011)
CEO age			−0.004					−0.001
			(0.005)					(0.005)
Severance pay				0.001				0.002
				(0.003)				(0.004)
G. parachute					−0.000			−0.000
					(0.002)			(0.003)
Inside debt						0.000		−0.000
						(0.002)		(0.002)
Non-firm wealth							0.000	−0.000
							(0.001)	(0.002)
N	125	123	125	118	118	117	118	109
R^2	0.104	0.123	0.110	0.163	0.162	0.161	0.108	0.141

Table 11: Alternative measures of bank risk. *Volatility (2003-2006)* and *Volatility (2007-2008)* are the standard deviations, measured over the periods indicated, of daily returns for firms with at least 60 days of trading. *Beta (2003-2006)* and *Beta (2007-2008)* are the firm's market betas measured over the periods indicated. To measure beta we use the CRSP value-weighted index return including dividends as the market return. *BHR (2007-2008)* denotes the buy-and-hold returns from 08/01/07 to 12/31/08, computed following Fahlenbrach and Stulz (2011). *Diff-volatility* (diff-beta) is the difference between the firm volatility (beta) in the period 2005-2006 and the firm volatility (beta) in the period 2003-2004. Panel A contains the means and medians of the ex ante risk measures (*Volatility (2003-2006)* and *Beta (2003-2006)*) for the subsamples of failed and surviving institutions. Panel B contains the means and medians of the ex post risk measures (*Volatility (2007-2008)*, *Beta (2007-2008)*, and *BHR (2007-2008)*) for the subsamples of failed and surviving institutions. Asterisks in the mean and median columns of the group of failed institutions represent statistically significant differences according to the t-test of means and the rank-sum test for differences in medians, respectively. Panel C reports the results of linear regressions with *LD* and *delta* as explanatory variables and the ex post risk measure indicated in the column title as dependent variable. *, ** and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively. We report robust standard errors in parentheses in Panel C.

Panel A. Ex ante risk measures and bank failure: surviving vs. failed banks

	Surviving		Failed	
	Mean	Median	Mean	Median
Volatility (2003-2006)	0.46	0.44	0.47	0.47
Beta (2003-2006)	1.04	1.00	1.09	1.05
diff - volatility	−0.02	−0.02	−0.01	−0.01
diff - beta	0.24	0.20	0.29	0.25
N	102		19	

Panel B. Ex post risk measures and bank failure: surviving vs. failed banks

	Surviving		Failed	
	Mean	Median	Mean	Median
Volatility (2007-2008)	0.86	0.83	1.60***	1.62***
Beta (2007 - 2008)	1.26	1.26	2.08***	1.88***
BHR (2007 - 2008)	−0.20	−0.21	−0.88***	−0.91***
N	101		19	

Panel C. Risk-taking incentives and risk: alternative risk measures

	Volatility (2007-2008)	Beta (2007-2008)	BHR (2007-2008)
LD	0.007***	0.015**	−0.007**
	(0.002)	(0.006)	(0.003)
Delta	−0.023***	−0.033*	0.018*
	(0.007)	(0.018)	(0.010)
N	120	120	117
R^2	0.083	0.222	0.079

Table 12: Robustness checks. *Panel A* contains estimation results for linear probability models with *failed* as the dependent variable. For each model, we report the value of the coefficients, the robust standard error of the coefficient estimates, the sample size, and the R^2. In column (i) we construct the sample as in Fahlenbrach and Stulz (2011). Column (ii) contains results using an alternative definition of *failed* that does *not* consider Merrill Lynch, National City, Provident, Mellon Financial and Countrywide as failed. In column (iii) we use a definition of *failed* that considers all the firms mentioned in column (ii) as failed, as well as Citigroup and Bank of America. Column (iv) excludes investment banks from the sample. Column (v) excludes firms that are too-big-to-be-acquired (TBTBA) in terms of market capitalization. Column (vi) excludes excludes firms that are too-big-to-be-acquired according to the FSB's 2011 list of systemically important banks. *Panel B* contains univariate regressions where the dependent variable is *failed*. In column (1) the independent variables are *LD* and *delta* winsorized at the 2% level. In column (2) the independent variables are the natural logarithm of $(1 + LD)$ and the natural logarithm of $(1 + delta)$. Column (3) reports probit marginal effects, and column (4) reports logit marginal effects (evaluated at the sample means in both cases). *, ** and *** represent significance levels at 10%, 5%, and 1%, respectively. In both panels, robust standard errors are reported in parentheses.

Panel A: Sample selection, failure definition, and too-big-to-be-acquired banks

	i	ii	iii	iv	v	vi
LD	0.01***	0.00***	0.00***	0.01**	0.00***	0.01***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
N	97	125	125	116	120	117
R^2	0.104	0.076	0.071	0.079	0.078	0.094
Option vega	0.06	0.05	0.08	0.06	0.08	0.13
	(0.08)	(0.06)	(0.07)	(0.07)	(0.08)	(0.09)
N	97	127	127	117	122	119
R^2	0.008	0.008	0.016	0.009	0.013	0.029
Delta	0.08***	0.01	0.01	0.05	0.01	0.01
	(0.03)	(0.01)	(0.01)	(0.04)	(0.01)	(0.01)
N	97	125	125	116	120	117
R^2	0.093	0.005	0.005	0.026	0.005	0.006
LD	0.00	0.01***	0.01***	0.04***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Delta	0.02	−0.02***	−0.02***	−0.21***	−0.02***	−0.03***
	(0.06)	(0.00)	(0.01)	(0.07)	(0.01)	(0.01)
N	97	125	125	116	120	117
R^2	0.105	0.110	0.102	0.151	0.113	0.138

Panel B: Alternative specifications and extreme values

	LPM		Probit		Logit	
	(1)	(2)	(3)	(4)	(5)	(6)
WLD	0.02***					
	(0.01)					
WDelta	−0.10**					
	(0.05)					
ln(LD)		0.22***				
		(0.07)				
ln(Delta)		−0.26**				
		(0.11)				
LD			0.01**	0.04*	0.02*	0.08
			(0.01)	(0.02)	(0.01)	(0.05)
Delta				−0.17		−0.29
				(0.13)		(0.22)
N	125	125	125	125	125	125
R^2	0.122	0.109				
Pseudo R^2			0.063	0.111	0.060	0.109

Appendices

A Incentive Measures

Delta. Delta is defined in equation (2), which we reproduce here:

$$\Delta = \Delta_S + \Delta_O = \left[n_S\left(\frac{S}{100}\right)\right] + \left[\sum_i n_i \frac{\partial O^i}{\partial S}\left(\frac{S}{100}\right)\right], \tag{2}$$

where Δ_S and Δ_O denote the delta from stocks and options, respectively, n_S denotes the number of (restricted and unrestricted) shares of the firm's stock held by the CEO, S the stock price, and i, n^i, and O^i are the identifier of the option grant, the number of options of grant i, and the value of an option of grant i, respectively.

To compute Δ_O, we follow Guay (1999) and assume that the value of an option of grant i (O_i) is given by the Black and Scholes (1973)'s formula for valuing European call options, as modified to account for dividends by Merton (1973):

$$O_i = [Se^{-dt}N(Z_i) - Ke^{-rT_i}N(Z_i - \sigma_S T_i^{(1/2)}], \tag{6}$$

where N is cumulative probability function for the standard normal distribution, K_i is the exercise price of the option, σ_S is the expected stock-return volatility over the life of the option, r is the natural logarithm of risk-free interest rate, T_i is the time to maturity of the option in years, d is the natural logarithm of expected dividend yield over the life of the option, and Z_i is defined as follows:

$$Z_i = \frac{ln(\frac{S}{K_i}) + T_i(r - d + \frac{\sigma_S^2}{2})}{\sigma_S\sqrt{T_i}}. \tag{7}$$

We then obtain the derivative of the value of each option with respect to the stock price S:

$$\frac{\partial O_i}{\partial S} = e^{-dT_i}N(Z_i). \tag{8}$$

Option Vega. Following Guay (1999), we define option vega in equation (1) in the text as follows:

$$option\ vega = \sum_i n_i \frac{\partial O_i}{\partial \sigma_S} \times 0.01. \tag{1}$$

From expression (6), one obtains:

$$\frac{\partial O_i}{\partial \sigma_S} = e^{-dT_i} N'(Z_i) S \sqrt{T_i}, \tag{9}$$

where N' is the density of the standard normal distribution and all other variables are as defined above.

To compute the value of the different variables in the expressions above, we follow the procedure detailed by Coles et al. (2013).[36]

Asset Volatility Vega (AVV). We follow the procedure described by Chesney et al. (2012) to compute the Asset Volatility Vega from stocks (AVV_S) and from options (AVV_O). Here we provide only an outline of this procedure. We refer to the article by Chesney et al. (2012) for all the details.

We compute the Asset Volatility Vega from stocks (AVV_S) and from options (AVV_O) separately. The Asset Volatility Vega for a single share of stock avv_S is defined as:

$$avv_S = \frac{\partial BS(V, D, r, T, \sigma_V)}{\partial \sigma_V} \times 0.01, \tag{10}$$

where $BS(V, D, r, T, \sigma_V)$ is the Black-Scholes value of equity as a call option on the firm's value (V), D is the book value of debt per share, r is the yield on Treasury bonds with time to maturity 7 years, T is the maturity of long-term debt (set equal to 7.5 years following Guay, 1999), and σ_V is the volatility of V.

It follows from the Black-Scholes formulation that:

$$avv_S = \varphi(d_1(V, D, r, T, \sigma_V)) V \sqrt{T} (1/100), \tag{11}$$

where

$$d_1 = \frac{ln(V/D) + (r + \sigma_V^2/2)T}{\sigma_V \sqrt{T}}. \tag{12}$$

To compute AVV_S, we multiply avv_S by the number of shares held by the CEO.

The Asset Volatility Vega for an option of stock option grant i (avv_{O_i}) is defined as:

$$avv_{O_i} = \frac{\partial CC}{\partial \sigma_V} \times 0.01, \tag{13}$$

where CC is the value of the stock option as a call on a call option on firm value (compound option). Chesney

[36] We depart from the procedure by Coles et al. (2013) only in that we use as risk-free interest rate the one provided by Execucomp.

et al. (2012) provide a closed form expression for avv_{O_i}.

We define AVV_O as:

$$AVV_O = \sum_i n_i avv_{O_i}. \tag{14}$$

Finally, we define Asset Volatility Vega (AVV) as:

$$AVV = AVV_S + AVV_O. \tag{15}$$

B Sample Selection

The following table lists the financial institutions included in the sample. For those firms not in SIC codes 6020 (Commercial Banks), 6035 (Savings Institutions, Federally Chartered), or 6036 (Savings Institutions, Not Federally Chartered), Column *FFIEC Inst. Type* reports the institution type in year 2006, according to the firm's history at the FFIEC's National Information Center. The institution types present in the sample are FHC (Financial Holding Company), FSB (Federal Savings Bank), and S&LHC (Savings and Loans Holding Company). The *Primary Dealer* column displays a 1 if the firm is listed as a primary dealer in 2006 by the New York Fed.

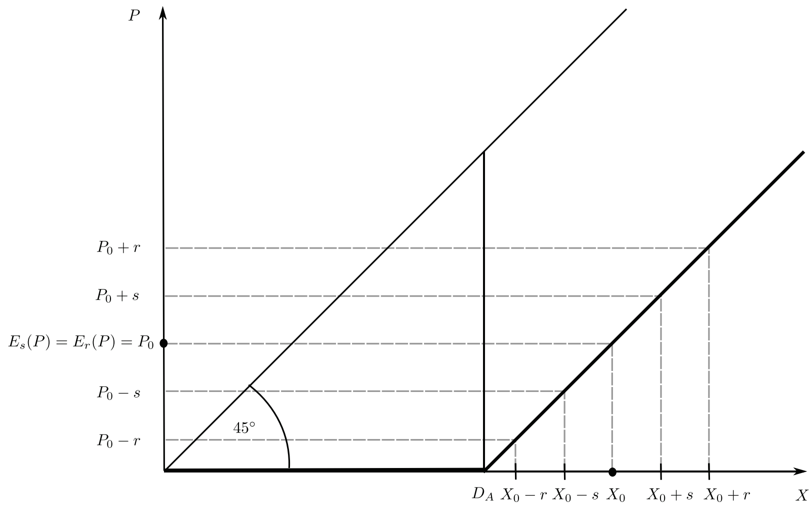
Number	Company Name	SIC	SIC - Description	FFIEC Inst. Type	Primary Dealer
1	AMERICAN EXPRESS CO	6199	FINANCE SERVICES	S&LHC	
2	AMERIPRISE FINANCIAL INC	6211	SECURITY BROKERS & DEALERS	S&LHC	
3	ANCHOR BANCORP WISCONSIN INC	6035	SAVINGS INSTN,FED CHARTERED		
4	ASSOCIATED BANCCORP	6020	COMMERCIAL BANKS		
5	ASTORIA FINANCIAL CORP	6035	SAVINGS INSTN,FED CHARTERED		
6	BANCORPSOUTH INC	6020	COMMERCIAL BANKS		
7	BANK MUTUAL CORP	6035	SAVINGS INSTN,FED CHARTERED		
8	BANK OF AMERICA CORP	6020	COMMERCIAL BANKS		
9	BANK OF HAWAII CORP	6020	COMMERCIAL BANKS		
10	BANK OF NEW YORK MELLON CORP	6020	COMMERCIAL BANKS		
11	BANK OF THE OZARKS INC	6020	COMMERCIAL BANKS		
12	BANKUNITED FINANCIAL CORP	6035	SAVINGS INSTN,FED CHARTERED		
13	BB&T CORP	6020	COMMERCIAL BANKS		
14	BBCN BANCORP INC	6020	COMMERCIAL BANKS		
15	BBX CAPITAL CORP	6035	SAVINGS INSTN,FED CHARTERED		
16	BEAR STEARNS COMPANIES INC	6211	SECURITY BROKERS & DEALERS		1
17	BOSTON PRIVATE FINL HOLDINGS	6020	COMMERCIAL BANKS		
18	BROOKLINE BANCORP INC	6035	SAVINGS INSTN,FED CHARTERED		
19	CAPITAL ONE FINANCIAL CORP	6141	PERSONAL CREDIT INSTITUTIONS	FHC	
20	CASCADE BANCORP	6020	COMMERCIAL BANKS		
21	CATHAY GENERAL BANCORP	6020	COMMERCIAL BANKS		
22	CENTRAL PACIFIC FINANCIAL CP	6020	COMMERCIAL BANKS		
23	CHITTENDEN CORP	6020	COMMERCIAL BANKS		
24	CITIGROUP INC	6199	FINANCE SERVICES	FHC	1
25	CITY HOLDING CO	6020	COMMERCIAL BANKS		
26	CITY NATIONAL CORP	6020	COMMERCIAL BANKS		
27	COLONIAL BANCGROUP	6020	COMMERCIAL BANKS		
28	COLUMBIA BANKING SYSTEM INC	6020	COMMERCIAL BANKS		
29	COMERICA INC	6020	COMMERCIAL BANKS		
30	COMMERCE BANCORP INC/NJ	6020	COMMERCIAL BANKS		
31	COMMERCE BANCSHARES INC	6020	COMMERCIAL BANKS		
32	COMMUNITY BANK SYSTEM INC	6020	COMMERCIAL BANKS		
33	COMPASS BANCSHARES INC	6020	COMMERCIAL BANKS		
34	CORUS BANKSHARES INC	6020	COMMERCIAL BANKS		
35	COUNTRYWIDE FINANCIAL CORP	6162	MORTGAGE BANKERS & LOAN CORR	FHC	1
36	CULLEN/FROST BANKERS INC	6020	COMMERCIAL BANKS		
37	DIME COMMUNITY BANCSHARES	6035	SAVINGS INSTN,FED CHARTERED		
38	DOWNEY FINANCIAL CORP	6035	SAVINGS INSTN,FED CHARTERED		
39	E TRADE FINANCIAL CORP	6211	SECURITY BROKERS & DEALERS	S&LHC	
40	EAST WEST BANCORP INC	6020	COMMERCIAL BANKS		
41	FIFTH THIRD BANCORP	6020	COMMERCIAL BANKS		
42	FIRST BANCORP P R	6020	COMMERCIAL BANKS		
43	FIRST COMMONWLTH FINL CP/PA	6020	COMMERCIAL BANKS		
44	FIRST FINL BANCORP INC/OH	6020	COMMERCIAL BANKS		
45	FIRST FINL BANKSHARES INC	6020	COMMERCIAL BANKS		
46	FIRST HORIZON NATIONAL CORP	6020	COMMERCIAL BANKS		
47	FIRST INDIANA CORP	6020	COMMERCIAL BANKS		
48	FIRST MIDWEST BANCORP INC	6020	COMMERCIAL BANKS		
49	FIRST NIAGARA FINANCIAL GRP	6036	SAVINGS INSTN, NOT FED CHART		
50	FIRST REPUBLIC BANK	6020	COMMERCIAL BANKS		
51	FIRSTFED FINANCIAL CORP/CA	6035	SAVINGS INSTN,FED CHARTERED		
52	FIRSTMERIT CORP	6020	COMMERCIAL BANKS		
53	FLAGSTAR BANCORP INC	6035	SAVINGS INSTN,FED CHARTERED		
54	FRANKLIN BANK CORP	6036	SAVINGS INSTN, NOT FED CHART		
55	FRONTIER FINANCIAL CORP/WA	6020	COMMERCIAL BANKS		
56	FULTON FINANCIAL CORP	6020	COMMERCIAL BANKS		
57	GLACIER BANCORP INC	6020	COMMERCIAL BANKS		
58	GOLDMAN SACHS GROUP INC	6211	SECURITY BROKERS & DEALERS		1
59	GREATER BAY BANCORP	6020	COMMERCIAL BANKS		
60	GUARANTY FINANCIAL GROUP INC	6020	COMMERCIAL BANKS		
61	HANMI FINANCIAL CORP	6020	COMMERCIAL BANKS		
62	HUDSON CITY BANCORP INC	6035	SAVINGS INSTN,FED CHARTERED		
63	HUNTINGTON BANCSHARES	6020	COMMERCIAL BANKS		
64	INDEPENDENT BANK CORP/MI	6020	COMMERCIAL BANKS		

65	INDYMAC BANCORP INC	6162	MORTGAGE BANKERS & LOAN CORR	FSB	
66	INVESTORS FINANCIAL SVCS CP	6020	COMMERCIAL BANKS		
67	IRWIN FINANCIAL CORP	6020	COMMERCIAL BANKS		
68	JPMORGAN CHASE & CO	6020	COMMERCIAL BANKS		1
69	KEYCORP	6020	COMMERCIAL BANKS		
70	LEHMAN BROTHERS HOLDINGS INC	6211	SECURITY BROKERS & DEALERS	S&LHC	1
71	M & T BANK CORP	6020	COMMERCIAL BANKS		
72	MAF BANCORP INC	6035	SAVINGS INSTN,FED CHARTERED		
73	MARSHALL & ILSLEY CORP	6020	COMMERCIAL BANKS		
74	MELLON FINANCIAL CORP	6020	COMMERCIAL BANKS		
75	MERCANTILE BANKSHARES CORP	6020	COMMERCIAL BANKS		
76	MERRILL LYNCH & CO INC	6211	SECURITY BROKERS & DEALERS		1
77	MORGAN STANLEY	6211	SECURITY BROKERS & DEALERS	S&LHC	1
78	N B T BANCORP INC	6020	COMMERCIAL BANKS		
79	NATIONAL CITY CORP	6020	COMMERCIAL BANKS		
80	NATIONAL PENN BANCSHARES INC	6020	COMMERCIAL BANKS		
81	NEW YORK CMNTY BANCORP INC	6036	SAVINGS INSTN, NOT FED CHART		
82	NORTHERN TRUST CORP	6020	COMMERCIAL BANKS		
83	OLD NATIONAL BANCORP	6020	COMMERCIAL BANKS		
84	PACWEST BANCORP	6020	COMMERCIAL BANKS		
85	PEOPLE'S UNITED FINL INC	6036	SAVINGS INSTN, NOT FED CHART		
86	PINNACLE FINL PARTNERS INC	6020	COMMERCIAL BANKS		
87	PNC FINANCIAL SVCS GROUP INC	6020	COMMERCIAL BANKS		
88	POPULAR INC	6020	COMMERCIAL BANKS		
89	PRIVATEBANCORP INC	6020	COMMERCIAL BANKS		
90	PROSPERITY BANCSHARES INC	6020	COMMERCIAL BANKS		
91	PROVIDENT BANKSHARES CORP	6020	COMMERCIAL BANKS		
92	RAYMOND JAMES FINANCIAL CORP	6211	SECURITY BROKERS & DEALERS	S&LHC	
93	REGIONS FINANCIAL CORP	6020	COMMERCIAL BANKS		
94	S & T BANCORP INC	6020	COMMERCIAL BANKS		
95	SANTANDER HOLDINGS USA INC	6035	SAVINGS INSTN,FED CHARTERED		
96	SCHWAB (CHARLES) CORP	6211	SECURITY BROKERS & DEALERS	FHC	
97	SIMMONS FIRST NATL CP CL A	6020	COMMERCIAL BANKS		
98	SOUTH FINANCIAL GROUP INC	6020	COMMERCIAL BANKS		
99	STATE STREET CORP	6020	COMMERCIAL BANKS		
100	STERLING BANCORP/NY	6020	COMMERCIAL BANKS		
101	STERLING BANCSHARES INC/TX	6020	COMMERCIAL BANKS		
102	STERLING FINANCIAL CORP/WA	6036	SAVINGS INSTN, NOT FED CHART		
103	SUNTRUST BANKS INC	6020	COMMERCIAL BANKS		
104	SUSQUEHANNA BANCSHARES INC	6020	COMMERCIAL BANKS		
105	SVB FINANCIAL GROUP	6020	COMMERCIAL BANKS		
106	SWS GROUP INC	6211	SECURITY BROKERS & DEALERS	S&LHC	
107	SYNOVUS FINANCIAL CORP	6020	COMMERCIAL BANKS		
108	TCF FINANCIAL CORP	6020	COMMERCIAL BANKS		
109	TD BANKNORTH INC	6020	COMMERCIAL BANKS		
110	TOMPKINS FINANCIAL CORP	6020	COMMERCIAL BANKS		
111	TRUSTCO BANK CORP/NY	6035	SAVINGS INSTN,FED CHARTERED		
112	U S BANCORP	6020	COMMERCIAL BANKS		
113	UCBH HOLDINGS INC	6020	COMMERCIAL BANKS		
114	UMB FINANCIAL CORP	6020	COMMERCIAL BANKS		
115	UMPQUA HOLDINGS CORP	6020	COMMERCIAL BANKS		
116	UNIONBANCAL CORP	6020	COMMERCIAL BANKS		
117	UNITED BANKSHARES INC/WV	6020	COMMERCIAL BANKS		
118	UNITED COMMUNITY BANKS INC	6020	COMMERCIAL BANKS		
119	WACHOVIA CORP	6020	COMMERCIAL BANKS		
120	WASHINGTON FEDERAL INC	6035	SAVINGS INSTN,FED CHARTERED		
121	WASHINGTON MUTUAL INC	6035	SAVINGS INSTN,FED CHARTERED		
122	WEBSTER FINANCIAL CORP	6020	COMMERCIAL BANKS		
123	WELLS FARGO & CO	6020	COMMERCIAL BANKS		
124	WESTAMERICA BANCORPORATION	6020	COMMERCIAL BANKS		
125	WHITNEY HOLDING CORP	6020	COMMERCIAL BANKS		
126	WILMINGTON TRUST CORP	6020	COMMERCIAL BANKS		
127	WILSHIRE BANCORP INC	6020	COMMERCIAL BANKS		
128	WINTRUST FINANCIAL CORP	6020	COMMERCIAL BANKS		
129	ZIONS BANCORPORATION	6020	COMMERCIAL BANKS		

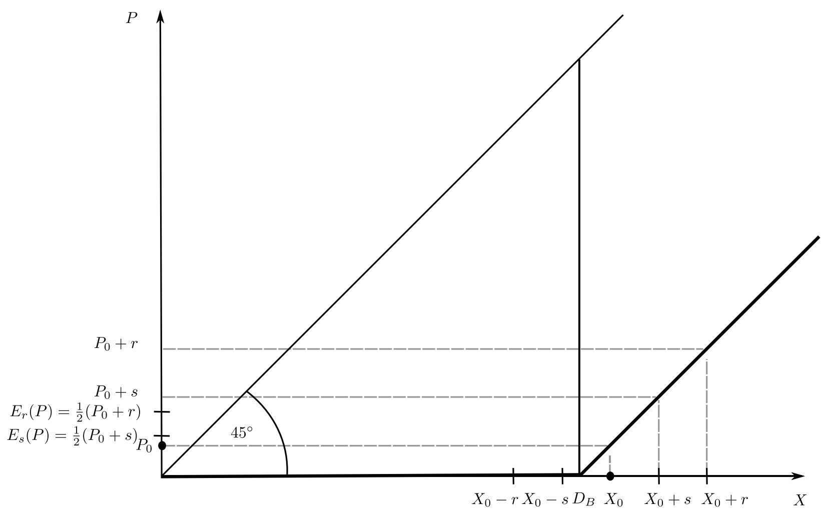
C Failed Firms

The following table lists the institutions that we identify as failed in the period 2007–2010. Columns *Year* and *Month* represent the last year and month, respectively, for which there is information for the corresponding firm in CRSP. The columns *Step 1–Step 4* refer to the four steps of the procedure to identify firm failure. A one in any of these columns indicates that the firm was identified as failed in that step. The four steps, described in Section 2, are: 1) bank subsidiary closure (as identified by the FDIC); 2) merger discount; 3) PROQUEST keyword search; 4) internet search.

Company Name	Year	Month	Step 1	Step 2	Step 3	Step 4
BEAR STEARNS COMPANIES INC	2008	5		1		
COLONIAL BANCGROUP	2009	7	1			
CORUS BANKSHARES INC	2009	8	1			
COUNTRYWIDE FINANCIAL CORP	2008	6		1		
DOWNEY FINANCIAL CORP	2008	10	1			
FIRSTFED FINANCIAL CORP	2009	2	1			
FRANKLIN BANKCORP	2008	10	1			
FRONTIER FINANCIAL CORP/WA	2010	4	1			
INDYMAC BANCORP INC	2008	6	1			
IRWIN FINANCIAL CORP	2009	8	1			
LEHMAN BROTHERS HOLDINGS INC	2008	8			1	
MELLON FINANCIAL CORP	2007	6		1		
MERRILL LYNCH & CO INC	2008	12				1
NATIONAL CITY CORP	2008	12				1
PROVIDENT BANKSHARES CORP	2009	4				1
SOUTH FINANCIAL GROUP INC	2010	9		1		
UCBH HOLDINGS INC	2009	10	1			
WACHOVIA CORP	2008	12		1		
WASHINGTON MUTUAL INC	2008	8	1			



(a) Firm A: Low Leverage



(b) Firm B: High Leverage

Figure 1: Leverage and risk-taking incentives. The figures depict the relation between the value of the firm (X) and the payoff (P) to an equity holder for two different firms (A and B), which differ only in the face value of their debt (D). Firm B in Panel (b) has a higher face value of debt than firm A in Panel (a) ($D_B > D_A$) and a higher leverage ($\frac{D_B}{X_0} > \frac{D_A}{X_0}$). We assume that firms are liquidated at debt maturity after the debt is repaid, so P can be understood as shareholders' liquidating dividend. In both figures, the thick line represents the payoff to equity holders at debt maturity (P) as a function of the value of the firm (X). The current firm value for either firm is X_0 and either firm may undertake one of two projects, safe (s) or risky (r). The value of the firm at debt maturity is assumed to be either $X_0 - k$, with probability 1/2, or $X_0 + k$, with probability 1/2, where $k = s$ for project s, $k = r$ for project r, and $r > s$. Thus, the distribution of firm value under project r is a mean-preserving spread of the distribution under project r. $P_0 = X_0 - D$ denotes the value of the firm's equity if firm value were X_0 at debt maturity. For firm A in Panel (a) the expected equity value upon liquidation is the same for both projects: $E_s(P) = \frac{1}{2}(P_0 - s) + \frac{1}{2}(P_0 + s) = P_0 = \frac{1}{2}(P_0 - r) + \frac{1}{2}(P_0 + r) = E_r(P)$. For firm B in Panel (b), equity value is zero if the project returns are negative. Therefore: $E_s(P) = \frac{1}{2}(P_0 + s) < \frac{1}{2}(P_0 + r) = E_r(P)$.