Illiquidity Commonality across Equity and Credit Markets

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Abstract

This paper examines whether illiquidity propagates across equity and credit markets and, if so, through which mechanisms illiquidity shocks are transmitted. Equity and CDS illiquidity co-movements are detected, but the extent of the commonality changes over time. One mechanism through which equity and CDS illiquidity might co-move is the limited availability of risk capital which prevents traders from providing liquidity to both equity and credit markets. Another mechanism might be the existence of CDS-to-equity illiquidity spillovers driven by the cross-market activity of traders. This paper demonstrates that equity-CDS illiquidity co-movements are strongly related to the debt-to-equity hedge ratio (based on a Merton model), thus providing evidence in favour of an hedging/arbitrage channel of illiquidity transmission. Moreover, it also detects a contribution of funding costs and risk aversion to the general rise of illiquidity in both equity and CDS markets. Finally, the paper disentangles common components of CDS and equity bid-ask spreads at individual firm level: hedging costs, information costs, funding costs, and systematic risk aversion are all significantly priced in equity and CDS bid-ask spreads.

Keywords: Market Microstructure; Illiquidity Commonality; Merton (1974) Model; Bid-Ask Spreads; Hedging Costs; Arbitrage; Information Flows; Funding Costs; Market Risk Aversion.

1 Introduction

This paper examines whether illiquidity propagates across equity and credit markets and, if so, through which mechanisms illiquidity shocks are transmitted. Although the study of equity-credit illiquidity commonality has important implications for asset pricing and risk management, the extent of the cross-market illiquidity co-movement and the causes of the phenomenon have not yet been assessed in the literature. Such assessment is important in order to understand whether, and at which extent, more integrated markets are less safe. The study of CDS-equity illiquidity co-movement is of particular interest for investors engaged in cross-market trades, for risk managers and for regulators who use credit derivative instruments for hedging equity positions.

Academics have highlighted that the illiquidity of individual assets is affected by the illiquidity of the overall market and that this commonality represents risk which is priced across securities. In fact, an investor would require a higher risk premium for holding an asset expected to become illiquid during market illiquidity events; i.e. when liquidity is most needed. Earlier studies have provided some evidence of illiquidity commonality in the U.S. equity market (Chordia, Sarkar, and Subrahmanyam 2005, Halka and Huberman 2001, Hasbrouck and Seppi 2001). Recent papers have extended the analysis of illiquidity commonality to corporate bonds, options, CDSs, and international equities (Chakravarty and Sarkar 2003, Karolyi and van Dijk 2007, Houweling, Mentink, and Vorst 2005, Mahanti, Nashikkar, and Subrahmanyam 2010, Kapadia and Pu 2010, Cao and Wei 2010). However, only few studies have attempted to offer demand-side or supply-side explanations for the phenomenon in the equity markets (Hameed, Kang, and Viswanathan 2010, Coughenour and Saad 2004, Brockman and Chung 2002, Bauer 2004, Fabre and Frino 2004, Zheng and Zhang 2006, Kamara and Sadka 2008, Koch and Starks 2004, Domowitz, Hansch, and Wang 2005).

Other recent research has attempted to detect the existence of illiquidity co-movements across different asset classes, in particular across equity, CDS, and bond markets (Tang and Yan 2006, Jacoby, Jiang, and Theocharides 2009). Related studies have provided evidence of CDS and bond spreads' dependence on equity liquidity risk (De Jong and Driessen 2005, Das and Hanouna 2009), and of co-movements in returns across these asset markets (Norden and Weber 2009). Further work has shown that the level of integration between equity and CDS markets is reduced by hedging costs, illiquidity, and other frictions (Kapadia and Pu 2010). However, the literature lacks an accurate and comprehensive investigation of the extent and causes of credit-equity illiquidity linkages. Thus, our study examines whether there is robust evidence of CDS-equity illiquidity commonality and sets an appropriate theoretical and empirical framework to explain its determinants.

In this paper we define illiquidity commonality as positive co-movement between equity and CDS bid-ask spreads. We analyse these co-movements across stocks and credit default swaps for 51 U.S. investment-grade firms over the period March 2003 - December 2009. The use of bid-ask spread as measure of illiquidity in equity and credit markets is the outcome of preliminary Principal Component Analysis for different illiquidity proxies (of trading costs, trading frequency, and trading impact on prices). Correlation analysis and graphic analysis suggest that equity and credit illiquidity co-move over time, but the extent of this commonality changes over time: commonality is much higher in 2003 than during the period 2004-2006 and then it rises again during the crisis period 2007-2009.

For a large majority of firms in the sample we detect the existence of *illiquidity spillovers* from CDS to equity market (for the remainder no evidence of spillovers is detected). At individual firm level we find that both CDS and equity illiquidity are influenced by generalized market illiquidity, but CDS bid-ask spreads are also significantly affected by firm's asset volatility. Despite CDS leads equity market in terms of illiquidity, we find strong evidence of equity leading CDS in terms of price levels (and returns). These results disclose: (i) market-wide effects on firms' equity and CDS illiquidity; and (ii) information flows of different nature transmitted from one market to the other. Information about price levels is concentrated in the equity market and then transmitted to the CDS market, while information about asset volatility is concentrated in the CDS market and then transmitted to the equity market via illiquidity spillovers.

Several illiquidity transmission mechanisms are therefore likely to be in place across the two markets, in particular during periods of higher volatility (Frank, González-Hermosillo, and Hesse 2008). In periods of turbulence market-wide factors, such as the higher cost of funding and the increase in market risk aversion, can prevent traders from providing liquidity to both equity and credit markets, thereby increasing illiquidity commonality within and across markets. The recent subprime crisis offers an example of the scale of these market-wide factors on cross-market illiquidity transmission. The early literature on limits to arbitrage (Schleifer and Vishny 1997, Kyle and Xiong 2001, Xiong 2001, Gromb and Vayanos 2002) firstly develops models where wealth constraints experienced by traders give rise to withdrawal of market liquidity. Similarly Brunnermeier and Pedersen (2009) show how the ability of traders to provide market liquidity depends on the availability of funding and provide a natural explanation for illiquidity commonality based on funding liquidity risk: shocks to traders' capital affect liquidity of all managed securities simultaneously. Gromb and Vayanos (2010) extend this model to a dynamic setting and show that arbitrageurs' financial constraints create a linkage across otherwise independent assets, i.e. fundamental and supply shocks to one arbitrageur's investment opportunity affect the liquidity and risk premia of all her opportunities.

Equity and credit are fundamentally-related since they both represent claims written on the same underlying firm's assets. The Merton (1974) structural model prices equity of the firm as a long call position on the firm's assets and risky debt of the firm as a short put position on the firm's asset plus a long position on a riskless bond. Consistently, prices in the equity and credit markets appear to co-move substantially over time (see Figure 7 displaying a close relation between average CDS premium and inverse of average equity price). Sophisticated investors with informational advantage trade on this fundamental linkage. They take simultaneous positions in equity and credit to benefit from mispricings across the two markets and to hedge off credit/equity risk. This paper exploits the hedging/arbitrage mechanism to explain CDS-equity illiquidity spillovers. Changes in a firm's asset volatility increase illiquidity of the firm's credit; this reduces traders'ability to build up hedging/arbitrage positions across credit and equity.

Therefore, we formulate and test the following hypotheses on the determinants of illiquidity commonality: H.1) the illiquidity spillovers across credit and equity are fundamentally-based and driven by the arbitrage/hedging trading at firm level across the two markets: it is therefore proportional to the size of the cross-market position (hedge ratio); H.2) the illiquidity co-movement across equity and credit is caused by market-wide factors: higher cost of funding and increased aversion to systematic risk increase bid-ask spreads for both equity and CDS. In panel analysis we find that the hedge ratio (estimated from the Merton model[1]) is a main determinant of liquidity commonality. Equity and CDS bid-ask spreads positively co-move in periods with larger potential hedging/arbitrage connections across the two markets. This result survives various robustness checks. Further analysis shows that funding costs (proxied by the TED spread) appear also strongly significant, though with lower impact than the hedge ratio. VAR analysis on market aggregate bid-ask spreads reveals that larger funding costs and increased risk aversion can explain on average the rise of illiquidity in both equity and CDS markets during the crisis period. Their contribution remains significant also after controlling for lagged price and illiquidity effects across the two markets.

The last part of the paper examines the determinants of bid-ask spreads for equity and CDS, using some of the insights from the previous analysis. The earlier finding of information flows of different nature driving across markets suggest the possibility of informed trading in place in both equity and CDS markets. We take into account this further element when attempting to disentangle the bid-ask spread components in each market. We test the hypothesis: H.3) Bid-ask spreads set by equity (CDS) market makers are determined by the cost of hedging risky positions in the credit (equity) market, the cost of trading with informed counterparties in equity and credit markets, the cost of the necessary funding, and the level of aversion to systematic risk.

To conclude, this paper offers new interesting results on illiquidity linkages across equity and CDS which may represent inputs for the development of a consistent theory of illiquidity contagion[2]. The paper demonstrates that: (i) Illiquidity co-moves across equity and credit market but the commonality varies in magnitude over time; (ii) There exist illiquidity spillovers which run mainly from CDS to equity market; (iii) Equity and CDS illiquidity are affected by general market-wide illiquidity, but CDS illiquidity is also particularly sensitive to shifts in firm's asset volatility; (iv) Equity-CDS illiquidity transmission can be explained by fundamental arbitrage/hedging trading across the two markets and by market-wide frictions, such as higher funding costs and market risk aversion; and (v) Hedging costs, information costs, and market-wide frictions are significant common components for bid-ask spreads in equity and credit markets at firm level.

[1] We calibrate the Merton model in order to estimate the sensitivity of debt to equity (hedge ratio) which determines the size of the equity position relative to the CDS position in the arbitrage/hedging strategy. The underlying assumption is that sophisticated investors use Merton's structural model to perform arbitrage/hedging trading across equity and credit markets. This assumption is not far from the actual practice of capital structure arbitrageurs and professional hedgers who refer to modified implementations of Merton's model (the most popular proprietary model used are Moody's KMV and RiskMetrics' CreditGrades).

[2] My current research is in fact oriented to the formal modeling of the hypotheses tested in this paper. In particular I am developing a funding-constrained market maker model with hedging and informational costs and an arbitrage model with frictions. This draft of the paper presents the intuitions behind each model.

The rest of the paper is organized as follows. Section 2 describes the methodology to define the appropriate proxy of equity and CDS illiquidity and statistical analysis to detect equity-CDS illiquidity co-movements. Section 3 presents analysis on illiquidity spillovers and potential drivers of illiquidity co-movement. This section also defines an arbitrage model for cross-market illiquidity transmissions and a market-making model for equity and CDS bid-ask spread components to formulate the three main hypotheses to be tested in the rest of the paper. Section 4 explains the empirical methodology for the tests and examines the main results. Section 5 concludes.

2 Analysis of Equity and CDS Illiquidity and Cross-Market Illiquidity Commonality

Most prior literature has examined illiquidity using different proxies for each specific market (Spiegel 2008). In this Section we ascertain that the percentage bid-ask spread can be good a measure of illiquidity for both equity and CDSs by performing Principal Component Analysis across a number of illiquidity proxies at weekly frequency: Amihud measure, Roll measure, effective spread, percentage bid-ask spread, run length, and inverse turnover index. We employ data on 51 U.S. investment-grade companies which are components of the Dow Jones 5-years On-the-run CDX North America Investment Grade Index (CDX.NA.IG). For each firm we select the corresponding stock and the 5 years on-the-run credit default swap. We collect daily quotes (bid and ask prices) and daily close trading data (price and volume) for firms' stocks from the CRSP Daily Stock dataset. Daily quotes and prices for CDSs are available on Bloomberg. The sample period goes from March 2003 to December 2009. Appendix A provides all details on the treatment and filtering of the data employed and on the construction of illiquidity measures for equity and CDSs. Figures 1-6 in Appendix C show the cross-sectional average for some equity and CDS illiquidity measures. The cross-sectional average is value-weighted on all 51 firms. We notice that the pattern of the equity percentage bid-ask spread is similar to the pattern of the effective spread, the Roll measure, and the Amihud measure. Moreover, the CDS and equity bid-ask spreads appears related and meaningful over highly volatile periods.

2.0.1 Principal Component Analysis and Combined Illiquidity Indexes

We perform Principal Component Analysis (PCA) to evaluate the weight of the bid-ask spread in the First Principal Component (FPC) and obtain a Composite Illiquidity Index for individual firms' equity and CDSs. For each firm we extract the First Principal Component across all equity (CDS) standardized illiquidity measures. Then, we select the standardized illiquidity proxies that on average have a positive loading higher than 10%. A Composite Illiquidity Index is then computed at weekly frequency for equity and CDS of individual firms as a linear combination of the selected illiquidity proxies. The weight of each proxy in the linear combination is the same across all firms because it is set equal to the value-weighted average loading of the proxy in the First Principal Components.
Figures 8-11 present the aggregate market results from Principal Component Analysis conducted across all weekly illiquidity measures for equity and CDS. For both equity and CDS, the average First Principal Component explains around 40% of common variance across different illiquidity proxies. On average bid-ask, effective spread, Roll measure, and Amihud measure display positive weights in the equity First Principal Component (going from 75% of bid-ask spread to 48% of Roll measure).

Trading frequency measures behave in a dissimilar fashion and are mainly captured by the less significant Second Principal Component. Bid-ask and run length have on average positive weights in the CDS First Principal Component, respectively 50% and 45%. CDS Roll measure displays a different pattern, while the effective spread is mostly not usable. The results of this analysis support the use of bid-ask spreads as a proxy for market illiquidity. In fact, given the available data, we observe that:

- For CDS illiquidity, the bid-ask spread is consistent on average with the pattern of the other illiquidity measures (run length) with positive loading in the FPC and therefore with the CDS Combined Illiquidity Index (obtained as a linear combination of bid-ask and run length);
- For equity illiquidity, the time pattern of the bid-ask spread is perfectly in line with other measures of equity transaction costs and price impact of trades (Amihud measure, Roll measure, and effective spread) and with the Combined Illiquidity Index. In fact, the PCA reveals that these four measures behave very similarly in the First Principal Component of equity illiquidity, though bid-ask spread displays the highest loading (75%).

2.1 Statistical Analysis on Equity and CDS Bid-Ask Spreads: Detecting Illiquidity Commonality

We perform our analysis of co-movements between equity and CDS illiquidity using equity and CDS percentage bid-ask spreads[3]. In Figures 12, 13, and 14 the normalized percentage equity and CDS bid-ask spreads are compared over the whole sample and in two sub-samples, before and after the recent financial crisis (i.e. July 2003-December 2006 and January 2007-December 2009). Equity and CDS bid-ask spreads are closely related: both are downward trending over the pre-crisis period, jump upwards during the crisis period and decline towards the end of the sample. Table 1 displays summary statistics on market aggregate equity and CDS bid-ask spreads at weekly frequency over the whole sample (March 2003 - December 2009). On average equity bid-ask spread is larger and more volatile than CDS bid-ask spread. Table 2 shows Pearson, Kendall's Tau, and Spearman's Rho measures of correlation between weighted-average equity and CDS bid-ask spreads. The three estimated correlations are used as alternative measures of liquidity commonality. Pearson correlation (ψ) measures the degree of *linear* association between equity and CDS bid-ask spreads. Rank correlation coefficients, such as Spearman's rank correlation (ρ) and Kendall's rank correlation (τ), measure how well the relationship between the two variables can be described using a *monotonic* function, without requiring the function to be linear[4]. Time average correlations are quite high, in the range of 20%-55% for the whole sample period, and respectively 36%-77% and 15%-45% in the period 2003-2006 and 2007-2009. Table 3 shows the distributions of the time-average measures of correlation across all 51 firms in the sample. Despite the dispersion of values being quite wide, the estimated measures remain mostly positive (over the whole sample period, as also illustrated in Figure 19, as well as over the pre-crisis and crisis sub-samples). Correlation distributions present insignificant or slightly negative mean values only in the middle of the period (2005-2006, results available upon request). Figure 15 illustrates the three measures of correlation between equity and CDS bid-ask spreads in

[3]Equity bid and ask prices are quoted in dollar terms, while CDS bid and ask prices are quoted in basis points. Therefore, for CDS bid-ask spread we use the difference between quoted bid and ask prices (in percentage units), while for equity bid-ask spread we used the ratio between quoted bid-ask spread and midquote price (in percentage units).

[4]In our study Fisher z-transformation (inverse hyperbolic function) is applied to all sample correlation coefficients r (where $r = (\psi, \tau, \rho)$): $z = 0.5ln(\frac{1+r}{1-r})$ (See Section 4 at 4.1).

cross-sectional average. The average correlation measures are larger (in the range of 10-20%) over periods of higher turbulence (from the second quarter of 2003 to the beginning of 2004; and from the third quarter of 2007 until the third quarter of 2009) than in the middle and at the end of the sample.

To summarize this preliminary statistical analysis, we have found illiquidity commonality across equity and CDS using different measures of association between equity and CDS bid-ask spreads of 51 firms. However, the illiquidity co-movement varies widely over time and becomes more prominent over periods of higher market turbulence, that is in 2003 and in 2007-2009.

3 Drivers of Equity-Credit Illiquidity Co-movements

Statistical analysis has detected time-varying illiquidity commonality across equity and CDS bid-ask spreads at firm and market level. The next step is to understand why illiquidity co-moves across the two markets. On the one hand, illiquidity of both CDS contracts and equity might be caused by: (1) a market-wide factor; (2) a firm's asset-specific factor. On the other hand, the co-variation of illiquidity across the two markets might be driven by: (I) illiquidity spillovers from one market to another or in both directions; (II) exogenous factors which affect both markets simultaneously without causing any illiquidity spillover. While the existence of illiquidity spillovers (in one or both directions) could be ascribed to correlated arbitrage/hedging trading across equity and CDS markets, illiquidity co-movements might alternatively arise from simultaneous increases in the equity and CDS bid-ask spreads, being rational response of dealers in segmented equity and CDS markets to market-wide frictions or to adverse movements in the firm's fundamentals (i.e. asset volatility). In this Section we analyse the data in order to shed some lights on which mechanisms of illiquidity transmissions might be in place and formulate some hypotheses accordingly.

3.1 Market-wide vs Firm-specific Drivers of CDS and Equity Illiquidity

Market-wide sources of illiquidity represent frictions which might affect trade volumes and transaction costs of different assets, therefore increasing the general level of market illiquidity. *Asset-specific* sources of illiquidity might affect both equity and CDS contracts, since they represent claims written on the same underlying firm's assets (equity resembles an in-the-money call option and CDS a deep out-the-money put option on the firm's assets). According to the contingent claims approach used in structural models (see Appendix B) when a firm's asset volatility increases, equity price decreases while CDS premium increases. The effect of asset volatility could be extended -in theory- to CDS and equity bid-ask spreads: when firm's fundamentals worsen and asset volatility increases, market makers rationally increase CDS and equity spreads. Therefore, a shift in asset volatility might cause an inverse movement in equity and CDS prices and a positive co-movement in equity and CDS bid-ask spreads.

We test separately for CDS and equity whether bid-ask spreads for each firm are affected by market-wide and asset-specific factors: we perform regressions of CDS (or equity) bid-ask spread on CDS (or equity) market average bid-ask spread and firm's asset volatility. Newey-West standard errors (robust to heteroskedasticity and serial correlation) are computed using GMM. Asset volatility is estimated as in Schaefer and Strebulaev (2008) by a weighted average of firm's equity and debt volatility (see Appendix B). The regressions reveal that equity and CDS bid-ask spreads are affected by average market illiquidity, but for most of the firms (41 over 51) CDS bid-ask spread is also strongly affected by the firm's asset volatility (see Table 4). In (unreported) regression analysis on CDS and equity prices, we find for a larger number of firms a (positive) significant effect of asset volatility on CDS premium and for a smaller number a (negative) significant effect on equity price, after controlling for aggregate market effects. An asset volatility shock has a larger impact on CDS liquidity and price than on the equity[5]. This result reflects the CDS nature of deep OTM put on the firm's assets with larger exposure to volatility risk.

3.2 Illiquidity Spillovers

To understand the dynamics of the illiquidity co-movements across equity and credit markets we need however to identify at individual firm level whether cross-market illiquidity spillovers are in place and, if so, in which direction. We test for the existence of illiquidity spillovers by performing pair-wise Granger causality tests at individual firm level for CDS and equity bid-ask spreads. We use daily data and include two lags. We also perform vector autoregressive (VAR) analysis on individual firms' equity and CDS bid-ask spreads and prices to check whether the results confirm those obtained in the Granger causality tests.

Tables 5 and 6 show that for almost two thirds of the firms (31 over 51) the Granger causality tests provide evidence (or stronger results in terms of p-values) in favour of illiquidity spillovers running from CDS to equity. For 6 firms the causality relationship runs in both directions, while for 13 firms we find no evidence of illiquidity spillovers[6]. From Tables 4, 5, and 6 we notice that in most cases when Granger causality runs from CDS to equity illiquidity, asset volatility affects only CDS bid-ask spreads, while market illiquidity affects both CDS and equity or only equity bid-ask spreads. CDS claims incorporate asset-specific volatility information that affects positively CDS illiquidity. The CDS illiquidity is then transmitted to the equity market. Ultimately, the illiquidity spillovers from CDS to equity market appear to be triggered by an increase in asset volatility.

VAR analysis at daily frequency tends to confirm most of the results in terms of illiquidity spillovers[7]. Additionally, for almost half of the firms we find a significant negative effect of lagged equity price on CDS bid-ask spread and/or a significant positive effect of lagged CDS premium on equity bid-ask spread[8] (after controlling for lagged illiquidity effects and within-market lagged price effects).

[5]The evidence does not change substantially between more volatile and calmer periods. No significant cross-sectional differences among firms (by sector, industry, size) are found in the results of this analysis.

[6]Also this result does not change substantially between more volatile and calmer periods and according to specific firms characteristics (sector, industry, size).

[7]VAR analysis results are not reported for brevity, but they are available upon request.

[8]In a recent contemporaneous paper illiquidity spillovers across different markets are explained theoretically as a consequence of dealers' attention to prices across those markets (Cespa and Foucault 2011). However, this behavioural explanation might result incomplete or insufficient when markets share common fundamentals. Equity prices' effect on CDS illiquidity (and CDS premia's effect on equity illiquidity) might be explained by rational market makers' attention to common fundamentals which influence prices in both markets. Moreover, the idea of separate dealership over segmented markets can be challenged by the hypothesis of dealers in each market laying off fundamental risk in the other one (See discussion in par. 3.5).

Interestingly, we find evidence of Granger causality running from equity prices to CDS premia but not the other way round for almost all firms in the sample (Table 7 and 8). The same results are found in terms of returns, using both transaction prices and midquote prices, and over more volatile and calmer periods (unreported for brevity, but available upon request). The analysis of illiquidity and price spillovers suggests therefore that information of different nature is anticipated in one market and then transmitted to the other one. Information about price levels is concentrated in the equity market and then transmitted to the CDS market. Information about asset volatility is concentrated in the CDS market and then transmitted to the equity market via illiquidity shocks.

3.3 Channels of Equity-Credit Illiquidity Propagation

The previous analysis has shown that: (i) Bid-ask spreads on individual equities and CDSs are closely related, particularly in turbulent periods; (ii) CDS illiquidity is sensitive to changes in asset volatility; (iii) CDS and Equity illiquidity are affected by generalized market illiquidity; (iv) For two thirds of the sample illiquidity spills over from the CDS to the equity market. Given this evidence, we examine the mechanisms through which CDS illiquidity can be transmitted to the equity market and market illiquidity can affect both CDS and equity bid-ask spreads.

We focus on the following causal linkage found in the data:
Higher Asset Volatility → Higher CDS Illiquidity → Higher Equity Illiquidity.
This finding allows us to exclude the hypothesis that equity and CDS illiquidity increase independently as result of changes in common fundamentals (asset volatility). The asset volatility effect is instead anticipated by the CDS bid-ask spreads. The illiquidity spillover from CDS to equity might then be the result of hedging/arbitrage trading decisions across equity and CDS markets.
We define this channel of illiquidity transmission as "*Equity-CDS Hedging/Arbitrage Demand*" channel. Below we illustrate some examples to clarify the mechanism.

Example (A): Arbitrageurs.
Mispricing between a company's debt and equity claims is the key driver of arbitrage demand across different asset classes for the same firm (i.e. capital structure arbitrage). A hedge fund typically uses a sophisticated variant of the Merton model to gauge the correct fundamental debt/equity relationship. The model predicts credit spreads based on the company's liability structure and equity volatility. When the arbitrageur finds that the market credit spread is substantially larger than the spread predicted by the structural model, she goes short on the CDS (in case the CDS is overpriced) and short on equity (in case equity is overpriced) and profits from the convergence between market and model-implied credit spreads while holding a hedged position. Due to arbitrage demand, a stock's illiquidity is likely to have a positive correlation with the illiquidity of the corresponding CDS: if an investor wants to build a portfolio with both stocks and CDS contracts, she may not trade equity at all if her CDS positions are too costly to build. As a result, when the illiquidity for the CDS of a particular firm increases, so does the illiquidity in the firm's stock.

Example (B): Dealers.
The market-maker can always balance her stock positions at the end of the day by making offsetting trades in the CDS market. Suppose the equity price is 498-502 and the CDS premium is 22-24. The market-maker who has sold a stock to a customer at 502 has a short position in a call on the firm's assets. She would make a loss if the asset price increases, but she can cover the risk by selling a CDS contract at 22 for an amount equal to 1 minus the hedge ratio[9]. The correct hedge ratio can be estimated with the Merton's model (as a first approximation). When the stock position is closed, the CDS trade is reversed as well. The bid-ask spread the market-maker sets for equity would then reflect the bid-ask spread in the CDS market; if the CDS bid-ask spread increases, so would do the bid-ask spread in the equity market.

The equity-CDS hedging/arbitrage channel implies that liquidity can spill over and co-move across equity and CDS markets even in the absence of systematic risk (Das and Hanouna 2009). However, systematic risk can foster correlated trading and loss of market liquidity. When investors are multi-market traders, such as hedge funds engaging in capital structure arbitrage, their correlated negative liquidity shocks spread across different asset markets, thereby increasing cross-market illiquidity commonality[10] (Fernando, Herring, and Subrahmanyam 2008). The ability of traders to provide market liquidity depends on their funding liquidity, i.e. on the availability of risky capital for trading. The supply of liquidity decreases when traders' funding shrinks and traders are forced to unwind their positions in various managed securities simultaneously.
We define this second channel of equity-credit illiquidity co-movements as "*Funding Supply*" channel.

In the next two sub-sections we develop some intuitions for simple models that allow us to formulate the hypotheses which are then tested in the paper. Current work is focused on the formal modeling and derivations of these hypotheses.

3.4 Capital Structure Arbitrage Model of Liquidity Commonality across Equity and CDS Markets

Building on the arbitrage model of Schleifer and Vishny (1997), the capital structure arbitrage model considers professional well-informed risk-neutral arbitrageurs who must obtain financing from less informed risk-averse investors (financiers) in order to trade. The model also includes wealthy noise traders who are willing to trade and have the resources to do it, but misperceive the assets' intrinsic values. In particular, noise trading drives assets' prices away from their intrinsic values and creates arbitrage opportunities across equity and credit markets. Both financiers and noise traders are less informed than the arbitrageurs; however, the difference between the two types is that the former know that arbitrageurs are more informed, while the latter don't. For this reason noise-traders trade, while investors don't trade but they invest their financial resources in the arbitrageurs' funds. We can think of the arbitrageurs as specialist hedge funds.

[9] She would only do this if the CDS sale at 22 more than compensates the cost of holding the equity position and bearing the risk.

[10] The Fernando et al (2008) model also suggests that the common liquidity risk is higher for securities traded in markets where a small group of traders operate and pursue similar trading strategies. This is compatible with the cross-market trading generated by capital structure arbitrage hedge funds and other equity/debt hedgers and speculators.

Arbitrageurs are well-informed: they can recognize any mispricing in the market because they are assumed to know the assets' intrinsic values. Arbitrageurs can correctly evaluate the intrinsic value of credit spreads by setting them equal to synthetic option-based spreads obtained from a sophisticated model. Consequently, they can perform credit-equity arbitrage. The uninformed financiers and the noise traders cannot obtain correct predictions of credit spreads' intrinsic values because they are uninformed about the variables to employ and the exact functional form of the structural model.

Suppose that an arbitrageur observes a mispricing between the equity and the CDS spread of a firm. For example, she believes that the stock of a company is undervalued. She therefore decides to go long on the equity and long on the CDS[11]. Suppose also that a group of arbitrageurs believe that for a large set of firms equity is undervalued. Hence, they perform trading across credit/equity markets for all the identified names: for each name they go long on the corresponding equity and long on the corresponding CDS. The size of the cross-market position is determined by delta hedging, therefore it is equal or proportional to the hedge ratio (debt sensitivity to equity risk) estimated using the structural model[12]. If the relevant markets are frictionless (i.e. perfectly liquid) and the arbitrageurs have the necessary funds to take the long positions in credit and equity simultaneously, then the arbitrage is implemented and there is convergence between the two markets. However, if market liquidity frictions exist and/or the arbitrageurs depend on the external resources of the financiers, then the scenario may change. Let's assume that the multi-market trade cannot be performed because a firm's CDS contract has become highly illiquid. Lack of immediacy in the CDS contract will cause a slippage in the arbitrage strategy and will be then transmitted to the firm's equity since the arbitrageurs will decide not to take a position. Commonality in illiquidity between the two markets increase more, the larger is the size of the arbitrage connection represented by the hedge ratio. We derive Hypothesis 1:

Hypothesis 1. "Equity-CDS Hedging/Arbitrage Demand" Channel of Illiquidity Commonality. *The commonality in illiquidity across equity and credit caused by hedging/arbitrage trading is proportional to the size of the cross-market hedge position.*

However, in this model arbitrage trading is implemented only if risk-adverse financiers decide to provide funds to the arbitrageurs. The assumption on investors' preferences is instrumental to distinguish between financiers' limits to invest (cost of funding) and their unwillingness to invest (risk aversion). A tightening of funding resources can be caused in fact by a market-wide increase in cost of funding or by an increase of risk aversion for uninformed financiers. This may happen when

[11] The arbitrageur bets on a stock rally, however she wants to hedge the risk of the equity position, so that the profits-and-losses related to the resulting portfolio are invariant to possible changes in equity market price (i.e. delta-neutral portfolio). Therefore, she hedges the long equity position with a long CDS position. When equity price increases, CDS value (premium) decreases because the company is less likely to default. In the meantime, the long equity position increases in value, so the two effects on the portfolio value are offsetting. However, if equity price decreases, the company may be more likely to default, so the CDS value (premium) increases. Meanwhile, the long equity position records a loss, but again the two effects (without company default) on the portfolio value are offsetting. If the company defaults on its debt, the CDS offers protection on the principal. The combined portfolio is therefore hedged. We ignore the matter of competition between arbitrageurs, for the moment.

[12] Yu (2005) reports that: "From what traders describe in media accounts, the equity hedge is often "static", staying unchanged through the duration of the strategy. Moreover, traders often modify the model-based hedge ratio according to their own opinion of the particular type of convergence that is likely to occur". For example "the trader may decide to underhedge" or "he may overhedge."

financiers observe larger unexpected systematic volatility which they believe will affect equity-credit price convergence and impede arbitrageurs' performance. Therefore, we derive Proposition 2:

Hypothesis 2. "Funding Supply" Channel of Illiquidity Commonality. *The commonality in illiquidity across equity and credit increases with the cost of capital and with risk aversion, both of which trigger withdrawal of funds and unwinding of arbitrageurs' positions.*

We have then derived two (not mutually exclusive) Hypotheses to be tested.

3.5 Model of Equity and Credit Dealership with Hedging of Inventory Exposures

The fundamental role of dealers is to provide liquidity in assets which cannot be easily traded because of their risky or information-intensive nature. The dealer buys a security on its own account (at the bid price) or sell a security from its own account (at the ask price). The dealer or specialist firm is therefore a financial intermediary with capital, investment, and risk management structure. We follow the integrated modelling approach of Froot and Stein (1998) that examine the decision-making problem of financial intermediaries in a scenario where some but not all risks they hold can be hedged. We apply it to the decision-making problem of a financially constrained specialist firm or dealer and analyse the resulting bid-ask spread structure.

The bid-ask spread is the cost of a round trip transaction. It also represents the compensation earned by a dealer for providing liquidity. Market-making costs can arise from inventory holding, order processing, and informed trading. Inventory holding costs are imposed by suboptimal portfolio positions to which the financially constrained dealer firm commits. A dealer firm in the equity market holds temporary unbalanced inventory positions in the stocks of some companies, however it has the option to continually delta hedge its equity positions in the CDS market, rather than keeping the inventory imbalances exposed. Given the nature of the dealer activity (making a market), the dealer firm is likely to hold the equity in inventory for short time and to settle the positions quickly in both equity and CDS markets. Once the specialist firm sells the equity, it sells the corresponding CDS as well paying the bid-ask spread on the CDS as cost of the round trip transaction. The bid-ask spread that the dealer charges on the equity transaction should include then the cost borne to hedge the positions (Engle and Cho 1999) which is given by the size of the position on the CDS (delta determined by the hedge ratio) times the CDS bid-ask spread paid. As a result, when the CDS bid-ask spread increases, so does the equity bid-ask spread in proportion to the delta-hedge of the position (this should be also large enough to have any recognizable effect).

Nevertheless, not all the risk related to the equity exposure is hedgeable. The risk component which is hedged off is the idiosyncratic or asset-specific risk; while the unhedgeable component relates to systematic risk. The dealer firm will therefore: 1) hedge any idiosyncratic risk that can be offloaded on fair market terms in the CDS market; 2) hold some capital to finance the inventory and the hedging and to absorb systematic risks (considering that raising more external funds is costly); 3) evaluate equity unhedgeable risk upon the level of market aversion to systematic risk.

The hedging activity also assumes that the dealer firm can have simultaneous active exposure to both equity and CDS markets. The decentralization in specialist firms can be a problem. Indeed in some specialist firms, single dealers are concentrated on single markets, and the coordination across desks for risk management decisions and hedging activity is costly. Moreover, the classical method of hedging off risk across credit and equity refers to the contingent-claims model pioneered by Merton (1974) which implies that the dealer can frictionlessly hedge all credit/equity risk. The existence of frictions in the equity and credit markets -combined with the issue of decentralization- renders hedging more costly and limits further the capacity of a dealer firm to pursue its risk management strategies. Therefore the dealer is likely to apply a form of *partial* rather than *perfect* hedging and remains exposed to the costs of informed trading.

In an ideal perfect hedging model where the specialist firm hedges all the risk related to its equity position in the CDS market, no cost of informed trading in the equity market would arises. Contrarily, partial hedging leaves the specialist firm exposed to the risk of losses due to informed trading. This risk is compensated by increasing the spread on the security. Equity and credit are claims written on the same underlying assets. In theory, if financial markets are in equilibrium, information regarding the state of an individual firm should be reflected equally in both debt and equity. In practice, however, there might be multiple sources of asymmetric information (i.e. private information of different nature concentrated in CDS and/or equity market). The direction and the lead-lag relationship between price changes in these securities can reflect the nature of this information. In earlier analysis (par. 3.1) information flows and illiquidity spillovers across equity and credit markets has been detected at firm level. It appears that equity prices (and returns) lead CDS premia (and returns), but for the majority of firms in the sample CDS bid-ask spreads lead equity bid-ask spreads. Moreover, CDS bid-ask spreads are more sensitive than equity bid-ask spreads to changes in asset volatility. We have argued that this finding is due to private information about asset price levels concentrated and used in the equity market and then transmitted to the credit market, versus private information about volatility/illiquidity concentrated and used in the CDS market and then transmitted to the equity market[13].

From this partial hedging model of dealership we derive Hypothesis H.3 to be tested:

Hypothesis 3. Determinants of Equity and CDS Bid-Ask Spreads. *The bid-ask spread in the equity (or credit) market is set by market makers upon: the cost of hedging the position in the credit (or equity) market, the cost of informed trading in equity and credit markets, the cost of funding needed, and the level of market aversion to systematic risk.*

[13]Consistently, Zhou (2005) finds that in-the-money options attract investors who possess mild firm-specific information (on price), while deep out-of-the-money options catch the attention of those who possess extreme information (on volatility and illiquidity).

4 Empirical Test of Determinants of Linkages between Equity and Credit Illiquidity

4.1 Test of Determinants of Illiquidity Commonality

4.1.1 Empirical Modeling

Firstly, we test Hypothesis 1 formulated in the capital structure arbitrage model:

Hypothesis 1. "Equity-CDS Hedging/Arbitrage Demand" Channel of Illiquidity Commonality. *The commonality in illiquidity across equity and credit caused by hedging/arbitrage trading is proportional to the size of the cross-market hedge position.*

We test the effect of the hedge ratio on the three different measures of equity-CDS illiquidity correlation. We perform the test using panel data and maximum likelihood estimation to compute firm-clustered standard errors. We also control for unobservable firm and time fixed effects (dummies). To construct the panel dataset and estimate firm and time fixed effects with an appropriate number of degrees of freedom, we reduce the length of the time series by aggregating variables into quarters. The measures of illiquidity correlation between equity and credit markets are also constructed over quarters. The linear equation estimated (including fixed effects) is the following:

$$Comm_{i,t}^{BA} = \alpha_0 + \beta_0 H_{i,t}^{SS} + \alpha_1 Firm_1 + ... + \alpha_{50} Firm_{50} + \gamma_1 Qtr_{2003:2} + ... + \gamma_{26} Qtr_{2009:3} + \epsilon_{i,t} \quad (1)$$

where $i = 1, \ldots, 51$ is the firm index; $t = 1, \ldots, 27$ is the time (quarter) index.

We use three alternative dependent variables as measures of illiquidity commonality:

$$Comm_{i,t}^{BA} = \begin{pmatrix} \psi_{i,t}^{BA} \\ \tau_{i,t}^{BA} \\ \rho_{i,t}^{BA} \end{pmatrix}$$

$\boldsymbol{\psi_{i,t}^{BA}}$ is Fisher's z-Transformation of Pearson Correlation between equity and CDS bid-ask spreads of firm i estimated over each quarter t;
$\boldsymbol{\tau_{i,t}^{BA}}$ is Fisher's z-Transformation of Kendall's Tau Rank Correlation between equity and CDS bid-ask spreads of firm i estimated over each quarter t;
$\boldsymbol{\rho_{i,t}^{BA}}$ is Fisher's z-Transformation of Spearman's Rho Rank Correlation between equity and CDS bid-ask spreads of firm i estimated over each quarter t.

On the right-hand side of Equation (1) we have $\boldsymbol{H_{i,t}^{SS}}$, the estimated debt-to-equity elasticity (hedge ratio) for firm i in quarter t. Appendix B describes the two methodologies followed (from Vassalou and Xing, 2004, and Schaefer and Strebulaev, 2008) to estimate the debt-to-equity hedge ratios on a weekly basis for 51 firms (sample: March 2003-December 2009)[14] using the Merton (1974) model approach. The two methodologies are called respectively VX and SS for brevity. In the regression specification (1) we employ the hedge ratio obtained from SS methodology. Figure 16 shows

[14]In addition to equity price data from CRSP and CDS premia from Bloomberg, we employ firms' accounting information from COMPUSTAT.

the time plot of its value-weighted average for 51 firms: H^{SS} gradually decreases from 2003 over the following years; then it raises again starting from the second semester of 2007 and decreases towards the end of 2008. Figure 17 displays the similar patterns of the average hedge ratios estimated with SS and VX methodology (March 2003-November 2008). Figure 18 shows that the time-pattern of the average hedge ratio closely tracks CDS market average premia and bid-ask spread. Finally, a comparison between Figure 16 and Figure 15 reveals a very close relation between average hedge ratio and CDS-equity liquidity commonality over the time.

Besides the hedge ratio, we include as regressors in Equation (1) the following variables:
$\boldsymbol{Firm_i}$ represents the fixed effect (dummy) for firm i, while $Qrt_{y:qtr}$ represents the fixed effect (dummy) for quarter qtr in year y ($y = 2003, ..., 2009$). In particular controlling for time effects represents a main robustness check for the effect of the hedge ratio on illiquidity commonality since time dummies can capture the effects of extreme events (2003 stock market drop, recent subprime crisis).
$\boldsymbol{Size_{i,t}}$: Log of firm's market capitalization;
$\boldsymbol{SysRisk_{i,t}}$: Proxy for systematic risk. This variable is the logistic transformation of the R^2 from an OLS estimation of CAPM standard market model for firm i excess returns over quarter t using daily data.
$\boldsymbol{Comm_{i,t}^{RET}}$: Pearson, Kendall, and Spearman measures (Fisher z-transformations) of equity-CDS return correlation.
Therefore, we also test whether: firms with larger dimensions, with equity returns more sensitive to market movements, and with higher return commonality across equity and CDS markets display wider equity-CDS illiquidity commonality. In lack of better variables we postulate that the firm's size is a proxy for media/analyst coverage and availability of public information about the firm.

In other specifications of the model equation, we use alternative proxies of arbitrage trading costs for robustness check: we replace $H_{i,t}^{SS}$ with $H_{i,t}^{VX}$ (hedge ratio estimated with Vassalou and Xing Methodology), and with $EqVol_{i,t}$ and $Lev_{i,t}$ (annualized firm's equity volatility and log of firm's leverage ratio).

Moreover, we test whether the results change when we use -as alternative dependent variables- the correlation measures between equity and CDS Combined Illiquidity Indexes (rather than equity and CDS bid-ask spreads):

$$Comm_{i,t}^{ILL} = \begin{pmatrix} \psi_{i,t}^{ILL} \\ \tau_{i,t}^{ILL} \\ \rho_{i,t}^{ILL} \end{pmatrix}$$

$\boldsymbol{\psi_{i,t}^{ILL}}$ is Fisher's z-Transformation of Pearson Correlation between equity and CDS Illiquidity Indexes of Firm i estimated over each quarter t;
$\boldsymbol{\tau_{i,t}^{ILL}}$ is Fisher's z-Transformation of Kendall's Tau Rank Correlation between equity and CDS Illiquidity Indexes of Firm i estimated over each quarter t;
$\boldsymbol{\rho_{i,t}^{ILL}}$ is Fisher's z-Transformation of Spearman's Rho Rank Correlation between equity and CDS Illiquidity Indexes of Firm i estimated over each quarter t.

Next, we test hypothesis H.2 formulated in the capital structure arbitrage model:

Hypothesis 2. "Funding Supply" Channel of Illiquidity Commonality. *The commonality in illiquidity across equity and credit increases with the cost of capital and with risk aversion, both of which trigger withdrawal of funds and unwinding of arbitrageurs' positions.*

We perform this test at individual firm level and at market level.
At individual firm level we estimate the linear model with panel data, including as explanatory variables (in addition to the hedge ratio) TED_t and $RiskAv_t$, respectively 3-months TED spread (proxy for funding costs) and the difference between 30-days implied and historical market (S&P500 Index) volatility (proxy for risk aversion).

$$Comm^{BA}_{i,t} = \alpha_0 + \beta_0 H^{SS}_{i,t} + \lambda_0 TED_t + \lambda_1 RiskAv_t + \alpha_1 Firm_1 + ... + \alpha_{50} Firm_{50} + \epsilon_{i,t} \tag{2}$$

where $i = 1, \ldots, 51$ is the Firm Index and $t = 1, \ldots, 27$ is the Time (quarter) index.
This analysis allow us also to evaluate and compare the relative contributions of hedge factor and market-wide factors to the increase in equity-CDS illiquidity commonality.

A second test of H.2 is performed at market level by estimating a VAR System with weekly variables. The endogenous variables of the system are: E^{BA}_t, CDS^{BA}_t, E^P_t, CDS^P_t; respectively, value-weighted averages across all 51 firms of equity and CDS bid-ask spreads, equity price, and CDS premium. We introduce also as exogenous variables in the VAR system TED_t and $RiskAv_t$. Figure 19 displays time patterns for TED_t and $RiskAv_t$. The estimated system is:

$$\boldsymbol{X_t} = \boldsymbol{\alpha_0} + \boldsymbol{\theta_1 X_{t-1}} + \boldsymbol{\theta_2 X_{t-2}} + \boldsymbol{\psi Y_t} + \boldsymbol{\epsilon_t} \tag{3}$$

$$\boldsymbol{X_t} = \begin{pmatrix} E^{BA}_t \\ CDS^{BA}_t \\ E^P_t \\ CDS^P_t \end{pmatrix}$$

$$\boldsymbol{Y_t} = \begin{pmatrix} TED_t \\ RiskAv_t \end{pmatrix}$$

Index t indicates the week. The system is estimated on the whole sample (March 2003-December 2009). Next, we estimate a VAR system with only bid-ask spreads as endogenous variables over the pre-crisis and crisis sub-samples (March 2003-December 2006 and January 2007-December 2009).

4.1.2 Results of Test of Hypothesis H.1

The hedge ratio estimated using SS methodology is always highly significant in explaining all three measures of equity-CDS bid-ask correlation in all specifications of panel equations (see Tables 9, 10, and 11). In Table 12 we examine the economic significance of this explanatory variable in terms of standard deviation impact: this is obtained by multiplying the estimated coefficients by the ratio between the independent and the dependent variable standard deviations. A 1 standard deviation (SD) change in hedge ratio determines around 0.15 SD change in the Pearson ψ measure, 0.25 SD change in Kendall τ, and 0.24 in Spearman ρ; or 0.12 SD change in Pearson ψ measure, 0.16 SD change in Kendall τ, and 0.15 in Spearman ρ when both time and firm fixed effects are considered.

Standardized betas for hedge ratios are always higher when no time and firm fixed effects are considered, however F-statistics reveals that time and firm fixed effects in panel data analysis are both significant, especially for Kendall and Spearman rank correlations (Tables 10 and 11). In particular, significant positive time effects are found (relative to the last quarter of 2009) for the years 2003, 2007, and 2008; that is when equity-CDS liquidity commonality is higher (see Figure 15). Notably, the significant impact of the hedge ratio on the illiquidity commonality measures survives the control for those specific time-effects. This implies that the hedge effect does not merely capture time patterns and high turbulence. The model specifications including only hedge ratio and time fixed effects as explanatory variables display also the best fit statistics (most negative values for Akaike and Bayesian Information Criteria; unreported).

When we employ firm's log leverage and equity volatility instead of the hedge ratio, we find that these two variables have a comparable positive (statistically and economically significant) effect, though the significance of equity volatility disappears when we control for time fixed effects. Table 9 shows that when we use equity volatility and log leverage instead of hedge ratio, the estimated intercept is significantly positive and the fit statistics (BIC) display worse (less negative) values. Moreover, in this formulation leverage and volatility have a significant impact only on bid-ask spreads commonality measures, while they appear insignificant for the correlation measures between equity and CDS Illiquidity Indexes (Table 13). In contrast the hedge ratio is found significant also for equity-CDS Illiquidity Indexes correlations (time fixed effects are weekly significant, firms' fixed effects are insignificant).

In addition, we control for other possible explanatory variables: firm's size, firm's systematic risk, and measures of correlation between equity and CDS returns. All these explanatory variables lack statistical significance when used together with the hedge ratio (see Tables 10 and 11). Only for Kendall τ and Spearman ρ, when hedge ratio is replaced by equity volatility and log leverage and when no time fixed effects are included, systematic risk and firm's log market capitalization appear positive and significant at 1% confidence level. Firms with larger market capitalization and equity returns more strongly dependent on market returns display larger equity-credit liquidity commonality. However, the evidence is weak since it disappears when we include hedge ratio as explanatory variable and allow control for time fixed effects.

If we replace the hedge ratio estimated using the SS methodology with the one estimated using the Vassalou-Xing (2004) methodology we find the latter to be significant in the panel data equations (Table 9); however the magnitude and the significance of the coefficient are drastically reduced when fixed effects are included (Tables 10 and 11). Moreover, the BIC fit statistics worsen with respect to the case when we use SS hedge ratio (Table 9). So the VX measure of hedge ratio is less useful than the SS measure

Overall, in all performed tests, the Hypothesis H.1 cannot be rejected. The effect of the hedge ratio on equity-CDS illiquidity commonality is strongly significant, both statistically and economically.

4.1.3 Results of Test of Hypothesis H.2

Panel analysis at individual firm level reveals a positive significant effect of TED spread on illiquidity commonality (measured by Kendall and Spearman correlations) after controlling for a firm's equity volatility and leverage, and for firms' unobservable fixed effects (Tables 10 and 11). Assessing the comparative strength of the two channels of illiquidity transmission formalized in Hypothesis H.1 and H.2, in Table 12 we notice that the economic impact of funding costs on the increase of equity-CDS illiquidity commonality is lower than the cumulative impact of hedging-related variables (equity volatility and leverage).

We also perform VAR analysis on aggregated CDS and equity bid-ask spreads, after assessing the stationarity of the series over the selected sample (unreported results obtained from Augmented Dickey-Fuller Equation Tests of Unit Root). We introduce as endogenous variables CDS and equity average market prices to control for the influence of fundamental/price effects on illiquidity. The estimation of the VAR system on the whole sample reveals that for both markets bid-ask spreads have a strong autoregressive component[15]. After controlling for this component and for lagged price effects, we still find that TED spread (proxy for funding illiquidity) and the difference between 30-days implied and historical market volatility (proxy for risk aversion) are significant in explaining the contemporaneous increase in equity and CDS illiquidity (Table 14). Tightening of funding constraints and increase in risk aversion contemporaneously augment both CDS and equity market illiquidity (therefore they increase CDS-equity illiquidity commonality). However, when a reduced VAR system is separately estimated over the pre-crisis and crisis sub-samples, we find that risk aversion and funding costs are significant only during the subprime crisis period (Table 15).

Hypothesis H.2 cannot be rejected. However, at individual firm level the economic impact of funding and risk aversion factors on illiquidity commonality is lower than the effect of the hedge ratio. Moreover, at market level their effect is detected only over the crisis period.

[15] Also at market level we detect the leading effect of CDS bid-ask spread on equity bid-ask spread which has been discussed in par 3.2

4.2 Test of Determinants of CDS and Equity Bid-Ask Spread

4.2.1 Empirical Modeling

We perform a test of Hypothesis H.3 which has been formulated in the previously discussed model for bid-ask spread components:

Hypothesis 3. Determinants of Equity and CDS Bid-Ask Spreads.*The bid-ask spread in the equity (or credit) market is set by market makers upon: the cost of hedging the position in the credit (or equity) market, the cost of informed trading in equity and credit markets, the cost of funding needed, and the level of market aversion to systematic risk.*

This test is performed on panel data at weekly frequency. We estimate the following equations:

$$Res.BA_{i,t}^{CDS} = \alpha + \beta(BA_{i,t}^{E} * H_{i,t}^{S}S) + \zeta\Phi_{k,t} + \gamma TED_t + \delta RiskAdv_t + \epsilon_{i,t}^{CDS} \tag{4}$$

$$Res.BA_{i,t}^{E} = \alpha + \beta[BA_{i,t}^{CDS} * (1 - H_{i,t})] + \zeta\Phi_{k,t} + \gamma TED_t + \delta RiskAdv_t + \epsilon_{i,t}^{E} \tag{5}$$

where $Res.BA_{i,t}^{CDS}$ and $Res.BA_{i,t}^{E}$ are respectively the residual bid-ask spreads of CDS and equity for firm i at time t after removing the autoregressive component; $H_{i,t}^{SS}$ is the debt-to-equity hedge ratio for asset i at time t; TED_t is the (exogenous) cost of external funding at time t proxied by the TED spread (3 months Libor rate minus 3 months Treasury rate at constant maturity); $RiskAdv_t$ is the (exogenous) level of systematic risk shock[16]; and $\Phi_{k,t}$ represents the private information relative to firm i at time t which includes:
(1) Information anticipated in CDS returns (related to asset volatility)
(2) Information anticipated by stock returns (related to asset value).
We also control for firms' fixed effects and market capitalization $Size_{i,t}$.

We follow the methodology of Acharya and Johnson (2007) to construct the components (1) and (2) of $\Phi_{i,t}$, which we define respectively CDS and stock innovations[17]. We regress CDS returns $\Delta CDS_{i,t}$ (or equity returns $\Delta E_{i,t}$) on contemporaneous stock (or CDS) returns in order to extract the residual component. We do this by means of separate time-series regressions for each firm i, also including five lags of CDS and stock returns to absorb any lagged information transmission within the credit and stock markets. To account for the nonlinear relation between CDS and stock returns, the regression specification for CDS includes interactions of stock returns (both contemporaneous and lagged) with inverse CDS level, while the regression specification for stock includes interactions of CDS returns (both contemporaneous and lagged) with CDS level.
$\Delta CDS_{i,t} = \alpha_i + \sum_{k=0}^{5}(\beta_{i,t-k} + \gamma_{i,t-k}/CDS_{i,t-k})\Delta E_{i,t-k} + \sum_{k=1}^{5}\delta_{i,t-k}\Delta CDS_{i,t-k} + u_{i,t}^{C}DS$
$\Delta E_{i,t} = \alpha_i + \sum_{k=0}^{5}(\beta_{i,t-k} + \gamma_{i,t-k}CDS_{i,t-k})\Delta CDS_{i,t-k} + \sum_{k=1}^{5}\delta_{i,t-k}\Delta E_{i,t-k} + u_{i,t}^{E}$
The residuals $\widehat{u_{i,t}}$ from each regression represent independent news arriving in the credit (or stock) market that is either not relevant or simply not appreciated by the stock (or credit) market at the time. We will define them as CDS (or equity) innovations: $\widehat{u_{i,t}^{CDS}} = CDS\ Inn$ and $\widehat{u_{i,t}^{E}} = Equity\ Inn$.

[16] This can be also considered as the aversion of market participants to systematic risk

[17] Acharya and Johnson (2007) uses this definition and methodology only for CDS innovations, however this work extends it to stock innovations.

4.2.2 Results of Test of Hypothesis H.3

In panel regression analysis at weekly frequency (Table 16 and 17) for equity and CDS bid-ask spreads the hedging cost components enter always positively and significantly in the estimated equations for all model specifications. When TED spread and market-wide volatility shock are used as explanatory variables, we find that they also have a positive significant effect on both CDS and equity bid-ask spreads. This effect remains after controlling for hedging costs, firms' fixed effects, and firm's size. Notably, the size variable is always significant: smaller companies have relatively higher bid-ask spreads. CDS and equity innovations (proxies for private information trading) appear also significant in all model specifications for equity and CDS bid-ask spreads and carry the expected positive and negative signs. Information anticipated in CDS returns and related to increase in asset volatility move upwards the bid-ask spreads. Information anticipated in stock returns and related to increase in asset value decreases bid-ask spreads. In terms of economic impact, 1 standard deviation (SD) change in hedging costs generates an increase of around 0.08 SD on both equity and CDS illiquidity, while 1 SD increase in TED drives the equity and CDS bid-ask upwards respectively by 0.20 and 0.06 SDs. The TED spread is strongly significant in all model specifications. When we include time fixed effects the large number of time-dummies weaken the model estimation, leading to an insufficient number of degrees of freedom to perform adequately statistical tests. The separate estimation of the two regressions over volatile and calm sub-periods reveal that the results in Tables 16 and 17 are mainly driven by highly volatile periods (2003 and 2007-2009), when the revisions of quotes has been more frequent and substantial and when positive illiquidity co-movements across equity and CDS have appeared[18].

A CDS resembles a deep OTM put option on the firm's assets. This put has a small delta and corresponds to a highly leveraged position on the underlying firm's assets. We detect a strong economic impact of CDS informed trading (CDS innovation) on CDS bid-ask spreads. Moreover, the systematic risk shock appears highly significant for CDS, while insignificant for equity bid-ask. This reflects the relatively larger exposure of CDS to systematic risk, most probably due to the extra leverage of the position. A firm's equity resembles an ITM call option on the firm's assets. The equity/call has a larger delta then the CDS/put. However, despite differences in the respective deltas, the standardized beta (economic impact) of the hedging cost component for equity bid-ask is only slightly larger than for CDS. Interestingly, equity bid-ask spreads are found particularly sensitive to funding costs (market-wide risk factor).

Hypothesis H.3 is strongly supported by the data. Hedging, private information, funding, and risk aversion are all statistically and economically significant cost components in CDS and equity bid-ask spreads of individual firms. To summarize the findings of this analysis: over volatile periods CDS and equity bid-ask spreads are found positively related through delta-hedging, however we also find a significant impact of funding costs, systematic risk shock, and information costs on both equity and CDS spreads. These findings suggest that: i) Part of the risk related to dealer's inventory positions in equity and CDS and reflected in their relative bid-ask spreads is systematic. ii) Market making firms are not able to completely hedge off their exposure to risk, so the information cost components have also a significant impact on equity and CDS bid-ask spreads.

[18] These results are not reported for brevity, but they are available upon request.

5 Conclusions

This paper examined linkages between equity and CDS market liquidity and set a theoretical framework to identify and test the determinants of their co-movements. The paper demonstrates that part of the illiquidity contagion across equity and credit market is fundamentally-based. Equity and CDS are almost substitute assets trading highly-correlated (firm's equity and credit) risks. As such, a wave of illiquidity originating in one market is easily transmitted to the other. In this work, the transmission of illiquidity is partially explained through the hedging/arbitrage channel. Much correlated trading across equity and CDS markets is fostered by sophisticated investors for hedging and speculative purposes (capital structure arbitrageurs). The illiquidity of one market limits the ability of building market positions and is transmitted to the other market. Moreover, the paper provides evidence of frictional-based illiquidity contagion across markets due to market-wide factors: in particular, the limited availability of financial resources of intermediaries and sophisticated traders can reduce trading across different markets, thereby increasing their illiquidity simultaneously.

This paper makes several important contributions to the emerging literature on illiquidity commonality across asset markets. First, unlike any previous study it examines explicitly the extent and causes of linkages between the illiquidity of equity and credit (CDS). Second, to the best of our knowledge, it is the first paper to apply the Merton (1974) structural model to capture the transmission of illiquidity shocks across fundamentally-related equity and credit markets. In particular, we employ Merton's model to estimate the debt-to-equity hedge ratio and predict illiquidity co-movements across CDS and equity markets due to arbitrage/hedging trading. Third, building on previous theoretical literature on limits to arbitrage, the paper demonstrates the contribution of funding costs and risk-aversion to the increase of illiquidity commonality. This analysis appears of critical importance since the credit crisis, which was mainly characterized in its early stages by a market-illiquidity contagion episode, exacerbated by traders' lack of financial resources which affected their ability to provide liquidity across multiple markets. Last, the paper provides an integrated framework for modeling equity and CDS bid-ask spreads and reveals a common significant influence of hedging, information, funding, and risk aversion cost components on both equity and credit market illiquidity.

The results of this work can be used to formulate recommendations for regulators and investors to monitor more closely the relationship of an asset illiquidity with other markets/assets in particular when characterized by common fundamentals and arbitrage connections, and the cross-market transmission of illiquidity. In portfolio allocation and in risk management fundamentally-related markets need to be considered together given that, under certain conditions, their functionality can be profoundly interrelated: if one market experiences a drop of liquidity, it is likely that another correlated market ceases to function in the same time. Additionally, this work supports the call for development of more sophisticated risk-management tools to monitor systematically the level of capital available for financial intermediation, and to detect and contain the effect of market volatility shocks on the transmission of illiquidity across different markets.

The paper is mainly empirical in nature. However, it also provides some insights for the development of illiquidity contagion models based on arbitrage relationships and information flows across correlated assets which may complement the rich theoretical literature on financial constraints' effect on market illiquidity. We are currently working on formal derivations of the hypotheses tested in this paper. These will provide a natural extension to the paper itself as well as a continuation of this relatively new research on cross-market illiquidity commonality.

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A Data Treatment and Construction of Illiquidity Measures for Equity and CDSs

A.1 Data

We employ data on 51 U.S. investment-grade companies which are components of the Dow Jones 5-years On-the-run CDX North America Investment Grade Index (CDX.NA.IG). We choose sample firms among the components of CDX.NA.IG Index to ensure continuous series of data for CDS quotes and prices, but we exclude from our sample those companies recording missing values in CDS series for more than 20 consecutive days. We therefore remain with 51 firms. For each firm we delete all observations which exhibit for equity (CDS) at least one of the following conditions:
-Null bid or ask price;
-Negative quoted spread (Ask price - Bid price<0);
-Daily absolute change in equity (CDS) price higher than the 99% percentile over the period;
-Daily absolute change in equity (CDS) ask-price higher than the 99% percentile over the period;
-Daily absolute change in equity (CDS) bid-price higher than the 99% percentile over the period.
We remain with an equity daily dataset of 71598 observations and a CDS daily dataset of 69174 observations.

A.2 Construction of Illiquidity Measures

The literature offers a broad range of measures of illiquidity which reflect three main dimensions: trading costs, trading frequency, and trade impact on prices. We construct and compare different measures of illiquidity at weekly frequency to show that bid-ask spreads are suitable measure of illiquidity for both equity and CDS markets and justify their use in the analysis of illiquidity commonality.

A.2.1 Equity Illiquidity Measures

I. Measures of Transaction Cost at weekly frequency:

- The **Roll measure** (Roll 1984) is computed over a 21-days rolling window. It is based on the magnitude of transitory price movements which induce negative serial correlation in price changes. For each company i the daily measure is constructed as:

$$Roll_{i,t} = \begin{cases} 2\sqrt{-Cov(\Delta P_{i,t}, \Delta P_{i,t-1})}, & \text{if } Cov(\Delta P_t, \Delta P_{t-1}) < 0. \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

  $\Delta P_{i,t}$ represents the price change (return) for firm i stock at the end of day t. The measure is averaged over each week (5 business days);

- The **percentage bid-ask spread** is obtained as the ratio between the quoted bid-ask spread and the mid-quote price. For each company i over each day t, the measure is constructed as

$$\frac{Ask_{i,t} - Bid_{i,t}}{0.5(Ask_{i,t} + Bid_{i,t})} \tag{7}$$

  and then it is averaged over each week (5 business days);

- The **effective spread** is obtained as absolute spread between transaction price and mid-quote price over mid-quote price. For each company i over each day t, the measure is constructed as

$$\frac{|P_{i,t} - 0.5(Ask_{i,t} + Bid_{i,t})|}{0.5(Ask_{i,t} + Bid_{i,t})} \tag{8}$$

and then it is averaged over each week (5 business days).

II. Measures of Trading Frequency at weekly frequency:

- For each day t the **Run length** measure is computed as the total number of consecutive days when either:
-Equity returns keep the same sign, i.e. trade direction remains invariant. Over two consecutive days we observe Buy - Buy; or Sell - Sell;
-Or equity returns are equal to zero, i.e. no trade is registered on consecutive days. Over two consecutive days we observe No trade - No trade;
-Or equity returns switch from positive (negative) to zero, i.e. trading switches from active to inactive. Over two consecutive days we observe Buy - No Trade; or Sell - No Trade;
The run length is short when assets are actively traded or when the price impact is low, as the variation in the asset series swamps directionality. Therefore, liquid assets have short run lengths, while illiquid assets have longer run lengths. To construct a weekly measure of run length we take the maximum value recorded for this measure over 5 business days.

- The **inverse turnover index** is obtained as ratio between number of outstanding shares and total traded number of shares over the day. The daily measure is averaged over each week (5 business days).

III.Measures of Market Depth (*Price Impact of Trading*) at weekly frequency:

- The weekly **Amihud Illiquidity Measure** (Amihud 2002) is calculated for each company i over each week w (5 business days) as weekly average ratio between the absolute price change at the end of the day t and the total amount of dollar volume traded during the day (approximately equal to total number of shares traded times price per share).

$$Amihud_{i,w} = \sum_{t=1}^{5} \frac{|P^i_{t,w} - P^i_{t-1,w}|}{Vol^i_{t,w}} \tag{9}$$

where $P^i_{t,w}$ is the closing price for firm i stock on day t in week w.

A.2.2 CDS Illiquidity Measures

For CDSs the same illiquidity measures are constructed as for equities, with the omission of the inverse turnover and the Amihud illiquidity measure. Bloomberg does not provide traded volume data for CDSs.

A.2.3 Winsorizing the 0.5% highest value of all Illiquidity Measures and Treatment of Missing Values

We winsorize the 0.5% highest value of all illiquidity measures. For each illiquidity measure we rank all observations in 200 groups (0 - 199) in ascending order. Each group contains 0.5% of total observations. We assign the maximum value recorded for the observations falling in the 198th group to all observations included in the 199th group (i.e. the 0.5% observations recording the highest values). Although missing values in the weekly illiquidity measure series are few, especially for equity, to avoid gaps we interpolate each variable using a linear method.

B Estimation of the hedge-ratio, using the Merton Model (1974)

To quantify the "arbitrage/hedging relationship" between CDS and equity bid-ask spreads and the relative size of cross-market positions, we estimate the sensitivity of debt to equity, i.e. the hedge ratio. Schaefer and Strebulaev (2008) show that even a simple version of Merton (1974) model can capture well the debt-to-equity sensitivity. Under the assumptions of the Black-Scholes (1973) model, the Merton (1974) model prices equity and risky debt of a firm as contingent claims written on the firm's assets. Equity is priced as a call option on the assets of the firm with strike price equal to the face value of firm's debt. The risky debt of the firm is evaluated as a short put position on the firm's asset with strike equal to the promised debt payment and a long position on a riskless bond[19].

Suppose that the total value of a firm's assets is equal to A_0 at time 0 and the volatility of assets' value is constant over time and equal to σ_A. The firms' liabilities consist of risky debt B - with face value D and maturity T - and equity E. We call L the leverage ratio (the ratio between present value of debt promised payment and total value of assets): $L = \frac{De^{-rT}}{A_0}$, where r is the continuously compounded risk-free interest rate in the market. According to the Black-Scholes pricing formula for non-dividend paying European call options (Black and Scholes 1973), at time 0 the equity value E_0 is given by:

$$E_0 = C^{BS}(A_0, \sigma_A, D, r, T) = A_0 N(d_1) - De^{-rT} N(d_2) \tag{10}$$

where N(.) is the cumulative function for the standard Normal distribution,
$d_1 = \frac{ln(\frac{A_0}{De^{-rT}})}{\sigma_A\sqrt{T}} + \frac{\sigma_A\sqrt{T}}{2} = \frac{-ln(L)}{\sigma_A\sqrt{T}} + \frac{\sigma_A\sqrt{T}}{2}$
and $d_2 = d_1 - \sigma_A\sqrt{T}$
The sensitivity (*first derivative*) of equity to firm's total assets value is determined by the call option delta: $N(d_1) = \Delta_C$.

At time 0, debt value is given by the difference between total assets' value and equity value:

$$B_0 = A_0 - E_0 \tag{11}$$

[19]There is a large literature which extends Merton's model in order to overcome the limitations of its simplified assumptions (Black and Cox 1976, Longstaff and Schwartz 1995). Merton's model and its extensions have been extensively tested. Some tests of structural models (Jones, Mason, and Rosenfeld 1984, Eom, Helwege, and Huang 2004) focus on corporate bond pricing and find that structural models generally under-predict spreads. However, recent research has more clearly assessed that the failure of the models has more to do with corporate bond market peculiarities, such as liquidity and tax effects, than with their ability to explain credit risk. Although the basic Merton (1974) model has revealed inaccurate to price credit instruments, it is very powerful to predict their sensitiveness to underlying equity (i.e. debt-to-equity hedging ratio) which can be used to hedge long (short) position on credit risk with long (short) position in corresponding equity (Schaefer and Strebulaev 2008, Cremers, Driessen, and Maenhout 2008).

Using equations (10) and (11) we obtain:

$$B_0 = De^{-rT}N(d_2) + A_0N(-d_1) \tag{12}$$

This implies:

$$B_0 = De^{-rT} - (De^{-rT}N(-d_2) - A_0N(-d_1)) = PV(D) - P^{BS}(A_0, \sigma_A, D, r, T) \tag{13}$$

As previously mentioned, the debt value at time 0 is equal to the present value of a long position on a riskless bond with face value D plus the value of a short position on a put option (derived from the Black-Scholes pricing formula for no-dividends paying European put options). Equation (12) can be used to calculate the sensitivity (first derivative) of risky debt value to assets' value which is given by the delta of the put option $N(-d_1) = \Delta_P$. The sensitivity of debt value to equity value is then given by:

$$\frac{\partial B}{\partial E} = \frac{\frac{\partial B}{\partial A}}{\frac{\partial E}{\partial A}} = \frac{N(-d_1)}{N(d_1)} = \frac{1}{\Delta_c - 1} = h \tag{14}$$

The elasticity of debt-to-equity (hedging ratio) is obtained as:

$$H = (\frac{\partial B}{\partial E})(\frac{E}{B}) = h(\frac{1}{L} - 1) \tag{15}$$

We perform the estimation of the debt-to-equity hedge ratio H following the two approaches: (i) the traditional methodology set by Vassalou and Xing (2004) - henceforth VX Methodology; and (ii) the methodology implemented by Schaefer and Strebulaev (2008) - henceforth SS Methodology. The VX methodology requires the knowledge of outstanding debt of the firm, equity value, and equity volatility to estimate the value and volatility of firm's assets from a system of two non-linear equations. We estimate equity volatility as historical annualized volatility, and equity value as the product between the firm's equity price and the number of outstanding shares. Following Vassalou and Xing (2004) we also obtain the outstanding amount of debt as book value of the firm's current debt plus one half of long-term debt value.

Following the VX Methodology, we recall equation (10) and notice that since equity is a function of assets' value, it is possible to apply Ito's Lemma to determine the instantaneous volatility of equity σ_E from total assets' volatility σ_A (Jones, Mason, and Rosenfeld 1984).

$$dE_t = df(A_t, t) = (\frac{\partial E_t}{\partial t} + \mu_A A_t \frac{\partial E_t}{\partial A} + \frac{\sigma_A^2}{2} A_t^2 \frac{\partial^2 E_t}{\partial A^2})dt + (\sigma_A A_t \frac{\partial E_t}{\partial A})dW_t. \tag{16}$$

It follows

$$E_0\sigma_E = A_0\sigma_A \frac{\partial E}{\partial A} = A_0\sigma_A N(d_1). \tag{17}$$

Therefore,

$$\sigma_E = \frac{\sigma_A A_0 N(d_1)}{E_0}. \tag{18}$$

Equations (10) and (18) represent two equations in two unknowns (A_0 and σ_A). We can determine the unknowns by solving the non-linear equations. In practice, we adopt a recursive procedure -known as the KMV method (Lando 2004)- that involves inverting the Black-Scholes formula (Vassalou and

Xing 2004, Crosbie and Bohn 2003, Bharath and Shumway 2008)[20].

The SS Methodology estimates asset volatility in a "more direct, model-free approach that is based only on observables" and "recognizes that debt bears some asset risk and that equity and debt covary" (Schaefer and Strebulaev 2008). We draw the basic idea from their methodology and estimate the asset volatility for each firm i at time t as square root of:

$$\sigma^2_{A(i,t)} = (1 - L_{i,t})\sigma^2_{E(i,t)} + L_{i,t}\sigma^2_{D(i,t)} + (1 - L_{i,t})L_{i,t}\sigma_{ED(i,t)} \tag{19}$$

$\sigma_{D(i,t)}$ is the time t unconditional volatility of firm i debt - estimated by historical annualized volatility of CDS; $\sigma_{E(i,t)}$ is the time t unconditional volatility of firm i equity - estimated by historical annualized volatility of equity; $\sigma_{ED(i,t)}$ is the time t covariance between firm i debt and equity - estimated by historical annualized covariance between equity and CDS returns; and $L_{i,t}$ is the leverage ratio of firm i at time t. Once A and σ_A are estimated we can estimate $N(d_1)$ and the CDS-to-equity hedge ratio H at time t.

[20] Crosbie et al (2003) explain that the model linking equity and asset volatility described by the system of Equations (1) and (6) holds only instantaneously. In practice market leverage moves around in a substantial way and the system does not provide reasonable results. Instead of using the instantaneous relationship given by Equations (1) and (6), we follow Crosbie et al (2003) and produce the hedging ratio using a more complex iterative procedure to solve for the asset volatility. Crosbie et al (2003) describe it as a procedure that "uses an initial guess of the volatility to determine the asset value and to de-lever the equity returns. The volatility of the resulting asset returns is used as the input to the next iteration of the procedure that in turn determines a new set of asset values and hence a new series of asset returns. The procedure continues in this manner until it converges."

C Figures and Tables

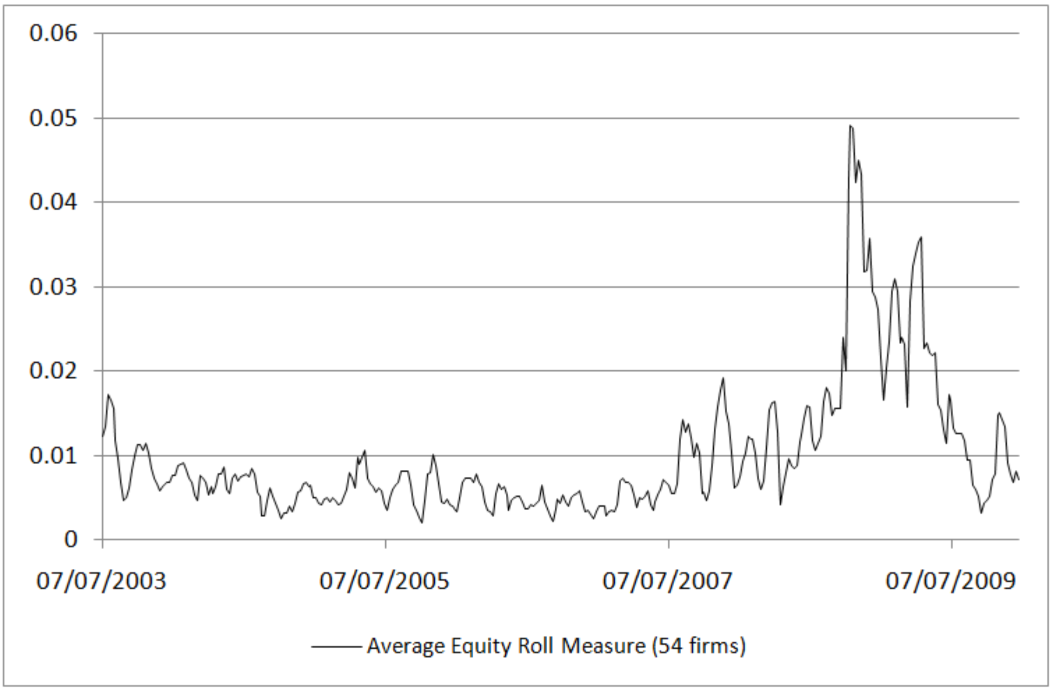

Figure 1: Cross-sectional weekly average of equity Roll measure
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

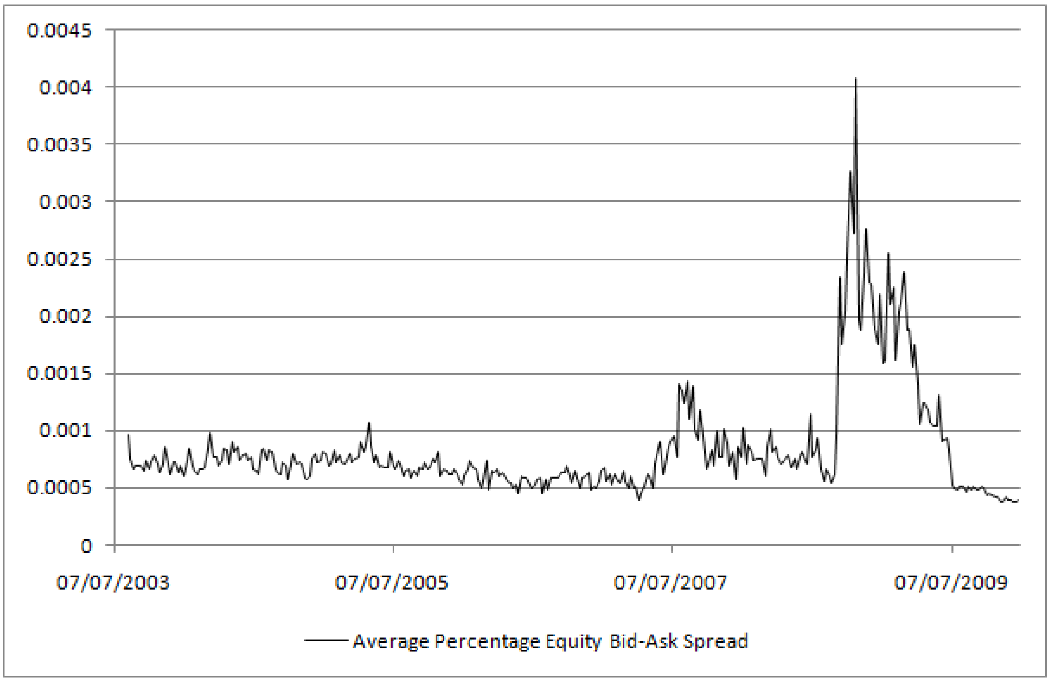

Figure 2: Cross-sectional weekly average of equity percentage bid-ask spread
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

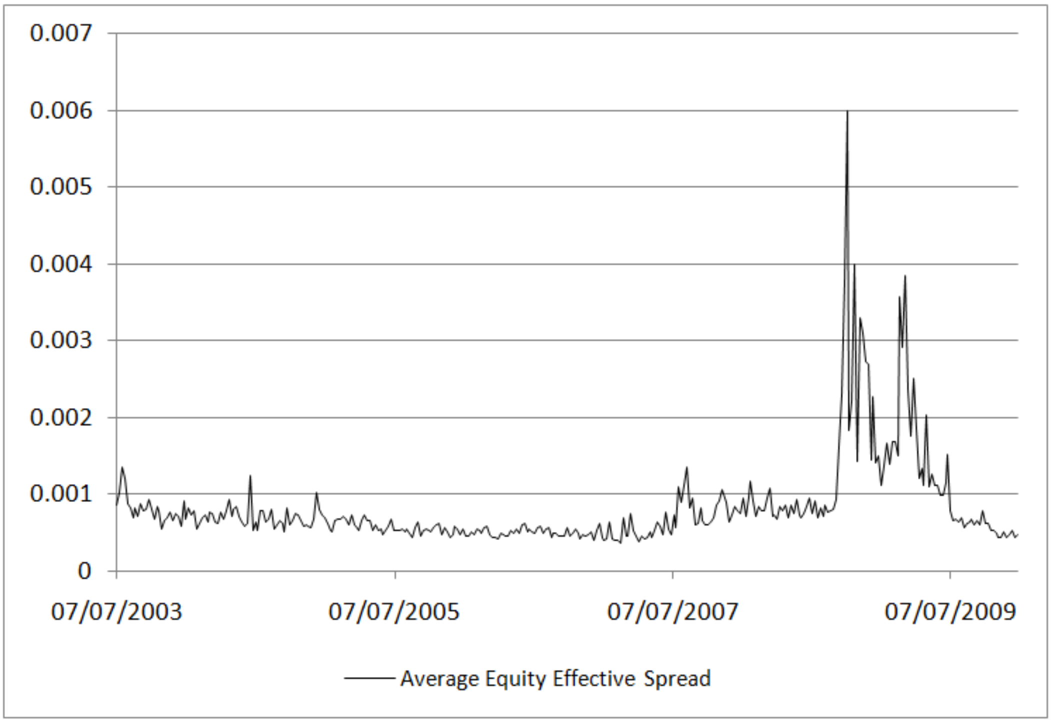

Figure 3: Cross-sectional weekly average of equity effective spread
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

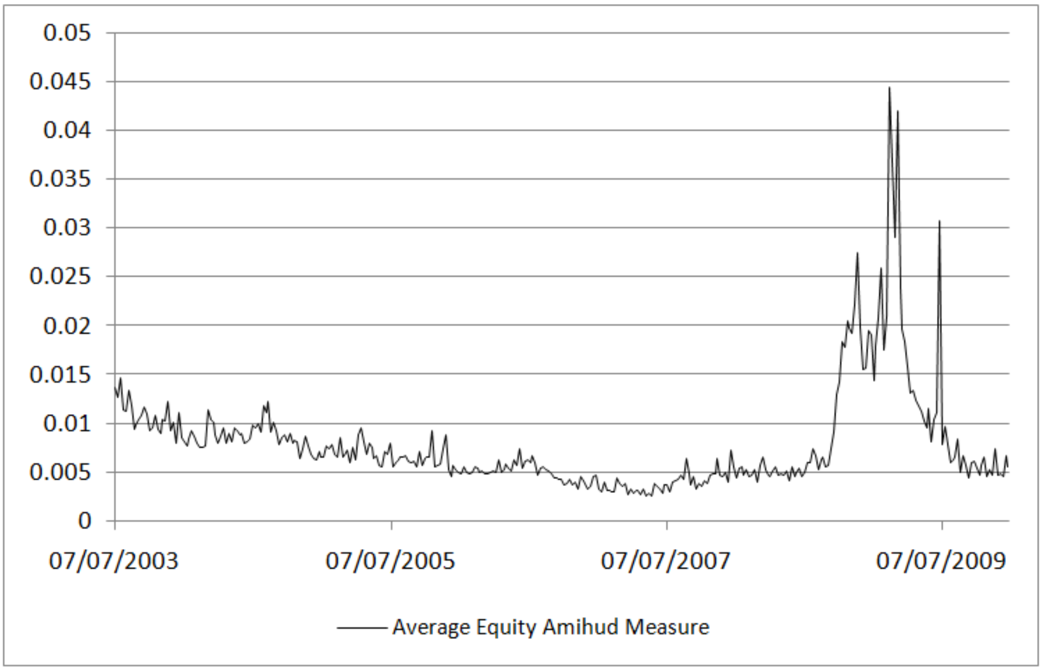

Figure 4: Cross-sectional weekly average of equity Amihud measure of price impact
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

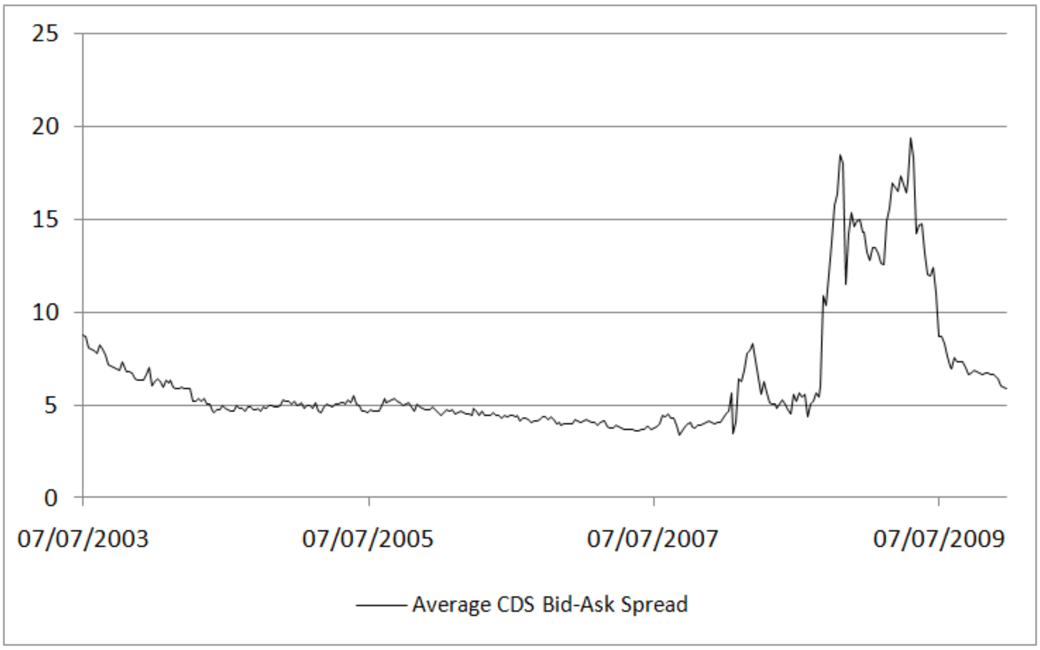

Figure 5: Cross-sectional average of CDS quoted bid-ask spread
(Measured in basis points, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

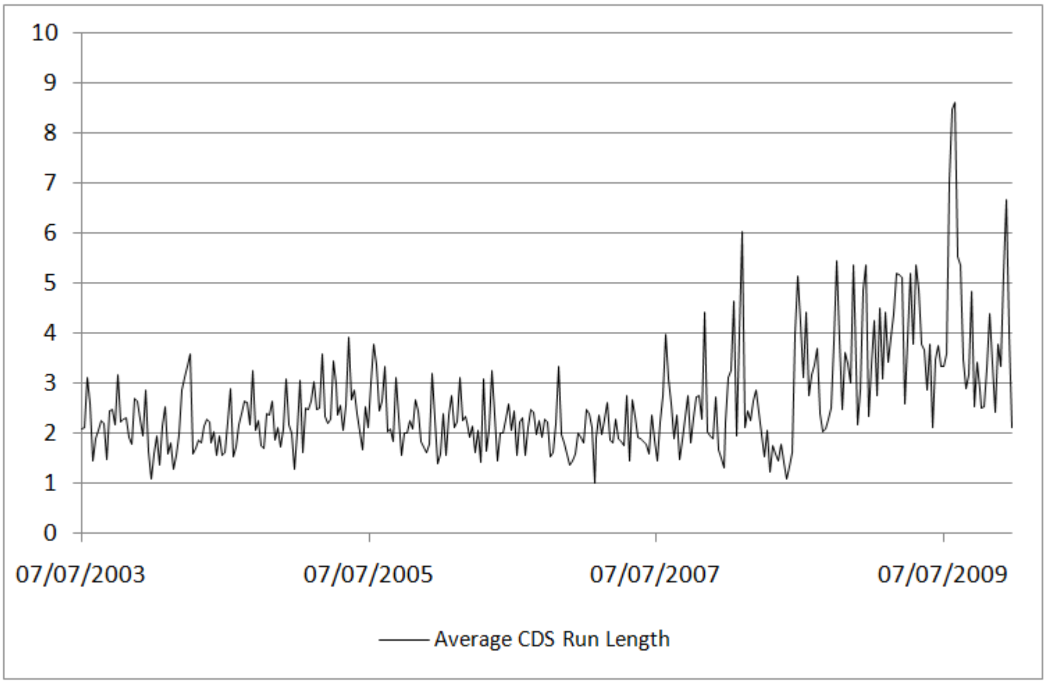

Figure 6: Cross-sectional average of weekly maximum value of CDS run length measure
(Measured in N^o of days, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

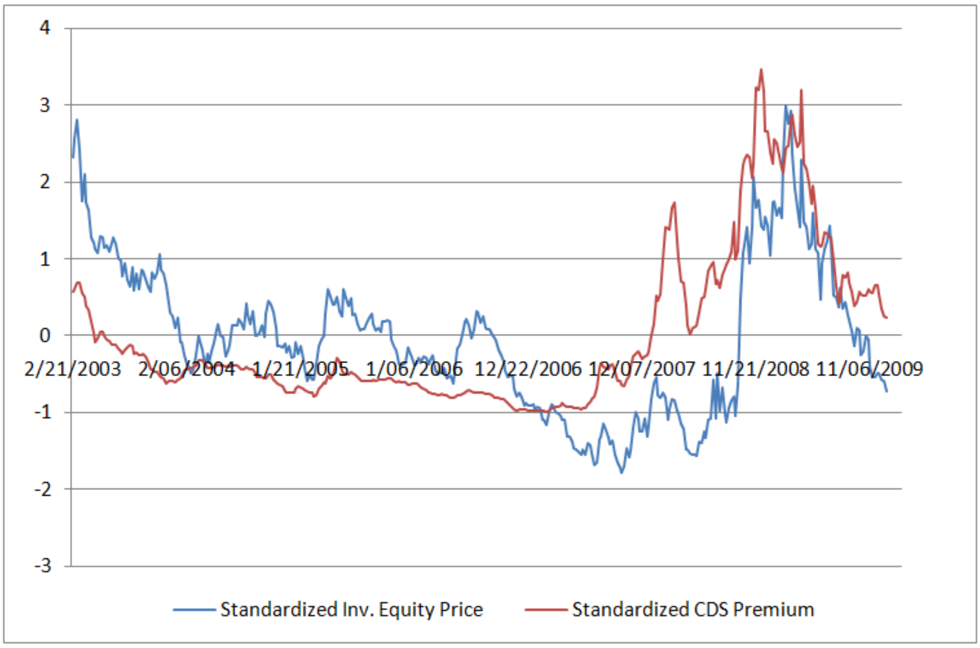

Figure 7: Cross-sectional average of standardized CDS Premium and inverse Equity price *(Weekly Frequency, March 2003 - December 2009, Cross-Section of 51 Firms)*

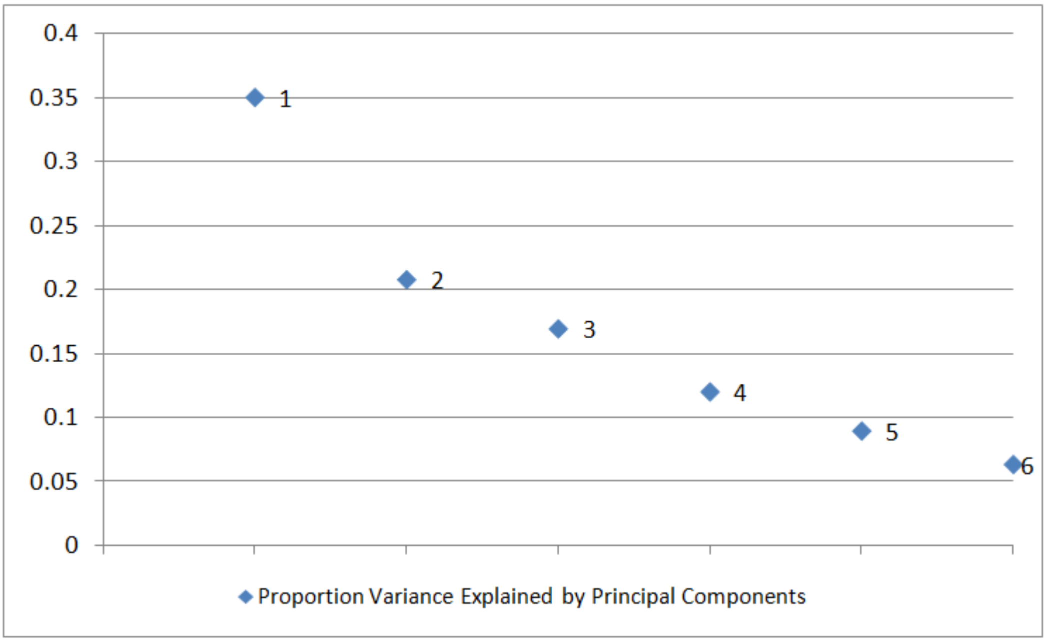

Figure 8: Equity PCA: Cross-sectional average of proportions of variance explained by each PC *(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)*

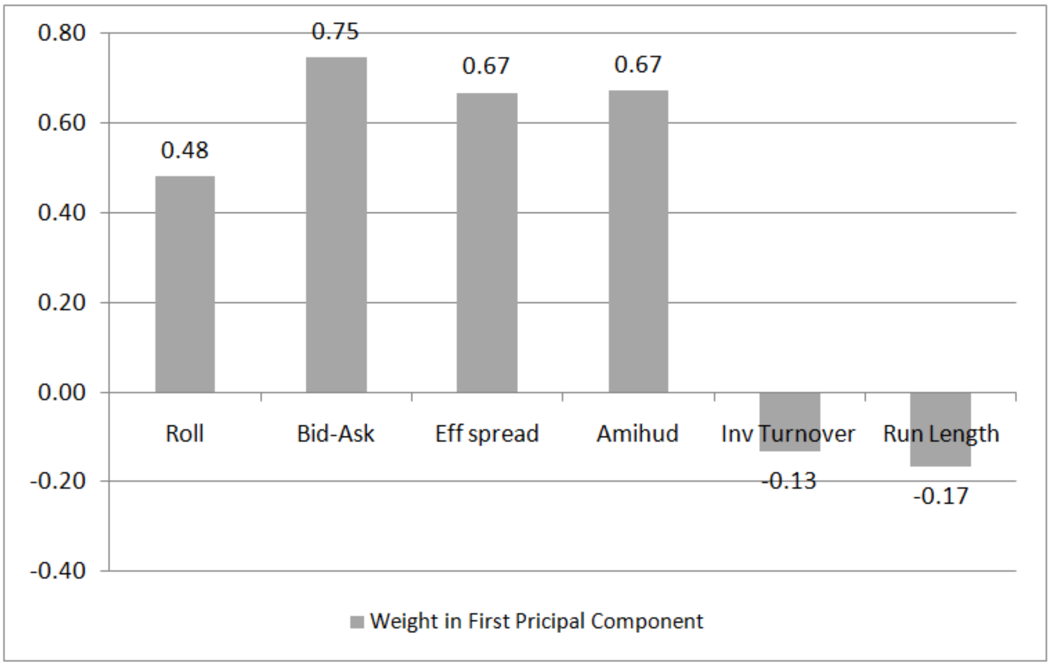

Figure 9: Equity PCA: Cross-sectional average of weights of illiquidity measures in the First PC *(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)*

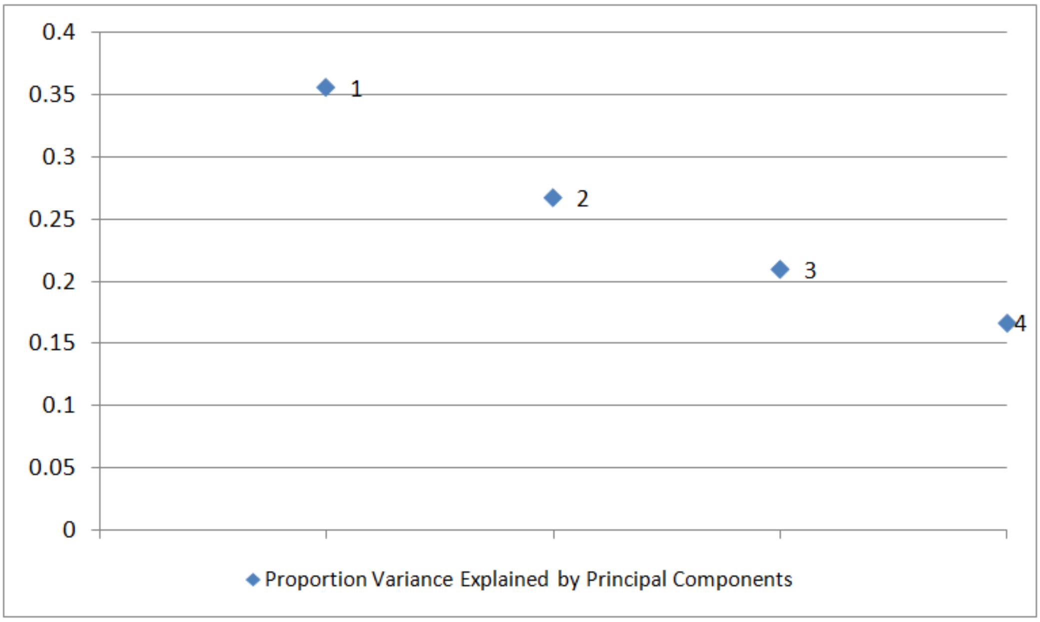

Figure 10: CDS PCA: Cross-sectional average of proportion of variance explained by each PC
(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)

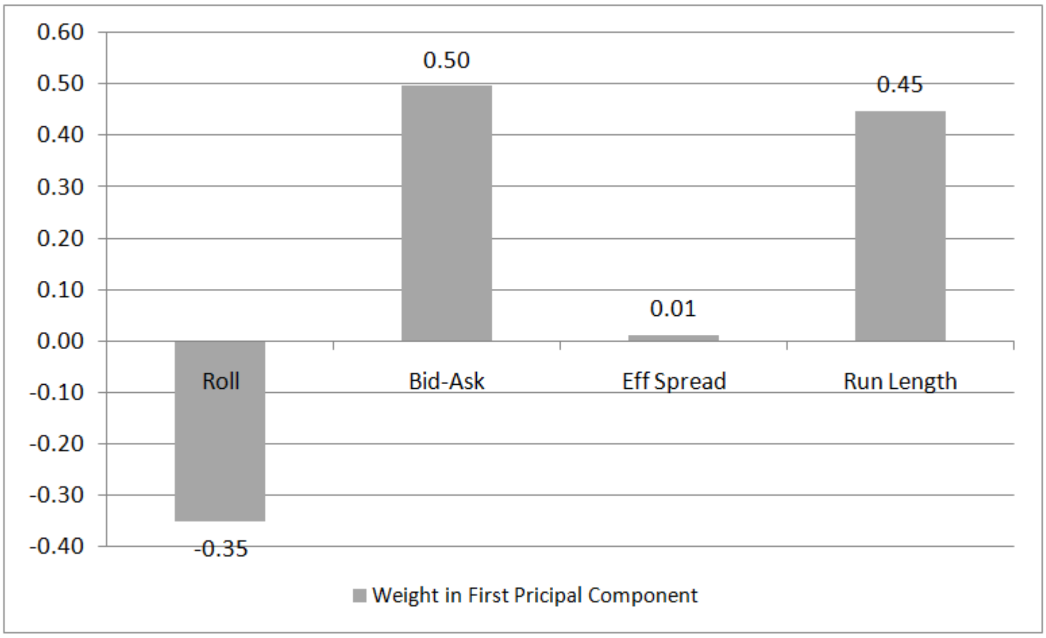

Figure 11: CDS PCA: Cross-sectional average of weights of illiquidity measures in the First PC
(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)

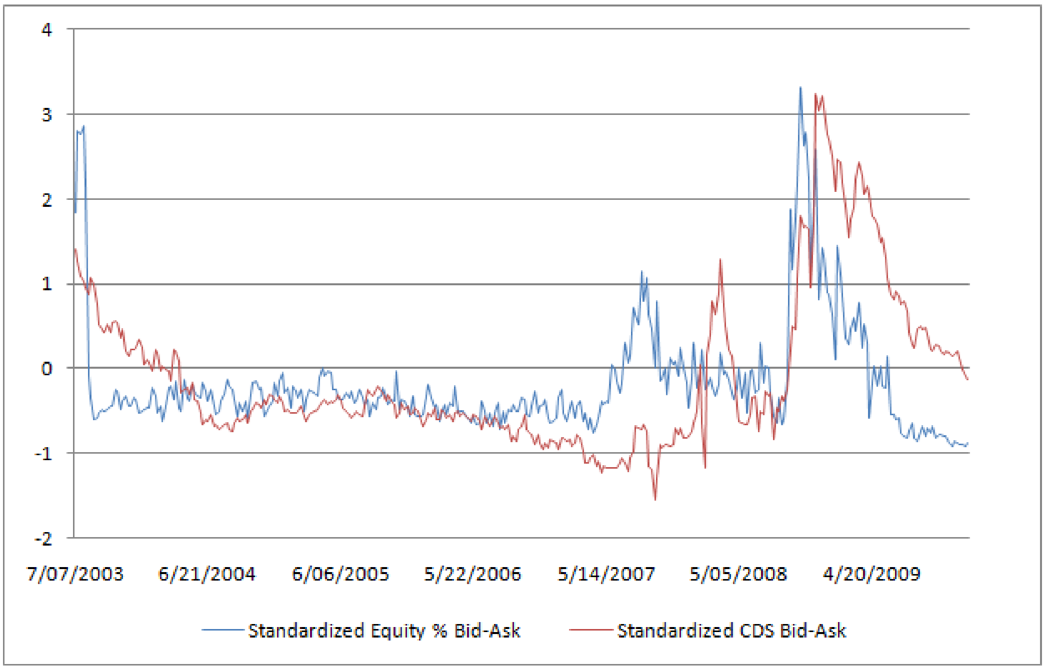

Figure 12: Cross-sectional average of standardized CDS and equity bid-ask spreads; All Sample *(Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)*

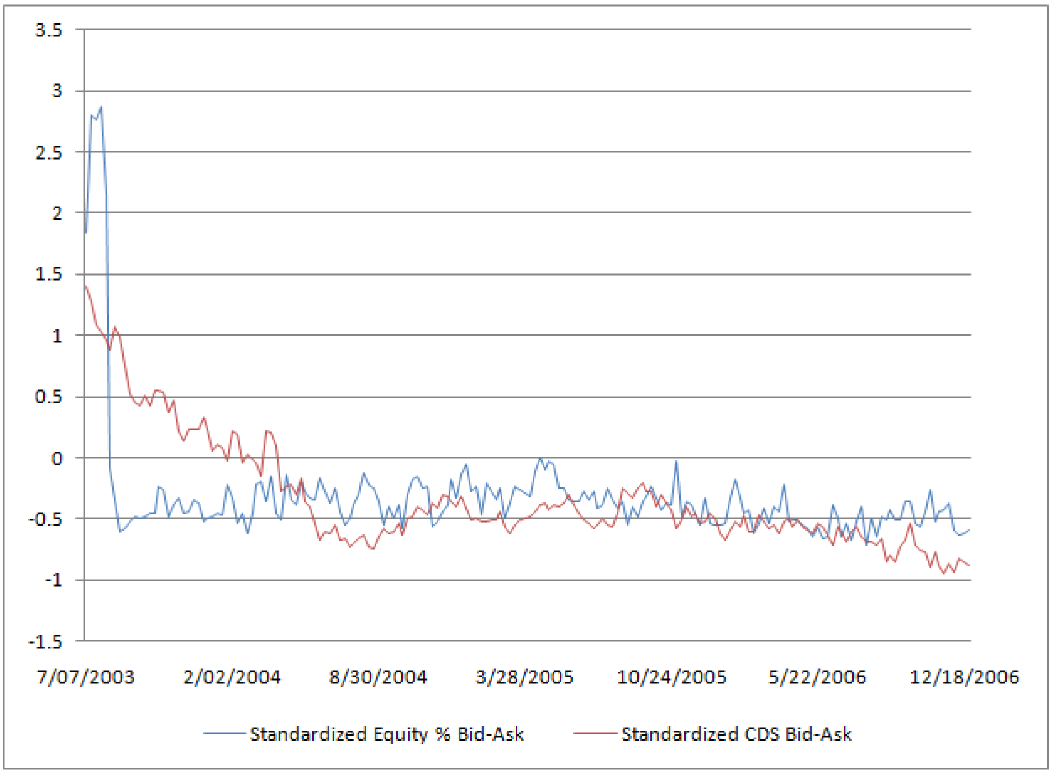

Figure 13: Cross-sectional average of standardized CDS and equity bid-ask spreads; Pre-Crisis Sample *(Weekly Frequency, July 2003 - December 2006, Cross-Section of 51 Firms)*

Figure 14: Cross-sectional average of standardized CDS and equity bid-ask spreads; Crisis Sample *(Weekly Frequency, January 2007 - December 2009, Cross-Section of 51 Firms)*

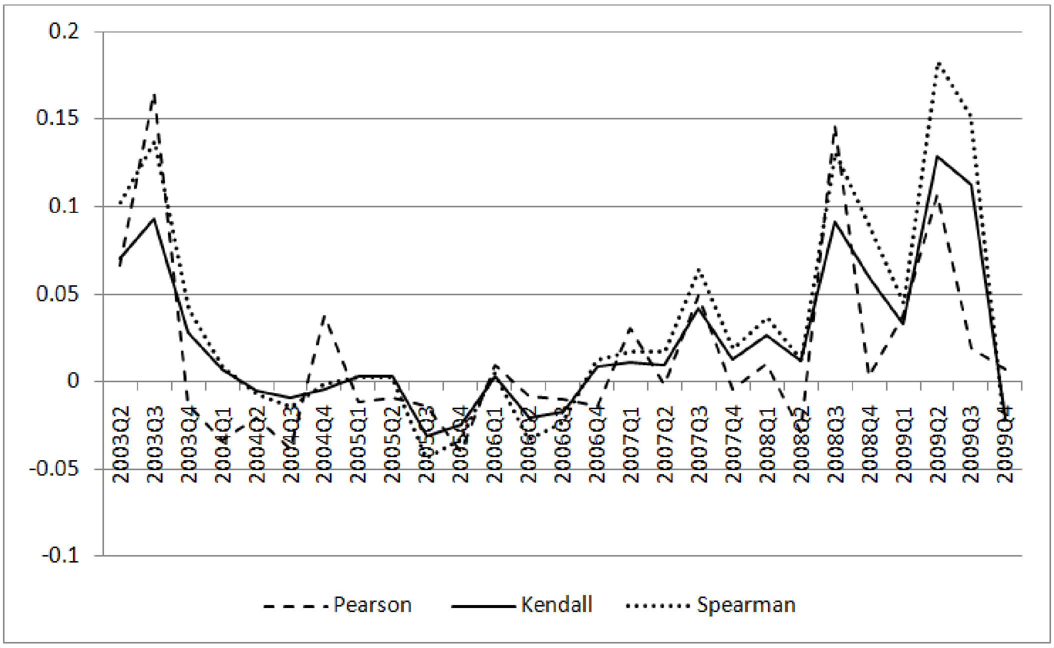

Figure 15: Cross-sectional average of CDS-equity liquidity correlations measures (Pearson, Kendall, and Spearman)
(Measured in decimals, Quarterly Frequency, March 2003 - December 2009, Cross-Section of 51 Firms)

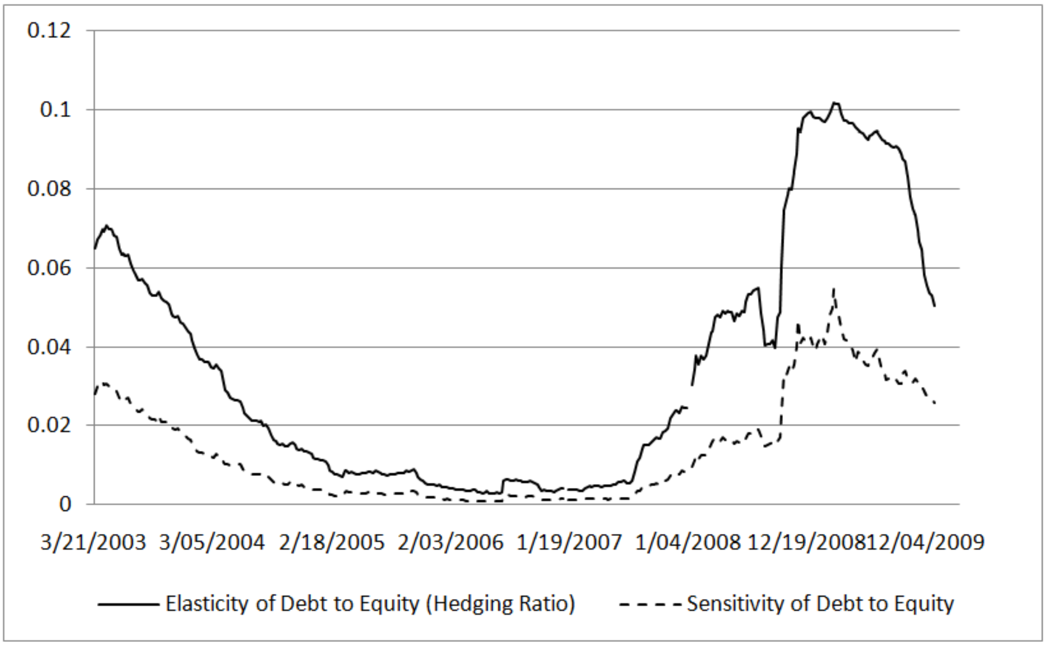

Figure 16: Cross-sectional average of debt-to-equity hedge ratio (Merton model calibration - SS Methodology)
(Measured in decimals, Weekly Frequency, March 2003 - December 2009, Cross-Section of 51 firms)

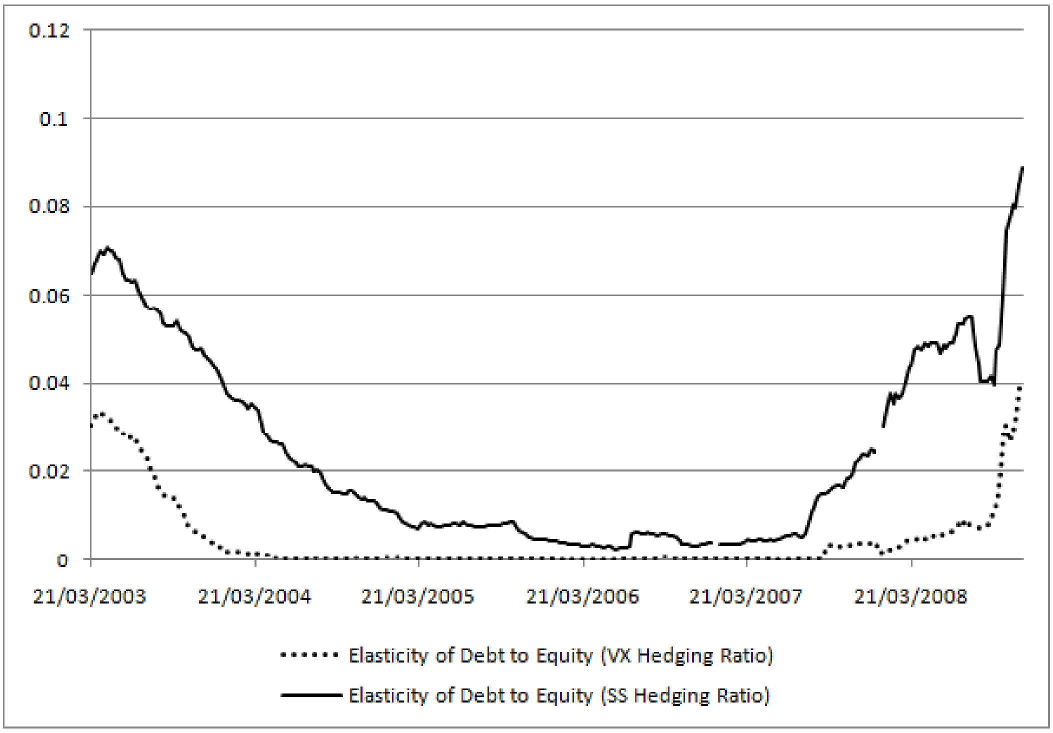

Figure 17: Cross-sectional average of debt-to-equity hedge ratio (Merton model calibration - SS vs VX Methodology)

(Measured in decimals, Weekly Frequency, March 2003 - November 2008, Cross-Section of 51 firms)

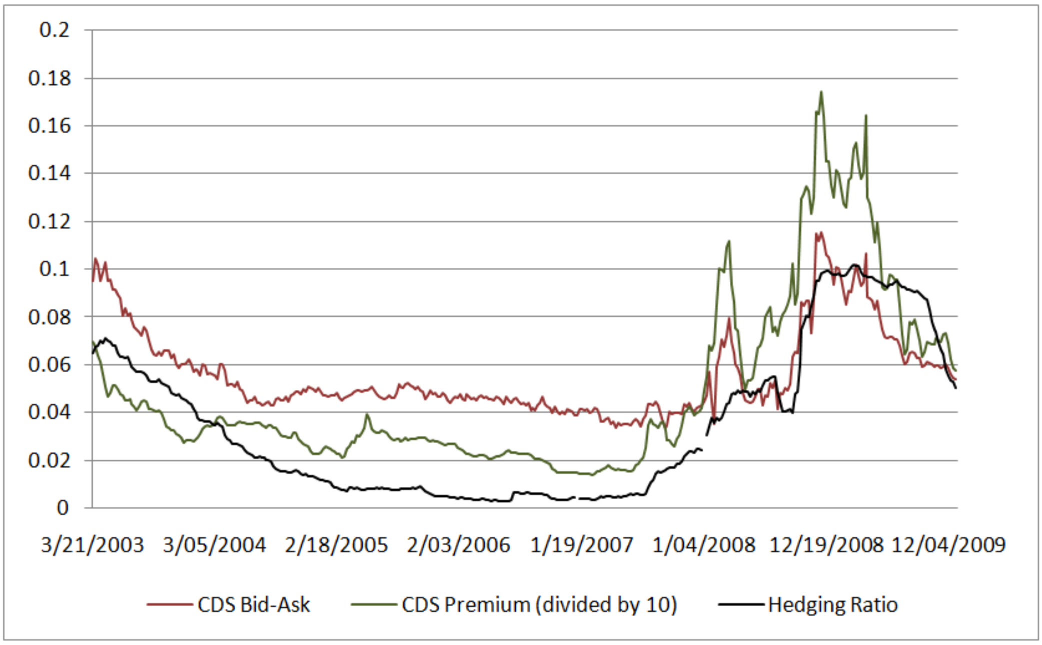

Figure 18: Cross-sectional averages of CDS premium, CDS bid-ask spread, and debt-to-equity hedge ratio (Merton model calibration - SS Methodology)

(CDS premium measured in 10 percentage units, CDS bid-ask spread in percentage units, hedge ratio in decimals, Weekly Frequency, March 2003 - December 2009, Cross-Section of 51 firms)

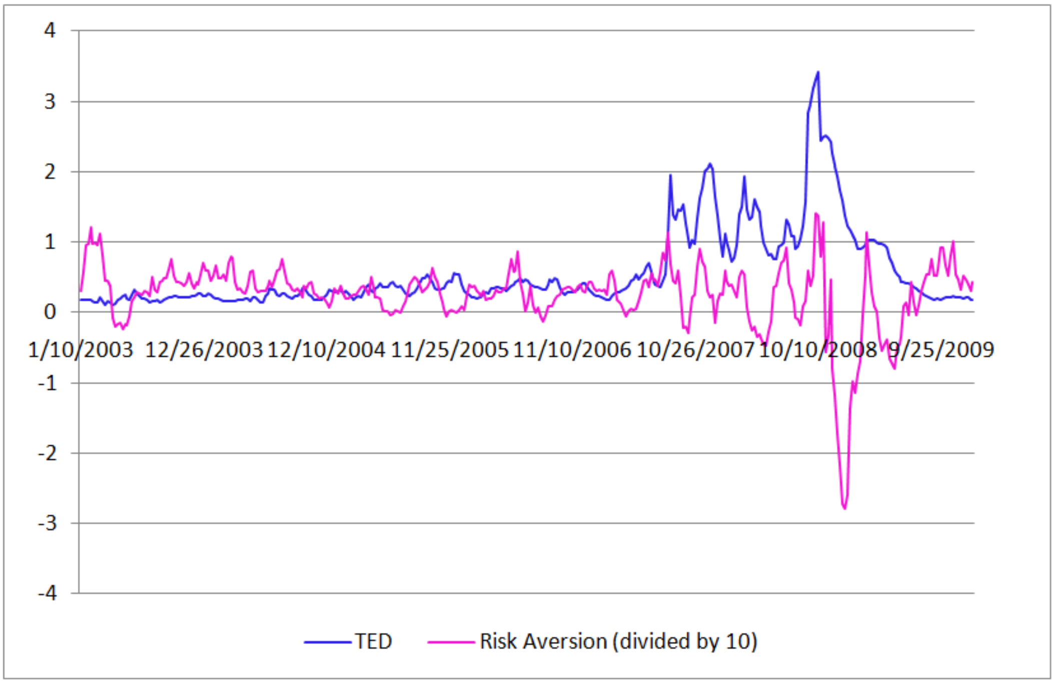

Figure 19: TED spread and difference between 30-Days S&P500 implied and historical volatility (risk aversion proxy)
(TED measured in percentage units, risk aversion in 10 percentage units, Weekly Frequency, March 2003 - December 2009)

Table 1: Summary statistics of cross-sectional weighted average (W.A.) Equity and CDS bid-ask spreads
(51 Firms, Weekly frequency, March 2003 - December 2009)

	Obs.	Mean	Std. Dev.	Median	Minimum	Maximum
W.A. Equity Bid-Ask	366	0.0888	0.0735	0.062	0.0275	0.435
W.A. CDS Bid-Ask	366	0.0566	0.0181	0.049	0.0334	0.1155

Table 2: Correlations between cross-sectional weighted average Equity and CDS Bid-Ask Spreads
(51 Firms, Weekly frequency, March 2003 - December 2009)

All Sample	
Pearson	0.557
Spearman	0.3132
Kendall	0.1997
Pre-Crisis Sample (2003-2006)	
Pearson	0.772
Spearman	0.522
Kendall	0.364
Crisis Sample (2007-2009)	
Pearson	0.448
Spearman	0.245
Kendall	0.154

Table 3: Distributions of Pearson, Kendall, and Spearman Correlations
between Equity and CDS Bid-Ask Spreads at firm level
(51 Firms, Weekly frequency, March 2003 - December 2009)

	Mean	**Median**	**Std. Dev.**	**Inter-quartile Range**	**Lowest**	**Highest**
All Sample						
Pearson	0.4572	0.4943	0.1918	0.3018	-0.0050	0.7975
Kendall	0.1903	0.1894	0.0968	0.1352	0.0036	0.4185
Spearman	0.2818	0.2776	0.1374	0.1962	0.0046	0.6052
Pre-Crisis Sample						
Pearson	0.5966	0.6557	0.1774	0.2418	0.0994	0.8445
Kendall	0.2239	0.2232	0.0967	0.1151	-0.0489	0.4196
Spearman	0.3286	0.3296	0.1341	0.1599	-0.0531	0.587
Crisis Sample						
Pearson	0.2897	0.268	0.1575	0.1379	-0.2019	0.6533
Kendall	0.1486	0.1426	0.1107	0.1123	-0.1304	0.4678
Spearman	0.2208	0.2055	0.1596	0.1703	-0.1941	0.668

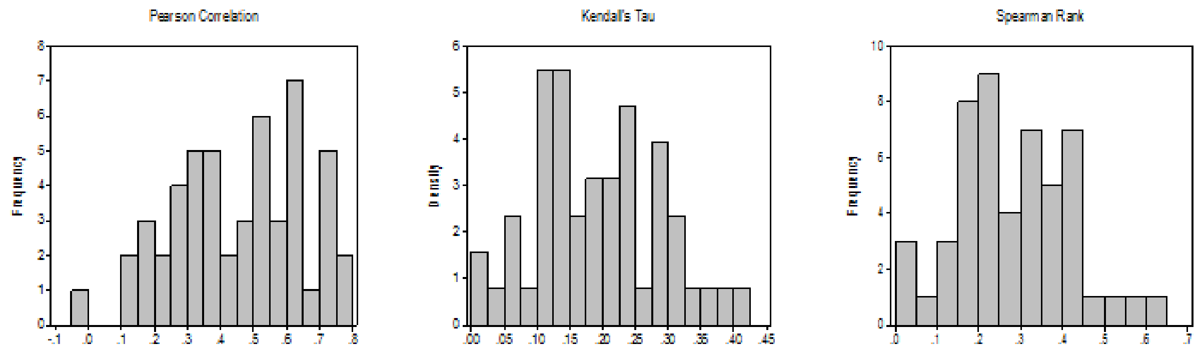

Figure 20: All Sample - Histograms of Equity-CDS Bid-Ask Spread Measures of Correlation

Table 4: Regressions of CDS and Equity Bid-Ask Spreads on Asset Volatility and Market Illiquidity

Market Illiquidity=Value-weighted average of bid-ask spreads across the 50 remaining firms. Newey-West SE estimated.

Dependent Variable	Equity Bid-Ask				CDS Bid-Ask			
Explanatory Variable	Asset Volatility		Equity Market Illiquidity		Asset Volatility		CDS Market Illiquidity	
	Coeff	*T-Value*	*Coeff*	*T-Value*	*Coeff*	*T-Value*	*Coeff*	*T-Value*
AA	0.0098	0.61	**1.0271**	**11.56**	**0.1141**	**2.95**	0.4258	1.69
ACE	-0.0337	-1.45	**1.3331**	**13.49**	0.0180	0.72	**0.8589**	**5.87**
AIG	0.0655	1.70	**0.6819**	**3.90**	**0.5928**	**6.57**	-2.9489	-4.75
APC	**0.0579**	**3.09**	**0.7841**	**8.90**	**0.0624**	**4.77**	**0.5787**	**7.00**
ARW	-0.0715	-1.03	**1.7999**	**5.02**	-0.0311	-1.07	**1.5386**	**6.76**
BA	-0.0009	-0.06	**0.7720**	**9.57**	**0.0836**	**4.36**	**0.4852**	**4.45**
BNI	0.0303	1.16	**0.7917**	**6.82**	**0.1510**	**8.43**	0.0375	0.37
CB	0.0255	1.14	**0.7979**	**7.85**	-0.0208	-0.93	**0.9249**	**8.01**
CCL	*-0.0650*	*-2.94*	**1.4734**	**7.89**	0.0098	1.41	**1.0230**	**14.22**
CAT	0.0113	1.06	**0.6551**	**11.18**	0.0182	1.75	**0.8559**	**12.63**
CPB	**0.0811**	**3.26**	**0.7593**	**7.90**	**0.1429**	**13.37**	0.0408	0.78
CSC	0.0250	1.65	**0.8911**	**10.71**	**0.1184**	**7.82**	0.1243	1.40
CAG	-0.0876	-1.55	**1.4517**	**7.02**	**0.2074**	**12.05**	-0.0667	-0.97
COP	*-0.0549*	*-3.49*	**0.9935**	**15.56**	**0.0998**	**4.02**	0.2282	1.64
DE	-0.0013	-0.08	**0.8452**	**8.84**	**0.0525**	**4.58**	**0.5251**	**5.94**
DIS	-0.0924	-1.88	**1.4643**	**6.98**	**0.1284**	**4.56**	0.1460	1.01
DOW	**0.0330**	**2.23**	**0.7500**	**10.62**	**0.0391**	**2.51**	**0.8386**	**8.97**
DVN	0.0683	1.86	**0.6704**	**3.46**	**0.1501**	**5.33**	0.0075	0.05
D	-0.0613	-1.08	**1.1273**	**4.85**	**0.0725**	**2.09**	**0.4521**	**2.37**
DUK	0.0319	1.67	**0.9534**	**7.31**	**0.0734**	**7.06**	**0.2325**	**2.63**
DD	-0.0015	-0.08	**0.8346**	**9.41**	**0.0910**	**7.38**	**0.2695**	**3.94**
EMN	0.0269	1.14	**0.9285**	**7.70**	**0.1591**	**5.44**	0.1252	0.85
FE	*-0.0573*	*-2.15*	**1.3896**	**10.92**	**0.0819**	**3.05**	**0.6023**	**3.48**
GIS	**0.0669**	**3.00**	**0.5971**	**7.92**	**0.1473**	**20.16**	**0.0626**	**2.11**
GR	-0.0611	-1.12	**1.5298**	**5.63**	**0.0654**	**2.25**	**0.6266**	**3.11**
HAL	-0.0060	-0.34	**1.0414**	**11.70**	0.0469	0.95	0.6576	1.89
HIG	**0.0323**	**3.14**	**0.8383**	**12.94**	**0.1457**	**7.13**	**0.3007**	**2.23**
HPQ	0.0148	0.94	**0.8069**	**13.03**	**0.1792**	**10.67**	-0.1017	-1.18
HON	-0.0092	-0.48	**0.9194**	**13.36**	**0.1809**	**6.25**	-0.0387	-0.29
IBM	**0.0424**	**1.96**	**0.5115**	**7.33**	0.0423	1.61	**0.5403**	**3.92**
KFT	**0.0749**	**3.83**	**0.5460**	**7.13**	**0.1440**	**13.34**	**0.1797**	**3.39**
KR	-0.0111	-0.18	**1.3653**	**5.36**	**0.1696**	**9.83**	0.1032	1.16
LMT	0.0082	0.33	**0.7511**	**7.87**	**0.1708**	**3.82**	0.1023	0.56
MAR	0.0390	1.67	**0.7827**	**7.13**	**0.0995**	**5.22**	**0.6694**	**6.90**
MCD	0.0118	0.41	**0.7909**	**7.36**	**0.1876**	**18.72**	-0.0680	-2.37
MET	0.0051	0.30	**0.9805**	**10.59**	**0.1932**	**7.34**	-0.0664	-0.39
MOT	**0.0571**	**3.01**	**1.2191**	**12.70**	**0.0591**	**2.84**	**0.8908**	**6.30**
NWL	0.0371	1.34	**1.0414**	**7.73**	**0.0957**	**5.70**	**0.5363**	**4.80**
JWL	-0.0934	-1.88	**1.6857**	**6.40**	**0.0779**	**5.51**	**0.6262**	**6.95**
NSC	0.0434	1.54	**0.9045**	**6.77**	**0.1584**	**9.72**	-0.0714	-0.81
NOC	0.0338	1.37	**0.5868**	**6.27**	0.0603	1.71	**0.6689**	**3.89**
OMC	-0.0048	-0.26	**0.8290**	**11.77**	0.0418	0.99	**0.7924**	**3.84**
PGN	0.0007	0.02	**1.0135**	**7.10**	**0.0762**	**2.01**	**0.4636**	**2.20**
RTN	0.0168	0.63	**0.8428**	**9.87**	**0.1834**	**4.96**	0.1103	0.74
SWY	0.0319	0.96	**1.1459**	**7.81**	**0.1547**	**12.46**	0.0327	0.54
SRE	-0.0665	-1.78	**1.4216**	**8.72**	**0.1114**	**5.31**	0.2355	1.90
SPG	0.0473	1.77	**0.9469**	**6.21**	**0.0573**	**4.17**	**0.8567**	**9.32**
TGT	-0.0057	-0.35	**0.8958**	**11.72**	0.0357	1.67	**0.7004**	**5.16**
TWX	-0.0460	-1.41	**1.4445**	**9.63**	**0.1179**	**4.38**	**0.3579**	**2.47**
VLO	0.0059	0.28	**0.8851**	**7.71**	**0.1212**	**6.65**	**0.2414**	**2.04**
WMT	**0.0682**	**6.18**	**0.3509**	**10.96**	**0.1184**	**7.29**	**0.1913**	**2.71**

Table 5: Pair-wise Granger Test of Causality for Equity and CDS Bid-Ask Spreads
H0: CDS Bid-Ask Spread does not Granger cause Equity Bid-Ask Spread (2 Lags included, Daily frequency)

Firms	**Nobs.**	**F-Test**	**P-Value**	**Reject H0/Accept H0 at 5% CL**
AA	1466	59.9936	<0.0000	Reject
ACE	1518	9.1177	<0.0001	Reject
AIG	1516	17.4975	<0.0001	Reject
APC	1491	16.9881	<0.0001	Reject
ARW	1515	1.6859	0.1856	Accept
BA	1488	28.8387	<0.0001	Reject
BNI	1465	3.6634	0.0259	Reject
CB	1467	4.5702	0.0105	Reject
CCL	1570	11.6181	<0.0001	Reject
CAT	1498	16.4636	<0.0001	Reject
CPB	1475	1.8253	0.1615	Accept
CSC	1507	1.0617	0.3461	Accept
CAG	1490	8.7571	0.0002	Reject
COP	1465	3.3264	0.0362	Reject
DE	1506	16.4090	<0.0001	Reject
DIS	1522	27.1472	<0.0001	Reject
DOW	1512	30.5571	<0.0001	Reject
DVN	1460	1.2620	0.2834	Accept
D	1509	4.8114	0.0083	Reject
DUK	1501	1.8493	0.1577	Accept
DD	1454	20.1767	<0.0001	Reject
EMN	1509	10.4492	<0.0001	Reject
FE	1501	4.4788	0.0115	Reject
GIS	1485	0.2082	0.8121	Accept
GR	1512	5.0773	0.0063	Reject
HAL	1413	0.1646	0.8483	Accept
HIG	1492	67.6365	<0.0001	Reject
HPQ	1494	7.7730	0.0004	Reject
HON	1513	19.9129	<0.0001	Reject
IBM	1491	0.9043	0.4051	Accept
KFT	1518	5.8800	0.0029	Reject
KR	1487	0.1288	0.8792	Accept
LMT	1476	0.8638	0.4218	Accept
MAR	1521	27.5132	<0.0001	Reject
MCD	1510	11.3569	<0.0001	Reject
MET	1483	49.8810	<0.0001	Reject
MOT	1520	77.2916	<0.0001	Reject
NWL	1492	29.8806	<0.0001	Reject
JWL	1489	26.7790	<0.0001	Reject
NSC	1463	0.8361	0.4336	Accept
NOC	1522	4.8627	0.0079	Reject
OMC	1494	19.0258	<0.0001	Reject
PGN	1498	2.7036	0.0673	Accept
RTN	1508	2.1903	0.1122	Accept
SWY	1508	4.9951	0.0069	Reject
SRE	1499	3.2681	0.0384	Reject
SPG	1494	31.7179	<0.0001	Reject
TGT	1451	13.6992	<0.0001	Reject
TWX	1518	14.6710	<0.0001	Reject
VLO	1497	16.1539	<0.0001	Reject
WMT	1467	0.4428	0.6423	Accept

Table 6: Pair-wise Granger Causality Test for Equity and CDS Bid-Ask Spreads
H0: Equity Bid-Ask Spread does not Granger cause CDS Bid-Ask Spread (2 Lags included, Daily frequency)

Firm	**Nobs.**	**F-Test**	**P-Value**	**Reject H0/Accept H0 at 5% CL**
AA	1466	6.6902	0.0013	Reject
ACE	1518	1.3555	0.2581	Accept
AIG	1516	5.9685	0.0026	Reject
APC	1491	1.7234	0.1788	Accept
ARW	1515	2.5515	0.0783	Accept
BA	1488	7.9250	0.0004	Reject
BNI	1465	1.2980	0.2734	Accept
CB	1467	5.3613	0.0048	Reject
CCL	1570	3.1875	0.0415	Reject
CAT	1498	4.0767	0.0172	Reject
CPB	1475	0.1819	0.8337	Accept
CSC	1507	0.9404	0.3907	Accept
CAG	1490	1.3451	0.2608	Accept
COP	1465	2.5152	0.0812	Accept
DE	1506	1.1151	0.3282	Accept
DIS	1522	3.5287	0.0296	Reject
DOW	1512	5.7999	0.0031	Reject
DVN	1460	0.2205	0.8022	Accept
D	1509	0.2924	0.7465	Accept
DUK	1501	0.0609	0.9409	Accept
DD	1454	0.2286	0.7957	Accept
EMN	1509	7.5038	0.0006	Reject
FE	1501	0.4488	0.6385	Accept
GIS	1485	0.0103	0.9897	Accept
GR	1512	2.4994	0.0825	Accept
HAL	1413	1.8050	0.1649	Accept
HIG	1492	26.4935	<0.0001	Reject
HPQ	1494	3.4759	0.0312	Reject
HON	1513	1.3895	0.2495	Accept
IBM	1491	0.1701	0.8436	Accept
KFT	1518	0.2944	0.7451	Accept
KR	1487	0.4776	0.6203	Accept
LMT	1476	0.0891	0.9148	Accept
MAR	1521	1.0449	0.3520	Accept
MCD	1510	2.9736	0.0514	Accept
MET	1483	10.1384	<0.0001	Reject
MOT	1520	11.3628	<0.0001	Reject
NWL	1492	8.8482	0.0002	Reject
JWL	1489	1.3277	0.2654	Accept
NSC	1463	1.3125	0.2695	Accept
NOC	1522	0.8304	0.4361	Accept
OMC	1494	6.6975	0.0013	Reject
PGN	1498	0.1549	0.8565	Accept
RTN	1508	0.3178	0.7278	Accept
SWY	1508	1.8260	0.1614	Accept
SRE	1499	0.9521	0.3861	Accept
SPG	1494	3.3116	0.0367	Reject
TGT	1451	0.1573	0.8545	Accept
TWX	1518	2.9280	0.0538	Accept
VLO	1497	2.5580	0.0778	Accept
WMT	1467	7.6398	0.0005	Reject

Table 7: Pair-wise Granger Causality Test for Equity and CDS Prices
H0: CDS Premium does not Granger cause Equity Price (2 Lags included, Daily frequency)

Firm	**Nobs.**	**F-Test**	**P-Value**	**Reject H0/Accept H0 at 5% CL**
AA	1466	1.47741	0.22857	Accept
ACE	1518	2.51792	0.08096	Accept
AIG	1516	2.62967	0.07243	Accept
APC	1491	0.48909	0.61329	Accept
ARW	1515	0.02035	0.97985	Accept
BA	1488	1.42373	0.24114	Accept
BNI	1465	1.11663	0.32766	Accept
CB	1467	0.72357	0.48519	Accept
CCL	1570	0.20444	0.81512	Accept
CAT	1498	0.93223	0.39390	Accept
CPB	1475	3.30396	0.03701	Reject
CSC	1507	1.33007	0.26477	Accept
CAG	1490	4.02463	0.01807	Reject
COP	1465	4.66300	0.00958	Reject
DE	1506	2.82465	0.05964	Accept
DIS	1522	5.77253	0.00318	Reject
DOW	1512	2.32195	0.09843	Accept
DVN	1460	1.10926	0.33008	Accept
D	1509	1.08840	0.33702	Accept
DUK	1501	0.67073	0.51149	Accept
DD	1454	3.60091	0.02754	Reject
EMN	1509	0.30618	0.73630	Accept
FE	1501	0.61126	0.54280	Accept
GIS	1485	1.24575	0.28803	Accept
GR	1512	0.74693	0.47400	Accept
HAL	1413	0.20469	0.81493	Accept
HIG	1492	0.80543	0.44709	Accept
HPQ	1494	1.66523	0.18950	Accept
HON	1513	1.16844	0.31113	Accept
IBM	1491	1.39256	0.24876	Accept
KFT	1518	3.90171	0.02041	Reject
KR	1487	2.85140	0.05808	Accept
LMT	1476	3.76724	0.02334	Reject
MAR	1521	1.26995	0.28114	Accept
MCD	1510	0.45348	0.63550	Accept
MET	1483	0.89092	0.41050	Accept
MOT	1520	2.00018	0.13567	Accept
NWL	1492	1.23382	0.29147	Accept
JWL	1489	1.98016	0.13841	Accept
NSC	1463	3.06709	0.04686	Reject
NOC	1522	1.02884	0.35767	Accept
OMC	1494	0.00233	0.99767	Accept
PGN	1498	3.73534	0.02409	Reject
RTN	1508	1.06557	0.34479	Accept
SWY	1508	1.01266	0.36350	Accept
SRE	1499	0.41287	0.66183	Accept
SPG	1494	4.46958	0.01161	Reject
TGT	1451	7.20587	0.00077	Reject
TWX	1518	0.61243	0.54217	Accept
VLO	1497	3.65548	0.02608	Reject
WMT	1467	5.36181	0.00479	Reject

Table 8: Pair-wise Granger Causality Test for Equity and CDS Prices
H0: Equity Price does not Granger cause CDS Premium (2 Lags included, Daily frequency)

Firm	**Nobs.**	**F-Test**	**P-Value**	**Reject H0/Accept H0 at 5% CL**
AA	1466	21.5015	<0.0001	Reject
ACE	1518	75.6083	<0.0001	Reject
AIG	1516	19.2105	<0.0001	Reject
APC	1491	10.8346	<0.0001	Reject
ARW	1515	17.5720	<0.0001	Reject
BA	1488	5.7822	0.0032	Reject
BNI	1465	22.9292	<0.0001	Reject
CB	1467	9.3896	0.0001	Reject
CCL	1570	26.1839	<0.0001	Reject
CAT	1498	15.2318	<0.0001	Reject
CPB	1475	4.6870	0.0094	Reject
CSC	1507	2.1810	0.1133	Accept
CAG	1490	6.1377	0.0022	Reject
COP	1465	12.8715	<0.0001	Reject
DE	1506	3.3997	0.0336	Reject
DIS	1522	9.4145	0.0001	Reject
DOW	1512	9.5109	0.0001	Reject
DVN	1460	16.8439	<0.0001	Reject
D	1509	8.4430	0.0002	Reject
DUK	1501	3.2677	0.0384	Reject
DD	1454	26.9218	<0.0001	Reject
EMN	1509	31.9114	<0.0001	Reject
FE	1501	26.4826	<0.0001	Reject
GIS	1485	3.0053	0.0498	Reject
GR	1512	9.5607	<0.0001	Reject
HAL	1413	2.7246	0.0659	Accept
HIG	1492	38.1435	<0.0001	Reject
HPQ	1494	5.7281	0.0033	Reject
HON	1513	30.2978	<0.0001	Reject
IBM	1491	38.2142	<0.0001	Reject
KFT	1518	11.9229	<0.0001	Reject
KR	1487	7.3418	0.0007	Reject
LMT	1476	1.4942	0.2248	Accept
MAR	1521	13.4211	<0.0001	Reject
MCD	1510	5.6396	0.0036	Reject
MET	1483	63.1481	<0.0001	Reject
MOT	1520	7.3404	0.0007	Reject
NWL	1492	24.9162	<0.0001	Reject
JWL	1489	14.3004	<0.0001	Reject
NSC	1463	37.4565	<0.0001	Reject
NOC	1522	5.1402	0.0060	Reject
OMC	1494	6.8976	0.0010	Reject
PGN	1498	16.5431	<0.0001	Reject
RTN	1508	12.0305	<0.0001	Reject
SWY	1508	10.1985	<0.0001	Reject
SRE	1499	51.7607	<0.0001	Reject
SPG	1494	45.5680	<0.0001	Reject
TGT	1451	15.4421	<0.0001	Reject
TWX	1518	12.0136	<0.0001	Reject
VLO	1497	6.6289	0.0014	Reject
WMT	1467	27.5064	<0.0001	Reject

Table 9: Test of Hypotheses H.1

Panel Regressions of Measures of Correlations between Equity and CDS Bid-Ask Spreads on Hedge Ratio

The regressions are estimated using restricted maximum likelihood method implemented with Newton-Raphson algorithm; Panel Dataset includes 51 Firms and 27 Quarters (from 2003:2 to 2009:4); Firm-clustered standard errors are estimated; t-statistics are reported in italic; Bayesian information criterion (BIC) fit statistics are reported.

Dependent Var.	**Pearson**	**Kendall**	**Spearman**
Explanatory Var.			
Model Specification I			
Intercept	-0.0114	0.0011	0.0023
	-1.44	*0.28*	*0.40*
Hedge Ratio SS	**0.4891**	**0.6421**	**0.9003**
	5.60	*9.41*	*9.12*
BIC	-1241.8	-1919.7	-903.9
Model Specification II			
Intercept	0.0038	**0.0090**	**0.0131**
	0.69	*2.26*	*2.28*
Hedge Ratio VX	**1.5942**	**1.4598**	**2.1583**
	4.79	*3.75*	*6.22*
BIC	-773.7	-1373.2	-694.5
Model Specification III			
Intercept	0.0280	**0.0424**	**0.06227**
	1.45	*2.92*	*2.97*
Equity Volatility	**0.0900**	**0.0938**	**0.1294**
	3.86	*5.12*	*4.88*
Log Leverage	**0.0222**	**0.0238**	**0.0342**
	3.07	*4.19*	*4.15*
BIC	-1236.1	-1888.3	-874.5
Model Specification IV			
Intercept	**0.0427**	0.0481	**0.0802**
	2.16	*1.77*	*3.57*
Equity Volatility	**0.0733**	**0.0781**	**0.1058**
	2.91	*3.96*	*3.68*
Log Leverage	**0.0219**	**0.0245**	**0.0352**
	3.00	*4.26*	*4.23*
Systematic Risk	0.0052	**0.0066**	**0.0099**
	1.27	*2.05*	*2.15*
BIC	-1201.1	-1846.0	-851.0

Table 10: Test of Hypotheses H.1 and H.2

Panel Regressions of Measures of Correlations between Equity and CDS Bid-Ask Spreads on Hedge Ratio, TED, and Risk Aversion

The regressions are estimated using restricted maximum likelihood method implemented with Newton-Raphson algorithm; Panel Dataset includes 51 Firms and 27 Quarters (from 2003:2 to 2009:4); Time and Firm Fixed Effects are included; Firm-clustered standard errors are estimated when possible; t-statistics are reported in italic; F-Tests of fixed effects (FE) use the pooled model with no firm/time FE as baseline for comparison: F-statistics and p-values (in italic) are reported; Yes=Fixed Effects included - No=Fixed Effects not included.

								Tests of FE	
Explanatory Var.	**Int.**	**Hedge Ratio SS**	**Hedge Ratio VX**	**Equity Vol.**	**Leverage**	**TED**	**Risk Aversion**	**Time FE**	**Firm FE**
Dependent Var.									
				Panel A.					
Pearson Correlation	0.0209	**0.3804**						5.38	1.25
	0.58	*2.66*						*<0.0001*	*0.1151*
	-0.0277	**0.3433**						5.40	No
	-1.22	*3.00*						*<0.0001*	
	0.0364	**0.5397**						No	1.17
	1.23	*5.55*							*0.1978*
	0.0330		0.7465					4.07	1.38
	0.76		*1.71*					*<0.0001*	*0.0605*
	0.0548			0.0669	**0.03**			5.55	1.10
	1.22			*1.77*	*1.97*			*<0.0001*	*0.2942*
	-0.0090			**0.0873**	**0.0205**			5.55	No
	-0.30			*2.85*	*2.74*			*<0.0001*	
	0.0879			**0.0727**	**0.0319**			No	1.01
	2.36			*2.55*	*2.54*				*0.4461*
	0.0813			**0.0714**	**0.0331**	0.0104	0.0011	No	1.02
	2.14			*2.40*	*2.62*	*1.14*	*0.60*		*0.4431*
				Panel B.					
Kendall Correlation	-0.0045	**0.4136**						3.99	1.62
	-0.16	*3.69*						*<0.0001*	*0.0043*
	-0.0470	**0.3898**						4.08	No
	-2.7	*4.32*						*<0.0001*	
	0.0421	**0.7146**						No	1.63
	1.83	*9.49*							*0.0042*
	0.0922		0.3557					2.71	2.04
	2.90		*1.12*					*<0.0001*	*0.0002*
	0.0836			-0.0097	**0.0451**			4.66	1.77
	2.37			*-0.33*	*3.76*			*<0.0001*	*0.0009*
	-0.0012			0.0251	**0.0191**			4.66	No
	-0.05			*1.04*	*3.23*			*<0.0001*	
	0.1232			**0.0705**	**0.0473**			No	1.72
	4.25			*3.17*	*4.83*				*0.0016*
	0.1184			**0.0586**	**0.048**	**0.0157**	-0.0003	No	1.72
	4.02			*2.54*	*4.89*	*2.22*	*-0.21*		*0.0015*

Table 11: Test of Hypotheses H.1 and H.2

Panel Regressions of Measures of Correlations between Equity and CDS Bid-Ask Spreads on Hedge Ratio, TED, and Risk Aversion (Cont'd)

								Tests of FE	
Explanatory Var. **Dependent Var.**	**Int.**	**Hedge Ratio SS**	**Hedge Ratio VX**	**Equity Vol.**	**Leverage**	**TED**	**Risk Aversion**	**Time FE**	**Firm FE**
				Panel C.					
Dependent Var.									
Spearman	-0.0011	**0.5718**						3.91	1.65
Correlation	*-0.03*	*3.52*						*<0.0001*	*0.0032*
	-0.0634	**0.5467**						3.98	No
	-2.51	*4.18*						*<0.0001*	
	0.0619	**0.9984**						No	1.64
	1.86	*9.16*							*0.0035*
	0.1386		0.5285					2.75	2.07
	3.04		*1.16*					*<0.0001*	*0.0001*
	0.1231			-0.0165	**0.0632**			4.55	1.78
	2.41			*-0.38*	*3.64*			*<0.0001*	*0.0008*
	0.0024			0.0345	**0.0273**			4.54	No
	0.07			*0.98*	*3.19*			*<0.0001*	
	0.1776			**0.0954**	**0.0672**			No	1.73
	4.24			*2.97*	*4.74*				*0.0014*
	0.1704			**0.078**	**0.0683**	**0.0231**	-0.0004	No	1.73
	4			*2.34*	*4.8*	*2.26*	*-0.21*		*0.0013*

Table 12: Test of Hypotheses H.1 and H.2
Panel Regressions of Measures of Correlations between Equity and CDS Bid-Ask Spreads on Hedge Ratio, TED, and Risk Aversion: Examination of Economic Significance of Explanatory Variables

Standardized betas are obtained by multiplying the estimated betas from Tables 9, 10, and 11 by the ratio between standard deviation of relative explanatory variable and standard deviation of dependent variable. Yes=Fixed Effects included - No=Fixed Effects not included. t-statistics from previous estimations in Tables 9, 10, and 11 are reported in italic.

Explanatory Var.	Hedge Ratio	Systematic Risk	Equity Vol.	Leverage	TED	Time FE	Firm FE
Dependent Var.							
	0.1161					Yes	Yes
	2.66						
	0.1493					No	No
Pearson Correlation	*5.60*						
			0.0818	**0.1182**		Yes	Yes
			1.77	*1.97*			
			0.1101	**0.0875**		No	No
			3.86	*3.07*			
		0.0361	**0.0896**	**0.0863**		No	No
		1.27	*2.91*	*3.00*			
	0.1585					Yes	Yes
	3.69						
	0.2461					No	No
	9.41						
			-0.0149	**0.2232**		Yes	Yes
Kendall Correlation			*-0.33*	*3.76*			
			0.09	**0.2377**	**0.0672**	No	Yes
			2.54	*4.89*	*2.22*		
			0.144	**0.1178**		No	No
			5.12	*4.19*			
		0.0576	**0.1199**	**0.1212**		No	No
		2.07	*3.96*	*4.26*			
	0.1517					Yes	Yes
	3.52						
	0.2389					No	No
	9.12						
			-0.0175	**0.2166**		Yes	Yes
			-0.38	*3.64*			
Spearman Correlation			**0.0829**	**0.2339**	**0.0685**	No	Yes
			2.34	*4.8*	*2.26*		
			0.1376	**0.1172**		No	No
			4.88	*4.15*			
		0.0598	**0.1125**	**0.1206**		No	No
		2.15	*3.68*	*4.23*			

Table 13: Robustness Check on Results Test of Hypothesis H.1

Panel Regressions of Measures of Correlation between Equity and CDS Combined Illiquidity Indexes on Hedge Ratio

The regressions are estimated using restricted maximum likelihood method implemented with Newton-Raphson algorithm; Panel Dataset includes 51 Firms and 27 Quarters (from 2003:2 to 2009:4); Time and Firm Fixed Effects are included; Firm-clustered standard errors are estimated when possible; t-statistics are reported in italic; F-Tests of fixed effects (FE) use the pooled model with no FE as baseline for comparison: F-statistics and p-values (in italic) are reported; Yes=Fixed Effects included - No=Fixed Effects not included.

					Tests of Fixed Effects	
Explanatory Var.	**Int.**	**Hedge Ratio**	**Equity Vol.**	**Leverage**	**Time FE**	**Firm FE**
Dependent Var.:						
Panel A.						
	-0.0222	**0.4945**			1.56	1.1
	-0.42	*2.35*			*0.036*	*0.2943*
	-0.0173	0.3030			1.49	No
Pearson Correlation	*-0.53*	*1.81*			*0.0547*	
	0.0212		0.0125	0.0121	1.42	1.05
	0.32		*0.22*	*0.54*	*0.0807*	*0.3893*
Panel B.						
	-0.0433	**0.3910**			1.56	1.15
	-1.19	*2.71*			*0.0356*	*0.2174*
	-0.0189	**0.2461**			1.47	No
Kendall Correlation	*-0.85*	*2.14*			*0.0617*	
	0.0134		-0.0353	0.0117	1.31	1.11
	0.29		*0.29*	*0.76*	*0.1364*	*0.2817*
Panel C.						
	-0.0638	**0.5655**			1.49	1.15
	-1.16	*2.61*			*0.0549*	*0.2172*
	-0.03	**0.3421**			1.39	No
Spearman Correlation	*-0.9*	*1.98*			*0.0913*	
	0.0209		-0.053	0.0185	1.26	1.11
	0.31		*-0.92*	*0.8*	*0.1705*	*0.2844*

Table 14: Test of Hypothesis H.2 at Market Level
(Market Prices-Augmented) VAR System Estimates

Endogenous Variables: Value-Weighted Averages of Equity and CDS Bid-Ask Spreads and Prices (2 Lags). Exogenous Variables: TED Spread and Difference between 30-days Market Implied and Historical Volatility. Sample period: March 2003 - December 2009; t-statistics reported in italic.

	CDS Bid-Ask	**Equity Bid-Ask**
CDS Bid-Ask (Lag 1)	**0.8271**	-0.5107
	11.7781	*-1.556*
CDS Bid-Ask (Lag 2)	0.0321	**0.7362**
	0.4619	*2.267*
Equity Bid-Ask (Lag 1)	-0.0014	**0.7204**
	-0.1264	*14.1705*
Equity Bid-Ask (Lag 2)	0.0088	**0.1981**
	0.8175	*3.9592*
CDS Premium (Lag 1)	0.0079	-0.0172
	1.3852	*-0.6469*
CDS Premium (Lag 2)	-0.0053	0.0065
	-0.922	*0.2425*
Equity Price (Lag 1)	-0.0003	**-0.0025**
	-1.3405	*-2.7575*
Equity Price (Lag 2)	0.0000	**0.0025**
	0.136	*2.6872*
TED	**0.0014**	**0.0084**
	2.5519	*3.233*
Risk Aversion	0.0001	**0.0007**
	1.4513	*2.9244*
Intercept	**0.0174**	-0.0075
	3.9062	*-0.3624*
Adj-R2	0.9545	0.9332

Table 15: Test of Hypothesis H.2 at Market Level (All Sample, Pre-Crisis, and Crisis Sample)
VAR System Estimates

Endogenous Variables: Value-Weighted Average Equity and CDS Bid-Ask Spreads (2 Lags). Exogenous Variables: TED Spread and Difference between 30-days Market Implied and Historical Volatility. Whole Sample Period: March 2003 - December 2009; Pre-Crisis Sub-Period: March 2003 - December 2006; Crisis Sub-Period: January 2007 - December 2009; t-statistics reported in italic.

	All Sample		**Pre-Crisis**		**Crisis**	
	CDS BA	**Equity BA**	**CDS BA**	**Equity BA**	**CDS BA**	**Equity BA**
CDS BA (Lag 1)	**0.9381**	-0.4749	**0.8789**	-0.3922	**0.8924**	-0.1751
	17.0365	*-1.9158*	*12.6916*	*-0.906*	*11.6259*	*-0.5989*
CDS BA (Lag 2)	0.0174	**0.5271**	-0.0376	0.6548	0.081	0.2401
	0.3221	*2.1664*	*-0.5907*	*1.6469*	*1.0681*	*0.8311*
Equity BA (Lag 1)	0.0019	**0.7061**	-0.0068	**0.813**	0.0143	**0.5009**
	0.1637	*13.2923*	*-0.5939*	*11.3055*	*0.7482*	*6.8758*
Equity BA (Lag 2)	0.0112	**0.2159**	**0.0409**	0.0893	-0.0109	**0.2248**
	0.9872	*4.2142*	*3.7038*	*1.2928*	*-0.6062*	*3.277*
Intercept	0.0004	-0.0033	**0.0046**	*-0.0093*	-0.0003	0.0019
	0.4154	*-0.8628*	*3.1043*	*-1.0012*	*-0.221*	*0.4064*
TED	**0.0012**	**0.0068**	-0.0007	0.0084	**0.0016**	**0.0167**
	3.2379	*4.0766*	*-0.3121*	*0.6294*	*2.1015*	*5.7628*
Risk Aversion	**0.0001**	**0.0008**	**0.0004**	-0.0002	**0.0001**	**0.0007**
	2.7901	*3.4267*	*3.9987*	*-0.4176*	*1.967*	*2.6474*
Adj. R2	0.9538	0.9074	0.9723	0.9481	0.9487	0.8337

Table 16: Test of Hypothesis H.3 for Equity Bid-Ask Spread at Firm Level
Panel Data Analysis of Determinants of Equity Bid-Ask Spread (All Sample, Weekly)

ML Estimation of Panel Regression: $Res.BA^{E}_{i,t} = \alpha_i + \beta_i\{BA^{CDS}_{i,t} * (1 - H_{i,t})\} + \zeta_i\Phi_{i,t} + \gamma_i TED_t + \delta_i RiskAdv_t + \epsilon^{E}_{i,t}$

Panel Dataset includes 51 Firms and 333 Weeks (from 15/08/2003 to 31/12/2009); Dependent Variable $Res.BA^{E}_{i,t}$: Equity Bid-Ask residual from regression on its first two lags; TED_t=Cost of funding proxied by TED spread; $RiskAdv_t$=Systematic risk shock proxied by the difference between S&P500 implied and historical volatility; $\Phi_{k,t}$=(CDS Innovation, Equity Innovation); Time and Firm Fixed Effects are included in some specifications; Firm-clustered standard errors are estimated when possible; t-statistics are reported in italic; F-Tests of time and firm fixed effects use the pooled regression model with no FE as baseline for comparison: F-statistics and p-values (in italic) are reported, Yes=Fixed Effects included - No=Fixed Effects not included. For the analysis of economic significance standardized betas are obtained by multiplying the estimated betas by the ratio between standard deviation of relative explanatory variable and standard deviation of dependent variable.

								Tests of FE	
Explanatory Var.	**Int.**	**(1-H) x CDS BA**	**CDS Inn.**	**Equity Inn.**	**TED**	**Risk Adv**	**Firm Size**	**Time FE**	**Firm FE**
Dependent Var.									
Resid.Equity BA	**-0.0049**	**0.0806**						No	No
	-7.25	*11.18*							
	0.0168	**0.0765**					**-0.0013**	No	No
	-1.72	*10.30*					*-2.23*		
	0.0332	**0.0325**						7.87	No
	4.02	*4.45*						*<0.0001*	
	-0.0051	**0.0913**						No	0.33
	-1.36	*11.88*							*0.9999*
	-0.0051	**0.0840**	**0.1849**	**-0.3899**				No	No
	-7.66	*11.71*	*7.92*	*-11.76*					
	0.0174	**0.0797**	**0.1857**	**-0.3899**			**-0.0013**	No	No
	1.80	*10.79*	*7.95*	*-11.76*			*-2.33*		
	-0.0174	**0.0533**			**0.0217**	**0.0003**		No	No
	-19.64	*7.43*			*26.29*	*3.06*			
	-0.0175	**0.0606**			**0.0216**	**0.0003**		No	0.15
	-4.72	*7.91*			*26.07*	*3.16*			*0.9999*
	0.0137	**0.0503**	**0.1361**	**-0.2869**	**0.0205**	0.0001	**-0.0017**	No	No
	1.45	*6.82*	*5.86*	*-8.68*	*24.53*	*1.31*	*-3.18*		

Economic Significance

Explanatory Var.	**(1-H) x CDS BA**	**CDS Inn.**	**Equity Inn.**	**TED**	**Risk Aver.**	**Firm i Size**	**Time FE**	**Firm FE**
Dependent Var.								
Resid.Equity BA	**0.0883**					Yes	No	No
	0.0580	**0.0500**	**-0.0698**	**0.1934**	0.0073	Yes	No	No

Table 17: Test of Hypothesis H.3 for CDS Bid-Ask Spread at Firm Level
Panel Data Analysis of Determinants of CDS Bid-Ask Spread (All Sample, Weekly)

ML Estimation of Panel Regression: $Res.BA^{CDS}_{i,t} = \alpha_i + \beta_i BA^{E}_{i,t} * H_{i,t} + \zeta_i \Phi_{i,t} + \gamma_i TED_t + \delta_i RiskAdv_t + \epsilon^{CDS}_{i,t}$

Panel Dataset includes 51 Firms and 333 Weeks (from 15/08/2003 to 31/12/2009); Dependent Variable $Res.BA^{CDS}_{i,t}$: CDS Bid-Ask residual from regression on its first two lags; TED_t=Cost of funding proxied by TED spread; $RiskAdv_t$=Systematic risk shock proxied by the difference between S&P500 implied and historical volatility; $\Phi_{k,t}$=(CDS Innovation, Equity Innovation); Time and Firm Fixed Effects are included in some specifications; Firm-clustered standard errors are estimated when possible; t-statistics are reported in italic; F-Tests of time and firm fixed effects use the pooled regression model with no FE as baseline for comparison: F-statistics and p-values (in italic) are reported, Yes=Fixed Effects included - No=Fixed Effects not included. For the analysis of economic significance standardized betas are obtained by multiplying the estimated betas by the ratio between standard deviation of relative explanatory variable and standard deviation of dependent variable.

								Tests of FE	
Explanatory Var.	**Int.**	**H x Equity BA**	**CDS Inn.**	**Equity Inn.**	**TED**	**Risk Adv**	**Firm Size**	**Time FE**	**Firm FE**
Dependent Var.									
Resid.Equity BA	**-0.0007**	**0.2339**						No	No
	-4.23	*10.91*							
	0.0161	**0.2085**					**-0.0010**	No	No
	5.36	*9.52*					*-5.62*		
	0.0007	**0.0878**						4.46	No
	0.25	*3.25*						*<0.0001*	
	-0.0005	**0.2510**						No	0.17
	-0.46	*11.28*							*0.9999*
	-0.0007	**0.2234**	**0.1591**	**-0.0649**				No	No
	-4.28	*10.58*	*21.97*	*-6.31*					
	0.0175	**0.1957**	**0.1600**	**-0.0661**			**-0.0011**	No	No
	5.93	*9.08*	*22.11*	*-6.43*			*-6.19*		
	-0.0029	**0.2000**			**0.0024**	**0.0003**		No	No
	-11.41	*8.46*			*8.54*	*8.68*			
	-0.0027	**0.2182**			**0.0023**	**0.0003**		No	0.13
	-2.31	*8.82*			*8.19*	*8.80*			*0.9999*
	0.0174	**0.1584**	**0.1506**	**-0.0510**	**0.0020**	**0.0002**	**-0.0012**	No	No
	5.89	*6.64*	*20.58*	*-4.90*	*7.05*	*5.42*	*-6.69*		

Economic Significance

Explanatory Var.		**H x Equity BA**	**CDS Inn.**	**Equity Inn.**	**TED**	**Risk Aver.**	**Firm i Size**	**Time FE**	**Firm FE**
Dependent Var.									
Resid.Equity BA		**0.0797**					Yes	No	No
		0.0606	**0.1766**	**-0.0396**	**0.0603**	**0.0047**	Yes	No	No