Do Bank Bail-Outs create Moral Hazard? Evidence from the recent Financial Crisis

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Abstract

We develop a new methodology to test for changes in bail-out expectations and the strength of market discipline in financial markets and apply it to crucial events during the recent financial crisis. We find that the rescue of Bear Stearns caused a significant decline in market discipline while the decline was most pronounced for the largest financial institutions and banks. Our results are in line with the idea of the bail-out being a "Too-Big-To-Fail" signal to the market participants, which in turn increased moral hazard. We also document a strong persistence of the moral hazard effect as it prevailed despite the non-intervention during the bankruptcy of Lehman Brothers.

Keywords: bail-out, too-big-to-fail, financial crises, market discipline, moral hazard

JEL: G14, G21, G28, H81

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1 Introduction

How to deal with banks in distress? The question of whether governments should bail-out banks has regained serious attention due to pivotal events during the recent financial crisis. Arguments in favor of bank bail-outs usually focus on the risk of contagion to other financial institutions which might subsequently cause substantial real effects (Dell Ariccia, Detragiache and Rajan, 2008) due to reduced lending and credit contractions (Puri, Rocholl and Steffen, 2011). On the contrary, an obvious argument against public interventions is the high amount of fiscal funds that bail-outs usually require (Calomiris and White,1994; Baer and Klingebiel (1995); Veronesi and Zingales, 2009).

However, the argument against bail-outs that has been put forward most forcefully deals with the emergence of moral hazard and the subsequent loss in market discipline. Policy makers fear that by saving troubled banks, they eliminate market participants' incentives to monitor and self-regulate banks' risk behavior. This, in turn, might induce a risk-shift that increases the likelihood of future financial crises. These implied long-term costs might even outweigh the short-term benefits of a bail-out. It is therefore crucial to investigate how markets actually do react to public interventions in the banking sector: Do bank bail-outs create moral hazard and decrease market discipline?

To answer this question, we develop a new methodology to test for changes in the strength of market discipline and apply it to events during the recent crisis. Motivated by the firm-value approach to debt pricing, we examine the relationship between equity and debt returns of US financial institutions and how it is affected by publicly observable risk factors.

We find that the rescue of Bear Stearns caused a significant reduction in market discipline. Despite the failure of Lehman Brothers, market discipline declined further after September 2008.

Regarding the persistence and even increase of moral hazard after the failure of Lehman Brothers we see two potential explanations: First, the magnitude of the subsequent turmoil after Lehman's bankruptcy might have revealed that the actual systemic effects of bank failures are too strong to let a systemic bank fail again in the future. Second, as a direct response to the financial turmoil created by the Lehman failure, governments and central banks in Europe and the US carried out massive interventions in order to support the financial system as a whole as well as on an individual level in the aftermath of the Lehman failure (Panetta et al., 2009). Therefore, even if the isolated effect of Lehman Brothers on market discipline might have been positive, countervailing actions in subsequent months might have undermined the credibility of this policy and reshaped expectations once again.

A broad literature exists on the importance and functioning of market discipline within the financial intermediation process. The basic theory of corporate finance describes the fundamental mis-alignment of incentives between equity holders and management of a bank on one side and their debt holders on the other side: While the latter are only interested in maximizing the probability of repayment of their fixed claim, equity holders want to maximize residual profits, i.e. firm value that is left after debt is repayed. Jensen and Meckling (1976) describe how this partial conflict of interest reflects an incentive to the management to take on a level of risk that exceeds the one maximizing firm value. This problem is especially severe when bank are hit by heavy losses and thus likely to default. The bank would then like to *gamble for resurrection*, i.e. increase the volatility of asset returns in order to make very high profits possible. Keeley (1990), Nier and Baumann (2006) and Fischer et al. (2011) provide empirical evidence that banks' risk-taking indeed increases as a consequence of higher perceived bail-out probabilities. Given the negative externalities of bank failures due to systemic effects, these inefficiently high levels of risk impose substantial social costs.

However, indirect control via the market funding process is in principle able to prevent this inefficient level of risk and thus serve as a governance mechanism (Calomiris and Kahn, 1991; Calomiris, 1999): If banks increase their risk profile, debt holders will require a higher risk premium on their investments in order to be compensated for potential losses. This increase in funding costs represents an incentive to the bank to adhere to a proper risk behavior, as the increased costs of capital would offset the gains from higher risk taking.

Yet, this market discipline mechanism crucially relies on the possibility of market participants to lose their investment in case of a default. Thus, incentives to monitor a bank's risk behavior weaken if perceived bail-out probabilities increase as a bail-out is essentially a guarantee written by the government. As a consequence of the lower monitoring effort, banks increase their risk-taking (Panageas, 2010).

Our paper relates to several existing empirical studies on the functioning of market discipline in financial intermediation and market reactions to government bailouts: Krishnan, Ritchken and Thomson (2005) analyze credit spreads and the introduction of subordinated debt and its effect on risk-taking of banks. Their results suggest that market discipline works rather poor. In contrast, Flannery and Sorescu (1996) study the period from 1983 to 1991 and find evidence for improved market discipline towards the end of the sample, a period when several bank holding companies were not rescued by the government. Balasubramnian and Cyree (2011) find a significant negative size effect on bank yields after the LTCM crisis, indicating a higher perceived chance of government bail-outs for large banks. Schweikhard and Tsesmelidakis (2011) investigate the decoupling of CDS and equity markets during the recent financial crisis. Calibrating a structural model to pre-crisis levels, they find a reduction of market spreads relative to model spreads which is then interpreted as a result of changes in bail-out expectations. This finding is supported by King (2009) who finds in his event study that government bailouts benefited creditors at the expense of shareholders. Finally, Kelly, Lustig and Van Nieuwerburgh (2011) show that during the financial crisis of 2008 the price of put options on individual member banks increased more than the price of a put option on a financial sector index, reflecting that investors take an implicit systemic guarantee into account.

Our paper is structured as follows: In chapter 2 we present the underlying theory to our approach and derive the general test design. Chapter 3 describes how our test methodology is operationalized and derives actual testable hypotheses. Chapter 4 describes our data set and chapter 5 presents our estimation results. Finally, chapter 6 concludes.

2 Theoretical Motivation

In order to assess the extent of market discipline present in the market, we draw upon fundamental insights from the structural firm value approach, which was pioneered by Merton (1974). It claims that the prices of equity E_t and debt D_t can be interpreted as derivatives on the fundamental firm value V_t and thus be valued using option pricing theory, i.e.

$$V_t = E_t + D_t \tag{1}$$

$$E_t = f(V_t) \tag{2}$$

$$D_t = g(V_t) \tag{3}$$

In particular, equity can be seen as a call option on the firm value with a strike price equal to the face value of debt. Accordingly, debt is equivalent to a risk-free investment plus a short put option on the firm value.

Following that approach, changes in the value of debt and equity are both driven by the same changes in the underlying firm value and should therefore be structurally linked. In particular, the sensitivity of debt to equity $\zeta_{D,E}$ can be written as

$$\zeta_{D,E} = \frac{\partial D}{\partial E}\frac{E}{D} = \frac{D_V}{E_V}\frac{E}{D} = \frac{D_V}{E_V}(\frac{1}{L} - 1) \tag{4}$$

with the market leverage L being defined as the ratio of market value of debt and market value of the firm, i.e. $L = D/V$. The elasticity itself depends on two non-observable inputs, i.e. the derivatives of debt and equity with respect to the firm value, while the leverage is observable from market data.

We derive how this sensitivity should change when people adjust their perception about future bail-out probabilities and study whether this is in line with the behavior we observed in the market during the recent crisis.

In doing so, it is important to note that bailing-out financial institutions aims at avoiding a market-wide collapse of the financial system. To achieve this, it is necessary to prevent a bank from complete failure, which can be achieved via guaranteeing the repayment of senior obligations, but does not require to compensate equity holders in addition. As a consequence, interventions in the crisis usually left equity holders suffering with an almost complete loss of their capital. As equity holders therefore did not benefit from bail-outs, equity prices should not be affected and thus contain all information about the true risk of bank failure, regardless of any potential government intervention. Hence, also the first derivative E_V should be unaffected by the bail-out probability. [1]

Yet the case is different for the valuation of debt. We know from theory that a risky (zero coupon) bond with maturity T is equal to an equivalent risk-free bond with risk-free rate r, adjusted for expected losses under the risk-neutral measure, i.e.

$$D = exp(-rT) \cdot [Prob^Q(\tau \geq T) + E^Q(R) \cdot Prob^Q(\tau < T)] \tag{5}$$

with τ being the first time the firm defaults and $E^Q(R)$ being the expected recovery rate given default under the risk-neutral probability measure Q. Adjusting this equation explicitly for the possibility of a bank bail-out and assuming independence of the firm value and the conditional bail-out probability PB, i.e. the bail-out probability given the firm is in default, one can rewrite equation (5) as:

$$D = exp(-rT) \cdot [Prob^Q(\tau \geq T) + E^Q(R) \cdot Prob^Q(\tau < T) \cdot (1 - PB) + Prob^Q(\tau < T) \cdot PB] \tag{6}$$

$$\begin{aligned} D &= exp(-rT) \cdot [1 - Prob^Q(\tau < T)(1 - E^Q(R)) \cdot (1 - PB)] \\ &\equiv exp(-rT) \cdot [1 - PD^Q(1 - R^Q) \cdot (1 - PB)] \end{aligned} \tag{7}$$

Taking now the derivative of debt w.r.t. the firm value one gets:

$$D_V = \frac{\partial D}{\partial V} = -exp(-rT) \cdot (1 - PB) \cdot [(1 - R^Q) \cdot \frac{\partial PD^Q}{\partial V} - PD^Q \cdot \frac{\partial R^Q}{\partial V}] \tag{8}$$

As the probability of default is declining in the firm value and the expected recovery rate should be non-declining for higher firm values, the term in square brackets is negative and the whole derivative is positive as predicted by theory.
More important for our analysis however is that the derivative unambiguously declines in the bail-out probability PB, i.e.

$$\frac{\partial D_V}{\partial PB} < 0 \tag{9}$$

[1] Veronesi and Zingales (2010) estimate the net effect of the Paulson Plan announcement on October 13, 2008 to be -2.8bn USD on the market capitalization of the 10 largest US banks. The effect however varies in between banks significantly.

As a consequence, also the elasticity of debt to equity is declining in the bail-out probability

$$\frac{\partial \zeta}{\partial PB} < 0 \tag{10}$$

This theoretical result, that the debt-to-equity sensitivity is diminishing in the expected bail-out probability, will be at the heart of our estimation approach. It is worthwhile to note that this derivation is independent of any model assumptions, in particular it does not depend on the assumed stochastic process of the underlying firm value nor on the modeling of any exogenous or endogenous default barrier. Therefore we propose to test for structural changes in bail-out expectations by testing for structural changes in the debt to equity sensitivity.

Yet, standard option pricing theory tells us that that the first derivatives of debt and equity, which are options on the firm value, depend on the riskiness of the firm or the moneyness of the underlying options.

Intuitively, when the firm is very healthy, the risk of bankruptcy is very low and changes in the firm value mainly affect the residual claim, i.e. the stock price. The sensitivity thus becomes very small for low risk companies.

If, however, the firm is very likely to default, small changes in firm value strongly affect the value of bonds but to a lesser extent the value of equity, i.e. $D_V(E_V)$ strongly increases (decreases) relative to the low risk case. Hence, the sensitivity should increase when a firm becomes more likely to default on its debt.

As a result one can see, that it is important to adjust for a firm's riskiness when testing for structural breaks in the elasticity because otherwise one might simply catch the effect of various levels of riskiness.

Schaefer and Strebulaev (2008) use a simple Merton-model to estimate the sensitivity of debt to equity and show that this sensitivity successfully explains the co-movement of stocks and bonds of non-financial companies. In particular, after calculating the sensitivity $\widehat{\zeta_{D,E}}$ from market and balance sheet data, they run a regression of the form:

$$bondreturn_t = \alpha_0 + \alpha_1 \cdot \widehat{\zeta_{D,E}} \cdot equityreturn_t + \epsilon_t \tag{11}$$

They can show that for their sample of non-financial firms the estimate of α_1 is close to and not significantly different from unity, as a correctly specified model would imply. Although at first sight this approach seems promising for our purpose as well, when applied to financial companies there are several drawbacks of calculating the debt-to-equity sensitivity directly from any particular firm value model.

First of all, banks are highly leveraged firms with low implied asset volatilities. A simple Merton model as well as most of its diffusion-only extensions (e.g. Black and Cox (1976)) cannot be reasonably calibrated to capture this. Most of the time, traditional firm value models imply a flat zero default probability and hence a zero credit spread even for longer time horizons. Modeling positive credit spread levels requires additional uncertainty about the distance to default, e.g. by introducing jumps (Zhou (2001)) or a non-observable default barrier (Finger et al. (2002)), but even then it appears to be difficult to calibrate the models for reasonable parameter values.

However, even by introducing additional uncertainty, these extensions still inherit a feature of classical firm value models which we consider misses out on the special characteristics of financial institutions. In classical firm value models, a company only defaults if its asset value drops below a certain critical threshold. This in turn implies that the entire risk of a company is measurable via its distance to default. [2] While this might be a reasonable assumption for non-financial firms, it entirely ignores the funding risks of banks. As witnessed by the recent financial crisis, a clear and present danger for financial firms is the inability to fund their own assets, even when the overall financial status is relatively solid. That is, banks are severely prone to default due to liquidity and funding problems, a feature which lies outside the theoretical firm value approach. While asset values and funding problems are often interrelated, they represent two distinct risks and should therefore be treated separately.

As a consequence, in contrast to Schaefer and Strebulaev (2008) we refrain from using theoretical model-specific elasticities as these models do not feature one of the main sources of risk for financial companies. Instead we base our analysis on actual observed elasticities and compare them to specific risk factors identified by the theoretical or empirical banking literature. In doing so, we precisely capture the essence of market discipline: If markets exert pressure to adhere to proper risk behavior via prices, than these prices should react consistently to specific risk factors of that particular company.

It is noteworthy that our approach rests only on a very limited and weak set of assumptions. In contrast to the substantial structure a fully fledged structural model requires, our approach only relies on very basic relationships of equity and debt and their sensitivity to changes in risk factors. While complete structural models are superior in many other applications, for our purpose, the convenience underlying our methodology is a virtue rather than a curse, as it increases the robustness of our results with respect to variations of the underlying model assumptions.

3 Identification strategy and estimation procedure

With the theoretical motivation in mind, we can now outline the general testing procedure designed to measure changes in the level of prevailing market discipline. Generally speaking,

[2] The distance to default can usually be interpreted as the number of asset value standard deviations the firm value exceeds the critical default barrier.

we apply a two-stage approach. In the first stage, we use a rolling time window in order to estimate the cross-sectional and time series dynamics of the debt-to-equity sensitivities. Additionally, for each time window we estimate corresponding various bank specific risk measures which aim at capturing the most relevant risk factors for banks, namely asset value risk and liquidity risk. In the second stage, we regress the estimated sensitivities on its corresponding risk proxies. Thereby we check for structural breaks after major events during the financial crisis.
In the following we shortly describe how the separate estimation steps are carried out and its underlying motivation:

3.1 Stage I: Estimating the debt-to-equity sensitivity

In order to estimate the debt-to-equity sensitivity we are relying on CDS data rather than on bond returns due to the superior data quality. While CDS changes and bond returns are directly linked via no-arbitrage bounds, available bond data show strong signs of illiquidity in particular during the heights of the crisis, a fact that might bias our results.

Using 30-day non-overlapping rolling time windows "w", we exploit the cross sectional variation between 34 US financial companies and time series variation for the period Jan 2004 to Sep 2010. The company and time dependent debt-to-equity sensitivity ("beta") is thereby estimated by running the following regression of daily bond on stock returns

$$\Delta CDS_{t,i} = \beta_0 + \beta_{1,i,w} \cdot equityreturn_{t,i} + error_{t,i} \tag{12}$$

and saving the $\beta_{1,i,w}$ -coefficient as the estimated sensitivity for the given time window w and chosen bank i.

3.2 Stage I: Computing the risk proxies

In order to cover the various risks for financial institutions, we employ several risk measures. Equity volatility and leverage can be identified as key variables for asset value risk. In addition we calculate various liquidity/funding risk measures and an option-implied skewness measure to capture default risk implied in equity markets.

3.2.1 Asset value risk proxies

Classical firm value models emphasize the importance of leverage and asset volatility as the main determinants of credit risk. Gorton and Santomero (1990) use the framework proposed by Black and Cox (1976) in order to test whether implied asset volatilities of junior bank debt are related to other credit risk proxies but find no significant relationship. In contrast, Flannery and Sorescu (1996) and Balasubramnian and Cyree (2011) find that in particular during times when financial companies were not perceived to be too-big-too-fail junior bank debt yield spreads were sensitive to variables such as leverage and stock volatility, in addition to conventional balance sheet risk characteristics such as loan composition and performance.

However in particular leverage can be expected to affect a company's overall risk and hence it debt-to-equity sensitivity in a non-linear fashion, as the impact of a firm's leverage increase on the overall riskiness of the company is very likely to depend on its current leverage. In order to visualize the impact of leverage and volatilities, we use the model by Finger et al. (2002) in order to derive hypothetical debt-to-equity sensitivities for a set of realistic market parameter, as experienced during the crisis. Figure 1 depicts the sensitivity for various values of the implied stock option volatility and leverage for a typical large US bank. The sensitivities are based on balance sheet data for JP Morgan Chase and calibrated to match the CDS level for June 2007, right before the onset of the financial crisis. [3]

What can be seen from figure 1, is that the model-based sensitivity is close to linear in the implied equity volatility and but rather concave in the leverage. A linear approximation of relation between the debt-to-equity sensitivity and leverage might therefore prove insufficient.

Hence, we proxy for asset value risk by using 1y at-the-money (ATM) call option volatilities, leverage as well as leverage squared in order to account for the non-linearity. Thereby (quasi market value) leverage is defined as debt valued at book prices relative to the sum of equity at market prices and debt at book prices. While the exact functional relationship between leverage and debt-to-equity sensitivity is certainly model dependent, we aim at capturing most of the non-linearity with this setup.

3.2.2 Liquidity/funding risk proxy

As financial institutions are refinancing a large portion of their debt via the rolling-over of short term debt, they are subject to potential liquidity and funding shortages. In order to control for this important risk source, we are employing different variants of two liquidity indicators. Firstly, we compute the average spread of Financial Commercial Paper (FCP) to Non-Financial Commercial Paper (NFCP) with a remaining time to maturity of 1,2 and 3 months for each rolling time window. Although the FCP-spread is based on a broad range of commercial paper, it should largely mirror the relative ease and difficulty of financial institutions to acquire short-term funding. Secondly, we compute the average 6- and 12-month Libor-OIS spread (OIS) for each time window. The Libor-OIS spread represents

[3] In order to ease comparability, the assumed exogenous parameters are the same as in Schweikhard and Tsesmelidakis (2011). Our CDS level calibration for June 2007 yields a mean recovery rate of $\overline{L} = 0.08$ which is comparable in size with the estimated pre-crisis level of 0.03 estimated by Schweikhard and Tsesmelidakis (2011)

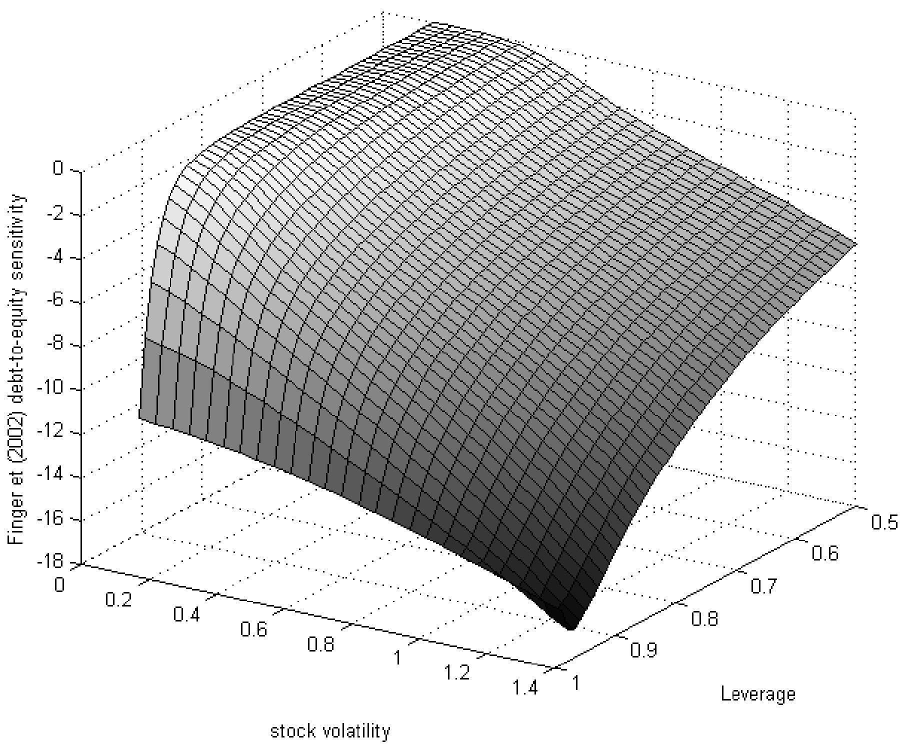

Figure 1: Theoretical debt-to-equity sensitivities, derived from Finger et al. (2002)

the yield difference between the (riskfree) Overnight-Index-Swap rate and unsecured bank loans for the same maturity, as reported by a panel of representative banks. It thus measures directly the difficulty to obtain unsecured short-term loans, one of the major funding sources of banks in particular.

Nevertheless not all financial institutions rely on short-term funding to the same extent, so that funding risk might be very different for individual firms. In order to account for that heterogeneity, for each firm we interact the two yield spreads with the company specific ratio of short- and long-term debt, i.e.

$$FCP - funding_{i,t} = FCP - spread_t * \frac{short - term\ debt\ of\ i\ in\ t}{long - term\ debt\ of\ i\ in\ t} \tag{13}$$

$$OIS - funding_{i,t} = OIS - spread_t * \frac{short - term\ debt\ of\ i\ in\ t}{long - term\ debt\ of\ i\ in\ t} \tag{14}$$

Short-term debt is thereby defined as current debt maturing within one year. It does not include deposits, as the yield spreads mainly apply to wholesale funding. [4]

3.2.3 Option-implied skewness measure

Recent contributions to the empirical asset pricing literature have shown that option surfaces contain information about the implied distribution of future stock returns. Various measures of idiosyncratic implied skewness have been successfully used in order to establish the link between skewness and stock returns. E.g. Yan (2011) examines the steepness of the implied volatility curve for short ATM options as a proxy for the average jump size and finds that stocks with higher slopes underperform. Rehman and Vilkov (2010) use the modelfree implied skewness measure from Bakshi, Kapadia, Madan (2003) and find that stocks with more negatively skewed return distribution perform significantly worse in the future. A similar finding was made by Xing, Zhang, Zhao (2010), who employ the difference between OTM and ATM option volatilities as an indicator of implied skewness. While Rehman and Vilkov (2010) find that the return differences stem from stock over- and undervaluations relative to their industry peers which are picked up by skewness, Xing, Zhang, Zhao (2010) show that the most negatively skewed stocks experience the worst earnings shocks in the next quarter.

While these papers differ with respect to the presumed sources of risk, they stress the importance of option-implied information for the riskiness of a firm and the implied default probability, as any default comes along with large negative stock returns. The riskier a company and the more likely it is to default on its debt, the higher the implied probabilities of very large negative stock returns should be, in particular relative to large positive returns.

[4] In addition, we have computed the funding spreads as a ratio of short-term debt to total liabilities which yields very similar results not reported in this paper.

As our interest lies in particular in the distribution of very large negative stock returns and due to its computational simplicity, we follow Xing, Zhang, Zhao (2010) by calculating our skewness measure as the difference between the 1y implied volatilities of OTM put and ATM calls

$$skewness_{t,i} = vol_{OTM\ Put} - vol_{ATM\ Call} \tag{15}$$

The higher the average measure for a given time window, the more likely are very large negative stock returns relative to very positive ones which we interpret as a signal for higher implied default risk.

3.3 Stage II: Testing for structural breaks after Bear Stearns and Lehman Brothers

As described above, the second step consists of running the following panel estimation by regressing the estimated betas from step one on the vector of risk measures RP, i.e.

$$\beta_{1,i,w} = \gamma_0 + \gamma_1 \cdot RP_{i,w} + error_{w,i} \tag{16}$$

and testing for structural differences in the γ_1-parameter for the different time periods, i.e. structural changes in the link between the debt-to-equity-sensitivity and the companies' risk factors after the Bear Stearns rescue in Mar 2008 and the Lehman bankruptcy in Sep 2008.

Our hypotheses regarding the development of the crisis are therefore:

Hypothesis 0: In the control period, γ_1 is significantly smaller than zero for our asset value, liquidity and skewness risk proxies, as higher risks should come along with lower debt-to-equity sensitivities.

As all these measures correspond to a higher risk level, the sensitivity should be decreasing in these measures. Only if these results hold, our assumptions appear to be a good approximation of the reality and the test approach proves to be suitable for the investigation of the main focus of our paper.

Hypothesis 1: γ_1 is significantly lower in absolute terms after the Bear Stearns bail-out relative to the control period, representing a decline in market discipline due to the bail-out of Bear Stearns.

The rescue of Bear Stearns should reshape the expectations of market participants towards a higher perceived probability of further bail-outs of other financial institutions. Therefore we expect a decline in market discipline after the bail-out. As shown in section 2, this should be reflected in a lower sensitivity of bond to equity returns and thus a lower coefficient γ_1.

For the period after the Lehman Brothers default, the expected sign of the coefficient γ_1 is not a priori clear. Due to the existence of various simultaneous but opposing effects around the timing of the Lehman Brothers default, there are explanations for several alternatives:

Hypothesis 2a: γ_1 is not significantly different to the control period, representing the re-establishment of the old level of market discipline due to the failure of Lehman Brothers.

The fact, that - contrary to the case of Bear Stearns - a large investment bank has not been bailed out, could be interpreted as a return to the expectations which lasted prior to Bear Stearns. In that case, the sensitivity should not structurally differ to the one in the control period, as the old level of market discipline has been reestablished.

Hypothesis 2b: γ_1 is similar in size to the period after the Bear Stearns rescue, i.e. the non-intervention in the Lehman Brothers default did not affect perceived future bail-out probabilities and market discipline over and above the effect realized after the Bear Stearns default.

Even though Lehman Brothers was not rescued, the tremendous disturbances after the bankruptcy can also be interpreted as a threat point to policy makers. This means that market participants interpret the turmoil after the Lehman failure as a signal of the enormous costs a non bail-out would trigger, and thus did not alter their expected probability of future bail-outs relative to the beliefs held after the Bear Stearns rescue.

Hypothesis 2c: γ_1 increases further for the period after the Lehman bankruptcy, representing a further decline in market discipline due to the financial turmoil and subsequent government actions

Already very soon after the Lehman default, market participants could realize its enormous external costs and observe the magnitude of government actions in order to prevent further financial companies from failing. This could have strengthened their beliefs about future government-sponsored bail-outs and led to a further decline in market discipline, overshadowing the potential signal sent out by the non-intervention in the Lehman filing.

Hypothesis 3: The change in γ_1 is different for the various firms, with more systemic companies showing a larger reduction in absolute terms after the Bear Stearns and Lehman failures

The more systemic a financial company, the higher are the associated external costs of its default. Thus more systemic firms should have a larger bail-out expectation attached. We measure the systemic component of a financial company by two proxies. Firstly, size is a natural candidate for systemic risk as larger firms are more interrelated with the financial system and own more assets which have to be liquidated in case of a bankruptcy. Due to the limited number of companies in the cross-section, we can only divide the sample into two sub-categories of "'small"' and "'big"' institutions based on their total asset holdings in mid 2008. Secondly, banks might be more systemically relevant than other financial companies again due to their higher interconnectedness with the financial markets. Banks were also the main beneficiaries of the TARP Capital Purchase Program and other equity infusion facilities under TARP. Finally, they were at the center of the 2009 Supervisory Capital Assessment Program (SCAP), a FED stress test for the largest 19 US financial institutions. As a consequence, banks are likely to be perceived as more systemic and should evidence a higher reduction in their γ_1 than other companies.

4 Data

In order to estimate our structural equations, we rely on a data set obtained from different sources. For the period from January 1 2004 to September 30 2010, the dataset contains information for 34 of the largest US financial institutions. Starting from the original list of financial companies by Adrian, Brunnermeier (2009), we added the in 2009 insolvent or taken-over banks Bear Stearns, Lehman Brothers, Merrill Lynch, Wachovia and Washington Mutual as well as Sally Mae and eliminated all companies for which we could not source a time series of CDS and option quotes. Daily equity prices and CDS quotes are obtained from CRSP and Thomson Datastream, equity option quotes from Optionmetrics, interest rate data from the Federal Reserve Bank and Bloomberg (Libor-OIS spreads) and quarterly balance sheet information from Compustat.
Regarding data cleansing, we ignore daily observations where we do not have market information on both the change in CDS level and the equity return for a given bank. Furthermore, we omit observations where the CDS level did not change at all or by more than 100 basis points in absolute value relative to the day before as some of the CDS time series show signs of significant illiquidity and lack of trading activity. Finally, we delete all observations for credit spreads of more than 2000bps as we expect very low liquidity in markets for CDS of extremely distressed companies. In addition, we ignore all observations for Bear Stearns, Merrill Lynch, Wachovia, Lehman Brothers, Washington Mutual and CIT after their announced take-overs or bankruptcies in 2008.

The debt-to-equity sensitivity for each firm and time window is only estimated, if there are at least 15 daily observations in the sample which is a compromise between the number of betas available for the stage II estimations and its quality. Analysis not reported in this paper shows however that the results are robust to changes in the length of the estimation window and the number of minimum observations required for each beta estimation.

As there is a well known phenomenon of excess correlation in times of extreme market distress, we would expect our findings to be seriously biased during the heights of the turmoil. Thus from our sample we exclude all observations for the whole month of the Bear Stearns bail-out, March 2008, as well as all observations from September 2008, the height of the financial crisis around the collapse of Lehman Brothers on September 10 2008 and other financial institutions in the days thereafter. Thereby we also get rid of the problem of precisely defining the point in time, when exactly new information about bail-outs entered the market.

Numbers from the quarterly or (semi-)annual reports are used from the day of their announcements.

These adjustments leave us with a total of 37,750 observations over the whole sample, with 25,262 observations falling into the control period, 2,704 observations in the post- Bear Stearns period and 9,784 observation after Sep 30 2009.
As can be seen from table 4, as expected most of the variables differ significantly between periods. The average CDS spread increases from 48 bps in the control period to 207 bps and 309bps after the Bear Stears and Lehman Brothers collapses, indicating a strong increase in the market perception of risks in the financial sector. The higher risk can also be seen from our risk proxies where implied volatilities and skewness as well as all funding spreads strongly increase after Bear Stearns and Lehman relative to the control period. [5] and due to declining equity prices, leverage increases, indicating a smaller equity buffer.

5 Results

5.1 Stage I results: debt-to-equity sensitivity

Table 2 presents summary statistics for our estimated debt-to-equity sensitivities. In line with our expectations, the average estimated sensitivity is negative in all three periods. Furthermore, the estimated sensitivity is very small in the control period but becomes significantly more negative after the Bear Stearns and Lehman Brothers incidents, as one would expect in a generally more risky financial environment.

From table 2 it can be noted that the maximum estimated sensitivity is 754 while economic theory tells us that it should be negative. Out of a sample of 1799 estimated betas, there are 2 outliers larger than 500 and 13 data points larger than 200 which we decided to exclude from the sample.[6]

Figure 2 displays a scatter plot of the estimated betas over time after the outlier correction. As can be seen in table 2, the average beta is negative but close to zero before the crisis but

[5] From our definition of the skewness indicator it stems that a higher positive value implies a more pronounced negatively skewed distribution

[6] Further analysis not reported in this paper shows however that including these 15 outliers in the dataset only affects the standard errors in the stage II regressions but leaves the point estimates almost unaffected.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Control Period					
CDS	25,262	48	64	1	1178
CDS Change	25,262	0.2	6	-99	99
Stock Return	25,262	0.00	0.02	-0.29	0.21
LIBOR-OIS Spread 6M	25,262	0.18	0.21	0.00	1.00
LIBOR-OIS Spread 12M	25,262	0.20	0.19	-0.04	0.87
FCP-NFCP Spread 1	24,437	0.04	0.06	-0.09	0.69
FCP-NFCP Spread 2	19,503	0.07	0.09	-0.12	0.66
FCP-NFCP Spread 3	10,206	0.10	0.16	-0.23	0.77
Implied Volatility	25,261	0.24	0.08	0.02	1.16
Skewness	25,261	0.046	0.02	-0.17	0.38
Leverage	25,262	0.79	0.19	0.07	0.98
Ratio of short-term Debt	23,747	0.95	1.22	0.00	5.44
After Bear Stearns, before Lehman Brothers					
CDS	2,704	207	237	32	1987
CDS Change	2,704	0.6	14	-85	96
Stock Return	2,704	0.00	0.05	-0.34	0.35
LIBOR-OIS Spread 6M	2,704	0.92	0.08	0.70	1.06
LIBOR-OIS Spread 12M	2,704	0.87	0.09	0.57	1.02
FCP-NFCP Spread 1	2,678	0.32	0.14	0.10	0.74
FCP-NFCP Spread 2	2,303	0.44	0.13	0.14	0.95
FCP-NFCP Spread 3	1,461	0.60	0.16	0.31	0.95
Implied Volatility	2,704	0.47	0.19	0.24	1.53
Skewness	2,704	0.09	0.05	-0.34	0.30
Leverage	2,704	0.86	0.17	0.35	1.00
Ratio of short-term Debt	2,602	0.72	0.90	0.00	3.53
After Lehman Brothers					
CDS	9,784	309	341	36	2000
CDS Change	9,784	-0.5	17	-100	100
Stock Return	9,784	0.00	0.05	-0.51	1.02
LIBOR-OIS Spread 6M	9,784	0.82	0.68	0.16	3.23
LIBOR-OIS Spread 12M	9,784	1.08	0.54	0.46	2.79
FCP-NFCP Spread 1	9,494	0.14	0.28	-0.06	2.36
FCP-NFCP Spread 2	7,940	0.14	0.27	-0.15	1.86
FCP-NFCP Spread 3	5,576	0.17	0.35	-0.48	2.00
Implied Volatility	9,767	0.53	0.22	0.18	1.66
Skewness	9,767	0.11	0.07	-0.28	0.89
Leverage	9,784	0.84	0.17	0.35	1.00
Ratio of short-term Debt	8,990	0.45	0.58	0.00	2.01

increases visibly during the second half of 2007. It stays at elevated levels in 2008 and 2009 and finally increases even further in early 2010, possibly in response to the European debt crisis. The increased diffusion of estimated betas over time is also notable.

Table 2: Estimated Beta - Summary Statistics

Sample	Obs	Mean	Std.Dev	Min	Max
Full Sample	1,799	- 46.84	95.82	- 755.11	754.54
Control	1,226	- 22.16	80.56	- 755.11	754.54
After BSC	115	- 85.91	69.81	- 279.70	67.15
After LEH	458	- 103.10	111.01	- 722.13	351.55

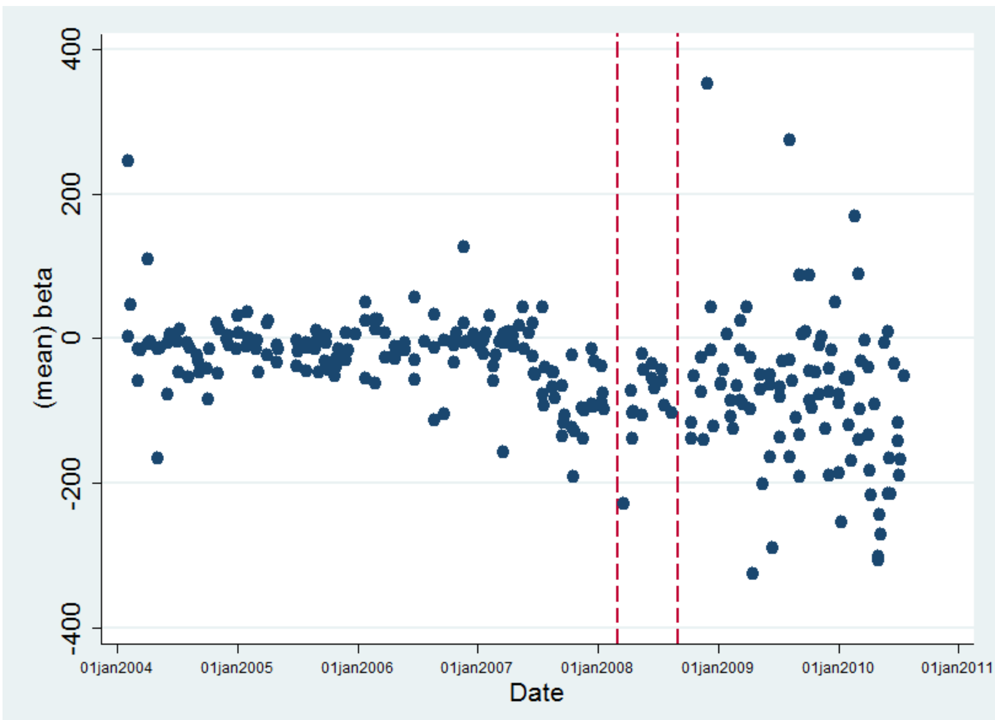

Figure 2: Stage I regression results: estimated company- and time-specific betas

5.2 Stage I results: risk proxies

Figure 3 depicts the evolution of the risk proxies. Until the first half of 2007, the risk proxies remain relatively stable. With the beginning of the crisis in mid 2007 however risk proxies react strongly to developments in the financial markets, with implied volatility and skewness doubling to 0.4 and 0.1 and the OIS-funding proxy jumping from almost zero to about 0.5%. After equity valuations for financial companies have reached its highs in mid 2007, declining stock prices lower equity buffers and increase effective leverage, a trend continuing until mid 2009.

Yet this is only a foretaste of things to come once the financial crisis reaches its heights with the collapse of Lehman Brothers. After the bail-out of Bear Stearns, the following short recovery is only of temporary nature as concerns regarding the health of the whole financial system drive OIS funding proxy, volatility and skewness further up and reach all time highs after the bankruptcy of Lehman Brothers. The funding proxy increases to over 1.5, which corresponds to a jump by almost 100bps in the Libor-OIS spread while skewness and implied volatility double another time to 0.2 and close to 0.9.

Here the high cross-sectional dispersion of risk proxies and skewness is noteworthy in particular. E.g. on October 16, 2008 the skewness measure reads only 15% for JP Morgan Chase but 21% and 24% for Morgan Stanley and Goldman respectively, indicating a much larger implied negative skew and tail risk for the latter. The risk proxies itself, just as the estimated beta in figure 1, show some recovery in early 2009, and increase again in the second half of 2010, which represents the end of our data sample.

5.3 Stage II results

Tables 3 and 4 show results for our main focus of this paper, the relationship between estimated debt-to-equity-sensitivity (beta) and risk proxies. Due to the high correlation of implied volatility with skewness and the other variables (see table 7 in the appendix), we do not include implied volatility in the joint regressions of table 4 as the high correlations visibly affect point estimates and standard errors. In order to conserve space, we only show the results for the 6-month OIS funding proxy as the results are very similar when using the other funding proxies. Standard errors and p-values are adjusted for heteroscedasticity in the cross-section.

Hypothesis 0: Validity of the analysis

In the control period, all estimated parameters for the individual risk proxies in regressions (2)-(6) are negative as expected and are statistically highly significant, with the exception of leverage where only leverage squared is significant. The same is true for joint estimations of the risk factors in regressions (7)-(11) again with the exception of leverage where we included leverage and leverage squared only combined in order to better capture the non-linearity effects of that variable. Here, the coefficient of leverage is always positive, dampening the negative squared effect. Overall, the control period gives strong support for our basis hypothesis 0 and the validity of our analysis.

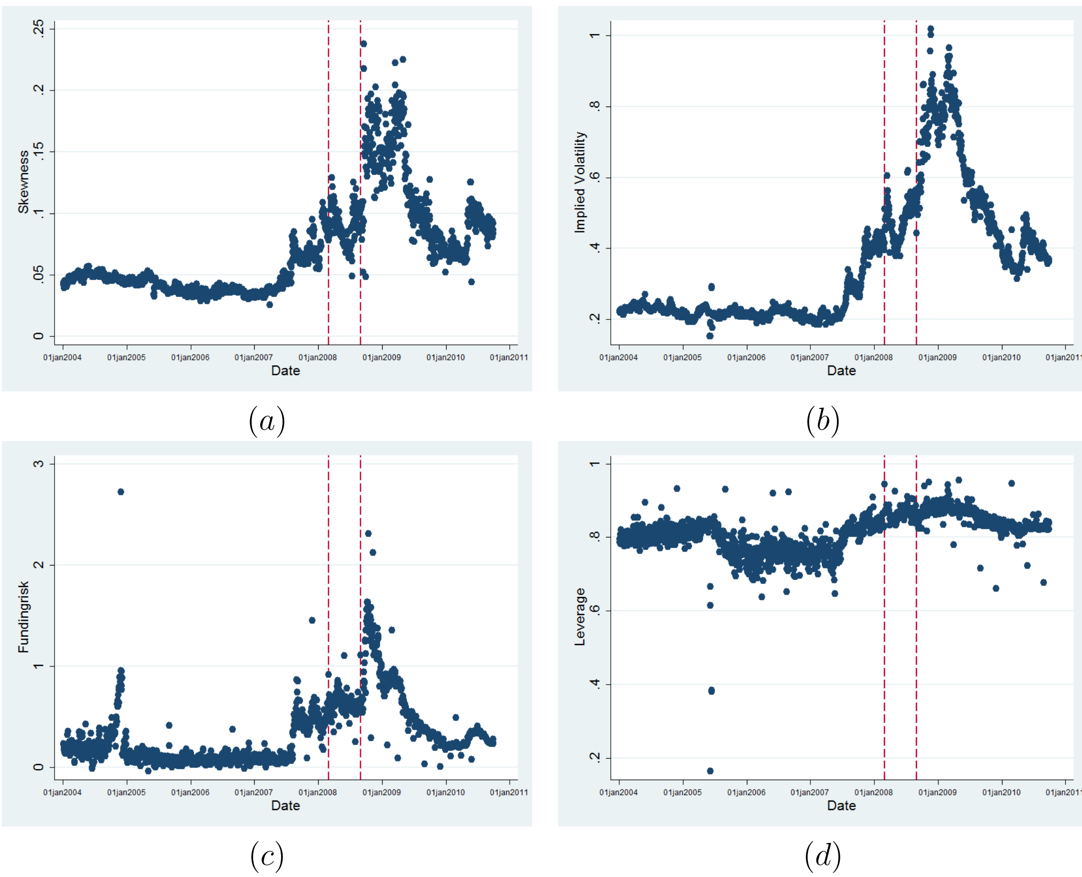

Figure 3: Stage I results: Monthly averages of (a) skewness, (b) implied volatility, (c) OIS-funding 12M and (d) leverage for each institution

Table 3: Stage II Regression Results I

Dependent variable: beta coefficient from first stage						
	(1) Constant	**(2) Skewness**	**(3) Implied Vol.**	**(4) OIS-Funding 6M**	**(5) Leverage**	**(6) Leverage^2**
			Coefficients of Regressors			
Control		-9.95	-5.07	-66.70	-167.22	-184.18
(p-value)		0.00	0.00	0.00	0.11	0.02
After BS		-2.42	-0.33	-41.57	-219.46	-205.47
(p-value)		0.14	0.37	0.00	0.01	0.00
After LEH		-0.83	0.24	2.39	-259.60	-220.62
(p-value)		0.37	0.41	0.71	0.01	0.00
			Time dummies			
Control	85.76	122.25	217.87	100.07	-5.10	36.33
(p-value)	0.00	0.00	0.00	0.00	0.84	0.03
After BS	24.81	35.40	51.26	55.21	-14.95	5.22
(p-value)	0.01	0.06	0.01	0.00	0.58	0.75
After LEH	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
(p-value)						
Constant	-110.35	-101.17	-121.96	-113.60	112.84	60.45
(p-value)	0.00	0.00	0.00	0.00	0.17	0.21
Observations	1784	1784	1784	1679	1784	1784
R squared	0.18	0.22	0.29	0.22	0.20	0.21

Table 4: Stage II Regression Results II

Dependent variable: beta coefficient from first stage						
		(7)	**(8)**	**(9)**	**(10)**	**(11)**
Skewness	Control		-8.26	-8.88		-7.66
	(p-value)		0.01	0.00		0.01
	After BS		-1.72	0.33		-0.05
	(p-value)		0.21	0.88		0.98
	After LEH		-1.02	0.73		0.73
	(p-value)		0.35	0.58		0.62
OIS-Funding 6M	Control		-49.53		-58.74	-46.00
	(p-value)		0.00		0.00	0.00
	After BS		-39.19		-41.72	-40.67
	(p-value)		0.00		0.00	0.00
	After LEH		6.78		8.95	9.02
	(p-value)		0.35		0.22	0.25
Leverage	Control	823.65		724.39	768.50	710.82
	(p-value)	0.00		0.00	0.00	0.01
	After BS	569.03		453.05	349.44	277.01
	(p-value)	0.04		0.09	0.08	0.25
	After LEH	190.53		84.90	30.61	-51.08
	(p-value)	0.60		0.84	0.94	0.90
Leverage^2	Control	-776.97		-662.94	-709.81	-641.31
	(p-value)	0.00		0.01	0.01	0.01
	After BS	-603.30		-504.64	-391.20	-328.66
	(p-value)	0.01		0.02	0.02	0.11
	After LEH	-321.91		-241.10	-224.41	-165.01
	(p-value)	0.24		0.46	0.45	0.62
Time Dummy	Control	-142.68	125.95	-27.26	-185.91	-74.61
	(p-value)	0.29	0.00	0.76	0.19	0.34
	After BS	-93.00	58.83	(omitted)	-92.68	(omitted)
	(p-value)	0.47	0.01		0.48	
	After LEH	(omitted)	(omitted)	90.66	(omitted)	93.50
	(p-value)			0.50		0.505
	Constant	-21.94	-104.63	-93.19	31.89	-46.16
	(p-value)	0.85	0.00	0.22	0.79	0.51
Observations		1784	1679	1784	1679	1679
R squared		0.22	0.24	0.25	0.26	0.28

Hypothesis 1: The effect of the Bear Stearns intervention

After the Bear Stearns rescue, estimated coefficients of skewness and implied volatility in regression (2) and (3) drop dramatically and become insignificant while the point estimate of the funding measure drops from -67 to -42 but remains significant. These findings are robust to the inclusion of other variables as witnessed by regressions (7) to (11). In addition, the coefficients of leverage and leverage squared become notably smaller and turn even insignificant in some cases.

Overall, the relationship between beta and fundamental bank risks has suffered strongly after the bail-out of Bear Stearns, giving overwhelming support for hypothesis 1 that expectations of future bail-outs have increased sharply, resulting in a significant loss in market discipline.

Hypothesis 2 a/b/c: The effect of the Lehman Brothers default

As can be seen in tables 3 and 4, the coefficients for all risk proxies in the single and joint regressions become very small and insignificant in the period after the Lehman Brothers default, with the only exception of the leverage coefficients in the single regressions.

Thus we strongly reject hypothesis 2a that the pre-crisis level of bail-out expectations and hence market discipline has been re-established.

In addition, tables 3 and 4 display a strong decline in all of the variables even relative to the post-Bear-Stearns period which clearly indicates that market discipline has weakened further, hence favoring hypothesis 2c that the non-intervention in the Lehman default was not sufficient to overcompensate increased bail-out believes induced by the following financial markets turmoil and subsequent government actions around the globe.

Hypothesis 3: Market discipline and company type and size

Tables 5 and 6 display results for the single regressions when the sample is split into banks vs non-banks and small vs big firms. Even though the sample of large financial companies contains various non-banks (AIG, ALL, HIG, FNA, FRE, LNC, SLM), the findings are similar for type and size sorting. In both cases, the coefficients are comparable in the control period but after Bear Stearns the risk coefficients of banks and/or large financial institutions drop more than their counterparts and become insignificant in the case of skewness and implied volatility. This is consistent with the interpretation, that the largest institutions and banks were perceived as too-big-too-fail already after the Bear Stearns bail-out while smaller institutions still show some (albeit weakened) signs of market discipline. Even though the coefficients drop even further in absolute value after the Lehman default, some of them remain significant however at very low levels when compared to the control period.

Table 5: Effect heterogeneity with respect to institution size

Dependent variable: beta coefficient from first stage				
Period	Size	**(12) Skewness**	**(13) OIS 6M Funding**	**(14) Implied Volatility**
Coefficients of Regressors				
Control	Non-Bank	-10.07	-62.57	-5.38
(p-value)		0.00	0.00	0.00
Control	Bank	-10.41	-56.75	-3.83
(p-value)		0.00	0.00	0.00
After BSC	Non-Bank	-7.79	-51.31	-1.28
(p-value)		0.00	0.00	0.00
After BSC	Bank	-0.43	-27.97	-0.38
(p-value)		0.84	0.01	0.64
After LEH	Non-Bank	-0.02	-58.04	-1.22
(p-value)		0.99	0.32	0.02
After LEH	Bank	-1.35	14.57	0.69
(p-value)		0.19	0.01	0.00
Time dummies				
Control	Non-Bank	121.54	115.33	264.91
(p-value)		0.00	0.00	0.00
Control	Bank	129.52	129.83	227.45
(p-value)		0.00	0.00	0.00
After BSC	Non-Bank	92.20	79.00	141.30
(p-value)		0.00	0.00	0.00
After BSC	Bank	18.25	71.13	87.46
(p-value)		0.40	0.00	0.01
After LEH	Non-Bank	22.72	59.91	136.62
(p-value)		0.26	0.00	0.00
After LEH	Bank	(omitted)	(omitted)	(omitted)
	Constant	-104.58	-137.74	-161.48
	(p-value)	0.00	0.00	0.00

Overall, the estimation results suggest that our structural regressions are successful in explaining cross sectional differences in debt-to-equity sensitivities. Even though regression (1) from table 3 suggests that even two simple level shifts have some explanatory power, regressions (2)-(11) imply that structural risk factors have a lot more to tell, raising the R^2 from 0.18 up to 0.28 in regression (10), turning even the time dummies insignificant.

In summary, the results support the view that market discipline has suffered significantly after the Bear Stearns bail-out in particular for large institutions but reached its bottom

Table 6: Effect heterogeneity with respect to institution type

Dependent variable: beta coefficient from first stage				
Period	Type	**(15) Skewness**	**(16) OIS 6M Funding**	**(17) Implied Volatility**
Coefficients of Regressors				
Control	Non-Bank	-9.66	-66.07	-3.05
(p-value)		0.00	0.00	0.00
Control	Bank	-10.26	-55.49	-6.02
(p-value)		0.03	0.00	0.00
After BSC	Non-Bank	-4.28	-61.29	-0.86
(p-value)		0.03	0.15	0.09
After BSC	Bank	-2.44	-28.54	0.13
(p-value)		0.21	0.01	0.80
After LEH	Non-Bank	-2.29	-41.18	-0.63
(p-value)		0.04	0.33	0.03
After LEH	Bank	0.05	9.92	0.83
(p-value)		0.97	0.05	0.00
Time dummies				
Control	Non-Bank	141.08	113.25	217.07
(p-value)		0.00	0.00	0.00
Control	Bank	131.12	109.43	272.29
(p-value)		0.00	0.00	0.00
After BSC	Non-Bank	85.50	75.22	133.48
(p-value)		0.00	0.00	0.00
After BSC	Bank	25.63	49.66	42.79
(p-value)		0.28	0.01	0.19
After LEH	Non-Bank	41.61	28.61	96.70
(p-value)		0.04	0.03	0.00
After LEH	Bank	(omitted)	(omitted)	(omitted)
	Constant	-117.52	-128.30	-163.19
	(p-value)	0.00	0.00	0.00

only after the Lehman collapse. This compares well to other empirical results on the recent financial crisis, as e.g. Kelly, Lustig and VanNieuwerburgh (2011) or Tsesmelidakis and Schweikhard (2011) also estimate the peaks of the bail-out effects to be in Oct or Sep 2008. As the Lehman failure should obviously have an opposite effect, we attribute this further decline after Bear Stearns to government actions following the Lehman collapse. Finally, as the period after the Lehman Brothers covers two full years, the results show that market discipline changes have long-lasting effects which do not reverse quickly. Thus any fiscal or regulatory intervention, which might lead to an undermining of market discipline, should be weighted very carefully against the costs of such action.

6 Conclusion

We developed a new methodology to test for changes in the strength of market discipline in financial markets and applied it to crucial events during the recent financial crisis. Our results yield several implications.

First, as there was a negative effect on market discipline due to the rescue of Bear Stearns in particular for large banks, the actual bail-out costs of this first intervention include substantial indirect costs due to the strong loss of market discipline which are largely unaccounted for in any cost calculation so far.

Second, if moral hazard concerns were one of the main reasons for the non-intervention in the Lehman Brothers collapse, our results indicate that the resulting financial turmoil and subsequent government interventions more than covered this potential effect. This adds to the view that Lehman Brothers should have been saved, especially after Bear Stearns had already been saved.

Third, a comparison of these two events shows that once market discipline is lost and moral hazard prevails, it is much harder to re-establish it than it was to eliminate it. Policymakers should take this into account when deciding about interventions in future crises and stick to a strict "always-or-never" bail-out policy in order to minimize fiscal and social losses.

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Appendix

Table 7: Correlation Matrix of Risk Factors

	Implied Vol.	Skewness	Libor-OIS 6M	OIS Spread 6M	Leverage
Implied Vol.	1				
Skewness	0.73	1.00			
Libor-OIS 6M	0.76	0.66	1.00		
OIS Spread 6M	0.36	0.34	0.50	1.00	
Leverage	0.28	0.28	0.13	0.28	1.00

Table 8: Coding of Financial Institutions for Heterogeneity Analysis

Ticker ID	Company	Company Type	Bank	Size
AIG	AMERICAN INTERNATIONAL GROUP	insurance	0	1
ALL	ALLSTATE CORP	insurance	0	1
AOC	AON CORP	insurance	0	0
AXP	AMERICAN EXPRESS CO	other	0	0
BAC	BANK OF AMERICA CORP	depository	1	1
BEN	FRANKLIN RESOURCES INC	other	0	0
BSC	BEAR STEARNS COMPANIES INC	broker	1	0
C	CITIGROUP INC	depository	1	1
CIT	CIT GROUP INC	depository	1	0
CNAFC	CNA FINANCIAL CORP	insurance	0	0
COF	CAPITAL ONE FINANCIAL CORP	depository	1	1
CVH	COVENTRY HEALTH CARE INC	insurance	0	0
FNM	FANNY MAE	other	0	1
FRE	FEDERAL HOME LOAN MORTG CORP	other	0	1
GS	GOLDMAN SACHS GROUP INC	broker	1	1
HIG	HARTFORD FINANCIAL SERVICES	insurance	0	1
HNT	HEALTH NET INC	insurance	0	0
JPM	JPMORGAN CHASE & CO	depository	1	1
LBTR	LEHMAN BROTHERS HOLDINGS INC	broker	1	0
LNC	LINCOLN NATIONAL CORP	insurance	0	1
MBI	MBIA INC	insurance	0	0
MER	MERRILL LYNCH & CO INC	broker	1	0
MET	METLIFE INC	insurance	0	1
MMC	MARSH & MCLENNAN COS	insurance	0	0
MWD	MORGAN STANLEY	broker	1	1
PGR	PROGRESSIVE CORP-OHIO	insurance	0	0
SLM	SLM CORP	other	0	1
STI	SUNTRUST BANKS INC	depository	1	1
TMK	TORCHMARK CORP	insurance	0	0
UNM	UNUM GROUP	insurance	0	0
UNP	UNION PACIFIC CORP	other	0	0
WB	WACHOVIA CORP	depository	1	0
WFC	WELLS FARGO & CO	depository	1	1
WM	WASHINGTON MUTUAL INC	depository	1	0