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 what mechanisms. Equity and CDS illiquidity co-movements are detected for a large sample of firms, but the extent of the *illiquidity commonality* changes over time and increases over crisis periods. For most firms illiquidity *spills over* from one market (CDS) to the other (equity).

We view equity and credit default swaps as claims written on the same underlying firm's assets and show that, besides the effect of traders' funding constraints, market volatility, and firm's systematic risk the equity-CDS illiquidity co-movements are strongly related to the *debt-to-equity hedge ratio* (based on the Merton 1974 model). The hedge ratio captures the arbitrage linkage between the two assets and the extent of cross-market activity of traders for hedging and speculative purposes and contributes to explain the existence of cross-market illiquidity spillovers.

The paper sheds some lights on how the demand of liquidity for hedging and speculative trading across two *fundamentally-linked* assets can generate and enhance cross-market contagion phenomena besides the well-documented effects of volatility and shortage of liquidity supply.

Keywords: Credit Default Swap, Equity, Bid-Ask Spreads; Illiquidity Commonality; Illiquidity Spillovers; Hedging; Capital Structure Arbitrage; Merton (1974) Model.

1 Introduction

This paper examines whether a lack of liquidity (*illiquidity*) spreads across equity and credit markets and, if so, through what mechanisms. Although the study of such commonality has important implications for asset pricing and risk management, the extent and causes of the cross-market illiquidity propagation have not yet been reported in the literature.

Structural models based on Merton (1974) view the equity of the firm as equivalent to a long call position on the firm's assets and the risky debt of the firm as a short put position on the firm's assets plus a long position on a riskless bond[1]. As a result, equity and credit markets have strong inter-linkages. In addition, the increased use of credit default swaps and equity for hedging risky positions and for arbitrage trading brings the relationship between these two assets even closer[2] and raises the possibility of illiquidity spreading from one market to the other. Studying CDS-equity illiquidity commonality is important to understand whether, when, and to what extent, more integrated markets might be less safe.

The rapid growth of the (over-the-counter) credit default swap market[3] in the last ten years has fueled a large amount of literature on the relationship between equity, debt, and credit default swaps. Some papers have provided evidence of: lead/lag relationships between returns in CDS, equity, and bond markets (Norden and Weber, 2009; and Marsh and Wagner, 2010); CDS and bond spreads' dependence on equity liquidity risk (De Jong and Driessen, 2005; and Das and Hanouna, 2009); time-varying integration between equity and CDS markets (Kapadia and Pu, 2012); effects of credit news and CDS market insider trading on the equity market (Acharya and Johnson, 2007; and Qiu and Yu, 2012); and volatility contagion across CDS, bond, and equity (Meng, Ap Gwilym and Varas, 2009). The findings of these studies support the hypothesis that, as investors trade across different asset classes, the link between CDS, bond, and equity markets strengthens. A few researchers have attempted to detect the existence of illiquidity co-movements across equity, CDS, and bond markets (Tang and Yan, 2006; and Jacoby, Jiang and Theocharides, 2009), but have not provided any insight or explanation for this phenomenon.

The literature lacks therefore an accurate and comprehensive investigation of the extent and causes of credit-equity illiquidity linkages. Our study fills this gap: the paper examines whether there is robust evidence of CDS-equity illiquidity commonality, investigates its dynamics and sets out an appropriate framework to explain its determinants. The research question of this paper is interesting

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[1] The theory behind the Merton (1974) model is explained in Appendix B.

[2] See Meng et al (2009).

[3] The CDS market has grown rapidly in the last decade. CDS gross notional amount outstanding increased from about US$10 trillions in 2005 to around US$60 trillions at its peak in 2007 (Bank for International Settlement Data). The main reason for the CDS market growth is that entering in a new CDS is the easiest way for a trader/investor to adjust her exposure to credit risk, rather than operating directly in the bond market or canceling CDS agreements already in place. Despite the financial crisis, the total gross notional amount was still around US$30 trillions in mid-2009 (BIS - Bank for International Settlement: Foreign exchange and derivatives market activity in 2007 - Triennal Central Bank Survey - December 2007; OTC derivatives market activity in the first half of 2009 - Monetary and Economic Department - November 2009). Further discussion is provided by Meng, ap Gwilym and Varas (2009), amongst others.

for academics, but is also of particular interest for investors engaged in cross-market trades, for risk managers, and for regulators. The co-movement of assets' illiquidity has in fact major implications for portfolio management, financial risk management and derivatives pricing.

We define the illiquidity commonality variable as the positive co-movement between equity and CDS bid-ask spreads (using the Kendall measure of association) and analyze 51 U.S. investment-grade firms over the period April 2003 - December 2009. 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 recent crisis period 2007-2009.

In this paper, we differentiate the concepts of *illiquidity commonality* (also defined as co-movement) and *illiquidity spillover* (also defined as contagion). Illiquidity commonality is the common surge of illiquidity in equity and credit assets, while illiquidity spillovers comprise the transmission of illiquidity shocks from one asset to the other. Illiquidity spillovers imply illiquidity commonality, but illiquidity commonality does not necessarily imply the existence of spillovers[4].

We test for the existence of illiquidity spillovers employing Granger causality and Vector Autoregressive tests. We find that for most firms illiquidity is transmitted across markets either from CDS to equity or in both directions: it is rare to observe a one-way transmission from equity to CDS. We notice that the direction of the illiquidity spillovers at firm level has no one-to-one correspondence with the direction of return spillovers and only for one third of firms does it follow the direction of volatility spillovers[5]. In addition, we analyze how market illiquidity and firm volatility affect equity and CDS bid-ask spreads. At the individual firm level we find that CDS and equity illiquidity are influenced by general market illiquidity, but for most firms the CDS bid-ask spread is also significantly affected by the volatility of the firm's assets.

These findings suggest that for the majority of firms different sets of information appear to be anticipated in one market and then transmitted to the other. In particular, extreme shifts in beliefs that generate higher firm's volatility and/or increase in bid-ask spreads appear to be detected first in the CDS market and then transmitted to the equity market. The asymmetric exposure of CDSs and equities to shocks in the firms' asset volatility and the existence of illiquidity spillovers running mainly from CDS to equity suggest the existence of a channel of illiquidity transmission based on information flows and trading activity across equity and credit markets.

While the existing literature (to the best of our knowledge) does not offer any theoretical model of illiquidity contagion based on informational or fundamental linkages between markets, it instead provides models of illiquidity commonality based on negative shocks to traders' income, costs of

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[4] In fact, both equity and credit may be influenced by the same exogenous factors causing an increase in their respective illiquidity, without generating illiquidity transmissions across the two markets.

[5] For all firms, return and price spillovers run from equity to CDS; for 40% of the firms volatility spillovers run from CDS to equity.

funding and market volatility. For example, the early literature on limits to arbitrage (Schleifer and Vishny, 1997; Kyle and Xiong, 2001; Xiong, 2001; and Gromb and Vayanos, 2002) argues that the wealth constraints experienced by traders give rise to the withdrawal of market liquidity in all markets where traders hold active positions, thereby increasing cross-market illiquidity commonality. Similarly, the Brunnermeier and Pedersen (2009) model shows how the ability of traders to provide market liquidity across multiple markets depends on the availability of funding. The Gromb and Vayanos (2010) model shows 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 of all her opportunities. Comerton-Forde et al (2010), Gârleanu and Pedersen (2011), Hameed et al (2010), and Ben-David et al (2012), amongst others, provide empirical evidence for these theories.

Following this stream of literature, our paper detects a significant positive effect of funding constraints and market volatility on equity-CDS illiquidity commonality. However, it also proposes and tests an additional channel of illiquidity propagation. Equity and credit are fundamentally related since they both represent claims written on the same underlying firm's assets. Consistently, we observe that the prices in the equity and credit markets co-move substantially over time[6]. The debt-to-equity hedge ratio measures the sensitivity of debt (or credit) claims to changes in the value of equity. When the credit conditions of a firm worsen and the firm's assets are more volatile, the hedge ratio increases. This means that credit and equity markets become more integrated and closer substitute of each other. Thus, one might expect their liquidity to be linked more strongly: both dealers in equity and CDS would respond to negative news about the firm by raising equity and CDS bid-ask spreads. However, this mechanism would not induce illiquidity spillovers across the two markets, but only illiquidity co-movements.

In order to justify the existence of illiquidity spillovers (running mainly from CDS to equity) the paper moves further to examine trading mechanisms across the two markets. An increase in the hedge ratio translates in larger trading needs for investors who hold simultaneous positions in the CDS and equity claims of the same firm. Who are these investors and why their trading activity may cause illiquidity contagion across CDS and equity? One category of traders we consider are the "informed" CDS dealers (mainly banks) hedging their CDS exposures in the equity (or equity option) markets. These CDS dealers take advantage of being informed about the credit risk of the firm-client: when the firm's hedge ratio is larger and the demand for its CDS is higher, the CDS dealers who supply liquidity take larger position in the equity of the firm in order to remain covered from the higher credit risk. The additional cost of hedging is then recovered by the CDS dealers by increasing the CDS bid-ask spread in proportion to the equity bid-ask spread they have to pay. The implication of this story is that when the size of the hedge ratio increases (and this should be also large enough to have any recognizable effect): (i) negative information about the firm is transmitted from the CDS to the equity market; (ii) the cost of hedging becomes a more important component of the CDS bid-ask spread; and (iii) CDS and equity bid-ask spreads become more highly correlated.

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[6] See Figure 1 displaying a close positive relationship between average CDS premium and inverse of average equity price for the firms in our sample.

Another category of "informed" traders we consider are the capital structure arbitrageurs (CSAs). The CSAs possess private information about the fundamental value of the firm, therefore they can observe any CDS mispricing and take positions across the CDS and equity markets (in proportion to the size of the hedge ratio) in order to profit from it. When the default risk of a firm is already high, a larger hedge ratio may cause: a contraction in the liquidity provisions from "informed" CDS dealers, a liquidity shock in the CDS market, the rise of a CDS mispricing and an increase in cross-market liquidity demand from CSAs. The "uninformed" dealers in the equity and CDS markets protect themselves from the informed liquidity demand of CSAs by raising equity and CDS bid-ask spreads[7].

Therefore, higher hedging and arbitrage trading from "informed" traders may induce illiquidity spillovers across CDS and equity markets. This mechanism should be reflected in a positive linkage between the hedge ratio and the illiquidity commonality variable. We define this hypothesis as the *Arbitrage/Hedging Channel of Illiquidity Commonality* across equity and CDS markets. We use a panel analysis to test this hypothesis and find that the hedge ratio (estimated from the Merton model[8]) is a main determinant of the positive increase in the Kendall measure of association between CDS and equity bid-ask spreads. Its contribution remains economically and statistically significant even after controlling for funding illiquidity, systematic risk factors, and market volatility.

Since this arbitrage/hedging channel contributes to a common increase in equity and CDS bid-ask spreads, we should observe its effects also on the CDS bid-ask spreads alone. Therefore, in order to provide further evidence in favour of this channel, we examine the determinants of CDS bid-ask spreads. After controlling for the effects of the cost of funding and market volatility, we confirm that hedging costs and informed trading flows across CDS and equity markets (indicative of sophisticated arbitrage trading) significantly increase CDS bid-ask spreads.

The rest of the paper is organized as follows. Section 2 describes the data employed and carries on statistical analysis to detect equity-CDS illiquidity co-movements. Section 3 presents preliminary analysis on illiquidity, return, and volatility spillovers. Section 4 explains the arbitrage/hedging channel of cross-market illiquidity transmissions and formulates the main hypothesis to be tested. Section 5 performs the test and illustrates its results. Section 6 analyses the determinants of CDS bid-ask spreads. Section 7 concludes.

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[7] This argument implies the existence of CDS dealers with heterogenous level of information. As explained in Section 4, different institutions can act as CDS (e.g., banks or insurance firms). Banks have potential access to private credit information of their clients, whereas other CDS dealers are more limited in accessing firms' information. See also Qiu and Yu (2012).

[8] Two main reasons support the use of the Merton (1974) model to estimate the sensitivity of debt to equity (hedge ratio). First, sophisticated investors rely on structural models to perform arbitrage trading across equity and credit markets. Capital-structure arbitrageurs — mainly hedge funds — use in fact modified implementations of Merton's model (the most popular proprietary models are Moody's KMV and RiskMetrics' CreditGrades). Second, the empirical literature has found that the simple Merton model can be correctly used to predict and hedge firms' credit risk exposure (Schaefer and Strebulaev, 2008).

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

In this Section we perform an analysis of co-movements between equity illiquidity and CDS illiquidity using equity and CDS percentage bid-ask spreads[9]. 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). The CDX.NA.IG index is composed of 125 firms; however, 51 companies (6 financial and 45 industrial firms) remain after excluding those recording missing values in the CDS price series for more than 20 consecutive days. We include only investment-grade firms in our sample, as they do not suffer from distress or restructuring events over the period considered. These companies have large market capitalization and are typically followed by a large number of analysts. Thus, their stocks are typically more liquid than the stocks of small and distressed firms. 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. The sample period goes from April 2003 to December 2009. The CRSP stock dataset includes all transactions and quotes from NYSE, AMEX, and NASDAQ. Daily quotes and prices for CDSs are available on Bloomberg. We use only CDS contracts with a maturity of five years because the trading liquidity is highest in this maturity. The CDS data provided by Bloomberg are daily price information contributed by some of the leading market participants. Bloomberg constructs a composite quote called Bloomberg Generic, which reflects the arithmetic average across the CDS spreads offered by various market participants[10]. Bid and ask prices are daily averages of market quotations, rather then transaction-based prices. This has some advantages, as highlighted by Völz and Wedow (2009). Firstly, the Bloomberg Generic time series covers a wide range of CDS price information from various participants, rather than broker-specific information that might not reflect true conditions of the inter-dealer market. The average has the advantage that prices are not distorted by the evaluation of a single market participant. Secondly, while some CDSs may be rarely traded, the indicative quotes reflect a broader picture of market activity. Appendix C.1 provides details of the treatment and filtering of the data employed.

In Figures 2, 3, and 4 the normalized percentage equity and CDS bid-ask spreads are compared over the whole sample and in two sub-samples, before and during 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 aggregate equity and CDS bid-ask spreads at weekly frequency over the whole sample (April 2003 - December 2009).

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[9] 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 (converted in percentage units), while for equity bid-ask spread we used the ratio between quoted bid-ask spread and midquote price (measured in percentage units). Most prior literature has examined illiquidity using different proxies (for trading costs, trading frequency or trading impact on prices) for each specific market (Spiegel 2008). In Appendix C.2 we ascertain that the percentage bid-ask spread can be an informative measure of illiquidity for both equity and CDSs. We construct a number of illiquidity proxies at weekly frequency (Amihud measure, Roll measure, effective spread, percentage bid-ask spread, run length and inverse turnover index) and then perform Principal Component Analysis across all of them.

[10] When calculating the generic time-series, Bloomberg excludes the infrequent quotes, but not the outliers.

On average, the equity bid-ask spread is larger and more volatile than the CDS bid-ask spread[11].

Table 2 shows Pearson, Kendall's Tau and Spearman's Rho measures of correlation between average equity and CDS bid-ask spreads[12]. The three estimated correlations are used as alternative measures of illiquidity 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[13]. The correlations between average equity and CDS bid-ask spreads 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 measures of correlation (averaged over time) 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 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 5 illustrates the cross-sectional averages for the three measures of correlation between equity and CDS bid-ask spreads calculated over each quarter. The average quarterly 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 evidence of illiquidity commonality across equity and CDSs, using different measures of the association between equity and CDS bid-ask spreads of 51 firms. However, the illiquidity co-movement varies over time and becomes more prominent over periods of higher market turbulence, such as in 2003 and in 2007-2009.

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[11] Our result contradicts the finding of Hilscher et al (2011). They show that the CDS bid-ask spread is higher than the equity bid-ask spread on average and speculate that informed trading privileges the most liquid market (i.e. the equity market). Following this conjecture our finding should instead support the hypothesis that informed trading takes place in the CDS market (as in Acharya and Johnson, 2007). See discussion in 3.2.

[12] The average is calculated as value-weighted average, with weights equal to the firms' market capitalization levels.

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

3 Drivers of Equity-Credit Illiquidity Commonality

Statistical analysis has detected the existence of illiquidity commonality across equity and CDS bid-ask spreads and found that the co-movement is substantial during crisis periods. The next step of the analysis is to investigate on: (1) the existence (and direction) of any illiquidity spillover across equity and CDS markets; and (2) the sources of the illiquidity co-movement.

While the simultaneous increase in equity and CDS bid-ask spreads might be the consequence of a rational response of dealers in segmented equity and CDS markets to market-wide frictions or to adverse movements in the firm's fundamentals (for example, an increase in asset volatility or a decrease in asset quality), the existence of illiquidity spillovers (in one or both directions) could also be ascribed to information flows and trading patterns across equity and CDS markets.

3.1 Illiquidity Spillovers

We test for the existence of illiquidity spillovers across equity and credit markets for the 51 firms in our sample 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 and then four lags. The sample period runs from April 2003 to December 2009. We also perform vector autoregressions (VAR) at the individual firm level for daily equity and CDS bid-ask spreads and prices. The VAR analysis can however detect only lead/lag relationships and not causality across equity and CDS markets.

Table 4 shows the results of the Granger causality tests between CDS and equity bid-ask spreads including 2 lags: the causality runs from CDS to equity for 26 firms and in both directions for 21 firms (but for 13 of these firms the evidence of casuality running from CDS to equity is much stronger than the other way round). When we increase the number of lags to 4 we find even stronger evidence in favour of CDS-to-equity causality (for 34 firms). Since the causality relationship may be (but not necessarily is) reflected in the "lead" of the CDS market on the equity market over time, we perform VAR analysis on daily individual firms' CDS and equity bid-ask spreads and prices to obtain additional results in terms of illiquidity spillovers. The lags included in the VAR are set using the Schwartz information criterion. The VAR tests show that, after controlling for past prices effects, lead/lag illiquidity connections between equity and CDS markets exist for 45 firms over 51. For 13 firms lagged values of CDS bid-ask spreads affect current equity bid-ask spread but not the other way round; for 8 firms lagged values of equity bid-ask spread affect current CDS bid-ask spread but not the other way round; while for 24 firms both effects are present[14]. The VAR results are quite

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[14] Detailed results of VAR analysis at firm level are not reported for brevity, but they are available upon request. VAR analysis has been also performed on prices and on returns (without bid-ask spreads). In all cases we detect price and return influences across both markets. This evidence offers some support to Cespa and Foucault (2011) theory that illiquidity spillovers might be explained by dealers' attention to prices across markets. However, their behavioral explanation may result incomplete or insufficient when the markets analyzed share common fundamentals. Equity and CDS illiquidity commonality might be explained by rational dealers' attention to common fundamentals affecting prices in both markets, rather than by their passive attention to prices across market. Moreover, the idea of separate trading over segmented markets can be challenged by the hypothesis of traders taking positions in both markets for arbitrage and hedging purposes.

conservative because the VAR performs controls also on past price effects. However, the VAR tests show that there are illiquidity connections across the two markets and the Granger causality tests detect a more pronounced evidence of contagion running from CDS to equity.

3.2 Return and Volatility Spillovers

Next, we want to gather some preliminary evidence on possible sources of cross-market illiquidity spillovers. We start by analysing the effects of a worsening of firm's asset quality. This phenomenon can in fact trigger an increase in both CDS and equity bid-ask spreads. At the same time, it also causes an increase in the firm's CDS premium and a decrease in its equity price. If the same information on asset quality is impounded in both returns (prices) and bid-ask spreads, consistently with the results on illiquidity spillovers' direction, we should observe stronger evidence of CDS returns (premia) Granger causing equity returns (prices) than the other way round. Therefore, we examine the causality relationship between equity and credit returns for each company in the sample. We find that for almost all firms equity returns Granger cause CDS returns, but not the other way round (see Table 5). The same results are found using equity returns calculated on either transaction prices or midquote prices and for equity-CDS prices (results unreported for brevity, but available upon request)[15].

Additionally, we study the relationship between CDS and equity volatility. A surge in equity (CDS) volatility might result in an increase in equity (CDS) bid-ask spread which then spills over. All volatilities are computed at daily frequency as exponentially-weighted moving average volatilities on a rolling window of 120 days of CDS and equity return data. The results from the Granger causality tests in Table 6 show that higher CDS volatility drives higher equity volatility more frequently than the other way round (in 18 cases versus 5, while for 16 firms volatility spillovers are detected in both directions). However, at individual firm level, the results on the direction of Granger causality for CDS-equity bid-ask spreads and volatilities match only for one third of the firms in the sample[16]. Therefore, the volatility spillovers do not appear to be the only drivers of the illiquidity spillovers.

These findings suggest that illiquidity spillovers across equity and credit markets are not simply a by-product of return spillovers and volatility spillovers. They also suggest that for some firms different sets of information might be anticipated in one market and then transmitted to the other. For example, while new information affecting the average performance of the firm may be firstly incorporated in the equity returns/prices and then transmitted to the CDS returns/premia, more extreme shifts in beliefs that generate higher firm's volatility and/or increase in bid-ask spreads may be detected first in the CDS market and then transmitted to the equity market.

The contingent-claim approach offers some support to this conjecture. According to the Merton (1974) model, the equity of an investment-grade firm (as those in our sample) corresponds to an

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[15] This result is consistent with the result of Norden and Weber (2009) who find that equity returns lead CDS price changes much more frequently than the other way round.

[16] For 12 firms both the illiquidity spillovers and the volatility spillovers run from CDSs to equity. For 6 firms both the illiquidity spillovers and the volatility spillovers run across markets in both directions.

in-the-money option written on the underlying firm's assets; while the CDS is equivalent to a deep out-the-money put option with same underlying. Zhou (2005) finds that in-the-money options attract investors who possess mild firm-specific information, while deep out-of-the-money options catch the attention of those who possess more extreme information. Moreover, Acharya and Johnson (2007) find that CDS can lead equity when there is bad news about the company; Qiu and Yu (2012) show that most of the information flow from the CDS to the equity market takes place before a firm's adverse credit events; and Marsh and Wagner (2010) find that the CDS market lags the equity market in pricing good news about the general economy, but it quickly impounds firm-specific bad news.

From the Granger causality tests reported in Tables 5 and 6, CDS volatility appears to spill over to equity volatility, while equity returns spill over to CDS returns. Since the empirical literature suggests that volatility is more affected by past negative news than by past positive news (see, for example, Dufour et al, 2008)[17], our results are compatible and consistent with the hypothesis of the CDS market quickly impounding (extreme) bad news about the firm and transmitting it to the equity market. How the negative information and the illiquidity are transmitted from CDS to equity markets remains an object of our investigation. In Section 4 we suggest the possibility of a trading channel connecting CDS and equity markets.

3.3 Market-specific vs Firm-specific Drivers of CDS and Equity Illiquidity

The final test we perform in this Section aims at disentangling the separate contributions of market-specific and firm-specific factors to CDS and equity bid-ask spreads. We define *market-specific* sources of illiquidity as those frictions which might affect the transaction costs of different assets within the same market (i.e. stocks of different companies, or CDSs issued on the debt of different companies). We define instead *asset-specific* sources of illiquidity as the variables that might affect both equity and CDS contract of a firm as claims written on the underlying firm's assets.

According to the contingent claims approach of the structural models (see Appendix B), when a firm's asset volatility increases its equity price decreases while its CDS premium increases. The effect of asset volatility could be extended — in theory — to CDS and equity bid-ask spreads: one may conjecture that when firm's asset volatility increases, dealers rationally increase CDS and equity bid-ask 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.

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[17] Chen and Ghysels (2011) find that moderately good (intra-daily) news reduces volatility (the next day), while both very good news (unusual high intra-daily positive returns) and very bad news (negative returns) increase volatility, with the latter having a more severe impact. Additionally, the ARCH literature has assessed that negative equity returns lead to higher impact on future volatility than positive returns (see the reviews by Bollerslev, Engle and Nelson, 1994; and Andersen, Bollerselv, Christoffersen and Diebold, 2006). Recent work has also found evidence of this relationship using high frequency returns (see Bollerslev, Litvinova and Tauchen, 2006; Barndorff-Nielsen, Kinnebrock and Shephard, 2010; and Visser, 2008). Patton and Sheppard (2011) also find that future volatility is much more strongly related to the volatility of past negative returns than to that of positive returns.

To verify this conjecture we test separately for the CDS and equity of each firm whether the bid-ask spread is affected by market and/or asset-specific factors. We perform regressions of the CDS (equity) bid-ask spread on CDS (equity) market average illiquidity and the firm's asset volatility. Newey-West standard errors (robust to heteroskedasticity and serial correlation) are computed using GMM. The firm's asset variance is estimated as in Schaefer and Strebulaev (2008), from a linear combination of firm's equity variance, debt variance, and covariance between equity and debt returns, with weights depending on the firm's leverage ratio (see Appendix B). We perform this regression only for the 45 industrial firms in our sample and exclude the financial firms, given the different nature of their balance sheets.

The regressions reveal that for all firms equity and CDS bid-ask spreads are affected by average market illiquidity; however, while for 22 firms out of 45 (half the sample) the CDS bid-ask spread is also strongly positively affected by the firm's asset volatility, for 80% of the sample this variable has no significant positive effect on the equity bid-ask spread (see Table 7)[18]. In (unreported) regression analysis on CDS and equity prices, we find for a larger number of firms a significant effect of asset volatility on the CDS premium, than on the equity price, after controlling for aggregate market effects[19]. These results suggest an asymmetric response of the two markets to firm-specific asset volatility shocks: they have a larger impact on CDS liquidity and CDS price than on equity. These results may reflect the CDS's nature as a deep out-the-money put option written on the firm's assets with larger exposure to volatility risk. Moreover, they may suggest that asset volatility shocks can be a source of illiquidity spillovers from CDS and equity, rather than of simultaneous (independent) illiquidity increases in CDS and equity.

3.4 Summary of the Preliminary Results

Our analysis so far has shown that: (i) bid-ask spreads on individual firms' equities and CDSs are closely related, particularly in turbulent periods; (ii) there exist CDS and equity illiquidity spillovers which travel for most firms from the CDS to the equity market and do not perfectly reflect the direction of returns and volatility spillovers across the two markets; (iii) for almost all firms equity returns spill over to CDS returns, while for a large number of firms volatility spillovers display the opposite direction; and (iv) for 50% of the firms asset volatility has a positive influence on CDS illiquidity, while only for 20% does it affect equity illiquidity (after controlling for the general level of their market illiquidity).

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

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

4 Arbitrage/Hedging Channel of Illiquidity Commonality across Equity and CDS Markets

The preliminary results in Section 3 suggest that negative firm-specific information and illiquidity are incorporated first in the CDS market and then transmitted to the equity market. In this second part of the paper we investigate possible channels of transmission.

The first (and simplest) hypothesis is that equity dealers look at the CDS market in order to capture negative shocks in the firm's riskiness (measured by the firm's asset volatility) and then set equity bid-ask spreads accordingly. Cespa and Foucault (2011) model of dealers' attention to cross-market prices proposes a similar channel of illiquidity spillovers. This hypothesis would be consistent with the results in Tables 6 and 7 (CDS illiquidity increases after negative shocks in asset volatility and then is propagated to the equity market). However, it would conflict with the results of the Granger causality tests between equity and CDS prices in Table 5. If the CDS market can capture better any shock to the firms' riskiness, then the CDS premia should be found a driving source of information for equity prices at least for some firms (i.e. the CDS market should lead the equity market in price discovery). However, Table 5 suggests the opposite: for all firms the equity price Granger causes the CDS premia and not the other way round.

So far we have confined the possible explanation for equity-CDS illiquidity spillovers to a world of "segmented traders" who are allowed to look at prices and spreads across CDS and equity markets, but not to take positions across markets. In this Section we instead consider CDS-equity information flows and trading activity as channel of illiquidity transmission. In particular, we attempt to understand: (1) which kind of traders engage in (and react to) cross-market trading activity; and (2) how they can trigger illiquidity spillovers across CDS and equity markets.

4.1 Some Basic Facts on CDS and Equity Market Microstructure

In normal times, equity and CDSs are highly liquid markets. In particular, the CDS market is much more liquid than its underlying corporate bond market. Thus, it is the market to which investors are more likely to turn when they want to take long or short credit positions for relatively limited time[20]. While the traders' composition in the equity market is very heterogeneous, the CDS market is mainly a trading venue for speculative and hedging activity of institutional investors. For example, hedge funds and private equity firms use CDSs for a variety of trading strategies (popularly known as *capital structure arbitrage*) that attempt to arbitrage across equity and credit markets[21].

Dealers in CDS and equity markets are different. The CDS market is a bilateral dealership over-the-

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[20] The corporate CDS market has nearly outsized the bond market: in September 2009 it has reached USD 9.7 trillion versus USD 10.0 trillion for their long-term debt securities (BIS, Quarterly Review, March 2010).

[21] Hedge funds constitute a major force in the CDS market. Between 2004 and 2006 they doubled their market share and with 30% of volume traded on both sides of the market, they became the second largest group of participants in the CDS market, after banks (British Bankers Association, 2006).

counter market, with no centralized quote disclosure mechanism and with a less than fully competitive network of (private) dealers, usually controlled by a group of major banks[22]. In the CDS market many banks act as dealers by posting bid and ask quotes for CDS protection. Apart from their role as dealers, banks use CDSs also for managing the risk connected to their own loan exposure (and they are net buyers of CDS protection)[23]. Therefore, some of the dealers in the CDS market potentially have access to companies' private credit information. The role of the dealers in the equity market is much less ambiguous, as they are liquidity-providers with no particular information advantage on the stocks for which they provide a market. Moreover, stocks are exchange-traded and all dealers can access a centralized and transparent quote disclosure mechanism.

Despite their differences, in both CDS and equity markets the fundamental role of the dealers is to provide liquidity in the relative assets. The dealer buys a security on her own account (at the bid price) or sell a security from her own account (at the ask price). The bid-ask spread is the cost of a round-trip transaction and also represents the compensation earned by the dealer for providing liquidity. Dealers try to make a profit by maximizing the spreads they earn, given the volumes traded and the costs they have to bear. Below we analyse some of these dealership costs and their possible effects on the commonality in equity and CDS bid-ask spreads.

4.2 The Behaviour of Traders across CDS and Equity Markets

Let us consider the three groups of agents examined in most market microstructure models: i) risk-averse dealers; ii) uninformed risk-averse noise traders; and iii) well-informed risk-neutral arbitrageurs. In the CDS market the dealers can be informed or uninformed agents, while noise traders are uninformed agents mostly demanding CDS protection[24]. In the equity market both dealers and noise traders are uninformed agents. Noise traders trade mainly for liquidity reasons. Arbitrageurs acquire and analyse public and private information (at a cost) to discover the "fair" value of the assets, the "correct" hedge ratio between the two markets, and how they vary over time. In this way, they can recognize immediately when prices in the equity and CDS markets are inconsistent and trade in order to profit from the mispricing.

Let us analyse what happens when a firm's credit condition worsens[25]. We begin by considering the interaction between noise traders and dealers in the CDS market and the hedging needs of CDS dealers. Then, we turn to examining the interaction between arbitrageurs and dealers in the CDS and equity markets. When the credit risk of a firm is higher, its debt-to-equity hedge ratio increases.

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[22] According to a survey by Fitch (2009) conducted amongst 26 banks which play a major role in the CDS market, the 5 largest banks are responsible for 88% of notional amount bought and sold.

[23] Banks' trading activity constitutes respectively 33% and 36% of total sold and bought volume of CDSs. Banks' loan portfolio activity represents instead 7% of total sold volume of CDS, and 18% of total bought volume. On the sell side of the CDS market insurance companies are also particularly active and provide around 18% of total CDS supply (British Bankers Association, 2006).

[24] For example, bond market investors with passive hedging demand can be considered noise traders in the CDS market. CDS dealers are net sellers of CDSs to noise traders.

[25] This expository choice is consistent with the observation that CDS-equity illiquidity commonality appears mainly during crisis periods, when firms' credit conditions worsen. We are currently working on the formalization of the model which in this version of the paper is described only qualitatively.

Noise traders demand more CDS insurance to protect themselves against the higher likelihood of the firm's default and losses on their bond positions. Qiu and Yu (2012) find that higher hedging demand from noise traders triggers more supply from informed CDS dealers (ahead of possible credit events) when the market is relatively calm. At this time the information flows from CDS to equity is at the highest level. Instead, during turbulent periods (that precede steep increases in firms' CDS premia and hedge ratios), fewer CDS dealers remain available to supply liquidity in the CDS market.

Consistent with Qiu and Yu (2012) result, we consider two possible scenarios:
Scenario (1): When the firm's default risk increases, the CDS dealer provides liquidity supply to match the increased demand of CDS protection from noise traders. Being risk-averse, the CDS dealer hedges her short CDS position (say X) by shorting the corresponding equity (for an amount equal to hX)[26]. The implicit cost of the hedging is the bid-ask spread of equity multiplied by the hedge ratio ($h \times Equity^{BA}$). This hedging cost is recovered by the dealer from the bid-ask spread she sets in the CDS market[27] (CDS^{BA}). This cost is naturally higher when she faces an increasing demand for CDS protection from CDS noise-"buyers". One implication of this story is that when the size of the hedge ratio increases (and this should be also large enough to have any recognizable effect): (i) negative information about the firm is transmitted from the CDS to the equity market; (ii) the cost of hedging becomes a more important component of the CDS bid-ask spread; and (iii) CDS and equity bid-ask spreads become more highly correlated.
This *hedging channel* can be a source of CDS-equity illiquidity spillovers[28,29].

Scenario (2): Qiu and Yu (2012) show that when the firm's default event is extremely likely, the hedge ratio is very high and hedging is increasingly difficult, the informed CDS dealers leaves the market to (fewer) uninformed CDS dealers. The reduction of CDS supply, while demand for CDS protection is high, may generate a supply-demand imbalance in the CDS market and a mispricing between CDS and equity (i.e. CDS premia above their fair value). This mispricing may fuel arbitrage trading across CDS and equity for a specific firm (so-called capital structure arbitrage)[30]. If the well-informed arbitrageurs (e.g., hedge funds) believe that the credit spread observed for a specific

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[26] The bigger is h, the more difficult is to hedge a CDS position, as this requires an increasing position in equity. However, when h increases, the incentive to hedge CDS position in the equity increases as well.

[27] Once the dealer closes her CDS position, she also closes her equity position and pays the bid-ask spread to the equity dealer as cost of the round-trip transaction.

[28] It is also a potential channel for the illiquidity spillovers asymmetry. When the hedge ratio h is very high, it is easier to hedge equity positions with CDSs than the other way around. Therefore we should expect a stronger effect of spillovers from CDS bid-ask spread to equity bid-ask spread, than the opposite. This is consistent with the results in Table 4.

[29] The hedging cost-component of bid-ask spreads has been analysed in the equity option market where an explicit connection between equity and option bid-ask spreads is established via the hedging activity of dealers (see Cho and Engle, 1999; Kaul, Nimalendran and Zhang, 2004; Landsiedl, 2005; Petrella, 2006, and Engle and Neri, 2010). In this paper we instead test the contribution of hedging to CDS-equity bid-ask spreads commonality.

[30] In more general terms, the capital structure arbitrage (CSA) is a trading strategy that attempts to exploit mispricing between a company's liabilities. In recent years such strategies have become increasingly popular, particularly among hedge funds, as a result of the development of the credit default swap market that has allowed market participants to take short positions in credit risk more easily (Currie and Morris, 2002). Yu (2005) analyses CSA convergence trades involving credit default swaps (CDS) and equity. He finds that the strategy appears to offer attractive Sharpe ratios. Similarly, Duarte, Longstaff and Yu (2005) find that CDS-based capital structure arbitrage can produce promising Sharpe ratios of around 0.8.

firm is too high with respect to its equity value, they take a short position (Z) in the CDS and a short position (hZ) in the corresponding equity[31]. The size of their cross-market positions is equal or proportional to the debt-to-equity hedge ratio estimated from a sophisticated structural model[32]. A higher hedge ratio commands larger cross-market positions and - therefore - larger liquidity demand (for a given level of CDS mispricing) from informed arbitrageurs[33] to which uninformed CDS and equity dealers react by increasing CDS and equity bid-ask spreads. Thus, if CDS-equity arbitrage is possible and convenient (i.e. the CDS mispricing and h are significantly above 0), then the bid-ask spreads should increase in both markets due to a surge in asymmetric information (see models by Glosten and Milgrom, 1985; Kyle, 1985; Amihud and Mendelson, 1986; Easley and O'Hara, 1987; and Admati and Pfleiderer, 1988.)[34].
This *arbitrage channel* can represent another potential source of CDS-equity illiquidity commonality.

In conclusion, when a firm's credit condition worsens and its debt-to-equity hedge ratio increases, higher positive commonality between CDS and equity bid-ask spreads can arise because of:
1) Higher hedging costs for CDS dealers:
The dealers recover the hedging costs by setting higher CDS bid-ask spreads, in proportion to the bid-ask spreads paid on the equity-"hedging" market (i.e. hedge ratio times equity bid-ask spread);
2) Potential larger demand for liquidity across CDS and equity markets from capital-structure arbitrageurs when a CDS-equity mispricing arises:
Uninformed dealers will seek protection against superior information of capital-structure arbitrageurs by setting higher bid-ask spreads in equity and credit markets, respectively in proportion to the size of the CDS informed flow (Z) and the size of the equity informed flow (hZ).

Accordingly, we derive the following hypothesis:
Hypothesis. Equity-CDS Arbitrage/Hedging Channel of Illiquidity Commonality*:*
The commonality of illiquidity across equity and credit markets increases with the debt-to-equity hedge ratio.

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[31] This cross-market trading should narrow the mispricing between CDS and equity.

[32] 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."

[33] We have assumed that during the crisis periods a liquidity shock in the CDS market would trigger CDS overpricing and CDS-equity arbitrage. With regards to this point, we cannot completely rule out the possibility of a liquidity shock in the equity market (with forced sale of stocks) which causes equity to be undervalued, rather than CDS to be overvalued. In this case, arbitrageurs would buy equity and buy the corresponding CDS; the delta factor would be $1/h$ and it would lead to opposite conclusions. A larger hedge ratio h would in fact imply a lower level of arbitrage activity across equity and CDS markets. As a consequence, the arbitrage channel would predict a smaller co-movement between CDS and equity bid-ask spreads. However, two points should be considered: first, this is not what we observe in the data (see Section 5) as illiquidity commonality and hedge ratio move in the same direction; second, several papers (amongst others, Dick-Nielsen et al, 2012) show that during the recent crisis periods corporate bond and CDS spreads have risen above their "fair" level because of liquidity shocks.

[34] In principal, if a CDS dealer could hedge all the risk related to her CDS position in the equity market, no cost of informed trading in the CDS market would arise. Nevertheless, when the hedge ratio is very high, the hedging activity can be very costly. It is more likely that the dealer applies a form of partial, rather than perfect, hedging (see Froot and Stein, 1998). Therefore, she can remain exposed to the risk of losses due to informed trading.

5 Empirical Test of Determinants of Equity-Credit Illiquidity Linkages

5.1 Empirical Modelling

In this Section we test the Hypothesis of "Equity-CDS Arbitrage/Hedging Channel of Illiquidity Commonality". To validate this hypothesis we need to show that the equity-CDS bid-ask spread co-movement increases with the debt-to-equity hedge ratio, controlling for other simultaneous effects. In fact, as previous literature has pointed out, the ability of dealers to provide liquidity in equity and CDS markets depends also on their funding availability and their aversion to systematic risk[35].

In this test the illiquidity commonality variable $\boldsymbol{Comm_{i,t}^{BA}}$ is represented by the Kendall's Tau measure of correlation[36] (Fisher-transformed) between daily equity and CDS bid-ask spreads of firm i constructed over each quarter t from April 2003 to December 2009.
As a first step we perform a preliminary analysis to filter the illiquidity commonality variable from the effects of some variables which previous market microstructure literature has found to be significant in affecting the cost of market making:
- The firm's systematic risk (Fama-French market, size, and book-to-market risk factors):
Higher exposure of a firm to market, size, and book-to-market risk factors ($\boldsymbol{MktRf}$, $\boldsymbol{SMB}$, and $\boldsymbol{HML}$) may cause higher inventory costs for dealers operating in the CDS and equity market of the specific firm, which then translate in higher bid-ask spreads.
- Tightening of funds (proxied by the spread between 3-months LIBOR rate and 3-months T-Bill yield, $\boldsymbol{TED}$):
Dealers in different markets open and maintain their positions by borrowing external funds (the cost of funding represents also an opportunity-cost). Therefore, the lack of funding liquidity can generate unwinding of positions across multiple markets, fire-sales, and large illiquidity discounts on assets. Additionally, the higher risk of assets' devaluation can cause further pressure on dealership costs.
- Increase in market volatility (proxied by the S&P500 option implied volatility index, $\boldsymbol{VIX}$):
Higher volatility can increase inventory dealership costs and cause dealers to impose larger bid-ask spreads across all markets where they provide liquidity.

We perform the following preliminary panel least squares regression:

$$Comm_{i,t}^{BA} = \alpha_0+\beta_1 MktRf_t+\beta_2 SMB_t+\beta_3 HML_t+\delta_1 TED_t+\delta_2 VIX_t+\alpha_1 Firm_1+...+\alpha_{17} Firm_{17}+\epsilon_{i,t} \tag{1}$$

where i is the firm index; t is the time (quarter) index.

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[35] The equity-CDS arbitrage/hedging channel implies instead that illiquidity can co-move and spill over across equity and CDS markets even in the absence of systematic risk (Das and Hanouna, 2009), just as a result of firm-specific trading patterns which intensify during crisis periods.

[36] Kapadia and Pu (2012) use the Kendall's Tau to measure the co-movement between CDS and equity returns. They stress two advantages of using this measures: firstly, the Kendall's Tau does not need any parametric setup; secondly, being intuitively related to the variable's co-movement, it is not affected by interpretation-ambiguity, unlike other measures, such as the coefficient of determination.

As second step, we use the residuals from this model $\boldsymbol{Res.Comm^{BA}_{i,t}}$ (which we refer to as *filtered illiquidity commonality*) to analyze the effect of the hedge ratio. Using the filtered variable should strongly reduce the possibility that we attribute illiquidity commonality to equity and credit common exposure to exogenous risk factors (systematic risk, funding illiquidity, and market volatility), rather than to the hedge ratio.

We perform the test using panel least squares regression and estimating firm clustered standard errors. The estimated equation (Specification I) is:

$$Res.Comm^{BA}_{i,t} = \gamma_0 + \theta H^{SS}_{i,t} + u_{i,t} \tag{2}$$

where i is the firm index; t is the time (quarter) index.

The analysis is performed on a sub-sample of 18 non-financial companies which display stationarity in both the illiquidity commonality and the hedge ratio series[37]. $\boldsymbol{Firm_i}$ represents the fixed effect (dummy) for firm i (i goes from 1 to 18).

On the right-hand side of Equation (2) we have $\boldsymbol{H^{SS}_{i,t}}$, the estimated debt-to-equity 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[38] using the Merton (1974) model approach. The two methodologies are called respectively VX and SS for brevity. For regression (2) we first employ the hedge ratio obtained from SS methodology alone (Specification I). In a further Specification (II) for the same regression we augment the right-hand side of Equation (2) with $\boldsymbol{Qtr_{2003:2}, ..., Qtr_{2009:3}}$, which represent the fixed quarter of the year effects (dummies). In particular, this represents a robustness check on the effect of the hedge ratio on illiquidity commonality since the time dummies capture the effects of extreme events (e.g., 2007-08 subprime crisis).

The analysis performed so far may be affected if the exogenous risk factors on the right-hand side of Equation (1) and the hedge ratio in Equation (2) are influenced by common determinants (for example worsening of firms' credit conditions and assets volatility). In this case the filtering step would attenuate the potential collinearity issue, but also the effect of the hedge ratio on the illiquidity commonality variable[39]. Therefore, we perform another panel regression where the hedge ratio variable is added to the right-hand side of Equation (1). This analysis allows us also to evaluate and compare the relative contributions of the hedge factor, the market volatility, the funding cost, and the systematic risk factors to the increase in equity-CDS illiquidity commonality. We estimate the augmented equation with panel least squares and call this second estimation exercise the "All-in Regression"[40]:

$$\begin{aligned} Comm^{BA}_{i,t} = \alpha_0 + \beta_1 MktRf_t + \beta_2 SMB_t + \beta_3 HML_t + \delta_1 TED_t + \delta_2 VIX_t + \theta H^{SS}_{i,t} + \\ \alpha_1 Firm_1 + ... + \alpha_{17} Firm_{17} + \upsilon_{i,t} \end{aligned} \tag{3}$$

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[37] Tests of unit roots have been performed on illiquidity commonality and hedge ratio to select these firms. The tests are run using Augmented Dickey-Fuller equations with number of lags set by Schwartz information criterion and at 5% confidence level.

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

[39] In addition, the use of an estimated dependent variable in the second-stage regression can pose some econometric challenges (e.g., generated regression problems).

[40] We define as Specification III the panel regression for Equation (3) without VIX, and as Specification IV the panel regression which includes VIX on the right-hand side of the Equation (3).

Finally, we repeat the entire analysis replacing the hedge ratio $\boldsymbol{H^{SS}}$ with its component orthogonal to general market default risk and volatility ($\boldsymbol{H^{SS,ORT}}$). This further check should alleviate the concern that the hedge ratio's influence on the equity-CDS illiquidity commonality simply picks up the increase in default risk and volatility at market level, particularly over the crisis period. A change in economic conditions can in fact influence default risk and hedge ratios of many firms. To isolate this orthogonal component we regress the hedge ratio on: i) the difference between Moody's AAA Corporate Bond Index yield and the 20-years government bond yield (market default risk factor $\boldsymbol{DEF}$) and ii) the $\boldsymbol{VIX}$ index. We then use the residuals from this regression ($\boldsymbol{H^{SS,ORT}}$).

5.2 Results of Test of Equity-CDS Arbitrage/Hedging Channel of Illiquidity Commonality

As proxies of illiquidity commonality we consider: $\boldsymbol{\psi_{i,t}^{BA}}$, $\boldsymbol{\tau_{i,t}^{BA}}$, and $\boldsymbol{\rho_{i,t}^{BA}}$, respectively the Fisher's z-Transformation of Pearson Correlation, Kendall's Tau Rank Correlation, and Spearman's Rho Rank Correlation between equity and CDS bid-ask spreads of firm i estimated over each quarter t. We also construct the same correlation measures between equity and CDS returns of firm i estimated over each quarter t: $\boldsymbol{\psi_{i,t}^{RET}}$, $\boldsymbol{\tau_{i,t}^{RET}}$, and $\boldsymbol{\rho_{i,t}^{RET}}$. Tables 8 and 9 report respectively the pair-wise correlation and (Granger) causality matrices for the relevant variables. The hedge ratio is highly correlated with all measures of illiquidity and return commonality. All these variables are also closely related to market default risk, VIX index, and TED spread (see Table 8). The pair-wise Granger causality matrix in Table 9 identifies for each pair of variables which causality relationship is most likely. Stronger evidence on causality directions suggest that all commonality proxies are influenced by the hedge ratio, which in turn is affected by market default risk and VIX index. The relationship between illiquidity and return commonality remains instead ambiguous. Table 10 display the summary statistics of these variables.

To test whether the Kendall's Tau measure of illiquidity commonality can be explained by the hedge ratio, we first filter-out the effects of firm's systematic risk factors (i.e. exposure to Fama-French factors: size, book-to-market, and market risk), funding cost, and market volatility from the illiquidity correlation (Kendall's Tau) measures between equity and CDS bid-ask spreads for the 18 non-financial firms. From the preliminary panel regression analysis all these variables are found to be positively significant in explaining an increase in illiquidity co-movement across equity and credit of the firms (see Table 11, Panel A). Moreover, the likelihood ratio tests of redundancy reveal a limited relevance of firms' fixed effects.

Next, we regress the residuals from the previous panel regression on the hedge ratio obtained through the SS methodology in order to test the main hypothesis of the paper: an increase in illiquidity correlation between CDS and equity bid-ask spreads may be driven by an increase in the debt-to-equity hedge ratio. The hedge ratio represents a first approximation of the arbitrage relationship between equity and CDS; in fact, it is obtained as the elasticity of the CDS (or underlying debt) value to the equity value of the firm (see Appendix B).

Figure 6 illustrates the time-series plot of the value-weighted average of the hedge ratio across all firms. It shows that the average debt-to-equity elasticity (hedge ratio) $\boldsymbol{H}$ and sensitivity $\boldsymbol{h}$ gradually decrease from 2003 over the following years; they then rise again from the second semester of 2007 and decrease towards the end of 2009. Figure 7 displays a similar pattern for both the average hedge ratio estimated with SS methodology and with VX methodology (April 2003-November 2008). Figure 8 shows that the time-pattern of the average hedge ratio closely tracks CDS market average premia and CDS average bid-ask spread. Noticeably, Figure 9 reveals a very close relationship between average hedge ratio and CDS-equity illiquidity commonality over time. This relation is the main object of our investigation.

The results of the First and Second-stage panel regressions reported in Table 11 (Panels A and B) confirm the existence of a positive relationship between equity-CDS illiquidity co-movements and the hedge ratio, even after controlling for the significant positive influence of funding costs, market volatility, and systematic risk factors. When the analysis is repeated over different sub-samples, the hedge ratio is found to be a significant explanatory variable for co-movements of illiquidity only during crisis periods (2003, and 2007-2009). It must be noted that the sample is composed of investment-grade firms with low leverage and hedge ratios over calmer periods (2004-2006) when also the illiquidity correlation across equity and credit is negligible or even slightly negative[41]. As a robustness check, the positive effect of the hedge ratio on the illiquidity commonality survives also when we control for fixed time effects and when we replace the hedge ratio with its component orthogonal to market default risk and volatility (see Table 11 - Panel B).

When we perform the All-in Panel Regression (Equation 3) we are able to evaluate the separate economic impact of the hedge ratio versus the impact of market frictions and systematic risk factors. Panel analysis in Table 12 (Panel A) reveals a positive and significant effect of the TED spread, VIX index, and systematic risk factors on illiquidity commonality, but also a positive influence of the hedge ratio, after controlling for firms' unobservable fixed effects. In Table 12 (Panel B) we notice that the economic significance of the hedge ratio (in terms of standard deviations impact) is around 0.16, while the aggregate economic significance of all exogenous factors is about 0.52. When we use the hedge ratio as regressor for the filtered illiquidity commonality (Equation 2) its economic significance is around 0.12. Consistent with our concern, we find that the results in terms of hedge ratio effect are typically stronger without the filtering.

For robustness checks we repeat the previous analysis using:
1) As alternative dependent variables (measures of illiquidity commonality) the Spearman rank measure of association and the Pearson correlation between equity and CDS bid-ask spreads;
2) As alternative proxy for arbitrage/hedging trading the hedge ratio estimated with Vassalou and Xing (2004) methodology. When we use the hedge ratio from VX Methodology instead of the SS hedge ratio we consider a restricted time sample running from April 2003 to October 2008.
A comparison between the results of the three alternative regressions in Panel A of Table 13 shows that using Spearman instead of Kendall correlation does not change the results, while using the

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[41] These results are unreported, but available upon request.

Pearson correlation as dependent variable in the All-in regression leads to the hedge ratio and the size factor being the only significant variables. The economic significance of the hedge ratio remains in a range between 0.13-0.16 standard deviations impact.
When we replace the hedge ratio estimated using the Schaefer and Strebulaev (SS) methodology with the one estimated using the Vassalou-Xing (2004) methodology we find that the latter is also significant in the panel regressions (Table 13, Panel B) and has the same economic significance as the SS hedge ratio. However, the R-squared halves with respect to the case when we use SS hedge ratio, so the Vassalou-Xing measure of hedge ratio appears less useful than the SS measure.

To sum up the results in this Section, the central hypothesis of the paper cannot be rejected in all the performed tests: the effect of the hedge ratio on equity-CDS illiquidity commonality is strongly significant, both statistically and economically, even after controlling for relevant exogenous risk factors, and it survives several robustness checks[42].

6 Empirical Test of Determinants of CDS Bid-Ask Spread

Since the arbitrage/hedging channel of CDS-equity illiquidity commonality (illustrated in Section 4) contributes to increase both CDS and equity bid-ask spreads, we can provide further evidence in favour of this hypothesis by analysing the determinants of the CDS bid-ask spread alone. In fact, one of the insights of the arbitrage/hedging channel is that CDS bid-ask spreads should depend on:
1) The cost of hedging in the equity market.
This cost is higher when the CDS dealer faces an increasing demand for CDS protection from “noise” buyers.
2) The amount of informed trading across equity and credit markets.
Asymmetric information costs should affect the CDS bid-ask spread more when the CDS mispricing (and so the trading interest of informed capital-structure arbitrageurs) increases.

Furthermore, we know that the CDS dealers need to hold some capital to finance their activity and that they set the bid-ask spreads in the CDS markets in order to recover the cost of the funding needed and the compensation for an increase in market volatility[43]. Therefore, in this Section we perform a further check on the “Equity-CDS Arbitrage/Hedging Channel” by testing whether hedging costs and asymmetric information costs represent additional determinants of CDS bid-ask spreads, besides funding costs and market volatility.

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[42] Given the unavailability of trading data for the CDS market, to test the existence of a trading-based channel of illiquidity commonality we rely on the hedge ratio as proxy of traders’ changing exposure across markets. The relatively low frequency of the analysis should bias the results towards *under-detecting* the incidence of cross-market hedging and arbitrage activity on illiquidity transmission, since the relative trading takes place at higher frequency. The data and tests we have employed are suggestive of the existence of a trading channel for cross-market illiquidity movements. However, future work employing more direct measures of cross-arbitrage and hedging activity, perhaps using intra-day data on actual transactions in the CDS market, would be valuable in shedding further light on this issue.

[43] Higher market volatility in fact augments the risk of keeping imbalanced positions and the risk of a freeze in funding availability.

6.1 Empirical Modelling

We perform the test at weekly frequency. The following elements represent desirable properties of this test when compared to the previous one performed on the illiquidity commonality variable: (i) the test is executed on CDS bid-ask spreads directly, therefore it does not need to rely on estimated measures; (ii) the frequency of the analysis increases from quarterly to weekly; and (iii) the test employs data for all 45 non-financial companies in the sample after assessing the stationarity of the relevant variables.

Firstly, we remove from each CDS bid-ask spread the influence of its five lagged values, since for all firms the CDS bid-ask spreads are found to be strongly autocorrelated. Then, we take the residual CDS bid-ask spreads and in panel analysis regress them on: (a) $\boldsymbol{TED}$ spread (proxy for funding costs); (b) $\boldsymbol{VIX}$ index (proxy for market volatility); (c) Equity and CDS private information flows (proxy for asymmetric information costs); and (d) Hedging costs represented by equity bid-ask spread times the delta-hedging factor ($\boldsymbol{BA^E} \times \boldsymbol{h^{SS}}$).
The following panel regression is estimated:

$$Res.BA_{i,t}^{CDS} = \alpha^{CDS} + \gamma^{CDS} TED_t + \delta^{CDS} VIX_t + \zeta^{CDS} \Phi_{i,t} + \lambda^{CDS}(BA_{i,t}^{E} \times h_{i,t}^{SS}) + \epsilon_{i,t}^{CDS} \quad (4)$$

$\boldsymbol{Res.BA_{i,t}^{CDS}}$ is the residual CDS bid-ask spread of firm i at time t. $\boldsymbol{\Phi_{i,t}}$ represents the private information relative to firm i at time t and includes:
(1) Information anticipated in CDS returns (according to the discussion in Section 3, this could be related mainly to changes in firm's asset volatility);
(2) Information anticipated in equity returns (according to the discussion in Section 3, this could be related mainly to changes in firm's asset value and/or in economy-wide conditions).

We follow the methodology of Acharya and Johnson (2007) to construct the components (1) and (2) of $\Phi_{i,t}$, which are defined respectively as CDS and equity innovations[44]. We regress CDS returns $\Delta CDS_{i,t}$ (equity returns $\Delta E_{i,t}$) on contemporaneous equity (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 equity returns to absorb any lagged information transmission within the credit and equity markets. To account for the nonlinear relation between CDS level and equity returns, the regression specification for CDS includes interactions of equity returns (both contemporaneous and lagged) with the inverse of CDS premium, while the regression specification for equity returns includes interactions of CDS returns (both contemporaneous and lagged) with the CDS premium.
$\Delta CDS_{i,t} = \alpha_i^{CDS} + \sum_{k=0}^{5}(\beta_{i,t-k}^{CDS} + \gamma_{i,t-k}^{CDS}/CDS_{i,t-k})\Delta E_{i,t-k} + \sum_{k=1}^{5} \delta_{i,t-k}^{CDS} \Delta CDS_{i,t-k} + u_{i,t}^{CDS}$
$\Delta E_{i,t} = \alpha_i^{E} + \sum_{k=0}^{5}(\beta_{i,t-k}^{E} + \gamma_{i,t-k}^{E} CDS_{i,t-k})\Delta CDS_{i,t-k} + \sum_{k=1}^{5} \delta_{i,t-k}^{E} \Delta E_{i,t-k} + u_{i,t}^{E}$
The residuals $\widehat{u_{i,t}}$ from each regression represent independent news arriving in the CDS (equity) market at time t that is either not relevant or simply not appreciated by the equity (CDS) market at time t (information anticipation). We will define these residuals CDS (equity) innovations: $\widehat{u_{i,t}^{CDS}} = CDS\ Inn$ and $\widehat{u_{i,t}^{E}} = Equity\ Inn$.

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

6.2 Results of the Test

In panel regression analysis at weekly frequency for residual CDS bid-ask spreads (Table 14) the hedging and private information cost components enter significantly in all estimated equations, also when TED spread and VIX index are used as explanatory variables. Both funding costs and market volatility are found to be positive and significant. The two exogenous variables have a larger impact if we perform the analysis only over the crisis period 2007-2009 (unreported results). The panel analysis allows a direct comparison of the economic impact of hedging and asymmetric information costs versus other determinants of the bid-ask spreads. A 1 standard deviation (SD) change in hedging costs generates an increase of around 0.04 SD in CDS residual illiquidity. A 1 SD increase in CDS innovations have more than double economic impact on CDS bid-ask spreads (0.09). The impact of TED and VIX together is in the range between 0.08 and 0.12 (depending on the regression specification).

CDS and equity innovations (proxies for private information in their respective markets) carry the expected signs: information anticipated in higher CDS returns - more likely related to firm-specific bad news and increase in a firm's asset volatility - move the CDS bid-ask spread upwards; while information anticipated in higher equity returns - more likely related to economy-wide good news and increase in a firm's asset value - reduce CDS bid-ask spreads. However, the CDS bid-ask spread appear to be significantly affected only by CDS innovations. This means that only private negative information anticipated in the credit markets can reduce CDS market liquidity, while private information in the equity market has no significant effect on CDS liquidity[45]. To verify whether this result is consistent with the arbitrage trading mechanism described in Section 4, we test whether the negative impact of informed flows in the CDS market on residual CDS bid-ask spread widens when the CDS mispricing is substantially positive and high. To proxy the CDS mispricing we use the residual component of the CDS premium regressed on structural variables (firm's leverage ratio, equity volatility, and interest rate). We then interact the CDS innovations variable with the lagged value of the CDS mispricing. Table 14 shows that this interaction term is significant and positive: informed flows in the CDS market increase CDS bid-ask spreads and their effect is stronger when the CDS mispricing is larger. A larger CDS mispricing indicates higher trading interest of informed capital-structure arbitrageurs across CDS and equity markets. In terms of economic significance (standard deviation impact), on average the interaction term adds 0.01 SD to the impact of CDS innovations[46], which is around 0.09 SD.

The hedging cost component is also found positive and significant. The effect of hedging costs on CDS bid-ask spreads should be larger when the CDS demand from noise traders is higher. Since we do not possess CDS transaction data, we use as proxy for CDS demand the lagged change in CDS price (as in Qiu and Yu, 2012). The hedging costs interacted with the proxy for CDS demand have

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[45] This result is consistent with the asymmetry in illiquidity spillovers: for most firms illiquidity is transmitted from CDS to the equity, while CDS illiquidity is only rarely Granger-caused by equity illiquidity. See discussion in 3.2.

[46] This number is calculated by multiplying the economic significance (standardized beta) of the interaction term 0.04 by the average lagged positive CDS mispricing 0.25%. However, over the recent crisis period (April 2007 - December 2009) the average CDS mispricing is equal to 0.40%. Therefore, the economic significance of the interaction term $CDS\ Inn \times CDS\ Mispricing\ (Lag\ 1)$ during the crisis period almost doubles.

a significant positive coefficient, which supports our conjecture. In terms of economic significance, on average the interaction term adds 0.07 SD to the impact of the hedging factor[47], which is around 0.04 SD.

To conclude this Section, the effects of hedging and private information costs on CDS bid-ask spread are strongly supported by the data, also after controlling for funding and market volatility, which are both statistically and economically significant cost-components of CDS bid-ask spreads. The hedging costs contribute to increase CDS illiquidity more when the CDS demand (from noise traders seeking CDS protection) is higher. The asymmetric information costs contribute to increase CDS illiquidity more when the CDS mispricing is wider and equity-CDS trading more attractive to capital-structure arbitrageurs.

7 Conclusions

This paper examines linkages between illiquidity in equity and CDS markets for investment-grade firms and sets a theoretical framework to identify and test the determinants of their co-movements. Illiquidity co-moves across equity and credit markets, but the commonality varies in magnitude over time and increases over the crisis period. CDS and equity are assets trading correlated (firm's equity and credit) risks. When they become closer substitute for each other, it is expected that a wave of illiquidity originating in one market can be easily transmitted to the other.

We detect the existence of illiquidity spillovers across CDS and equity markets and observe that negative firm-specific information and illiquidity tend to be anticipated in the CDS market and then transmitted to the equity market. We conjecture that the transmission of illiquidity across markets can be partially explained by an arbitrage/hedging channel. Two mechanisms support this hypothesis. First, CDS dealers (banks) are potentially *informed* agents with access to the credit information of the reference entities. They hedge their CDS exposures in the equity market and then recover the hedging costs (given by the hedge ratio times the equity bid-ask spread) through the CDS bid-ask spreads. When the firm's hedge ratio increases (i.e. the arbitrage linkages between the markets strengthens), the hedging cost paid by CDS dealers becomes a larger component of the CDS bid-ask spread and the correlation between CDS and equity bid-ask spreads increases. By hedging their positions, the informed CDS dealers also transfer negative firm-specific information to the equity market. Second, during more turbulent times, when the hedge ratio increases even further, informed CDS dealers may withdraw from providing CDS liquidity. Since in this time the CDS demand remains high, CDS supply-demand imbalance may create CDS mispricing and fuel CDS-equity arbitrage trading. Uninformed equity and CDS dealers who remain available to provide liquidity in the respective markets will protect themselves from the higher likelihood of informed trades of sophisticated arbitrageurs by increasing the bid-ask spreads on equity and CDS. As a consequence, the correlation between equity and CDS illiquidity increases.

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[47] This number is calculated by multiplying the economic significance (standardized beta) of the interaction term 0.09 by the average lagged positive CDS price change 0.78%.

To the best of our knowledge, this arbitrage/hedging channel has never been considered in previous empirical and theoretical literature on illiquidity commonality. Rather than identifying solely funding costs and general market volatility as common determinants of the increase in equity and CDS bid-ask spreads, we show that the debt-to-equity hedge ratio (as first general approximation of the equity-credit linkage) can explain a significant part of the cross-market illiquidity commonality.

To summarize, this paper makes several new contributions to the emerging literature on credit-equity linkages. First, unlike any previous study, it examines explicitly the extent and causes of illiquidity commonality across equity and credit (CDS) markets. Second, building on previous theoretical literature on the limits to arbitrage, it confirms the contribution of funding costs and systematic risk in driving the illiquidity linkage across equity and credit markets. This analysis appears of critical importance since the credit crisis, which was characterized in its early stages by a market-illiquidity contagion episode, exacerbated by traders' lack of financial resources. Third, to the best of our knowledge, it is the first work to apply a structural model to explain the transmission of illiquidity shocks across correlated equity and credit markets due to their arbitrage linkage. In particular, we employ the Merton (1974) model to estimate the debt-to-equity hedge ratio and predict illiquidity commonality across CDS and equity markets due to arbitrage/hedging trading. Finally, the paper provides also a novel framework for modelling CDS bid-ask spreads and reveals a significant influence of hedging and asymmetric information costs, besides funding and market volatility components, on CDS illiquidity.

The paper provides some inputs for the development of a consistent theory of illiquidity contagion based on arbitrage linkages and information flows across correlated assets which may explain the channels of the illiquidity propagation in a rigorous manner. A theoretical model represents therefore a natural extension to this paper, as well as a continuation of the relatively new research on cross-market illiquidity commonality. We are currently working on a formalization of the mechanisms tested empirically in this paper.

Moreover, while this paper is focused on the study of CDS-equity illiquidity linkages, future research will be devoted to a more extensive identification of the sources and nature of information flows across equity and credit markets and on their effect on prices and bid-ask spreads. Future work employing intra-daily and actual transaction data in CDS and equity markets would be particularly valuable in shedding further light on this issue.

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A Figures and Tables

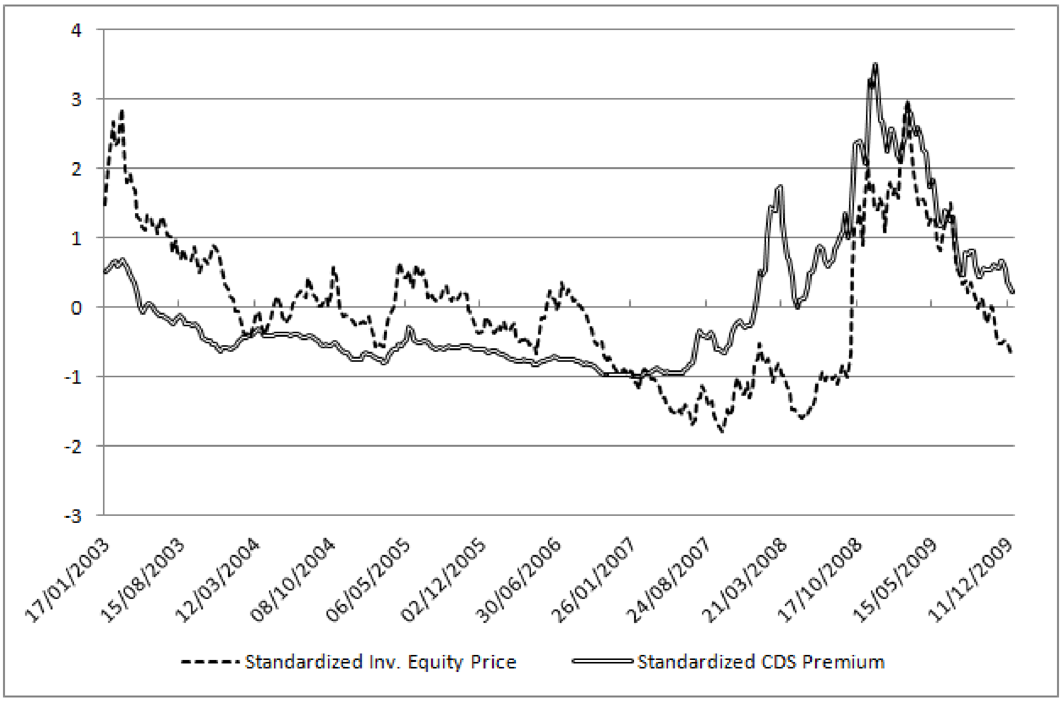

Figure 1: Cross-Sectional Value-Weighted Average of Standardized CDS Premium and Inverse Equity Price

(Weekly Frequency, March 2003 - December 2009, Cross-Section of 51 Firms)

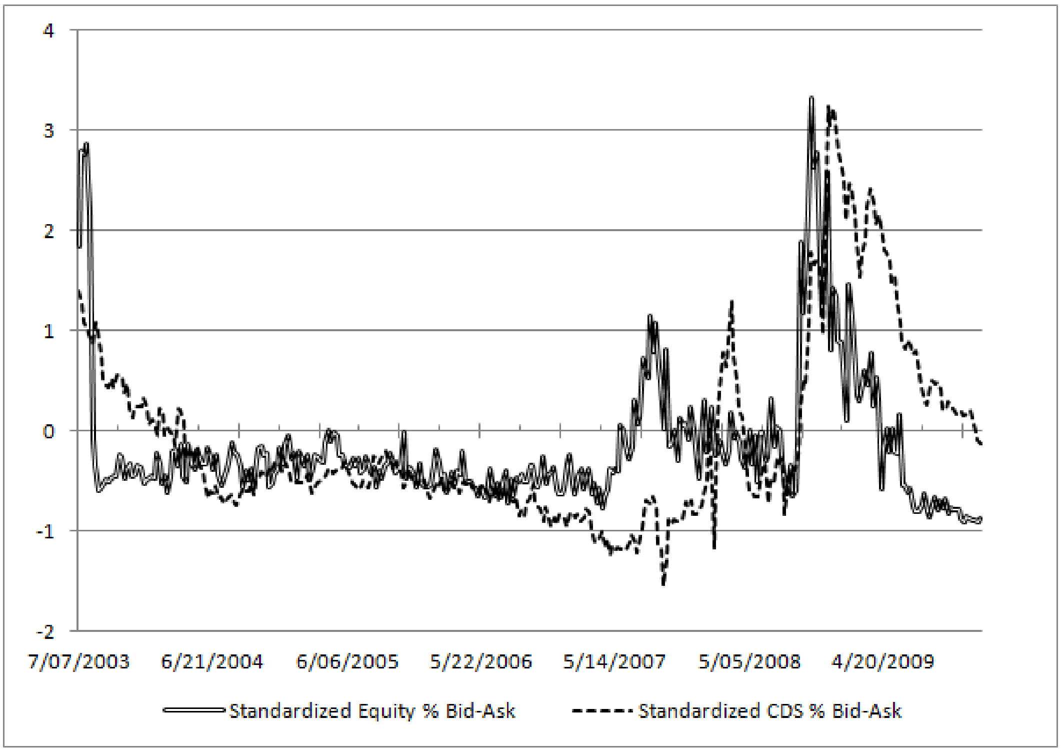

Figure 2: Cross-Sectional Value-Weighted Average of Standardized CDS and Equity Bid-Ask Spreads - All Sample

(Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

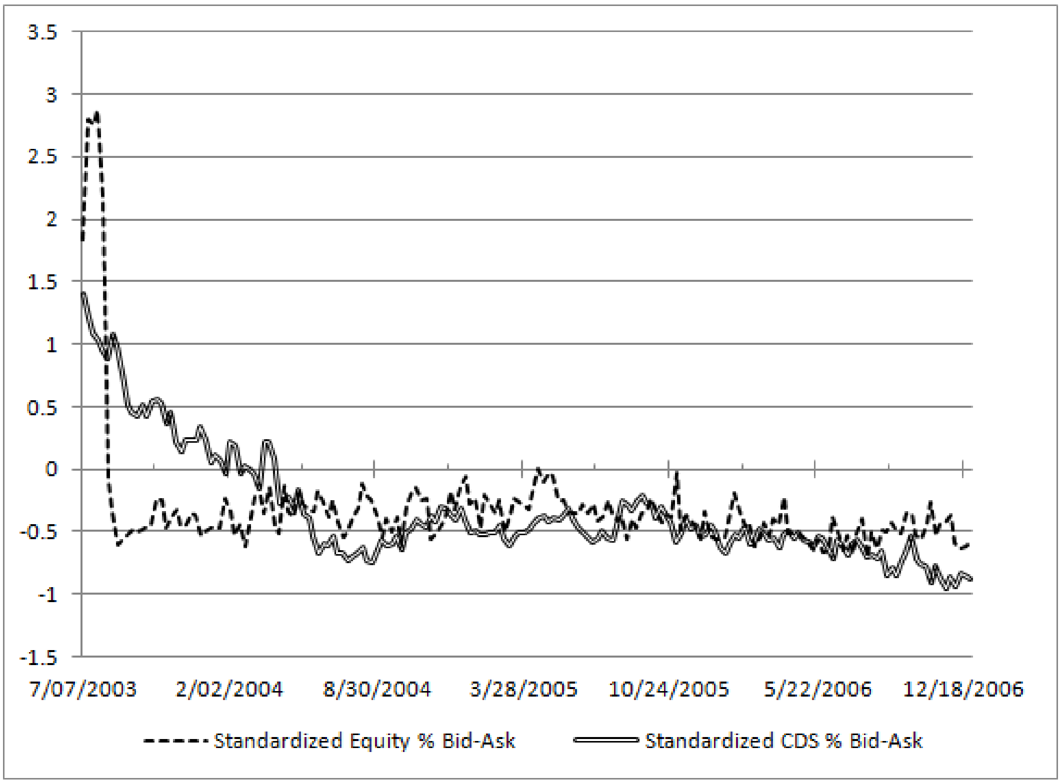

Figure 3: Cross-Sectional Value-Weighted Average of Standardized CDS and Equity Bid-Ask Spreads - Pre-Crisis Sample

(Weekly Frequency, July 2003 - December 2006, Cross-Section of 51 Firms)

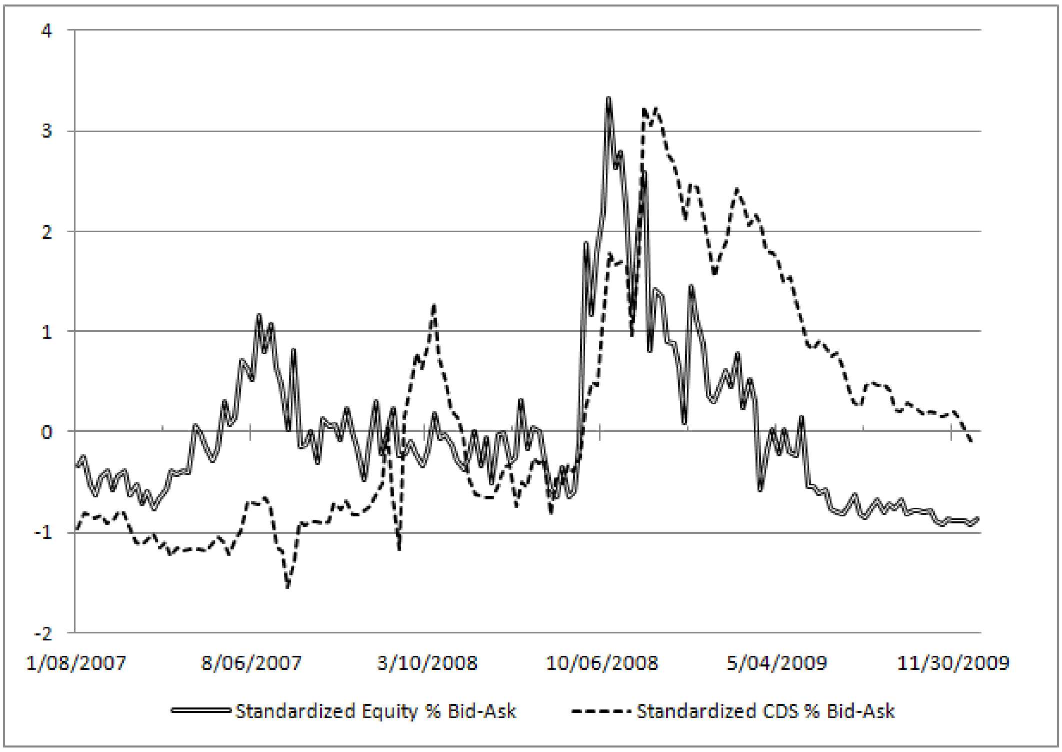

Figure 4: Cross-Sectional Value-Weighted Average of Standardized CDS and Equity Bid-Ask Spreads - Crisis Sample

(Weekly Frequency, January 2007 - December 2009, Cross-Section of 51 Firms)

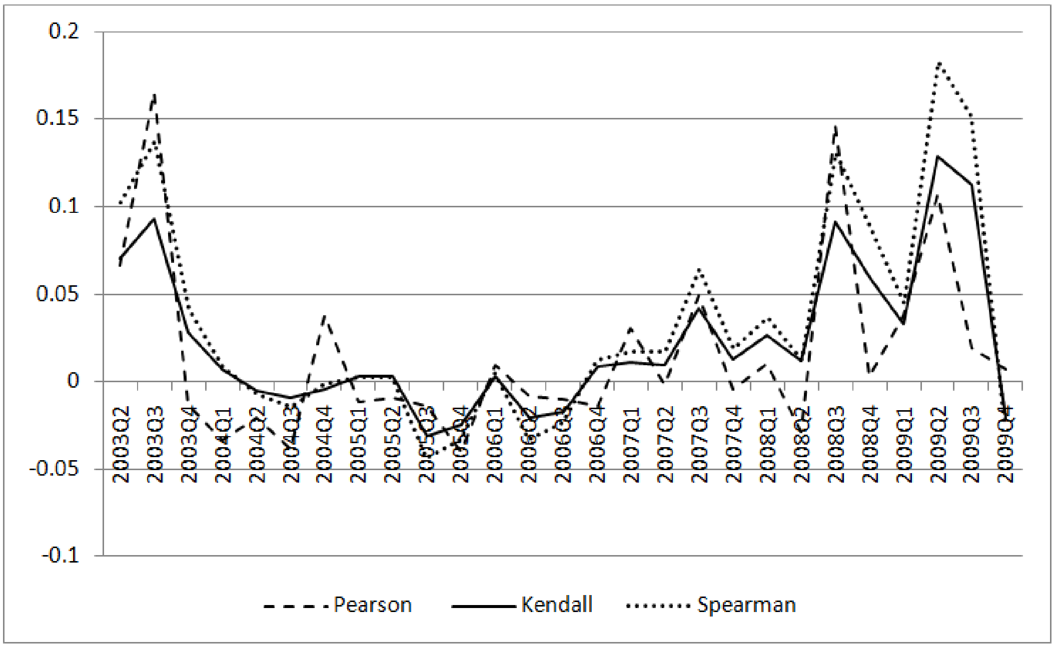

Figure 5: Cross-Sectional Value-Weighted Average of Correlation Measures (Pearson, Kendall and Spearman) between CDS and Equity Bid-Ask Spreads

(Measured in decimals, Quarterly Frequency, March 2003 - December 2009, Cross-Section of 51 Firms)

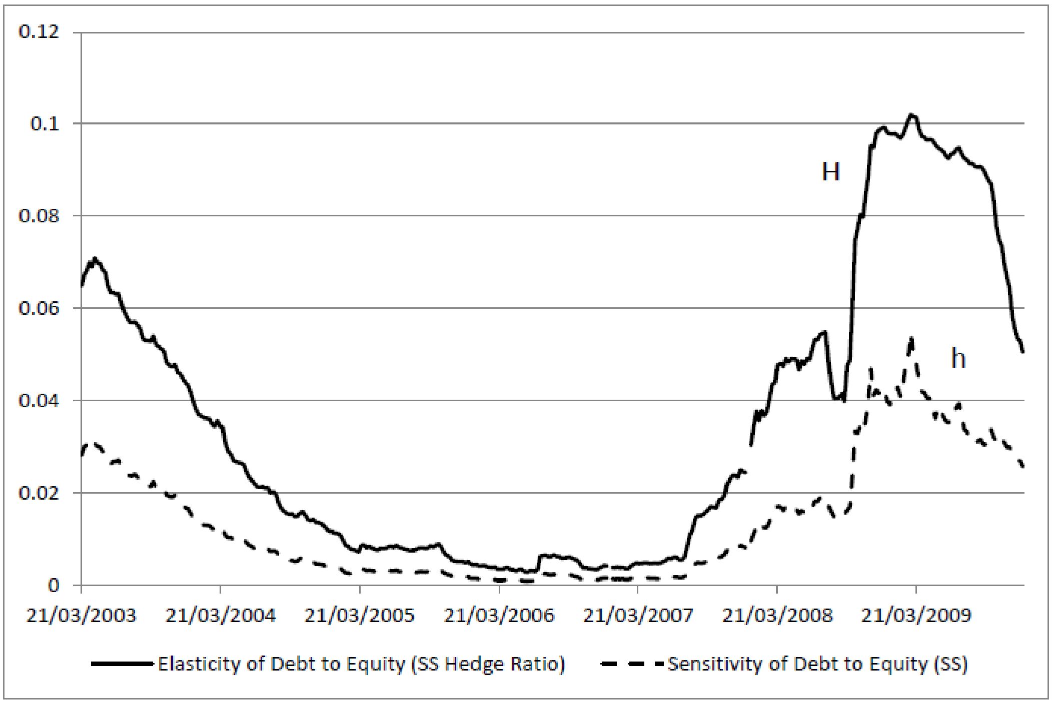

Figure 6: Cross-Sectional Value-Weighted Average of Debt-to-Equity Sensitivity and Hedge Ratio (Merton Model Calibration - SS Methodology)

(Measured in decimals, Weekly Frequency, March 2003 - December 2009, Cross-Section of 51 firms)

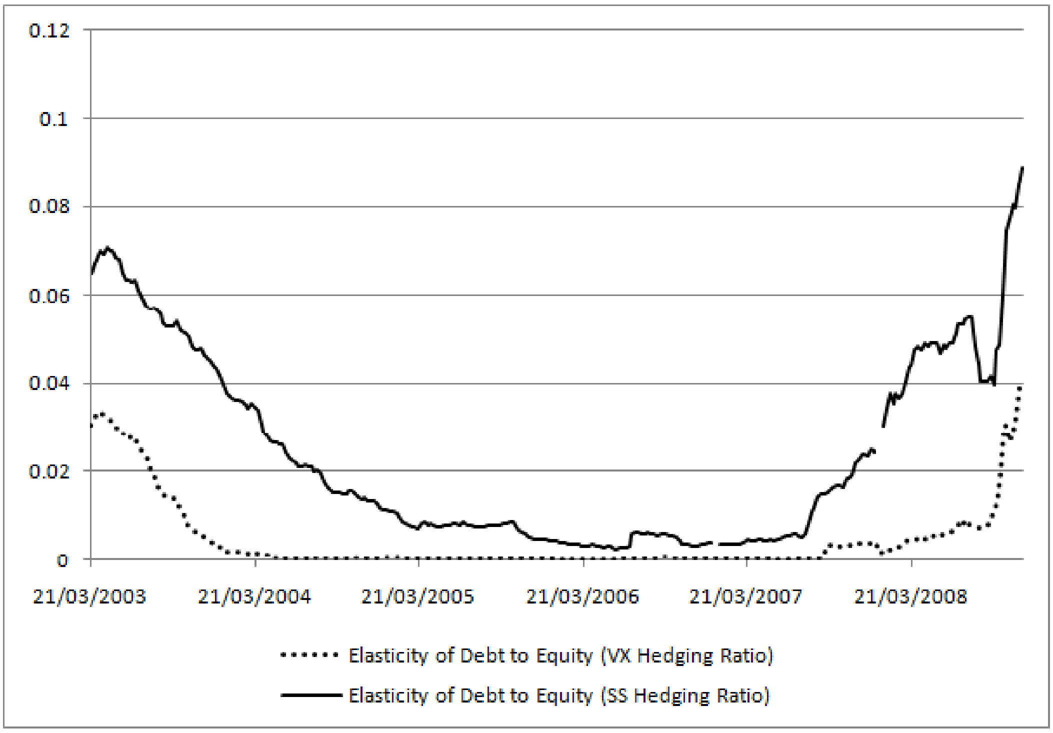

Figure 7: Cross-Sectional Value-Weighted Average of Debt-to-Equity Hedge Ratio (Merton Model Calibration - SS vs VX Methodology)
(Measured in decimals, Weekly Frequency, March 2003 - November 2008, Cross-Section of 51 firms)

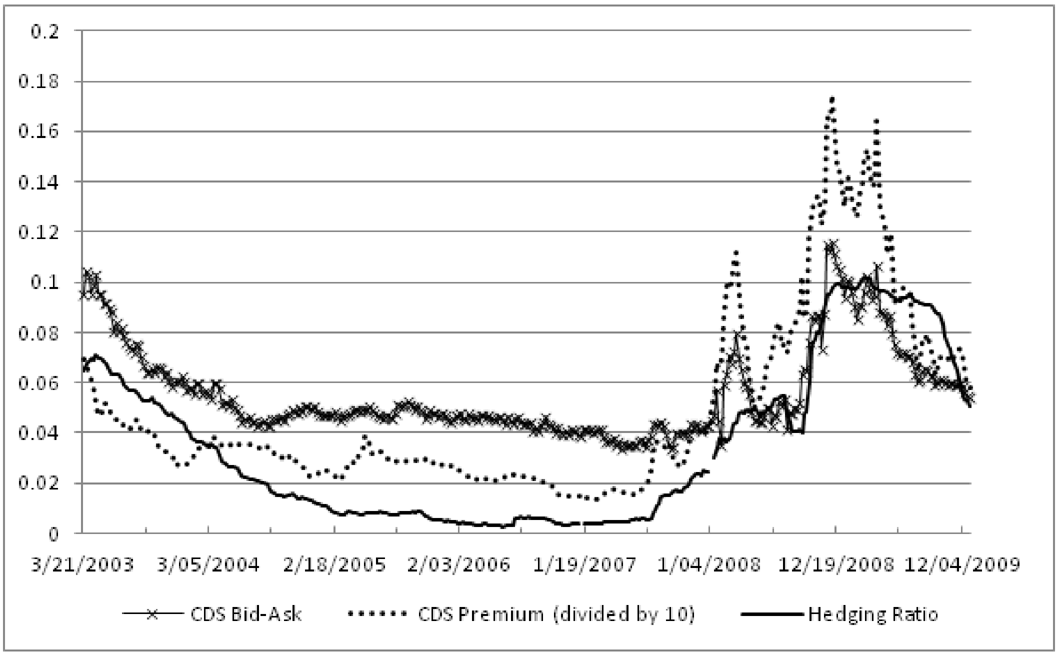

Figure 8: Cross-Sectional Value-Weighted Averages of CDS Premium, CDS Bid-Ask Spread, and Debt-to-Equity Hedge Ratio (Merton Model Calibration - SS Methodology)
(CDS premium measured in 10 percentage units, CDS bid-ask spread in percentage units, hedge ratio in decimals, Weekly Frequency, March 2003 - December 2009, Cross-Section of 51 firms)

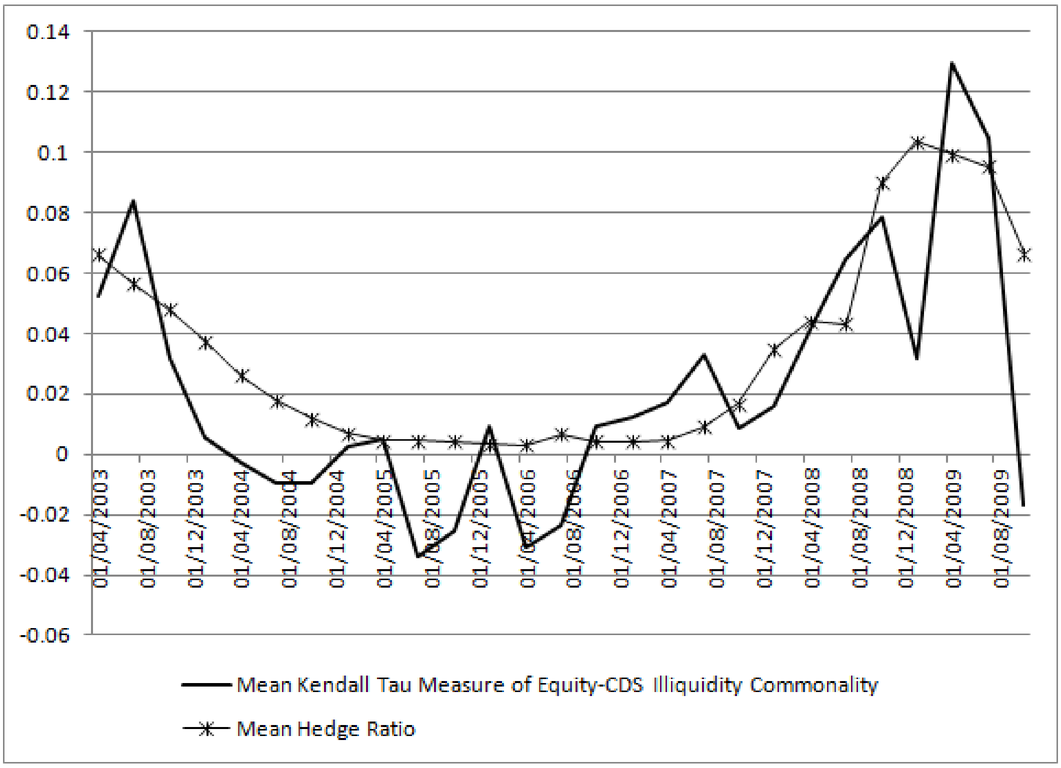

Figure 9: Cross-Sectional Value-Weighted Averages of CDS-Equity Illiquidity Correlation (Kendall Measure) and Debt-to-Equity Hedge Ratio (Merton Model Calibration - SS Methodology)
(Measured in decimals, Quarterly Frequency, April 2003 - December 2009, Cross-Section of 45 non-financial firms)

Table 1: Summary Statistics of Cross-Sectional Value-Weighted Average of Equity and CDS Bid-Ask Spreads
(51 Firms; Weekly frequency; April 2003 - December 2009; Bid-Ask Spread measured in percentage units)

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

Table 2: Correlations between Cross-Sectional Value-Weighted Average of Equity and CDS Bid-Ask Spreads
(51 Firms; Weekly frequency; April 2003 - December 2009; Correlations measured in decimals)

All Sample:	
Pearson	0.557
Spearman	0.313
Kendall	0.200
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; April 2003 - December 2009; Correlations measured in decimals)

	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

Table 4: Pair-wise Granger Test of Causality for Equity and CDS Bid-Ask Spreads (at 1% C.L.) - Panel A

(2 Lags included, Daily frequency, ∗ indicates that evidence is stronger for CDS to Equity than the other way round as the difference between the relative F-stats is > 20)

		Null Hypothesis Tested: Equity BA does not Granger cause CDS BA			**Null Hypothesis Tested: CDS BA does not Granger cause Equity BA**			
Company Name	**Obs**	**F-Stat**	**P-value**	**Test Result**	**F-Stat**	**P-value**	**Test Result**	**Causality Direction**
Honeywell International	1477	9.65655	0.00007	Reject	72.0589	0.00000	Reject	Both directions*
EI du Pont de Nemours	1319	0.02757	0.97280	Accept	16.4846	0.00000	Reject	CDS to Equity
Goodrich	1470	12.9241	0.00000	Reject	94.7041	0.00000	Reject	Both directions*
IBM	1402	1.31877	0.26780	Accept	0.91107	0.40230	Accept	No causality
ConocoPhillips	1293	12.8915	0.00000	Reject	13.0634	0.00000	Reject	Both directions
Kroger	1411	16.3281	0.00000	Reject	59.1789	0.00000	Reject	Both directions*
General Mills	1378	0.93471	0.39290	Accept	12.8862	0.00000	Reject	CDS to Equity
Caterpillar	1426	5.26131	0.00530	Reject	8.04736	0.00030	Reject	Both directions
Deere	1461	1.88282	0.15250	Accept	24.2157	0.00000	Reject	CDS to Equity
Boeing Capital	1408	3.63554	0.02660	Accept	70.3464	0.00000	Reject	CDS to Equity
Dow Chemical	1477	0.69962	0.49690	Accept	29.8767	0.00000	Reject	CDS to Equity
Lockheed Martin	1357	2.85577	0.05790	Accept	22.3741	0.00000	Reject	CDS to Equity
Motorola	1496	6.59504	0.00140	Reject	53.2859	0.00000	Reject	Both directions*
FirstEnergy	1449	0.52073	0.59420	Accept	18.9554	0.00000	Reject	CDS to Equity
Progress Energy	1438	0.45748	0.63300	Accept	3.77172	0.02320	Accept	No causality
Halliburton	1239	6.84928	0.00110	Reject	11.58	0.00001	Reject	Both directions
Alcoa	1324	2.07183	0.12640	Accept	14.6745	0.00000	Reject	CDS to Equity
Northrop Grumman	1502	0.40535	0.66680	Accept	16.7724	0.00000	Reject	CDS to Equity
Raytheon	1457	4.93599	0.00730	Reject	31.055	0.00000	Reject	Both directions*
Campbell Soup	1357	1.0173	0.36180	Accept	22.762	0.00000	Reject	CDS to Equity
Walt Disney	1489	1.55099	0.21240	Accept	44.4972	0.00000	Reject	CDS to Equity
Hewlett-Packard	1411	4.72621	0.00900	Reject	32.8771	0.00000	Reject	Both directions*
Duke Energy	1438	11.4569	0.00001	Reject	49.0586	0.00000	Reject	Both directions*
Arrow Electronics	1466	9.53989	0.00008	Reject	63.6657	0.00000	Reject	Both directions*
Omnicom Group	1433	7.58392	0.00050	Reject	32.8313	0.00000	Reject	Both directions*

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Table 4: **(...Continued from previous page)**

Pair-wise Granger Test of Causality for Equity and CDS Bid-Ask Spreads (at 1% C.L.) - Panel B

(2 Lags included, Daily frequency, ∗ indicates that evidence is stronger for CDS to Equity than the other way round as the difference between the relative F-stats is > 20)

		Null Hypothesis Tested: Equity BA does not Granger cause CDS BA			**Null Hypothesis Tested: CDS BA does not Granger cause Equity BA**			
Company Name	**Obs**	**F-Stat**	**P-value**	**Test Result**	**F-Stat**	**P-value**	**Test Result**	**Causality Direction**
Computer Sciences	1440	6.06369	0.00240	Reject	3.05712	0.04730	Accept	Equity to CDS
McDonald's	1475	3.1774	0.04200	Accept	46.7617	0.00000	Reject	CDS to Equity
Target	1273	0.18758	0.82900	Accept	14.2473	0.00000	Reject	CDS to Equity
Burlington Northern SF	1315	2.29332	0.10130	Accept	28.3297	0.00000	Reject	CDS to Equity
Wal-Mart Stores	1320	12.7869	0.00000	Reject	9.35591	0.00009	Reject	Both directions
ConAgra Foods	1400	10.2588	0.00004	Reject	46.5928	0.00000	Reject	Both directions*
Nordstrom	1412	0.55032	0.57690	Accept	5.15584	0.00590	Reject	CDS to Equity
Chubb	1370	3.10743	0.04500	Accept	14.9602	0.00000	Reject	CDS to Equity
Norfolk Southern	1311	2.39611	0.09150	Accept	7.51527	0.00060	Reject	CDS to Equity
Newell Rubbermaid	944	1.82804	0.16130	Accept	11.5742	0.00001	Reject	CDS to Equity
Dominion Resources	1465	2.38068	0.09280	Accept	28.4344	0.00000	Reject	CDS to Equity
American Intern. Group	1495	3.55763	0.02870	Accept	20.874	0.00000	Reject	CDS to Equity
Anadarko Petroleum	1397	1.49916	0.22370	Accept	7.01297	0.00090	Reject	CDS to Equity
Carnival	1551	3.98564	0.01880	Accept	6.79041	0.00120	Reject	CDS to Equity
Safeway	1464	8.22348	0.00030	Reject	57.5242	0.00000	Reject	Both directions*
Time Warner	1478	1.89036	0.15140	Accept	34.1322	0.00000	Reject	CDS to Equity
ACE	1496	5.59855	0.00380	Reject	38.5151	0.00000	Reject	Both directions*
Eastman Chemical	1470	9.18974	0.00010	Reject	54.5439	0.00000	Reject	Both directions*
Simon Property Group	1425	7.09729	0.00090	Reject	17.1519	0.00000	Reject	Both directions
Valero Energy	1434	2.17625	0.11380	Accept	16.0766	0.00000	Reject	CDS to Equity
Hartford Fin.Services Group	1421	44.622	0.00000	Reject	54.4471	0.00000	Reject	Both directions
Marriott International	1492	0.49772	0.60800	Accept	19.4288	0.00000	Reject	CDS to Equity
Sempra Energy	1433	7.80696	0.00040	Reject	17.1864	0.00000	Reject	Both directions
Devon Energy	1333	0.58351	0.55810	Accept	1.06841	0.34390	Accept	No causality
MetLife	1388	9.95191	0.00005	Reject	23.3621	0.00000	Reject	Both directions
Kraft Foods	1478	2.93716	0.05330	Accept	44.7342	0.00000	Reject	CDS to Equity

Table 5: Pair-wise Granger Test of Causality for Equity and CDS Returns (at 1% C.L.) - Panel A(2 Lags included, Daily frequency)

		Null Hypothesis Tested: Equity Ret. does not Granger cause CDS Ret.			**Null Hypothesis Tested: CDS Ret. does not Granger cause Equity Ret.**			
Company Name	**Obs**	**F-Stat**	**P-value**	**Test Result**	**F-Stat**	**P-value**	**Test Result**	**Causality Direction**
Honeywell International	1476	22.5254	0.00000	Reject	0.8284	0.43700	Accept	Equity to CDS
EI du Pont de Nemours	1318	16.5996	0.00000	Reject	0.0044	0.99560	Accept	Equity to CDS
Goodrich	1469	12.0712	0.00001	Reject	0.9293	0.39510	Accept	Equity to CDS
IBM	1402	21.6103	0.00000	Reject	0.7024	0.49560	Accept	Equity to CDS
ConocoPhillips	1292	16.5660	0.00000	Reject	1.5302	0.21690	Accept	Equity to CDS
Kroger	1410	3.5061	0.03030	Accept	1.7045	0.18220	Accept	No causality
General Mills	1377	1.8178	0.16280	Accept	0.8072	0.44630	Accept	No causality
Caterpillar	1425	35.8506	0.00000	Reject	0.7449	0.47500	Accept	Equity to CDS
Deere	1460	22.8571	0.00000	Reject	2.4517	0.08650	Accept	Equity to CDS
Boeing Capital	1407	15.5715	0.00000	Reject	1.1175	0.32740	Accept	Equity to CDS
Dow Chemical	1476	21.8746	0.00000	Reject	4.5982	0.01020	Reject	Both directions
Lockheed Martin	1356	1.8347	0.16010	Accept	0.5797	0.56020	Accept	No causality
Motorola	1495	14.8009	0.00000	Reject	3.0415	0.04810	Accept	Equity to CDS
FirstEnergy	1448	31.0695	0.00000	Reject	1.0539	0.34880	Accept	Equity to CDS
Progress Energy	1437	9.9939	0.00005	Reject	2.7832	0.06220	Accept	Equity to CDS
Halliburton	1238	16.5024	0.00000	Reject	0.1917	0.82560	Accept	Equity to CDS
Alcoa	1323	20.5129	0.00000	Reject	0.5764	0.56210	Accept	Equity to CDS
Northrop Grumman	1501	11.3915	0.00001	Reject	0.1740	0.84030	Accept	Equity to CDS
Raytheon	1456	6.4501	0.00160	Reject	1.7575	0.17280	Accept	Equity to CDS
Campbell Soup	1356	0.7341	0.48010	Accept	1.3428	0.26150	Accept	No causality
Walt Disney	1488	10.3409	0.00003	Reject	0.6174	0.53950	Accept	Equity to CDS
Hewlett-Packard	1410	8.9610	0.00010	Reject	1.2891	0.27590	Accept	Equity to CDS
Duke Energy	1437	4.2866	0.01390	Accept	0.6868	0.50330	Accept	No causality
Arrow Electronics	1465	43.3120	0.00000	Reject	2.2501	0.10580	Accept	Equity to CDS
Omnicom Group	1432	19.7300	0.00000	Reject	0.1598	0.85240	Accept	Equity to CDS

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Table 5: **(...Continued from previous page)**
Pair-wise Granger Test of Causality for Equity and CDS Returns (at 1% C.L.) - Panel B
(2 Lags included, Daily frequency)

		Null Hypothesis Tested: Equity Ret. does not Granger cause CDS Ret.			**Null Hypothesis Tested: CDS Ret. does not Granger cause Equity Ret.**			
Company Name	**Obs**	**F-Stat**	**P-value**	**Test Result**	**F-Stat**	**P-value**	**Test Result**	**Causality Direction**
Computer Sciences	1439	5.1909	0.00570	Reject	1.9757	0.13900	Accept	Equity to CDS
McDonald's	1474	3.1670	0.04240	Accept	2.3948	0.09150	Accept	No causality
Target	1273	8.0365	0.00030	Reject	0.4572	0.63320	Accept	Equity to CDS
Burlington Northern SF	1315	17.6678	0.00000	Reject	0.1708	0.84300	Accept	Equity to CDS
Wal-Mart Stores	1320	7.2472	0.00070	Reject	4.1119	0.01660	Accept	Equity to CDS
ConAgra Foods	1399	6.4537	0.00160	Reject	3.7718	0.02320	Accept	Equity to CDS
Nordstrom	1411	38.8123	0.00000	Reject	1.6191	0.19840	Accept	Equity to CDS
Chubb	1369	20.2430	0.00000	Reject	3.5390	0.02930	Accept	Equity to CDS
Norfolk Southern	1310	26.8072	0.00000	Reject	0.0170	0.98310	Accept	Equity to CDS
Newell Rubbermaid	943	11.8539	0.00001	Reject	0.9385	0.39160	Accept	Equity to CDS
Dominion Resources	1464	6.8437	0.00110	Reject	0.6302	0.53260	Accept	Equity to CDS
American Intern. Group	1494	16.9218	0.00000	Reject	7.3920	0.00060	Reject	Both directions
Anadarko Petroleum	1396	20.1116	0.00000	Reject	0.4528	0.63600	Accept	Equity to CDS
Carnival	1550	7.3039	0.00070	Reject	0.0959	0.90850	Accept	Equity to CDS
Safeway	1463	4.3313	0.01330	Accept	0.3468	0.70700	Accept	No causality
Time Warner	1477	22.1372	0.00000	Reject	0.8263	0.43790	Accept	Equity to CDS
ACE	1495	42.6476	0.00000	Reject	0.0376	0.96310	Accept	Equity to CDS
Eastman Chemical	1469	32.2516	0.00000	Reject	0.3471	0.70680	Accept	Equity to CDS
Simon Property Group	1424	33.9180	0.00000	Reject	1.2383	0.29020	Accept	Equity to CDS
Valero Energy	1433	30.1477	0.00000	Reject	1.2658	0.28230	Accept	Equity to CDS
Hartford Fin.Services Group	1420	43.4927	0.00000	Reject	1.8302	0.16080	Accept	Equity to CDS
Marriott International	1491	36.9348	0.00000	Reject	2.0099	0.13440	Accept	Equity to CDS
Sempra Energy	1432	13.6967	0.00000	Reject	1.1088	0.33020	Accept	Equity to CDS
Devon Energy	1332	10.5095	0.00003	Reject	0.1466	0.86360	Accept	Equity to CDS
MetLife	1387	34.4126	0.00000	Reject	2.5251	0.08040	Accept	Equity to CDS
Kraft Foods	1477	3.4567	0.03180	Accept	2.7806	0.06230	Accept	No causality

Table 6: Pair-wise Granger Test of Causality for Equity and CDS Volatility (at 1% C.L.) - Panel A(2 Lags included, Daily frequency)

		Null Hypothesis Tested: Equity Vol. does not Granger cause CDS Vol.			**Null Hypothesis Tested: CDS Vol. does not Granger cause Equity Vol.**			
Company Name	**Obs**	**F-Stat**	**P-value**	**Test Result**	**F-Stat**	**P-value**	**Test Result**	**Causality Direction**
Honeywell International	1549	5.32693	0.00490	Reject	11.9133	0.00001	Reject	Both directions
EI du Pont de Nemours	1517	0.96815	0.38000	Accept	4.78274	0.00850	Reject	CDS to Equity
Goodrich	1563	0.19327	0.82430	Accept	0.19562	0.82230	Accept	No causality
IBM	1459	2.71322	0.06670	Accept	6.13909	0.00220	Reject	CDS to Equity
ConocoPhillips	1513	1.17301	0.30970	Accept	6.20588	0.00210	Reject	CDS to Equity
Kroger	1539	2.02711	0.13210	Accept	5.92694	0.00270	Reject	CDS to Equity
General Mills	1537	0.11188	0.89420	Accept	0.4156	0.66000	Accept	No causality
Caterpillar	1505	2.24694	0.10610	Accept	9.88471	0.00005	Reject	CDS to Equity
Deere	1530	1.65853	0.19080	Accept	11.2271	0.00001	Reject	CDS to Equity
Boeing Capital	1512	2.08635	0.12450	Accept	4.65806	0.00960	Reject	CDS to Equity
Dow Chemical	1525	2.06503	0.12720	Accept	1.66296	0.18990	Accept	No causality
Lockheed Martin	1536	0.82183	0.43980	Accept	7.32844	0.00070	Reject	CDS to Equity
Motorola	1544	6.36213	0.00180	Reject	0.34717	0.70670	Accept	Equity to CDS
FirstEnergy	1556	3.34316	0.03560	Accept	4.65785	0.00960	Reject	CDS to Equity
Progress Energy	1550	11.2197	0.00001	Reject	4.79218	0.00840	Reject	Both directions
Halliburton	1509	3.28885	0.03760	Accept	13.5669	0.00000	Reject	CDS to Equity
Alcoa	1534	9.4765	0.00008	Reject	5.42228	0.00450	Reject	Both directions
Northrop Grumman	1563	6.53175	0.00150	Reject	11.1753	0.00002	Reject	Both directions
Raytheon	1538	2.44959	0.08670	Accept	5.39561	0.00460	Reject	CDS to Equity
Campbell Soup	1566	0.85412	0.42590	Accept	0.76645	0.46480	Accept	No causality
Walt Disney	1533	9.24651	0.00010	Reject	11.1033	0.00002	Reject	Both directions
Hewlett-Packard	1512	4.30404	0.01370	Accept	9.31248	0.00010	Reject	CDS to Equity
Duke Energy	1548	0.82741	0.43740	Accept	7.40831	0.00060	Reject	CDS to Equity
Arrow Electronics	1564	5.72523	0.00330	Reject	15.4489	0.00000	Reject	Both directions
Omnicom Group	1546	0.69593	0.49880	Accept	1.69638	0.18370	Accept	No causality

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Table 6: **(...Continued from previous page)**
Pair-wise Granger Test of Causality for Equity and CDS Volatility (at 1% C.L.) - Panel B
(2 Lags included, Daily frequency)

		Null Hypothesis Tested: Equity Vol. does not Granger cause CDS Vol.			**Null Hypothesis Tested: CDS Vol. does not Granger cause Equity Vol.**			
Company Name	**Obs**	**F-Stat**	**P-value**	**Test Result**	**F-Stat**	**P-value**	**Test Result**	**Causality Direction**
Computer Sciences	1536	19.9354	0.00000	Reject	2.25889	0.10480	Accept	Equity to CDS
McDonald's	1524	8.09558	0.00030	Reject	19.2949	0.00000	Reject	Both directions
Target	1515	6.07164	0.00240	Reject	15.4058	0.00000	Reject	Both directions
Burlington Northern SF LLC	1536	0.11477	0.89160	Accept	0.39538	0.67350	Accept	No causality
Wal-Mart Stores	1494	1.63434	0.19540	Accept	11.0373	0.00002	Reject	CDS to Equity
ConAgra Foods	1549	1.6611	0.19030	Accept	1.94036	0.14400	Accept	No causality
Nordstrom	1536	4.85863	0.00790	Reject	10.4275	0.00003	Reject	Both directions
Chubb	1543	14.1185	0.00000	Reject	7.68667	0.00050	Reject	Both directions
Norfolk Southern	1531	1.22545	0.29390	Accept	0.54135	0.58210	Accept	No causality
Newell Rubbermaid	1550	4.27579	0.01410	Accept	5.76115	0.00320	Reject	CDS to Equity
Dominion Resources	1542	1.3423	0.26160	Accept	14.1147	0.00000	Reject	CDS to Equity
American Intern. Group	1539	46.2559	0.00000	Reject	23.8591	0.00000	Reject	Both directions
Anadarko Petroleum	1547	4.28249	0.01400	Accept	1.92212	0.14660	Accept	No causality
Carnival	1538	1.69174	0.18450	Accept	2.08267	0.12490	Accept	No causality
Safeway	1537	3.51825	0.02990	Accept	10.3127	0.00004	Reject	CDS to Equity
Time Warner	1544	0.71915	0.48730	Accept	2.04066	0.13030	Accept	No causality
ACE	1551	26.5361	0.00000	Reject	13.9356	0.00000	Reject	Both directions
Eastman Chemical	1563	12.6982	0.00000	Reject	13.3616	0.00000	Reject	Both directions
Simon Property Group	1525	0.70557	0.49400	Accept	5.63519	0.00360	Reject	CDS to Equity
Valero Energy	1539	4.76093	0.00870	Reject	0.55913	0.57180	Accept	Equity to CDS
Hartford Fin.Services Group	1545	13.648	0.00000	Reject	27.7733	0.00000	Reject	Both directions
Marriott International	1554	4.64991	0.00970	Reject	3.35204	0.03530	Accept	Equity to CDS
Sempra Energy	1551	12.7352	0.00000	Reject	2.25406	0.10530	Accept	Equity to CDS
Devon Energy	1514	9.70201	0.00007	Reject	17.5007	0.00000	Reject	Both directions
MetLife	1524	17.3873	0.00000	Reject	8.62053	0.00020	Reject	Both directions
Kraft Foods	1542	0.33171	0.71770	Accept	0.07701	0.92590	Accept	No causality

Table 7: Regressions of CDS and Equity Bid-Ask Spreads on Asset Volatility and Market Illiquidity
45 Industrial Firms; Weekly frequency; April 2003 - December 2009;
CDS Market Illiquidity = Value-weighted average of CDS bid-ask spreads across the 44 remaining firms;
Equity Market Illiquidity = Value-weighted average of Equity bid-ask spreads across the 44 remaining firms;
Positive significant (at 1% C.L.) coefficients in bold; Newey-West S.E. estimated.

		Dep. Var. Equity Bid-Ask Spread				**Dep. Var. CDS Bid-Ask Spread**			
Permno	**Ticker**	**Equity Market Ill**		**Asset Vol**		**CDS Market Ill**		**Asset Vol**	
		Coeff	**p-value**	**Coeff**	**p-value**	**Coeff**	**p-value**	**Coeff**	**p-value**
10145	HON	**0.9127**	**0.0001**	-0.0026	0.9017	**0.9334**	**0.0000**	-0.0407	0.0000
11703	DD	**0.7095**	**0.0000**	0.0185	0.1747	**0.9179**	**0.0000**	**0.0382**	**0.0000**
12140	GR	**1.2947**	**0.0000**	0.0415	0.0883	**0.6977**	**0.0000**	0.0021	0.5217
12490	IBM	**0.7442**	**0.0000**	0.0239	0.1849	**0.7956**	**0.0000**	-0.0406	0.0000
13928	COP	**0.9451**	**0.0081**	0.0108	0.6225	**0.6203**	**0.0000**	-0.0036	0.1384
16678	KR	**0.7274**	**0.0079**	-0.1506	0.0023	**0.7314**	**0.0000**	-0.0002	0.9743
17144	GIS	**1.1031**	**0.0000**	-0.0066	0.8730	**0.4410**	**0.0000**	**0.0347**	**0.0000**
18542	CAT	**0.9141**	**0.0000**	0.0627	0.0290	**1.7590**	**0.0000**	**0.0653**	**0.0000**
19350	DE	**0.8704**	**0.0000**	0.0298	0.0988	**1.1517**	**0.0000**	**0.0478**	**0.0000**
19561	BA	**0.6745**	**0.0000**	**0.0363**	**0.0030**	**1.3947**	**0.0000**	**0.0706**	**0.0000**
20626	DOW	**0.8822**	**0.0000**	**0.0817**	**0.0001**	**2.9490**	**0.0000**	**0.0994**	**0.0000**
21178	LMT	**2.0731**	**0.0003**	0.0720	0.1482	**0.8362**	**0.0000**	-0.0756	0.0000
22779	MOT	**1.7936**	**0.0000**	**0.3197**	**0.0000**	**2.7295**	**0.0000**	**0.1173**	**0.0000**
23026	FE	**2.1069**	**0.0030**	-0.0580	0.0492	**0.7234**	**0.0000**	**0.0308**	**0.0000**
23114	PGN	**0.9714**	**0.0000**	0.0393	0.3044	**0.6667**	**0.0000**	-0.0956	0.0000
23819	HAL	**1.1143**	**0.0016**	0.0501	0.1443	**0.4850**	**0.0000**	-0.0115	0.0008
24643	AA	**0.8955**	**0.0000**	**0.0867**	**0.0000**	**5.2807**	**0.0000**	**0.2015**	**0.0000**
24766	NOC	**1.1949**	**0.0000**	0.0559	0.2146	**0.8489**	**0.0000**	**0.0646**	**0.0000**
24942	RTN	**0.9591**	**0.0098**	-0.0471	0.1600	**0.7163**	**0.0000**	-0.0700	0.0000
25320	CPB	**1.2514**	**0.0001**	0.0439	0.3552	**0.1627**	**0.0041**	**0.0561**	**0.0000**
26403	DIS	**0.6358**	**0.0000**	0.0209	0.3212	**0.9670**	**0.0000**	0.0077	0.1224
27828	HPQ	**0.5683**	**0.0000**	-0.0296	0.2380	**0.9634**	**0.0000**	-0.0505	0.0000
27959	DUK	**1.1297**	**0.0001**	**0.0781**	**0.0014**	**0.1846**	**0.0023**	0.0038	0.3758
29209	ARW	**0.7554**	**0.0006**	0.0541	0.2016	**2.0952**	**0.0000**	-0.0200	0.0003
30681	OMC	**0.5606**	**0.0001**	-0.0095	0.7880	**2.3112**	**0.0000**	-0.0200	0.0362
40125	CSC	**1.7570**	**0.0061**	-0.0412	0.4200	**0.5096**	**0.0000**	-0.0035	0.3270
43449	MCD	**0.2519**	**0.0012**	0.0067	0.8520	**0.3642**	**0.0000**	0.0272	0.1076
49154	TGT	0.2794	0.0768	-0.0091	0.5817	**1.2647**	**0.0000**	**0.0165**	**0.0029**
50227	BNI	0.4397	0.0484	-0.0882	0.0054	**0.7158**	**0.0000**	-0.0622	0.0000
55976	WMT	**0.2768**	**0.0017**	-0.0564	0.0278	**0.7477**	**0.0000**	-0.0521	0.0000
56274	CAG	**0.5374**	**0.0000**	0.0046	0.9268	**0.3484**	**0.0000**	**0.0206**	**0.0009**
57817	JWN	**1.1609**	**0.0002**	0.0517	0.0598	**2.9263**	**0.0000**	**0.1400**	**0.0000**
60986	NWL	**1.0236**	**0.0033**	**0.1358**	**0.0000**	**0.9752**	**0.0000**	**0.0674**	**0.0000**
64311	NSC	**1.0680**	**0.0001**	-0.0489	0.1250	**0.7198**	**0.0000**	-0.0552	0.0000
64936	D	**1.9557**	**0.0058**	0.0215	0.6875	**0.4879**	**0.0000**	-0.0477	0.0000
70332	APC	**0.9337**	**0.0001**	**0.0521**	**0.0083**	**1.3697**	**0.0000**	**0.0535**	**0.0000**
75154	CCL	**1.9054**	**0.0000**	-0.0072	0.6473	**3.0202**	**0.0000**	-0.0054	0.2321
76149	SWY	**0.6973**	**0.0000**	-0.0129	0.7992	**0.7673**	**0.0000**	**0.0206**	**0.0003**
77418	TWX	**1.3812**	**0.0000**	0.0471	0.3028	**1.2639**	**0.0000**	**0.0363**	**0.0000**
80080	EMN	**1.0327**	**0.0002**	0.0526	0.1295	**1.3878**	**0.0000**	-0.0431	0.0000
85269	VLO	**0.7816**	**0.0002**	**0.0773**	**0.0001**	**0.5905**	**0.0000**	**0.1769**	**0.0000**
85913	MAR	**1.2102**	**0.0000**	**0.0746**	**0.0016**	**2.4101**	**0.0000**	**0.1775**	**0.0000**
86136	SRE	**0.8180**	**0.0004**	-0.0198	0.5074	**0.4755**	**0.0000**	-0.0001	0.9908
87137	DVN	**0.9887**	**0.0015**	-0.0126	0.5586	**0.2252**	**0.0019**	**0.0118**	**0.0124**
89006	KFT	**0.4462**	**0.0017**	0.0247	0.2493	**0.6190**	**0.0000**	**0.1007**	**0.0000**

Table 8: Pearson Correlation Matrix between Illiquidity Commonality, Return Commonality, TED, VIX and Market Default Risk

Time Sample: 2003Q2-2009Q4; Number of Total Quarterly Observations: 1215; Number of Cross-section: 45 Firms;
Comm (K) = Fisher transformation of Kendall Tau Measure of Association; Comm (S) = Fisher transformation of Spearman Measure of Association

	Ill.Comm (K)	**Ill.Comm (S)**	**Ret.Comm (K)**	**Ret.Comm (S)**	**Hedge Ratio**	**TED**	**VIX**
Ill.Comm (S)	0.995381						
t-Statistic	*361.1159*						
p-value	*<0.00001*						
Ret.Comm (K)	-0.068303						
t-Statistic	*-2.384421*						
p-value	*0.0173*						
Ret.Comm (S)		-0.072636	0.996432				
t-Statistic		*-2.536464*	*411.1636*				
p-value		*0.0113*	*<0.00001*				
Hedge Ratio	**0.258303**	**0.251053**	**-0.254563**	**-0.256957**			
t-Statistic	**9.312236**	**9.033028**	**-9.167993**	**-9.26028**			
p-value	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**			
TED	0.109773	0.110083	-0.100302	-0.09801	**0.215783**		
t-Statistic	*3.846441*	*3.857447*	*-3.511029*	*-3.429677*	**7.696638**		
p-value	*0.0001*	*0.0001*	*0.0005*	*0.0006*	**<0.00001**		
VIX	0.188536	0.187813	-0.22052	-0.222179	**0.551195**	0.744990	
t-Statistic	*6.686281*	*6.659684*	*-7.874163*	*-7.93645*	**23.00773**	*38.89642*	
p-value	*<0.00001*	*<0.00001*	*<0.00001*	*<0.00001*	**<0.00001**	*<0.00001*	
Default	0.177576	0.173902	-0.249649	-0.2503	**0.521315**	0.786631	0.950148
t-Statistic	*6.284526*	*6.15039*	*-8.979128*	*-9.004082*	**21.27631**	*44.37234*	*106.1322*
p-value	*<0.00001*	*<0.00001*	*<0.00001*	*<0.00001*	**<0.00001**	*<0.00001*	*<0.00001*

Table 9: Pair-wise Granger Causality Test Matrix between Illiquidity Commonality, Return Commonality, TED, VIX and Market Default Risk

Null Hypothesis: X does NOT Granger cause Y

Time Sample: 2003Q2-2009Q4; Number of Total Quarterly Observations: 1215; Number of Cross-sections: 45 Firms;

Comm (K) = Fisher transformation of Kendall Tau Measure of Association; Comm (S) = Fisher transformation of Spearman Measure of Association

X	**Hedge Ratio**	**Ill.Comm (K)**	**Ill.Comm (S)**	**Ret.Comm (K)**	**Ret.Comm (S)**	**VIX**	**Default**
Y							
Hedge Ratio	-	0.59798	0.49305	5.84912	5.67158	**22.0451**	**57.8109**
	-	*0.55010*	*0.61090*	*0.00300*	*0.00350*	*<0.00001*	*<0.00001*
Ill.Comm (K)	**26.3359**	-	-	4.2486	-	**29.6549**	**28.3934**
	<0.00001	-	-	*0.01451*	-	*<0.00001*	*<0.00001*
Ill.Comm (S)	**24.8627**	-	-	-	3.89849	**27.1447**	**26.2406**
	<0.00001	-	-	-	*0.02051*	*<0.00001*	*<0.00001*
Ret.Comm (K)	**45.5806**	3.82037	-	-	-	**52.9075**	**59.2915**
	<0.00001	*0.02220*	-	-	-	*<0.00001*	*<0.00001*
Ret.Comm (S)	**46.8871**	-	3.18702	-	-	**54.6119**	**60.9786**
	<0.00001	-	*0.04170*	-	-	*<0.00001*	*<0.00001*
VIX	3.08414	4.78519	4.14365	9.96393	9.52758	-	**163.2780**
	0.04620	*0.00850*	*0.01610*	*0.00005*	*0.00008*	-	*<0.00001*
Default	9.85346	2.0633	1.57617	5.81489	5.42138	123.675	-
	0.00006	*0.12750*	*0.20720*	*0.00310*	*0.00450*	*<0.00001*	-

Table 10: Summary Statistics for Illiquidity Commonality, Return Commonality, TED, VIX and Market Default Risk

Time Sample: 2003Q2-2009Q4; Number of Total Quarterly Observations: 1215; Number of Cross-sections: 45 Firms;
All Variables are measured in percentage units;
Comm (K) = Fisher transformation of Kendall Tau Measure of Association; Comm (S) = Fisher transformation of Spearman Measure of Association

	Ill.Comm (K)	**Ill.Comm (S)**	**Ret.Comm (K)**	**Ret.Comm (S)**	**Hedge Ratio**	**TED**	**VIX**	**Market Default Spread**
Mean	2.19	3.09	-4.03	-5.90	3.38	0.59	20.36	0.79
Median	1.83	2.71	-3.74	-5.37	0.53	0.35	16.66	0.61
Maximum	50.52	71.01	26.42	41.43	15.06	2.35	58.61	1.85
Minimum	-62.29	92.99	-44.54	-67.57	0.01	0.18	11.04	0.47
Std. Dev.	12.76	18.49	10.28	15.19	4.77	0.53	10.55	0.34

Table 11: Test of Equity-CDS Arbitrage/Hedging Channel of Illiquidity Commonality - Two-Steps Panel Regressions

The panel regressions are estimated with least squares; Panel dataset includes 18 non-financial companies and 27 quarters (from 2003:2 to 2009:4); Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; Likelihood tests of fixed effects (FE) redundancy use the panel regressions with no fixed effects as baseline for comparison: F-statistics and p-values (in italic) are reported; No = No FE included; Coefficients in bold when regressors are significant at 1% or 5% C.L.; Coefficients marked with $*$ when regressors are significant at 10% C.L.; All variables are measured in decimals.

Panel A.

First-step Regression of Equity-CDS Illiquidity Commonality on Exogenous Risk Factors

	Specification	**Int.**	**MktRf**	**Smb**	**Hml**	**TED**	**VIX**	$\boldsymbol{Adj-R^2}$	**LR Test (Firm) Fixed Effects**
Dep.Var.	I	**-0.0410**	**21.3075**	**30.0406**	6.7020	**7.0610**		6.69%	1.0739
Kendall		*-3.46*	*3.25*	*2.97*	*0.99*	*4.55*			*0.38*
Correlation	II	**-0.0615**	**19.3255**	**25.9097**	**11.7533**	**4.1235**	**0.1874**	7.45%	0.3676
(CDS-Equity BA)		*-4.12*	*1.63*	*2.47*	*3.06*	*2.11*	*2.13*		*1.08*

Panel B.

Second-step Regression of Residuals from First-stage Regression on Hedge Ratio

	Specification	**Int.**	$\boldsymbol{H^{SS}}$	$\boldsymbol{H^{SS,ORT}}$	$\boldsymbol{Adj-R^2}$	**LR Test (Time) Fixed Effects**
Dep.Var.	I	**-0.0086**	**0.3970**		1.29%	No
Filtered Kendall		*-3.05*	*3.38*			
Correlation	I	**-0.0083**	**0.3825**		8.53%	2.4725
(CDS-Equity BA)		*-2.20*	*2.31*			*0.0001*
	II	-0.0045	0.2068$*$		0.20%	No
		-1.62	*1.69*			
	II	**-0.0083**	**0.3825**		7.57%	2.4842
		-2.20	*2.31*			*0.0001*
	I			**0.3840**	0.62%	No
				2.02		
	I			**0.5186**	8.79%	2.6676
				2.20		*0.0001*
	II			0.2575	0.17%	No
				1.36		
	II			**0.5186**	7.84%	2.5494
				2.20		*0.0001*

Table 12: Test of Equity-CDS Arbitrage/Hedging Channel of Illiquidity Commonality - All-in Panel Regression

The panel regressions are estimated with least squares; Panel dataset includes 18 non-financial companies and 27 quarters (from 2003:2 to 2009:4); Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; Likelihood tests of fixed effects (FE) redundancy use the panel regressions with no fixed effects as baseline for comparison: F-statistics and p-values (in italic) are reported; No = No FE included; Coefficients in bold when regressors are significant at 1% and 5% C.L.; Coefficients marked with ∗ when regressors are significant at 10% C.L.; All variables are measured in decimals; 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.

Panel A.
Regression of Equity-CDS Illiquidity Commonality on Exogenous Risk Factors and Hedge Ratio

	Specification	**Int.**	**MktRf**	**Smb**	**Hml**	**TED**	**VIX**	H^{SS}	$H^{SS,ORT}$	$Adj-R^2$	**LR Test (Firm) Fixed Effects**
Dep.Var.	III	**-0.0435**	**16.3739**	**23.0302**	10.4497	**5.8369**		**0.5434**		8.40%	0.9582
Kendall		*-3.69*	*2.49*	*2.25*	*1.51*	*3.76*		*3.27*			*0.50*
Correlation	III	**-0.0436**	**16.2548**	**22.8609**	10.5402∗	**5.8073**		**0.5565**		8.53%	No
(CDS-Equity BA)		*-3.05*	*2.51*	*2.36*	*1.95*	*3.12*		*4.37*			
	IV	**-0.0453**	**16.4088**	**22.9595**	10.7479	**5.6216**	0.0172	**0.5195**		8.21%	0.9572
		-2.57	*2.47*	*2.22*	*1.49*	*2.59*	*0.13*	*2.05*			*0.51*
	IV	**-0.0445**	**16.2556**	**22.8045**	10.6950∗	**5.7003**	0.0082	**0.5468**		8.34%	No
		-2.49	*2.51*	*2.33*	*1.75*	*2.36*	*0.08*	*2.87*			
	III	**-0.0394**	**17.4670**	**25.3686**	6.8913	**7.1215**			**0.4983**	7.49%	1.0832
		-3.33	*2.59*	*2.48*	*1.03*	*4.59*			*2.29*		*0.37*
	III	**-0.0394**	**17.4670**	**25.3686**	6.8913	**7.1215**			**0.4983**	7.21%	No
		-2.72	*2.90*	*2.51*	*1.27*	*3.87*			*2.69*		
	IV	**-0.0551**	**16.9347**	**23.4450**	10.5931∗	**4.9270**	0.1390∗		0.3765∗	7.76%	1.0864
		-3.44	*2.57*	*2.24*	*1.46*	*2.36*	*1.40*		*1.53*		*0.36*
	IV	**-0.0551**	**16.9347**	**23.4450**	10.5931	**4.9270**	0.1390		0.3765	7.48%	No
		-3.40	*2.73*	*2.31*	*1.72*	*1.99*	*1.75*		*1.69*		

Panel B.
Economic Significance of Regressors

	Specification	**MktRf**	**Smb**	**Hml**	**TED**	**VIX**	H^{SS}	$H^{SS,ORT}$	$Adj-R^2$	**LR Test (Firm) Fixed Effects**
Dep.Var.	III	**0.1674**	**0.1049**	**0.0728**	**0.2413**		**0.1619**		8.53%	No
Kendall		*2.51*	*2.36*	*1.95*	*3.12*		*4.37*			
Correlation	IV	**0.1674**	**0.1046**	0.0738∗	**0.2368**	0.0068	**0.1591**		8.34%	No
(CDS-Equity BA)		*2.51*	*2.33*	*1.75*	*2.36*	*0.08*	*2.87*			
	III	**0.1798**	**0.1164**	0.0476	**0.2959**			**0.1113**	7.21%	No
		2.90	*2.51*	*1.27*	*3.87*			*2.69*		
	IV	**0.1744**	**0.1076**	0.0731∗	**0.2047**	0.1148∗		0.0841∗	7.48%	No
		2.73	*2.31*	*1.72*	*1.99*	*1.75*		*1.69*		

Table 13: Test of Equity-CDS Arbitrage/Hedging Channel of Illiquidity Commonality - Robustness Checks

The All-in panel regressions are estimated with least squares; Panel regressions includes 18 non-financial companies and 27 quarters (from 2003:2 to 2009:4) when Hedge SS is used; Panel regressions includes 30 non-financial companies and 23 quarters (from 2003:2 to 2008:4) when Hedge VX is used; Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; No firms' fixed effects included; Coefficients in bold when regressors are significant at 1% and 5% C.L.; Coefficients marked with $*$ when regressors are significant at 10% C.L.; All variables are measured in decimals; 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.

Panel A.
All-in Panel Regressions: Comparison between Three Alternative Dependent Variables

	Specification		**Int.**	**MktRf**	**Smb**	**Hml**	**TED**	**VIX**	H^{SS}	$Adj-R^2$
Dep.Var.	IV	*Coeff*	**-0.0445**	**16.2556**	**22.8045**	10.6950	**5.7003**	0.0082	**0.5468**	8.34%
Kendall		*t-stat*	*-2.49*	*2.51*	*2.33*	*1.75*	*2.36*	*0.08*	*2.87*	
Correlation		*Econ. Sign.*		**0.1674**	*0.1046*		**0.2368**		**0.1591**	
Dep.Var.	IV	*Coeff*	**-0.0659**	**23.5711**	**33.5391**	14.1709	**8.0997**	0.0239	**0.7888**	8.37%
Spearman		*t-stat*	*-2.63*	*2.48*	*2.23*	*1.39*	*2.63*	*0.13*	*2.37*	
Correlation		*Econ. Sign.*		**0.1669**	**0.1059**		**0.2315**		**0.1579**	
Dep.Var.	IV	*Coeff*	-0.0154	8.0886	**39.5789**	-6.3317	4.7113	-0.1281	**0.5321**	3.61%
Pearson		*t-stat*	*-1.17*	*1.02*	*2.89*	*-0.94*	*1.58*	*-1.15*	*2.29*	
Correlation		*Econ. Sign.*			**0.1499**				**0.1277**	

Panel B.
All-in Panel Regression - Alternative Hedge Ratio (Vassalou and Xing, 2004)

	Specification		**Int.**	**MktRf**	**Smb**	**Hml**	**TED**	**VIX**	H^{VX}	$Adj-R^2$
Dep.Var.	III	*Coeff*	0.0090	-5.7458	14.9055	-9.0884	1.5265		**1.2799**	4.73%
Kendall		*t-stat*	*1.00*	*-1.05*	*1.52*	*-1.42*	*1.29*		*2.39*	
Correlation		*Econ.Sign.*							**0.1715**	
	IV	*Coeff*	-0.0093	-3.8054	11.6913	-6.6383	-0.5774	0.1705	**1.0813**	4.97%
		t-stat	*-0.86*	*-0.71*	*1.12*	*-1.08*	*-0.26*	*1.45*	*1.84*	
		Econ.Sign.							**0.1480**	

Table 14: Test of CDS Bid-Ask Spread Determinants:
Effect of Hedging Costs, Private Information Costs, Market Volatility and Funding Costs on Residual CDS Bid-Ask Spreads
The panel regressions are estimated with least squares; Panel dataset includes 45 non-financial companies and 300 weeks (Sep 2003 to Dec 2009); Residual CDS bid-ask spreads are obtained from a regression of CDS bid-ask spread on its first five lags (at individual firm's level); Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; No firms' fixed effects 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.

		Int.	$H^{SS}\times$ **Equity BA**	$H^{SS}\times$ **Equity BA** × **CDS Ret.(Lag 1)**	**CDS Inn**	**CDS Inn** × **CDS Mispricing (Lag 1)**	**Equity Inn**	**TED**	**VIX**	**Adj-**R^2
Dep.Var.	*Coeff*	-0.00080	0.00057		0.00018		- 0.00001	0.00074	0.00003	2.6%
Res. CDS	*t-stat*	*-5.51*	*3.66*		*6.56*		*- 0.05*	*3.23*	*2.72*	
Bid-Ask	*Econ.Sign.*		**0.0369**		**0.0855**		**- 0.0013**	**0.0726**	**0.0570**	
	Coeff	-0.00062	0.00057	0.00051	0.00019		-0.00010	0.00023	0.00003	3.2%
	t-stat	*-5.05*	*1.82*	*4.64*	*6.25*		*-1.52*	*1.62*	*3.50*	
	Econ.Sign.		**0.0368**	**0.0919**	**0.0912**		**-0.0234**	**0.0227**	**0.0577**	
	Coeff	-0.00067	0.00054	0.00049	0.00020	0.00024	-0.00012	0.00024	0.00003	3.7%
	t-stat	*-5.76*	*1.81*	*4.99*	*6.58*	*1.89*	*-1.87*	*1.62*	*3.92*	
	Econ.Sign.		**0.0349**	**0.0890**	**0.0926**	**0.0431**	**-0.0285**	**0.0548**	**0.0619**	
	Coeff	-0.00033	0.00086	0.00048	0.00020	0.00025	-0.00013	0.00058		3.5%
	t-stat	*-5.59*	*2.72*	*4.90*	*6.54*	*1.90*	*-1.99*	*3.96*		
	Econ.Sign.		**0.0559**	**0.0874**	**0.0935**	**0.0438**	**-0.0310**	**0.0569**		

B The Theory of the Merton Model (1974)

Merton model (1974) conjectures that the total value of a firm's asset A follow a log-normal diffusion process with constant growth rate μ^A and constant volatility σ^A:

$$dA_t = \mu^A A_t dt + \sigma^A A_t dW_t \tag{B.1}$$

where dW_t is a variable following a Wiener process.
The firms' liabilities consist of risky debt B (with face value D and maturity T) and equity E. The firm's leverage L is defined as the ratio between the present value of debt promised payment D and the total value of the assets A. Thus, it is equal to: $L = \frac{De^{-rT}}{A}$, where r is the continuously compounded risk-free interest rate in the market.

Under the assumptions of the Black-Scholes (1973) model[48], 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 debt D. The risky debt of the firm is instead evaluated as a short put position on the firm's asset (with strike equal to the promised debt payment D) and a long position on a riskless bond. Therefore, according to the Black-Scholes pricing formula for non-dividend paying European call options, at time 0 the equity value E_0 is given by:

$$E_0 = C^{BS}(A_0, \sigma^A, D, r, T) = A_0 N(d_1) - De^{-rT} N(d_2) \tag{B.2}$$

where N(.) is the cumulative function for the standard Normal distribution,
$d_1 = \frac{ln(\frac{A}{De^{-rT}})}{\sigma^A\sqrt{T}} + \frac{\sigma^A\sqrt{T}}{2} = \frac{-ln(L)}{\sigma^A\sqrt{T}} + \frac{\sigma^A\sqrt{T}}{2}$
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, the debt value B_0 is given by the difference between the total assets' value and the equity value:

$$B_0 = A_0 - E_0 \tag{B.3}$$

Using Equations (B.2) and (B.3) we obtain:

$$B_0 = De^{-rT} N(d_2) + A_0 N(-d_1) \tag{B.4}$$

This implies:

$$B_0 = De^{-rT} - (De^{-rT} N(-d_2) - A_0 N(-d_1)) = PV(D) - P^{BS}(A_0, \sigma^A, D, r, T) \tag{B.5}$$

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[48] The Assumptions behind Black-Scholes model (1973) and Merton model (1974) are the following:
- Market are competitive and efficient: agents are price-takers and trading has no affect on prices;
- There are no transaction costs;
- Agents trade continuously;
- Agents have unlimited access to short-selling and assets are indivisible;
- There are no bankruptcy costs in case of firm's default;
- There are no corporate taxes or tax advantages from issuing debt;
- Agents can borrow and lend at the same continuously compounded risk-free rate r;
- The firm has issued only two kinds of claims: non-dividend paying equity and debt. Debt is a pure zero-coupon bond that pays at maturity T an amount D.

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 non-dividends paying European put options).
Thus, the credit spread on the risky bond at time t is given by: $s_t = -\frac{1}{T-t} ln(\frac{B_t}{D}) - r$.

Equation (B.4) can be used to calculate the sensitivity (first derivative) of risky debt to assets' value which is given by the delta of the put option: $N(-d_1) = \Delta_P$.
The sensitivity of debt to equity is then given by:

$$\frac{\partial B}{\partial E} = \frac{\frac{\partial B}{\partial A}}{\frac{\partial E}{\partial A}} = \frac{N(-d_1)}{N(d_1)} = \frac{1}{\Delta_c} - 1 = h \tag{B.6}$$

Therefore it depends on the delta of a European call option written on the firm's assets with exercise price equal to the face value of debt. The debt-to-equity elasticity (hedge ratio) is obtained as:

$$H = (\frac{\partial B}{\partial E})(\frac{E}{B}) = h(\frac{1}{L} - 1) \tag{B.7}$$

Two common methodologies to calibrate the Merton model are the one of Vassalou and Xing (2004) - henceforth VX Methodology - and the one implemented by Schaefer and Strebulaev (2008) - henceforth SS Methodology.

The VX methodology requires the knowledge of the outstanding debt of the firm, the equity value, and the equity volatility[49] in order to estimate the value and volatility of the firm's assets from a system of two non-linear equations. Following Vassalou and Xing (2004), we recall Equation (B.2) 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 et al, 1984).

$$dE_t = df(A_t, t) = (\frac{\partial E}{\partial t} + \mu_A A_t \frac{\partial E}{\partial A} + \frac{{\sigma^A}^2}{2} A_t^2 \frac{\partial^2 E}{\partial A^2})dt + (\sigma^A A_t \frac{\partial E}{\partial A})dW_t. \tag{B.8}$$

It follows:

$$E_0 \sigma^E = A_0 \sigma^A \frac{\partial E}{\partial A} = A_0 \sigma^A N(d_1). \tag{B.9}$$

and

$$\sigma^E = \frac{\sigma^A A_0 N(d_1)}{E_0}. \tag{B.10}$$

Equations (B.2) and (B.10) represent a system of two equations in two unknowns (A_0 and σ^A). Therefore we can determine the unknowns by solving the non-linear equations. In practice, we adopt a recursive procedure (the so-called KMV method; see also Crosbie and Bohn, 2003, and Bharath

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[49] Typically, equity volatility is estimated from historical annualized volatility of equity daily log returns; the firm's equity value is obtained as a product of the firm's equity price and the number of its outstanding shares (i.e. the firm's market capitalization); and the outstanding amount of debt can be obtained as the book value of the firm's current debt plus half of its long-term debt value.

and Shumway, 2004) that involves inverting the Black-Scholes formula[50].

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). The methodology requires an estimation of the asset volatility for each firm i at time t as square root of:

$$\sigma_{i,t}^{A\,2} = (1 - L_{i,t})\sigma_{i,t}^{E\,2} + L_{i,t}\sigma_{i,t}^{D\,2} + 2(1 - L_{i,t})L_{i,t}\sigma_{i,t}^{ED} \tag{B.11}$$

$\sigma_{i,t}^{D}$ is the time t unconditional volatility of firm i debt - estimated as the historical annualized volatility of debt log returns; $\sigma_{i,t}^{E}$ is the time t unconditional volatility of firm i equity - estimated as the historical annualized volatility of equity log returns; $\sigma_{i,t}^{ED}$ is the time t covariance between firm i debt and equity - estimated as the historical annualized covariance between equity and debt returns; and $L_{i,t}$ is the leverage ratio of firm i at time t. Once A and σ^{A} are estimated, then it is possible to estimate also $N(d_1)$, the debt-to-equity hedge ratio H and the credit spread implied by the Merton (1974) model.

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[50] Crosbie et al (2003) explain that the model linking equity and asset volatility, described by the system of Equations (B.2) and (B.10), holds only instantaneously. In practice the market leverage moves around in a substantial way and the system does not provide reasonable results. Instead of using the instantaneous relationships given by Equations (B.2) and (B.10), we follow Crosbie et al (2003) and produce the hedge 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. This usually takes no more than a handful of iterations if a reasonable starting point is used".

C Data Treatment and Analysis of Equity and CDS Illiquidity Measures

C.1 Data Filtering

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). The CDX.NA.IG is composed of 125 firms. We select the sample of firms among the components of CDX.NA.IG Index to ensure continuous series of data for CDS quotes, but we exclude those companies recording missing values in the 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 bid-ask spread (Ask price - Bid price<0);
-Daily absolute change in equity price (CDS midquote) 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.

C.2 Analysis 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.

C.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:

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

  $\Delta P_{i,t}$ represents the price change (return) for firm i stock at the end of day t. The Roll measure is then 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:

$$\frac{Ask_{i,t} - Bid_{i,t}}{0.5(Ask_{i,t} + Bid_{i,t})} \tag{C.2}$$

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

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

$$\frac{|P_{i,t} - 0.5(Ask_{i,t} + Bid_{i,t})|}{0.5(Ask_{i,t} + Bid_{i,t})} \tag{C.3}$$

  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. 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, 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** (see 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 the total number of traded shares times the price per share).

$$Amihud_{i,w} = \sum_{t=1}^{5} \frac{|P^i_{t,w} - P^i_{t-1,w}|}{Vol^i_{t,w}} \tag{C.4}$$

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

C.2.2 CDS Illiquidity Measures

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

C.2.3 Treatment of Outliers and 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 in data we interpolate each variable using a linear method.

Figures C.1 - C.6 show the cross-sectional average for all equity and CDS illiquidity measures. The cross-sectional average is value-weighted on all 51 firms. From Figures C.1 - C.4 we notice that the pattern of the equity percentage bid-ask spread is similar to the patterns of the effective spread, the Roll measure, and the Amihud measure. Moreover, Figures C.5 and C.6 show an increasing pattern over the crisis period for both average CDS bid-ask spread and CDS run length measure.

C.2.4 Principal Component Analysis

Principal Component Analysis has been used in previous literature to study the relationship between different illiquidity proxies (see Dick-Nielsen et al, 2012, for the corporate bond market; and Jacoby et al, 2009, for bonds, equity, and CDSs). Following the methodology of these papers, we perform Principal Component Analysis (PCA) across all equity (and CDS) normalized illiquidity measures to evaluate the weight of the bid-ask spread in the First Principal Component (FPC). The Principal Components are computed on the correlation matrix of the illiquidity variables. We also obtain a Composite Illiquidity Index. This is computed at weekly frequency for equity and CDS of individual firms as a linear combination of the selected illiquidity proxies with average loadings in the FPC higher than 10%[51].

Aggregate results from Principal Component Analysis performed across all weekly illiquidity measures for equity and CDS of all firms are displayed in Figures C.7-C.10. Figures C.7 and C.9 show that for both equity and CDS, the average First Principal Component explains around 40% of common variation across different illiquidity proxies. Dick-Nielsen et al (2012) find the same result across illiquidity measures for corporate bonds. On average, bid-ask, effective spread, Roll measure, and Amihud measure have positive weights in the Equity First Principal Component, going from 75% of bid-ask spread to 48% of Roll measure (see Figure C.8). Trading frequency measures behave in a dissimilar fashion and are mainly captured by the less significant Second Principal Component (unreported result). Bid-ask and run length have on average positive weights in the CDS First Principal Component, respectively 50% and 45% (see Figure C.10). CDS Roll measure displays instead a different pattern.

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[51] 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 across all firms' First Principal Components.

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 measure (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 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. The PCA reveals that these four illiquidity measures behave similarly in the First Principal Component of equity illiquidity; however, bid-ask spread displays the highest loading (75%).

Figure C.1: Cross-sectional Value-Weighted Average of Equity Roll Measure
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

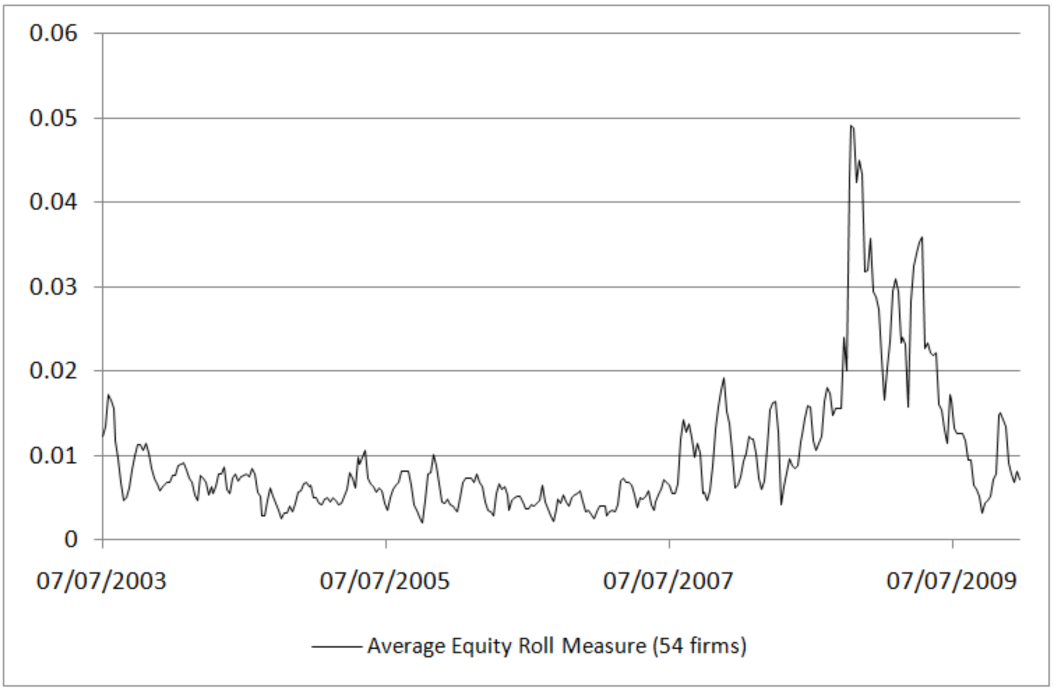

Figure C.2: Cross-sectional Value-Weighted Average of Equity Percentage Bid-Ask Spread
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

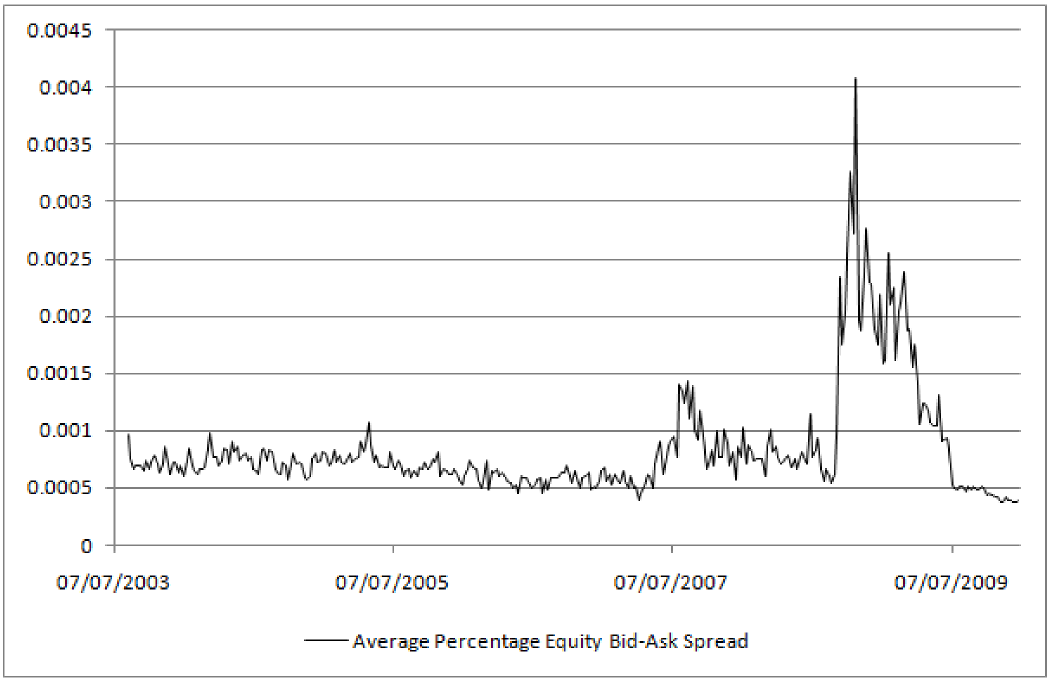

Figure C.3: Cross-sectional Value-Weighted Average of Equity Effective Spread
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

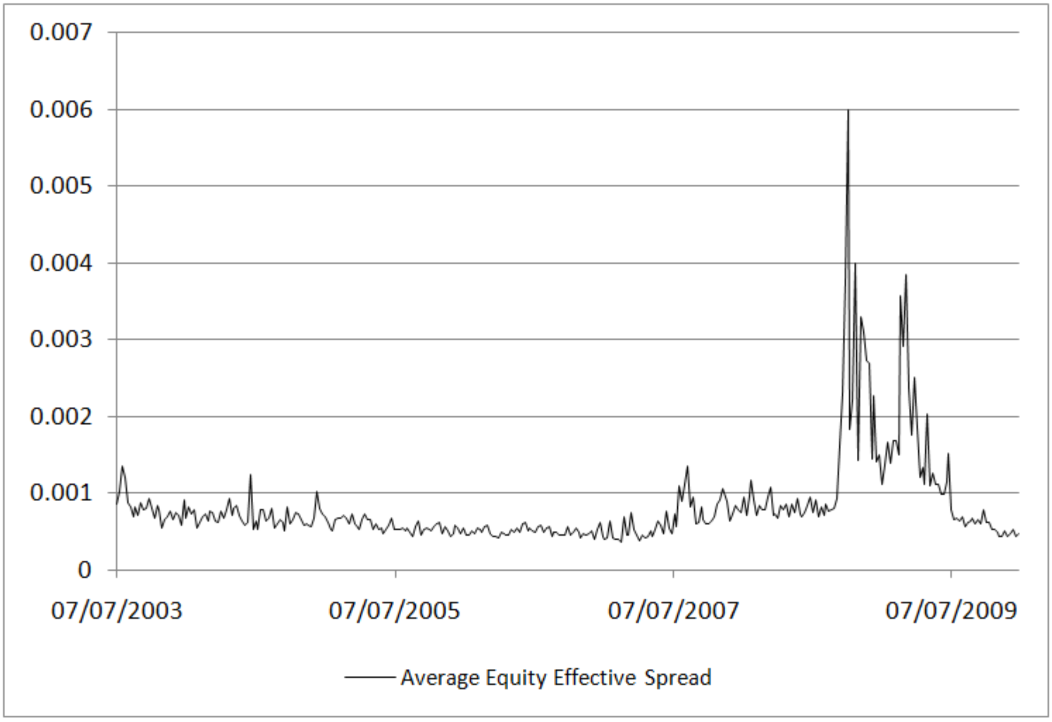

Figure C.4: Cross-sectional Value-Weighted Average of Equity Amihud Measure
(Measured in decimals, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

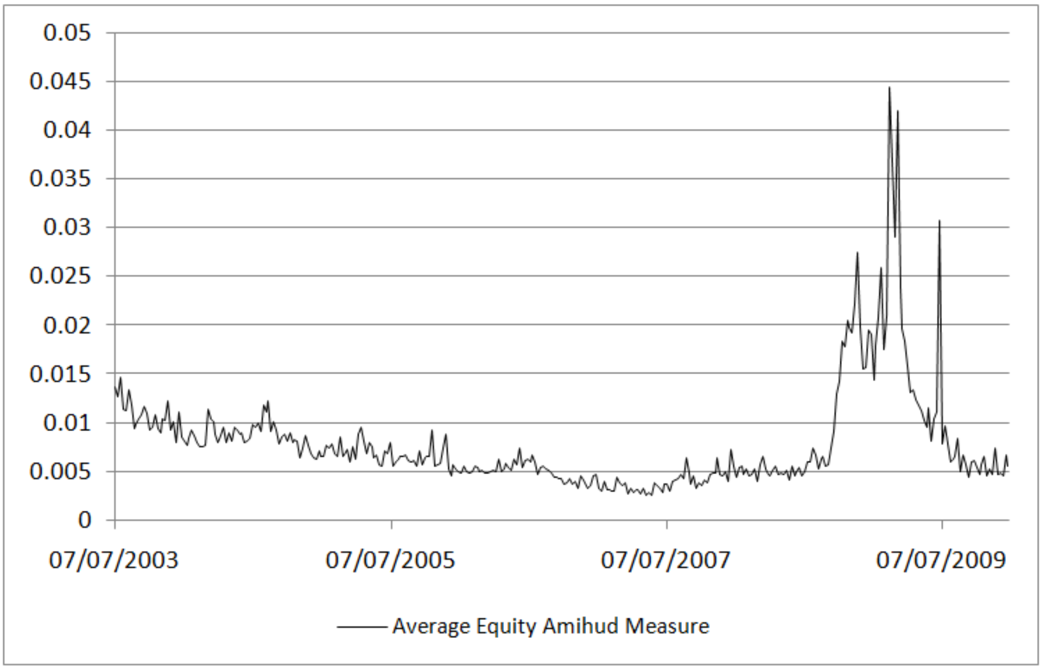

Figure C.5: Cross-sectional Value-Weighted Average of CDS Quoted Bid-Ask Spread
(Measured in basis points, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)

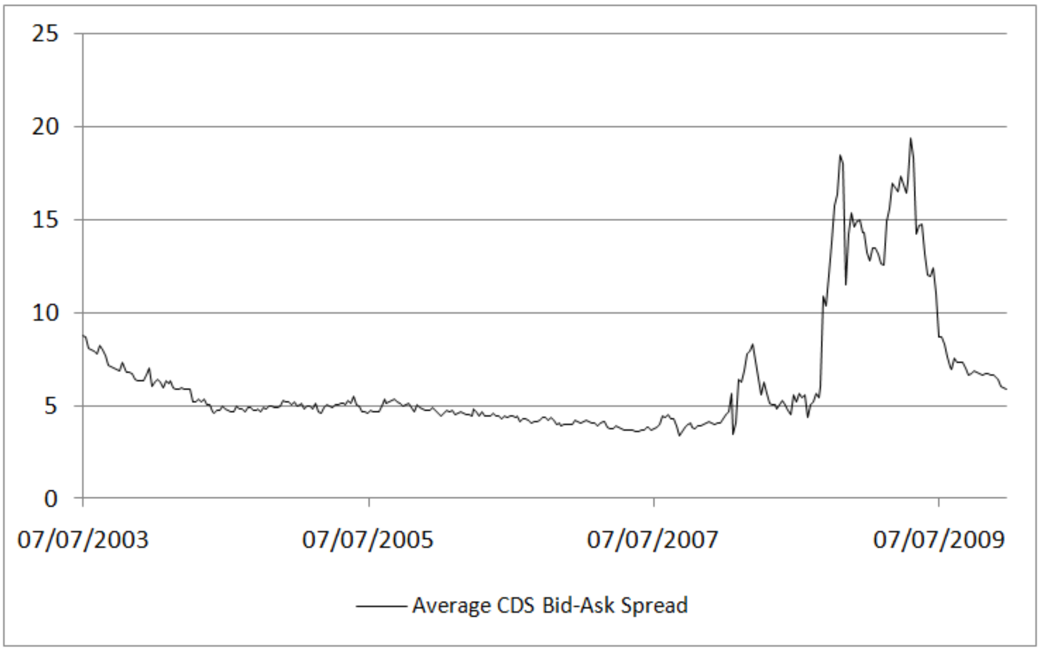

Figure C.6: Cross-sectional Value-Weighted Average of Weekly Maximum Value of CDS Run Length
(Measured in N^o *of days, Weekly Frequency, July 2003 - December 2009, Cross-Section of 51 Firms)*

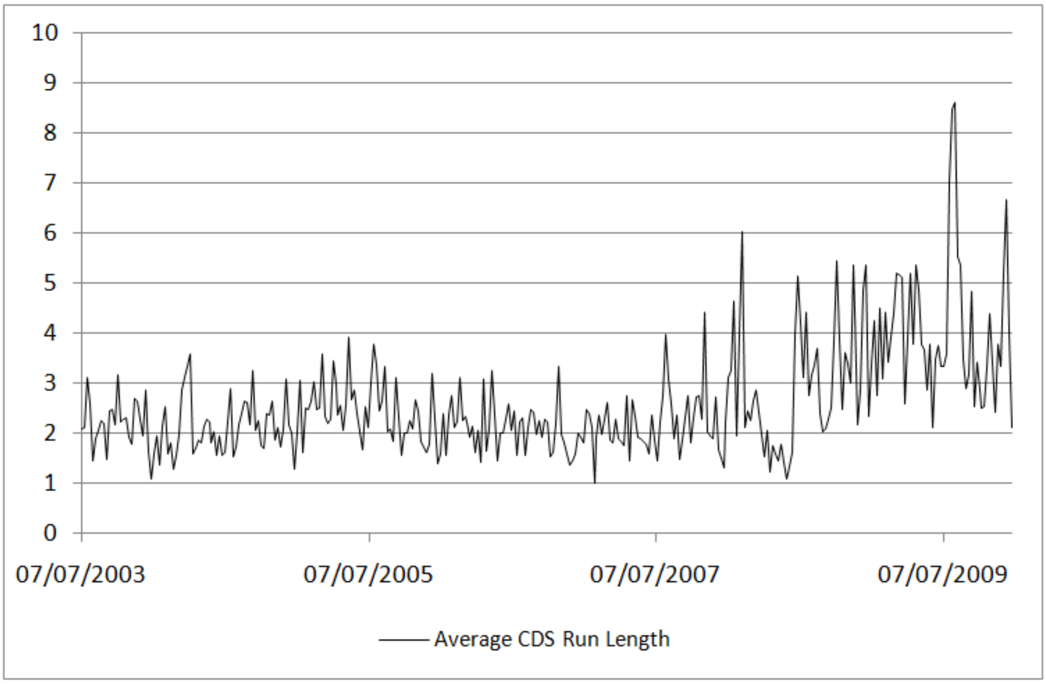

Figure C.7: PCA for Equity Illiquidity Measures: Cross-sectional Value-Weighted Average of Proportions of Variance explained by each PC

(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)

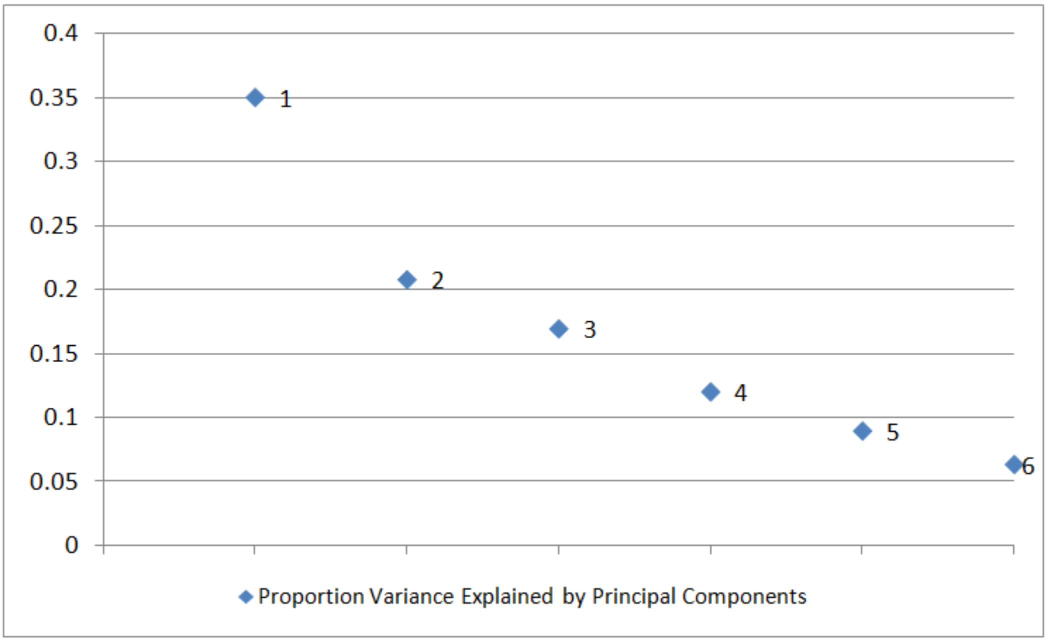

Figure C.8: PCA for Equity Illiquidity Measures: Cross-sectional Value-Weighted Average of Loadings of Illiquidity Measures in the First PC

(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)

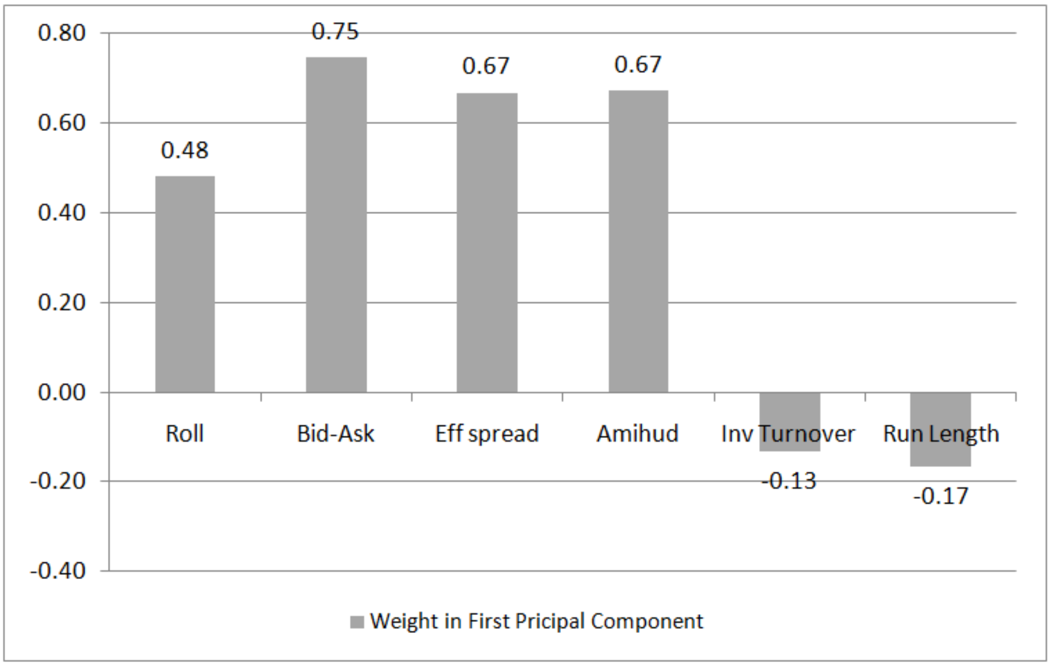

Figure C.9: PCA for CDS Illiquidity Measures: Cross-sectional Value-Weighted Average of Proportions of Variance explained by each PC

(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)

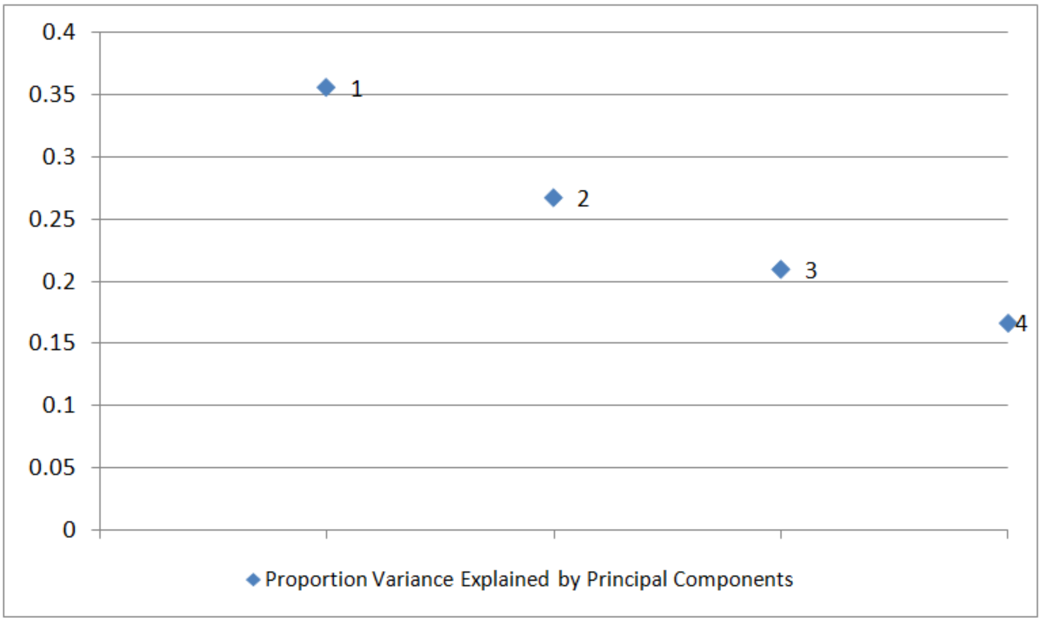

Figure C.10: PCA for Equity Illiquidity Measures: Cross-sectional Value-Weighted Average of Loadings of Illiquidity Measures in the First PC

(Measured in decimals, July 2003 - December 2009, Cross-Section of 51 Firms)