# Co-movements in Equity and CDS Illiquidity

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**Abstract**

This paper shows that bid-ask spread co-movements between equity and credit default swaps exist and increase over crisis periods. This commonality is found strongly related to several systematic risk factors and to the debt-to-equity hedge ratio which captures the hedging/arbitrage trading across the two markets. The paper also shows that hedging and information costs, besides higher funding costs and market volatility risk, are significantly priced in CDS bid-ask spreads.

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# 1 Introduction

Does illiquidity co-move across equity and credit markets and, if so, through what mechanisms? Equity and credit markets have strong inter-linkages, as outlined by the structural models (Merton, 1974)[1]. In addition, the increased use of credit default swap (CDS) contracts and equity for hedging and arbitrage trading over the past decade brings the relationship between these two assets even closer. Studying the commonality between equity and CDS markets illiquidity is important to understand whether, when, and to what extent, higher integration across the two markets may cause more risk to investors. Although the study of such commonality has important implications for asset pricing and risk management, the extent and causes of the cross-market illiquidity commonality have not yet been reported in the literature.[2]

Some theoretical literature provides models of commonality in illiquidity across different markets based on systematic risk factors, such as common negative shocks to traders' income, higher costs of funding and increasing market volatility (Schleifer and Vishny, 1997; Kyle and Xiong, 2001; Xiong, 2001; Gromb and Vayanos, 2002, 2010; and Brunnermeier and Pedersen, 2009). Severe financial constraints experienced by traders and high volatility risk may give rise to a forced withdrawal of liquidity in all markets where traders hold active positions, thereby increasing the cross-market commonality in illiquidity. Comerton-Forde et al (2010), Gârleanu and Pedersen (2011), Hameed et al (2010), and Ben-David et al (2012), amongst others, provide some empirical evidence for this theory. However, no paper so far has tested this mechanism for the equity-CDS illiquidity linkages.

Meanwhile, the rapid growth of the (over-the-counter) credit default swap market[3] in the

[1] Equity and credit are claims written on the underlying firm's assets, so they are fundamentally related.

[2] Several studies have instead examined within-market illiquidity commonality and highlighted that since the illiquidity of an individual asset is affected by the illiquidity of the overall market, this commonality represents risk which is priced in the security (see: Halka and Huberman, 2001, Hasbrouck and Seppi, 2001, and Chordia et al, 2005 for the U.S. equity market; Chakravarty and Sarkar, 2003, Houweling et al, 2005, Cao and Wei, 2010, and Karolyi et al, 2012, respectively for corporate bonds, options, and international equity markets).

[3] CDS gross notional amount outstanding has increased from about US$10 trillions in 2005 to around US$60 trillions at its peak in 2007. Despite the financial crisis, the total gross notional amount was still around US$30 trillions in mid-2009 (Bank for International Settlement Data).

last few 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, 2012); CDS and bond spreads' dependence on equity liquidity risk (de Jong and Driessen, 2012; and Das and Hanouna, 2009); time-varying integration between equity and CDS returns (Kapadia and Pu, 2012); effect of bad credit news and CDS market informed trading on the equity market (Acharya and Johnson, 2007; and Qiu and Yu, 2012); effect of the introduction of CDS contracts on the quality of equity and bond markets (Boehmer et al, 2013; and Das et al, 2014); 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 into or explanation of this phenomenon. The literature therefore lacks an accurate and comprehensive investigation of the extent and causes of credit-equity illiquidity linkages and how they have evolved over time. Our study fills this gap: it is the first to investigate the existence of equity-credit commonality in illiquidity and to show that traders' funding constraints, higher market volatility and hedging/arbitrage activity across markets are channels through which illiquidity can increase and spread across the two markets. Moreover, the paper employs this finding to shed some light on the determinants of the CDS bid-ask spread, which have been left quite unknown and unassessed by the existing literature.[4]

We analyze 45 U.S. firms over the period April 2003 - December 2009. We measure illiquidity with bid-ask spreads. First, we capture the co-movement between equity and CDS bid-ask spreads. Correlation analysis and graphic analysis suggest that the commonality changes over time: it is much higher in 2003 than during the period 2004-2006 and then it rises again

[4] A paper by Meng and Ap Gwilym (2008) reports a positive relationship between CDS bid-ask spreads and credit ratings, firm's volatilities and demand-supply pressure over a limited time sample running from 2003 to 2005.

during the recent crisis period 2007-2009. Second, we investigate the determinants of this phenomenon.

Our paper detects a significant positive effect of systematic factors, such as higher funding constraints and market volatility, on the equity-CDS bid-ask spread commonality (proxied by the Kendall's tau measure of association). Furthermore, it shows that the hedge ratio (estimated from the Merton's model) is another important determinant of the increase in the bid-ask spread commonality. The debt-to-equity hedge ratio measures the sensitivity of debt (or credit) claims to changes in the value of equity. When the credit condition of a firm worsens, this sensitivity increases: credit and equity markets become more integrated and closer substitutes for each other. Thus, one might expect the liquidity costs in the two markets to be linked more strongly.

In order to investigate further the relationship between CDS and equity bid-ask spreads we test for the existence of cross-market spillovers. We find that for most firms in the sample illiquidity is transmitted either from CDS to equity or in both directions: it is rare to observe a one-way transmission from equity to CDS. The direction of illiquidity spillovers at the firm level does not have a one-to-one correspondence with the direction of return spillovers and only for a quarter of firms does it follow the direction of volatility spillovers. In addition, we find that CDS and equity illiquidity are influenced by general market illiquidity, but for most firms only 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 more extreme shifts in beliefs that generate higher firm's volatility and/or an increase in bid-ask spreads appear to be detected first in the CDS market and then transmitted to the equity market.[5]

The parallel literature on liquidity linkages of equity options and futures with the underlying equity market[6] offers some intuition on how illiquidity may be transmitted across markets via dealers' hedging activity and information signals. CDS dealers (mostly sophisticated banks)

[5]This finding is consistent with the work of Acharya and Johnson (2007), Marsh and Wagner (2010), Qiu and Yu (2012), and Boehemer et al (2013).

[6]See, amongst others: Biais and Hillon, 1994; Kumar and Seppi, 1994; Easley et al, 1998; Cho and Engle, 1999; John et al, 2003; de Fontnouvelle et al, 2003; Kaul et al, 2004; Huh et al, 2012.

can hedge their unbalanced CDS positions in the equity market, particularly in presence of higher credit risk. They recover the hedging cost (given by the delta-hedging ratio times the equity bid-ask spread) by increasing the CDS bid-ask spread. As Biais and Hillon (1994) and Huh at al (2012) explain, larger hedging activity in the derivative market where most informed traders trade (CDS) may convey a signal of higher information risk to the dealers in the underlying market (equity). As a result, equity dealers protect themselves by increasing the bid-ask spreads in the equity market. This increase widens further the cost of hedging for CDS dealers and the CDS bid-ask spreads, thereby reinforcing the co-movements.

Besides this hedging channel, an arbitrage channel can also help to explain the commonality in illiquidity. When capital structure arbitrageurs observe a significant mispricing between CDS and equity (particularly after a negative shock to the firm), they may decide to trade across the two markets to profit from it. As Foucault et al (2014) also point out, the arbitrageurs' informed trading activity represents an act of liquidity consumption to which dealers in CDS and equity respond by increasing bid-ask spreads in both markets. Therefore, higher hedging and arbitrage trading may induce commonality in illiquidity across CDS and equity markets.

We further test these hypotheses by analyzing the determinants of CDS bid-ask spreads. After controlling for the significant effects of higher market volatility and crisis-periods effects, we confirm that also hedging costs, asymmetric information and mispricings across CDS and equity markets (indicative of trading interest of sophisticated arbitrageurs) significantly contribute to an increase in CDS bid-ask spreads.

The paper's novel contribution to the literature is three-fold. First, the paper carries out an in-depth analysis of bid-ask spread co-movements across equity and CDS markets. Second, it identifies various channels (funding, hedging, arbitrage) that explain this co-movement. Third, it models the determinants of CDS bid-ask spreads (funding costs, market volatility, hedging costs, asymmetric information).

Some of our findings are in line with contemporaneous work by Boehmer et al (2013). In that paper the authors report that the *introduction* of a CDS contract on a specific name can have a negative effect on the price informativeness and liquidity of the corresponding equity. The effect augments when credit risk is high, due to speculative trading driving away uninformed traders from the equity market. They obtain this result by examining the effect of a dummy variable (equal to 1 if a CDS contract for the specific name exists, 0 otherwise) on the equity. Despite this clear complementarity, our paper has a distinct nature and contribution. First, rather than looking only at the effect of the CDS introduction, our paper studies the liquidity determinants and dynamics of actively-quoted CDS contracts (measuring liquidity with bid-ask spreads) and illustrate how CDS illiquidity co-moves with equity illiquidity in some periods. Second, while one of the explanations we offer for the illiquidity commonality across equity and CDS is the speculative trading channel in part illustrated also by Boehmer et al (2013), we find additional negative influences that come from: higher hedging costs for CDS dealers; negative information signals conveyed to equity dealers by the increasing hedging activity of CDS dealers; and larger funding costs and market volatility risk which affect negatively dealers' inventories across all markets. Third, Boehmer et al (2013) study a sample that goes from 2003 to 2007, while we extend our sample to 2009. This difference is particularly significant for the richness of our results. CDSs start being traded in 2003. At first, the CDS market was particularly illiquid and opaque, but then in 2004-2006 its liquidity increased. After 2007, during the crisis, the CDS market liquidity decreased again (see Figure 1). At the beginning of 2009 several operational and trading changes have been introduced in order to increase the standardization, openness and transparency of the CDS market. It is therefore important to look dynamically to changes in CDS liquidity, in relationship with the equity market liquidity, and to understand why they both dropped over particular periods. Moreover, since we look at the crisis period, we need to study carefully the common effects that traders' funding constraints and market-wide volatility have on the liquidity of both CDSs and equity.

The paper is organized as follows. Section 2 describes the data employed and presents the statistical evidence on the existence of equity-CDS illiquidity co-movements. Section 3 tests the effects of the systematic risk factors and of the debt-to-equity hedge ratio on the commonality in illiquidity between CDS and equity and explains the mechanisms behind the hedging/arbitrage channel. Section 4 analyses the determinants of CDS bid-ask spreads. Section 5 concludes.

# 2 Detecting Co-movements between Equity and CDS Bid-Ask Spreads

In this section we first report some basic facts about equity and CDS markets, then we describe the data sample used, and finally we analyse the co-movements between equity and CDS bid-ask spreads.

## 2.1 CDS AND EQUITY MARKET MICROSTRUCTURE

In normal times, equity and CDSs are 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 short time.[7] While the traders' composition in the equity market is very heterogeneous, the CDS market is mainly a trading venue for hedging and speculative activity of institutional investors. For example, banks hedge their large portfolios of loans in the CDS market and 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.[8]

The microstructure of CDS and equity markets is different. The CDS market is a bilateral dealership over-the-counter market, with no centralized quote disclosure mechanism and with a less than fully competitive network of (private) dealers, usually controlled by a group

[7] In September 2009 the corporate CDS market has nearly outsized the bond market, reaching USD 9.7 trillion versus USD 10.0 trillion for their long-term debt securities (BIS, Quarterly Review, March 2010).

[8] 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).

of major banks.[9] 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 also use CDSs for managing the risk connected to their own loan exposure (and they are net buyers of CDS protection).[10] 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 their respective assets. The dealer buys a security on her own account (at the bid price) or sells 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.

### 2.2 DATA DESCRIPTION

For the analysis of equity-CDS bid-ask spread co-movements we employ data on 45 U.S. companies which are components of the Dow Jones 5-years CDX North America Investment Grade Index (CDX.NA.IG) in order to ensure continuous series of CDS quotes. We use 5-year CDS contracts because trading liquidity and data availability is highest in this maturity. The CDX.NA.IG index is composed of 125 firms; however, 45 firms remain after excluding financial firms[11] and companies recording missing values in the CDS series for more than 20

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

[10] Banks' trading activity constitutes 33% and 36% respectively of total sold and purchased 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).

[11] We exclude the financial and insurance companies, after observing that during the crisis these firms (e.g. American International Group) have been target of direct/indirect Government intervention which likely had a one-off impact also on the trading costs of their securities (and set the firms apart for a different kind of analysis).

consecutive days over the period 2003-2009. In our sample we include investment-grade firms that did not suffer from major distress or restructuring events over the period considered. These companies have large market capitalization and are typically followed by a large number of analysts. Their stocks and CDSs are typically more liquid than the stocks and CDSs of small and distressed firms. This sample selection ensures more conservative results in terms of detecting substantial equity and CDS illiquidity and commonality across their bid-ask spreads.

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. The major source of the CDS data disseminated by Bloomberg is the Credit Market Analysis (CMA) database. Mayordomo, Pena and Schwartz (2010) show that the CMA database leads in CDS price discovery, when compared to other five major CDS data providers (GFI, Fenics, Reuters, Markit and JP Morgan). Bloomberg constructs a composite quote which reflects the arithmetic average across the best bid and ask CDS spreads offered by the leading dealers in the market.[12] Bid and ask prices are market quotations, rather then transaction-based prices. This has some advantages, as highlighted by Völz and Wedow (2011). First, the Bloomberg CDS time series covers a wide range of CDS price information from various participants, rather than information from one specific broker that might not reflect the true conditions of the inter-dealer market. Thus, quotes are not distorted by the evaluation of a single market participant. Second, while some CDSs may be traded discontinuously, the indicative quotes reflect a broader picture of market activity and liquidity. After filtering the data[13], we obtain a daily equity dataset of 75,825 observations and a daily CDS dataset of 72,739 observations. Equity bid and ask prices are

[12] When calculating the average, Bloomberg excludes infrequent quotes, but not outliers.

[13] For each firm we delete all observations which exhibit for equity and CDS at least one of the following conditions: null bid or ask price; negative bid-ask spread (Ask price - Bid price $<0$). Equity and CDS bid-ask spreads and returns are winsorized at the 0.5% lowest and highest values.

quoted in dollar terms, while CDS bid and ask prices are quoted in basis points. For CDS bid-ask spread we use the difference between quoted bid and ask prices (as in Bongaerts et al, 2011; Völz and Wedow, 2011; Corò et al, 2013; and Pires et al, 2014), while for equity bid-ask spread we used the ratio between quoted bid-ask spread and mid-quote price.[14]

## 2.3 STATISTICAL ANALYSIS

Our illiquidity measures are equity and CDS bid-ask spreads.[15] The (value-weighted) average bid-ask spread over the whole sample (April 2003 - December 2009) is 8.1 bps and 5.7 bps respectively for equity and CDS. On average, the equity bid-ask spread is larger and more volatile than the CDS bid-ask spread. The standard deviations are equal to 5.8 bps for equity and 1.8 bps for CDS. Given the different distributional properties of the two variables, in Figures 1, 2, and 3, we plotting the normalized/standardized bid-ask spreads to facilitate the comparison of their time-trends 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).[16] We observe that 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.

Pearson's, Kendall's Tau and Spearman's Rho measures of correlation between equity and

[14] As Corò et al (2013) point out, there is an ongoing debate on whether CDS bid-ask spread should be measured by the absolute difference between ask and bid quotes, or by this difference normalized by the mid-quote point (as for example in Hilscher et al, 2013). Pires et al (2014) provide a convincing numerical argument and show that since the CDS bid-ask spread is already a proportional measure there is no need to divide it by the mid-quote (as it is done instead for the equity bid-ask spread). This choice is particularly appropriate to perform a correct comparison between CDS and equity bid-ask spreads.

[15] 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 preliminary work we ascertain that the bid-ask spread can be an informative measure of illiquidity for both equity and CDSs. To do so, we construct a number of illiquidity proxies at weekly frequency (for equity: Amihud measure, Roll measure, effective spread, bid-ask spread, run length and inverse turnover index; for CDSs: only run length and bid-ask spread, due to lack of transaction prices and volume data) and then perform Principal Component Analysis (PCA) across all of them. For both CDS and equity we observe that the pattern of the average bid-ask spread over time is consistent with other measures of transaction costs and price impact of trades. The PCA also reveals that the bid-ask spread has the highest loading in the First Principal Component, amongst all other illiquidity measures. The results of this analysis are unreported for brevity, but available upon request.

[16] For the empirical analysis in the remainder of the paper we use instead actual bid-ask spreads (not normalized).

CDS bid-ask spreads are calculated for each firm over each quarter (with no overlapping observations). The three estimated correlations are used as alternative measures of commonality in illiquidity. Pearson's correlation ($\psi$) measures the degree of *linear* association between equity and CDS bid-ask spreads. Rank correlation coefficients, such as Spearman's rank correlation ($\rho$) and Kendall's rank correlation ($\tau$), measure how well the relationship between the two variables can be described using a *monotonic* function, without requiring the function to be linear.[17] The cross-sectional value-weighted averages are 56% for Pearson, 31% for Spearman's Rho, and 20% for Kendall's Tau. Table 1 shows the distributions of these measures of correlation (averaged over different time samples) across all 45 firms. Despite the dispersion of values being quite wide, the estimated measures remain on average largely positive over the whole sample period, as well as over the sub-samples 2003 and 2007-09. Correlation distributions present insignificant mean and median values only in the middle of the period (2004-2006). Figure 4 illustrates the cross-sectional averages for the three measures of correlation between equity and CDS bid-ask spreads. 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 co-movements between equity and CDS bid-ask spreads of 45 firms using different measures of association. However, the co-movement varies over time and becomes prominent only over periods of higher credit risk and market turbulence, such as in 2003 and in 2007-2009. Outside these periods, little or no co-movement is observable.

[17] 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 Test of the Determinants of Commonality between Equity and CDS Bid-Ask Spreads

Statistical analysis has detected the existence of time-varying co-movements between equity and CDS bid-ask spreads. The next step of our study is to investigate the sources of the illiquidity co-movement.

Equity and CDS bid-ask spreads might surge contemporaneously because of an independent response of equity and CDS dealers to market-wide frictions. Previous literature has pointed out that the ability of dealers to provide liquidity in equity and CDS markets depends on the cost of funding, on the level of market volatility, and on the level of systematic risk. An increase in these factors in fact causes larger uncertainty and inventory risk for dealers, and wider dealership costs (see, amongst others, Brunnermeier and Pedersen, 2009).

In addition, because of the arbitrage linkage between the two markets, an increase in CDS and equity bid-ask spreads may be the result of a common response of dealers to: (i) adverse movements in the firm's fundamentals; or (ii) transmission of negative shocks across the two markets.[18] In this case, the closer the fundamental linkage between the two markets, the larger the commonality between CDS and equity bid-ask spreads. The theoretical linkage between the two markets is well explained by the structural models of default risk (Merton, 1974) and can be captured by the debt-to-equity hedge ratio, as illustrated also in Appendix. 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 the other simultaneous effects.

## 3.1 TEST MODELLING AND VARIABLES' CONSTRUCTION

In this test the bid-ask spread commonality variable $Comm_{i,t}^{BA}$ is represented by Kendall's Tau measure of correlation (Fisher-transformed) between daily equity and CDS bid-ask

[18] Bid-ask spreads can co-move across equity and CDS markets even in the absence of systematic risk, just as a result of firm-specific negative shocks (see Das and Hanouna, 2009, for related work).

spreads of firm $i$ constructed over each quarter $t$ from April 2003 to December 2009.[19]

We regress the bid-ask spread commonality $Comm_{i,t}^{BA}$ on some variables which previous market microstructure literature has found to be significant in affecting the dealership costs:
- Systematic risk factors (Fama-French market, size, and book-to-market factors):
Higher exposure of a firm to market, size, and book-to-market risk factors ($MktRf$, $SMB$, and $HML$) may cause higher inventory costs for dealers operating in both the CDS and equity market of the specific firm, which then translate in higher bid-ask spreads.
- Cost of external funds (proxied by the spread between the 3-month LIBOR rate and the 3-month T-Bill yield, $TED$):
Dealers in different markets open and maintain their positions by borrowing external funds (the cost of funding also represents an opportunity-cost). Therefore, the higher funding cost 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.
- Market volatility (proxied by the S&P500 option implied volatility index, $VIX$):
Higher volatility can increase inventory costs and cause dealers to impose larger bid-ask spreads across all markets where they provide liquidity.
Furthermore, we analyse the effect of the hedge ratio $H_{i,t}^{SS}$ on the bid-ask spread commonality $Comm_{i,t}^{BA}$.

We perform the following panel least squares regression (estimating firms' clustered standard errors):

$$Comm_{i,t}^{BA} = \alpha_i + \beta_1 MktRf_t + \beta_2 SMB_t + \beta_3 HML_t + \delta_1 TED_t + \delta_2 VIX_t + \theta H_{i,t}^{SS} + \epsilon_{i,t} \tag{1}$$

[19] Kapadia and Pu (2012) use Kendall's Tau to measure the co-movement between CDS and equity returns and the level of integration between the markets. They stress three advantages of using this measure: first, Kendall's Tau does not need any parametric setup; second, it is not impacted by non-linearities; third, being intuitively related to the variables' co-movement, it is not affected by interpretation-ambiguity, unlike other measures, such as the coefficient of determination. A more positive Kendall's Tau corresponds to equity-CDS markets being more integrated in their liquidity costs.

where $i$ is the firm index and $t$ is the time (quarter) index. $\alpha_i$ represents firm-fixed effects.

$H_{i,t}^{SS}$ is the estimated debt-to-equity hedge ratio for firm $i$ in quarter $t$. The Appendix describes the two methodologies followed (from Vassalou and Xing, 2004, and Schaefer and Strebulaev, 2008) to estimate the debt-to-equity hedge ratios[20] using the Merton (1974) model.[21] The two methodologies are called respectively VX and SS for brevity. To estimate Equation (1) we employ the hedge ratio obtained from SS methodology. Afterwards, we check also the effect of the hedge ratio obtained from the VX methodology in order to provide more robustness to the results.

We indicate as Specification I the panel regression for Equation (1) without the VIX Index; and as Specification II the panel regression which includes the VIX index on the right-hand side of the Equation. This differentiation aims to disentangle the potential effect of TED-VIX collinearity on the estimation results. In all model specifications we include firms' fixed effects.[22] In further Specifications (III and IV) we also control for time effects. In Specification III we augment the right-hand side of Equation (1) by interacting the hedge ratio variable $H_{i,t}^{SS}$ with $Qtr_{2003:2}, ..., Qtr_{2009:3}$, which represent dummies for each quarter of each year in the sample. In Specification IV we control for time-fixed effects in Equation (1): we drop all regressors which vary only over the time-dimension (the three Fama- French factors, TED and VIX) and replace them with the time-dummies and a control variable which proxies firms' exposures to systematic risk $SysRisk_{i,t}$. This variable is obtained for each

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

[21] 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 firms' hedge ratios (Schaefer and Strebulaev, 2008).

[22] We cannot control for time-fixed effects in the Specifications I and II as some regressors change only over the time-dimension ($MktRf$, $SMB$, $HML$, $TED$, $VIX$). However, Specification III and IV include time-fixed effects. Furthermore, in order to report only robust results and mitigate eventual concerns on unit-roots in the key-variables, the panel regression are performed on a sub-sample of 18 companies which display stationarity in both the commonality and the hedge ratio series. The tests of unit roots are run using Augmented Dickey-Fuller equations with number of lags set by Schwartz information criterion and at 5% significance level. In unreported results, we observe that the results of the regression hold unchanged when all 45 firms are included in the analysis.

firm as a Fisher z-transformation of the $R^2$s from the regressions of the firm's daily excess returns on the three Fama-French factors over each quarter. In particular, Specifications III and IV represent two robustness checks on the effect of the hedge ratio on the commonality variable, since the time dummies can capture the effects of extreme events (e.g., 2007-08 subprime crisis).

Furthermore, we repeat the estimation of Specifications I and II of Equation (1) by replacing the hedge ratio $H^{SS}$ with its component orthogonal to general market default risk and volatility ($H^{SS,ORT}$). This check should alleviate the concern that the hedge ratio's influence on the equity-CDS bid-ask spread commonality simply picks up the increase in default risk and volatility at the 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-year government bond yield (market default risk factor $DEF$); and ii) the $VIX$ index. We then use the residuals from this regression ($H^{SS,ORT}$) as an explanatory variable in Equation (1).

Finally, to mitigate concerns about the endogeneity of the hedge ratio in the specified model, we first perform the Hausmann-Wu test of endogeneity, using as instruments for the hedge ratio the equity volatility, the squared equity volatility and the leverage ratio. Second, we re-estimate Equation (1) - Specification I by 2-Stage Least Squares, using the above instruments. These variables in fact appear highly correlated with the hedge ratio (by construction), but almost uncorrelated with the errors in Equation (1), as confirmed heuristically by correlation analysis between the three instruments and the residuals estimated from the previous regressions (Specifications I and II).

### 3.2 ANALYSIS OF THE VARIABLES AND RESULTS OF THE TEST

Tables 2 and 3 respectively report the pair-wise correlation and (Granger) causality matrices for all the relevant variables. The hedge ratio is highly correlated with all measures of bid-ask spread and return commonality.[23] All these variables are also closely related to market default risk, the VIX index, and the TED spread (see Table 2). The pair-wise Granger causality matrix in Table 3 identifies which causality relationship is most likely for each pair of variables. 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 bid-ask spread and return commonality remains instead ambiguous.

The hedge ratio represents a first approximation to 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 the Appendix). Figure 5 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) $H$ and sensitivity $h$ 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 6 displays a similar pattern for both the average hedge ratio estimated with SS methodology and with VX methodology (April 2003-November 2008). Noticeably, Figure 7 reveals a very close relationship between the average hedge ratio and CDS-equity bid-ask spread commonality over time.

The panel analysis in Table 4 (Panel A) reveals positive and significant effects of the TED spread, VIX index, and systematic risk factors on the bid-ask spread commonality, but also a positive influence of the hedge ratio, after controlling for firms' unobservable fixed effects. The positive effect of the hedge ratio on the bid-ask spread commonality survives when we replace the hedge ratio with its component orthogonal to market default risk and market volatility ($H^{SS,ORT}$). We also evaluate the separate *economic* impact of the hedge ratio versus the impact of market frictions and systematic risk factors. In Table 4 (Panel B) we notice that the the aggregate economic significance of all systematic factors is about 0.52

[23] We construct the following commonality variables: $\psi_{i,t}^{BA}$, $\tau_{i,t}^{BA}$, and $\rho_{i,t}^{BA}$, 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 $t$; and $\psi_{i,t}^{RET}$, $\tau_{i,t}^{RET}$, and $\rho_{i,t}^{RET}$ the same correlation measures between equity and CDS returns. For more details on the correlation measures see section 2.3.

(in terms of standard deviations impact) and the economic significance of the hedge ratio is around 0.16.[24]

In Table 5 we control more directly for time-effects. This check is needed since the period analyzed includes the crisis event. We notice that when the hedge ratio is interacted with time-quarter dummies (Panel A), its positive effect on the bid-ask spread commonality variable is strong and significant only during the first two quarters of 2003, the first three quarters of 2007, the third quarter of 2008 and the second quarter of 2009. The effect of the hedge ratio instead decreases and even turns negative during the third quarter of 2005. Furthermore, the panel analysis results reported in Table 5 (Panel B), where the bid-ask spread commonality is regressed on the hedge ratio, the firm's exposure to systematic risk and the time dummies, confirm that the positive and significant effects of hedge ratio and systematic risk is not wiped out after controlling for time fixed effects.

In Table 6 (Panel A) we present the results of the Hausmann-Wu test on the hedge ratio's endogeneity.[25] The auxiliary panel regression for the test includes the hedge ratio as the dependent variable and three instrumental variables as regressors (equity volatility, squared equity volatility and leverage ratio). Given the choice of instruments, the Hausmann-Wu test rejects the hypothesis of endogeneity of the hedge ratio, since the coefficient of the fitted variable appears insignificant.[26] Using the same instrumental variables, we also perform a 2-Stage Least Squares estimation (with and without fixed effects) of Equation (1) Specification I. The results are reported in Table 6 (Panel B) and confirm the significance of the hedge ratio's coefficient and the robustness of the results to potential endogeneity of this explanatory variable.

[24] The economic significance is obtained by multiplying the estimated beta coefficient by the ratio of the standard deviation of the explanatory variable to the standard deviation of the dependent variable.

[25] The Hausmann-Wu test is a t-test on the coefficient of the fitted values from the "auxiliary regression". These fitted values are used as additional regressor in the panel equation (Specification I).

[26] The same result is achieved also when using only equity volatility and leverage, and only equity volatility or only leverage as instruments. The correlation between the hedge ratio and the instruments is in the order of 70%. The correlation between the instruments and the residuals from the panel regression (Specification I in Table 4) is insignificant and around 0. The test loses power when applied to small samples. Since we may be in presence of a small sample bias, we need to be cautious when interpreting the results of the test. For this reason, we also perform a 2-Stages Least Squares estimation.

As final robustness checks we repeat the analysis (Specifications I and II) using:

1) As alternative dependent variables (measures of bid-ask spread commonality) the Spearman rank measure of association and the Pearson correlation between equity and CDS bid-ask spreads;

2) As an alternative measure of the hedge ratio, the one estimated with the Vassalou and Xing (2004) methodology.[27] Details on this methodology are provided in the Appendix.

A comparison between the results of the three alternative regressions in Panel A of Table 7 shows that using Spearman's instead of Kendall's correlation does not change the results, while using the Pearson correlation as dependent variable in the regression leads to the hedge ratio and the size factor being the only significant variables. The economic impact of the hedge ratio remains in a range between 0.13-0.16 standard deviations.

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 7, 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 the hedge ratio appears less useful than the SS measure.

To sum up the results in this section, the equity-CDS bid-ask spread commonality increases with higher funding costs, higher market volatility and systematic risk. The debt-to-equity hedge ratio is also found strongly significant, both statistically and economically, and survives several robustness checks.

### 3.3 INTERPRETATION OF THE HEDGE RATIO'S SIGNIFICANCE FOR THE EQUITY-CDS ILLIQUIDITY LINKAGES

The hedge ratio can explain part of the commonality between equity and CDS bid-ask spreads, even after controlling for the positive effect of systematic factors. This may happen for two reasons:

[27] When we use the hedge ratio from the VX Methodology instead of the SS hedge ratio we consider a restricted time sample running from April 2003 to October 2008.

1) A negative shock to the common underlying firm may generate a similar response from dealers in the equity and CDS markets, who *independently* increase their respective bid-ask spreads.
2) A negative shock to the common underlying firm may generate information flows, trading and spillovers across equity and CDSs, to which the dealers in the two markets may respond in a *correlated* manner. To disentangle this second type of effect, we start by looking at the existence of spillovers across CDS and equity markets.

#### 3.3.1 *Spillovers*

We first test for the existence of illiquidity spillovers across equity and credit markets for the 45 firms in our sample by performing pair-wise Granger causality tests at the individual firm level for daily CDS and equity bid-ask spreads over the period running from April 2003 to December 2009. We also perform vector autoregressions (VARs) at the individual firm level for daily equity and CDS bid-ask spreads and prices. Table 8 shows the results of the Granger causality tests: the causality runs from CDS to equity for 24 firms and in both directions for 17 firms (but for 12 of these firms the evidence of casuality running from CDS to equity is much stronger than the other way round).[28]

Next, we examine the causal relationship between equity and credit returns for each company in the sample. If the same information on the firm's asset quality is impounded in both returns and bid-ask spreads, consistent with the results on the direction of illiquidity spillovers, we should observe stronger evidence for CDS returns Granger causing equity returns than the other way round. However, what we observe is exactly the opposite. We find that for most of the firms (36 out of 45) equity returns Granger cause CDS returns, but not the other way round (see Table 9). Additionally, we study the relationship between

[28]The reported results are obtained from Granger-causality tests including only two lags of the variables. Increasing the number of lags appear to strengthen the result in favour of illiquidity spillovers running form CDS to equity. Detailed results of VAR analysis at firm level are not reported for brevity, but they are available upon request. The VAR results are quite conservative because the VAR performs controls also on past price effects and the analysis can only detect lead/lag relationships and not causality across equity and credit markets. Nevertheless, the VAR tests show illiquidity connections across the two markets and a more pronounced evidence for illiquidity contagion running from CDS to equity or in both ways.

CDS and equity volatility. A surge in equity (CDS) volatility might result in an increase in the equity (CDS) bid-ask spread which then spills over. The results from the Granger causality tests in Table 10 show that higher CDS volatility drives higher equity volatility more frequently than the other way round (in 17 cases versus 5, while for 11 firms volatility spillovers are detected in both directions). Vast empirical literature suggests that volatility is more affected by past negative news than by past positive news.[29] At the individual firm level, the results on the direction of Granger causality for CDS-equity bid-ask spreads and volatilities match only for 25% of the firms in the sample.[30]

Finally, we perform regressions of each individual CDS (equity) bid-ask spread on the firm's asset volatility and CDS (equity) market average illiquidity (the average excludes the individual firm). 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 11).[31] In (unreported) regression analysis on CDS and equity prices, we find a significant effect of asset volatility on the CDS premium for a larger number of firms than on the equity price, after controlling for aggregate market effects.[32] 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 reflect the CDS' 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 a shock to asset volatility can be a source of illiquidity spillovers from CDS to equity, rather than of simultaneous (independent) illiquidity increases in both CDS and equity.

[29] See, for example, Dufour et al (2008); Chen and Ghysels (2011); Bollerslev, Engle and Nelson, (1994); Andersen, Bollerselv, Christoffersen and Diebold (2006); Bollerslev, Litvinova and Tauchen, (2006); Barndorff-Nielsen, Kinnebrock and Shephard, (2010); and Patton and Sheppard (2011)

[30] For 8 firms both the illiquidity spillovers and the volatility spillovers run from CDSs to equity. For 3 firms both the illiquidity spillovers and the volatility spillovers run across markets in both directions.

[31] 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.

[32] 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.

The reported results in this section seem to suggest that negative firm-specific information and illiquidity are incorporated first in the CDS market and then transmitted to the equity market. Previous and contemporaneous literature to our paper offers some support to this finding. Zhou (2005) finds that in-the-money options (likewise the equity written on the firm's asset value) attract investors who possess mild firm-specific information, while deep out-of-the-money options (likewise the CDS contracts) catch the attention of those who possess more extreme information. Acharya and Johnson (2007) find that CDS can lead equity when there is bad news about the company 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. Finally, Boehmer et al (2013) paper reports that the introduction of traded CDS contracts in the market over the period 2002-2007 has generated a negative information spill-over on the quality of already-traded equity claims. All these papers are close to our work. However, our paper moves further in this literature area by showing that information spillovers contribute to explain the existence of illiquidity linkages across equity and CDS markets — via dealers' hedging activity and their responses to speculative demand (see next paragraph 3.3.2) — and to model the determinants of CDS bid-ask spreads (see section 4).[33]

#### 3.3.2 *Theoretical Explanations*

Existing theoretical models of cross-market commonality in illiquidity base the increase in equity and CDS bid-ask spreads on funding constraints of traders (see Brunnermeier and Pedersen, 2009). Our results confirm the importance of this "funding channel" on equity-CDS illiquidity co-movements. However, this channel cannot explain alone the cross-market transmission of illiquidity shocks based on informed flows. A model by Cespa and Foucault (2014) justifies the existence of cross-market illiquidity spillovers on the assumption that dealers in one market (e.g. the equity market) look at the other market (e.g. the CDS market) in order to capture negative shocks in the firm's riskiness and then set the bid-ask

[33]Notably, our paper also explores a longer time-sample of data which includes the whole period 2007-09 of the financial crisis and compares it to the more tranquil period 2004-2006.

spreads accordingly. Both these theories confine the explanations for equity-CDS illiquidity spillovers to a world of "segmented traders" who may (or may not) look at prices and spreads across CDS and equity markets, but do not take positions across the markets. Instead we will now consider CDS and equity as non-segmented markets and analyse information flows and trading activity across the two markets as potential channels of illiquidity transmission.

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. As explained in section 2.1, in the CDS market the dealers can be informed or uninformed agents, while noise traders are uninformed agents mostly demanding CDS protection.[34] In the equity market both dealers and noise traders are uninformed agents. Noise traders enter into trades 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 immediately recognize when prices in the equity and CDS markets are inconsistent and trade in order to profit from the mispricing.

Let us analyse what may happen when the credit risk of a firm and its debt-to-equity hedge ratio increase and how this may affect the CDS-equity bid-ask spread commonality. We begin by considering the CDS dealers and their hedging needs and then turn to examining the interaction between the dealers in the CDS and equity markets, and the interaction between arbitrageurs and dealers.

The risk-averse CDS dealer who supplies liquidity to noise-traders and arbitrageurs can hedge her short CDS unbalanced position (say $X$) by shorting the corresponding equity (for an amount equal to $hX$).[35] The implicit cost of the hedging is the bid-ask spread of equity multiplied by the hedge ratio ($h \times Equity^{BA}$).[36] This hedging cost is recovered by the dealer

[34] 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.

[35] 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.

[36] 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.

from the bid-ask spread she sets in the CDS market ($CDS^{BA}$). When the size of the hedge ratio $h$ increases (this should also be large enough to have a recognizable effect) and the CDS dealer faces an increasing demand for CDS protection from noise-"CDS buyers", the cost of hedging surges and becomes a more important component of the CDS bid-ask spread, creating a stronger linkage between the liquidity costs in the CDS market and the liquidity costs in the equity market.

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). A recent paper by Huh et al (2012) offers some further interesting results: it shows that when option dealers hedge their unbalanced positions in the equity market in presence of asymmetric information, they involuntarily convey a signal to equity dealers about the higher information risk. As a consequence, equity bid-ask spreads widen and further increase option bid-ask spreads. This *hedging channel* can easily be applied to our case of CDS dealers hedging in the equity market (as some dealers-banks also have an informational advantage) and it can help to explain not only the effect of the hedge ratio on the bid-ask spread commonality, but also the existence of illiquidity spillovers running from CDS to equity (signal effect).

In paragraph 3.3.1 we assess that firm-specific bad news tends to be priced first in the CDS market and then in the equity market. Qiu and Yu (2012) also find that the information flow from CDS to equity is at the highest level just ahead of possible credit events, when the hedge ratio is particularly high. This asymmetry can generate a temporary mispricing between CDS and equity for a specific firm and it can fuel arbitrage trading across the two markets (so-called capital structure arbitrage).[37] For example, if well-informed arbitrageurs

[37] In recent years capital structure arbitrage (CSA) has 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 (2006) and Duarte, Longstaff and Yu (2007) analyse CSA trades involving credit default swaps (CDS) and equity and find that the strategy appears to offer attractive Sharpe ratios of around 0.8. The LIPPER TASS Asset Flow Report for hedge funds in the second quarter of 2008 disclaims a per-annum average compounded growth of 17% for funds invested in capital structure arbitrage strategies over the period January 1994 - June 2008.

(e.g., hedge funds) believe that the equity price for a specific firm is too high with respect to its CDS spread, they take a short position ($Z$) in the CDS and a short position ($hZ$) in the corresponding equity.[38] The size of their cross-market positions is equal or proportional to the debt-to-equity hedge ratio estimated from a sophisticated structural model.[39] A higher hedge ratio, coupled with a substantial mispricing, therefore commands a larger correlated liquidity demand from informed arbitrageurs across the two markets, to which uninformed CDS and equity dealers react by increasing CDS and equity bid-ask spreads. A very recent model by Foucault et al (2014) has formalized this mechanism of market liquidity drop due to an information advantage on the arbitrageurs' side. Thus, if the CDS-equity arbitrage is possible and convenient (i.e. the CDS mispricing and $h$ are significantly above 0), then 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.).[40]
This *arbitrage channel* can represent another potential source of CDS-equity bid-ask spread commonality.

To sum up, when a firm's credit condition worsens and its debt-to-equity hedge ratio increases, higher commonality between CDS and equity bid-ask spreads can arise because of:

[38] After a negative shock, the CDS premium may either over-react to the arrival of the new information or incorporate it correctly before the equity price. The cross-market arbitrage trading narrows the mispricing between CDS and equity and allows the capital structure arbitrageurs to profit from the trading regardless of whether the CDS premium will then decrease (after the initial over-reaction) to match the correct level of the equity price, or the equity price will decrease to match the new correct level of the CDS premium.

[39] Yu (2006) 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."

[40] In principle, 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 high, hedging activity can be very costly and dealers are more likely to apply a form of partial, rather than perfect, hedging (see Froot and Stein, 1998). Therefore, they can remain exposed to the risk of losses due to informed trading. The information risk is not borne instead by superiorly-informed CDS dealers, who may decide not to increase CDS bid-ask spreads when this risk is higher. Thus, on aggregate, we should observe an average increase in CDS bid-ask spreads in response to larger information risk, but the effect should be less pronounced than in the equity market. Consistently, average equity bid-ask spread appears higher and more volatile than average CDS bid-ask spread during turbulent times (see Figure 1). Moreover, it should be noticed that when the firm's credit risk is very high, the superiorly-informed CDS dealers may decide to withdraw from the market: thus, the CDS dealers who remain available to supply CDS contracts to noise traders could be mainly uniformed agents.

1) Larger hedging trades of CDS dealers who need to rebalance their positions in the equity market;

2) Negative signal of higher asymmetric information conveyed by CDS dealers to equity dealers via their hedging activity;

3) Larger demand for liquidity across CDS and equity markets from better-informed capital-structure arbitrageurs (when a CDS-equity mispricing arises), to which uninformed dealers react by setting higher bid-ask spreads in both equity and credit markets.

# 4 Test of the Determinants of CDS Bid-Ask Spread

The equity-CDS illiquidity commonality channels offers also some interesting hypotheses on the determinants of CDS bid-ask spread which we test in the last part of the paper.

First, we know that CDS dealers need to hold some capital to finance their activities and that they set the bid-ask spreads in the CDS markets in order to recover the cost of the funding needed. Higher market volatility augments the cost of keeping unbalanced positions and the risk of a freeze in funding availability.

Second, the hedging/arbitrage channel of commonality illustrated in section 3 suggests that CDS bid-ask spreads should also depend on:

1) The cost of hedging in the equity market.

This cost should become more significant when the hedge ratio is substantial and when the CDS dealer faces an increasing demand for CDS protection from "noise-traders" (e.g. bondholders).

2) The amount of informed trading across equity and credit markets.

Asymmetric information should affect the CDS bid-ask spread via an increase in CDS dealers' hedging activity and/or via informed arbitrage trading across the markets (when a CDS-equity mispricing arises).

### 4.1 TEST MODELLING

In panel analysis, we regress CDS bid-ask spreads on: (i) Hedging costs, represented by the equity bid-ask spread times the delta-hedging factor ($BA^E \times h^{SS}$); (ii) A proxy for asymmetric information ($AsymInfo$); (iii) A proxy for CDS mispricing ($CDS\ Mispricing$); and (iv) the VIX index.

The asymmetric information ($AsymInfo$) is proxied by the dispersion of analysts' forecasts. If analysts' disagreement on the future perspectives of a well-known large U.S. firm is wide, this means that less public information is available and the risk of asymmetric information is higher. We construct the dispersion of analysts' forecasts on firm's earnings per share over a forecasting period of three months as the ratio between the median of earnings forecasts for each firm across all analysts and the relative standard deviation. We follow the methodology of Buraschi et al (2013). We use analysts' forecasts of earnings per share taken from the Institutional Brokers Estimate System (I/B/E/S) database.[41]

Additionally, we want to examine whether the hedging-cost effect on CDS bid-ask spreads is caused primarily by an increase in the hedging activity of CDS dealers because of: (1) higher asymmetric information; or (2) higher liquidity demand. Therefore, we interact the hedging-cost proxy ($BA^E \times h^{SS}$) respectively with the analysts' forecasts dispersion ($AsymInfo$) and with a proxy for the amount of CDS liquidity demand. Since we do not possess CDS transaction data, for this purpose we use the weekly change in total bonds' traded volume ($\Delta BondV$). For each firm, we select the transacted volumes for all its traded bonds over each week from the TRACE database; we then sum the volumes and take the first difference with respect to the previous week. If there is an increase in the volume of traded bonds for a specific firm, it is more likely that there would also be an increase in the demand for CDS

[41] This database contains individual analyst's forecasts organized by forecast date and last date when the forecast was revised and confirmed as accurate. Following Buraschi et al (2013), and Diether, Malloy, and Scherbina (2002), we use only stock-split unadjusted data. As an initial step, we match analysts' forecast data with our equity and CDS data. We extend each forecast date to its revision date: if, for example, a forecast is made in January 2007 and it is last confirmed in March 2007, we use this forecast for January, February, and March 2007. If more than one forecast per month is recorded for the same analyst, we use the forecast which was confirmed most recently.

protection from bondholders.

Finally, we test for the impact of capital structure arbitrageurs' trading activity. When mispricing arises in the CDS market, they perform informed trading across the equity and credit markets. To investigate the effect of this cross-market arbitrage, we include as explanatory variable a proxy for CDS mispricings ($CDS\ Mispricing$), obtained as lagged residuals from a structural model. For this purpose, we use an implicit structural model that includes the usual controls for firms' leverage ratio, asset volatility and for short spot interest rate (Merton, 1974), but also controls for firms' (equity) illiquidity, size and market-wide default risk.

The following panel regression (including firm-fixed effects $\alpha_i$) is estimated:

$$
\begin{aligned}
BA_{i,t}^{CDS} &= \alpha_i + \beta_0(BA_{i,t}^{E} \times h_{i,t}^{SS}) + \beta_1(BA_{i,t}^{E} \times h_{i,t}^{SS}) \times AsymInfo_{it-1} + \beta_2(BA_{i,t}^{E} \times h_{i,t}^{SS}) \times \Delta BondV_{it} \\
&= +\gamma AsymInfo_{it-1} + \delta CDS\ Mispricing_{it-1} + \zeta VIX_t + \epsilon_{i,t}
\end{aligned}
\tag{2}
$$

We perform the test at the weekly frequency. The following elements represent desirable properties of the test of Equation (2) when compared to the previous test performed on the bid-ask spread commonality variable — Equation (1): (i) the test is executed on CDS bid-ask spreads directly, therefore it does not need to rely on estimated measures of correlation; (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.

### 4.2 RESULTS OF THE TEST

In the panel regression analysis at the weekly frequency for CDS bid-ask spreads (Table 12) market volatility (VIX) is found positively significant. Its significance is larger when we perform the analysis only over the crisis period 2007-2009 (unreported results). After controlling for all cost-components, the economic impact of VIX is always in a range between

0.23 and 0.25 SD (depending on the regression specification). In addition, the hedging-cost component enters significantly in all estimated equations, also when we include a control for (time and firms) fixed effects or the VIX index. A 1 standard deviation (SD) change in hedging costs generates an increase of around 0.4 SD in the CDS bid-ask spread. The hedging cost component alone can explain about one third of the variation in the CDS bid-ask spreads. When we add other control variables (particularly time-fixed effects), the impact of the hedging costs on the CDS bid-ask spread remains still significant, but it is halved.

In principle, the effect of hedging costs on CDS bid-ask spreads should be larger when the CDS demand from noise bondholders is higher. However, we find that the hedging cost interacted with the change in the amount of traded bond volumes has at most a weakly significant positive coefficient (with less than 10% significance level). In terms of economic impact, the interaction term adds on average only 0.09 SD to the impact of the hedging factor.[42,43] We find instead that the hedging activity of CDS dealers becomes a more significant cost-component of the CDS bid-ask spread when it is triggered by higher asymmetric information, rather than by higher liquidity demand in the CDS and bond markets. In fact, the hedging cost interacted with the analysts' forecasts dispersion is positively significant at the 1% significance level. On average a 1 SD increase in the interaction variable has an additional impact of 0.17 SD on the hedging factor.[44]

Table 12 also shows that the CDS mispricing variable is found highly significant (with 1% significance level and 0.32 SD economic impact). Interestingly, when the CDS mispricing is included in the panel regression together with the proxy for asymmetric information, the latter appears only weakly insignificant (at 10% significance level). This result seems to suggest that: 1) the asymmetric information risk is connected to some form of speculative

[42]This number is calculated by multiplying the economic significance of the interaction term 0.01 by the average positive change in total bond volumes transacted.

[43]We also repeat the analysis using as proxy for increased CDS demand the lagged value of CDS returns (as in Qiu and Yu, 2012), but we still find insignificant results.

[44]This number is calculated by multiplying the economic significance of the interaction term 0.11 by the average value of the lagged dispersion variable.

trading across markets; 2) potential speculative demand can also affect directly the CDS bid-ask spreads, outside the hedging channel. CDS dealers do not know with certainty the timing and size of capital structure arbitrageurs' trading and cannot completely protect themselves by hedging in the equity market. Some unhedged information risk remains and increases dealership costs further.

To conclude, the CDS bid-ask spread is significantly influenced by the cost of dealers' hedging activity in the equity market. This activity consolidates the linkage between the liquidity of the CDS market and the liquidity of the equity market. Higher asymmetric information increases the effect of CDS dealers' hedging activity on the CDS bid-ask spread, more significantly than higher liquidity-demand. The explanatory power of analysts' disagreement and CDS mispricing (proxy for arbitrage interest) suggests that CDS dealers may not be able to perfectly hedge against the risk of informed speculative activity.[45] Time-fixed effects and higher market volatility are also found highly significant in explaining an increase in CDS dealership costs and bid-ask spreads. The most complete specifications of the panel regression in Equation (2) exhibit impressive adjusted $R^2$s between 50% and 62%.[46]

[45] Given our lack of high-frequency transaction data for the CDS market, we have used panel analysis at weekly frequency. The relatively low frequency of the analysis should bias the results towards *under-detecting* the incidence of cross-market hedging and arbitrage activity on CDS bid-ask spreads, since the relative trading takes place at higher frequency. Nevertheless, the data and test we have employed in this paper suggest that hedging-costs and arbitrage activity are significant determinants of the CDS bid-ask spreads.

[46] The adjusted $R^2$s drop to 40% when fixed effects are removed, but they are still substantial. In separate panel analysis, we also find a strong effect of CDS bid-ask spreads and VIX on equity bid-ask spreads. We observe that the equity bid-ask spreads is not significantly influenced by CDS mispricings and asymmetric information. The information risk signal is instead conveyed from the CDS market via the hedging activity of CDS dealers. In fact, when we include the past value of the CDS dealers' hedging costs in the panel equation (we use past values to avoid endogeneity issues), we find that this variable is highly significant. However, the adjusted $R^2$ is lower than those obtained from the regressions of CDS bid-ask spreads. Results are unreported for brevity, but are available upon request.

# 5 Conclusions

This paper examines linkages between illiquidity in equity and CDS markets and sets a framework to identify and test the determinants of their co-movements. CDS and equity are assets trading correlated (firm's equity and credit) risks. We find that illiquidity co-moves across equity and credit markets, but the commonality varies in magnitude over time and increases over periods of higher credit risk and market turbulence, when equity and CDSs become also closer "substitutes" for each other.

We find that higher funding costs of traders and higher market volatility are common determinants of the increase in equity and CDS bid-ask spreads. When traders are forced to withdraw their positions due to lack of funding or higher market risk, liquidity decreases in both markets and liquidity costs rise.

In addition, we show that the debt-to-equity hedge ratio has a significant impact on the cross-market bid-ask spread commonality and that the hedge ratio's significance can be explained by a hedging/arbitrage channel. Two mechanisms support this finding. First, risk-averse CDS dealers (mainly banks) 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, the hedging cost paid by CDS dealers becomes a larger component of the CDS bid-ask spread. In addition, when the hedging increases because of a larger risk of informed trading, CDS dealers convey a negative signal to equity dealers. As a consequence, equity dealers protect themselves by setting higher equity bid-ask spreads (and this has a further effect on CDS bid-ask spreads). Second, since new (negative) information about the firm tends to be impounded in the CDS price first and then transmitted to the equity price, a temporary CDS-equity mispricing can arise and fuel informed CDS-equity arbitrage trading. Uninformed equity and CDS dealers 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 further.

In light of the results on the effects of the funding channel and the hedging/arbitrage channel, the paper also performs a novel analysis on the determinants of CDS bid-ask spreads and detects a significant positive influence of higher market volatility and larger hedging and asymmetric information on CDS dealers' costs and CDS illiquidity.

To summarize, this paper makes several new contributions to the emerging literature on credit-equity linkages. First, unlike any previous study, it explicitly examines the extent and causes of the commonality in illiquidity between equity and credit (CDS) markets. Second, building on previous theoretical literature, it confirms that higher funding costs, market volatility and systematic risk can cause stronger illiquidity linkages across equity and credit markets. This analysis appears of critical importance since the credit crisis was characterized by a market-illiquidity contagion episode which was exacerbated by traders' lack of financial resources. Third, to the best of our knowledge, this is the first work that employs the debt-to-equity hedge ratio estimated from the Merton (1974) model to show that the commonality in illiquidity across CDS and equity markets can be also explained by the hedging and arbitrage trading across the two correlated markets. Finally, the paper applies the insights of the commonality analysis to provide a novel framework for modelling CDS bid-ask spreads and understanding the CDS liquidity dynamics.

The paper offers some inputs for the future development of a consistent theory of illiquidity commonality across correlated assets based on their arbitrage/hedging linkages and information flows. Moreover, while this paper is focused on the study of CDS-equity illiquidity linkages, further research should be devoted to a more extensive identification of the sources and nature of information flows across correlated markets and to their effects on prices and bid-ask spreads.

# Appendix:
# Estimation of the Debt-to-Equity Hedge Ratio from the Merton's Model (1974)

The Merton model (1974) assumes that the total value of a firm's asset $A$ follow a log-normal diffusion process with constant growth rate $\mu^A$ and constant volatility $\sigma^A$:

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

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[47], the Merton (1974) model prices equity and risky debt of a firm as contingent claims written on the firm's assets. The equity $E_0$ of the firm is priced as a call option on the assets of the firm with strike price equal to the face value of debt $D$.

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

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 $d_2 = d_1 - \sigma^A \sqrt{T}$.

[47] 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 $D$.

The sensitivity (first derivative) of equity to firm's total assets value is determined by the call option delta: $N(d_1) = \Delta_C$.

The risky debt $B_0$ 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:

$$B_0 = PV(D) - P^{BS}(A_0, \sigma^A, D, r, T) = De^{-rT} - (De^{-rT}N(-d_2) - A_0N(-d_1)) \quad \text{(A.3)}$$

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:

$$\frac{\partial B}{\partial E} = \frac{\frac{\partial B}{\partial A}}{\frac{\partial E}{\partial A}} = \frac{N(-d_1)}{N(d_1)} = \frac{1}{\Delta_c} - 1 = h \quad \text{(A.4)}$$

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:

$$H = (\frac{\partial B}{\partial E})(\frac{E}{B}) = h(\frac{1}{L} - 1) \quad \text{(A.5)}$$

Two common methodologies to estimate $H$ 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[48] in order to estimate the value and volatility of the firm's assets from a system of two non-linear equations. Since the equity is a function of assets' value (A.2), it is possible to apply Ito's Lemma to determine the instantaneous volatility of

[48] 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.

equity $\sigma^E$ from total assets' volatility $\sigma^A$ (Jones et al, 1984):

$$\sigma^E = \frac{\sigma^A A_0 N(d_1)}{E_0}. \tag{A.6}$$

Equations (A.2) and (A.6) represent a system of two equations in two unknowns ($A_0$ and $\sigma^A$). 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 and Shumway, 2004) that involves inverting the Black-Scholes formula[49].

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:

$$\sigma_{i,t}^{A\,2} = (1 - L_{i,t})\sigma_{i,t}^{E\,2} + L_{i,t}\sigma_{i,t}^{D\,2} + 2(1 - L_{i,t})L_{i,t}\sigma_{i,t}^{ED} \tag{A.7}$$

$\sigma_{i,t}^D$ 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 $\sigma^A$ are estimated, then it is possible to estimate also $N(d_1)$ and the debt-to-equity hedge ratio $H$ implied by the Merton (1974) model.[50]

[49] Crosbie et al (2003) explain that the model linking equity and asset volatility, described by the system of Equations (A.2) and (A.6), 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 (A.2) and (A.6), 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".

[50] For this purpose, we set $T = 5$ (maturity of the CDS contracts) and $r$ equal to the 1-month T-Bill yield.

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# Figures and Tables

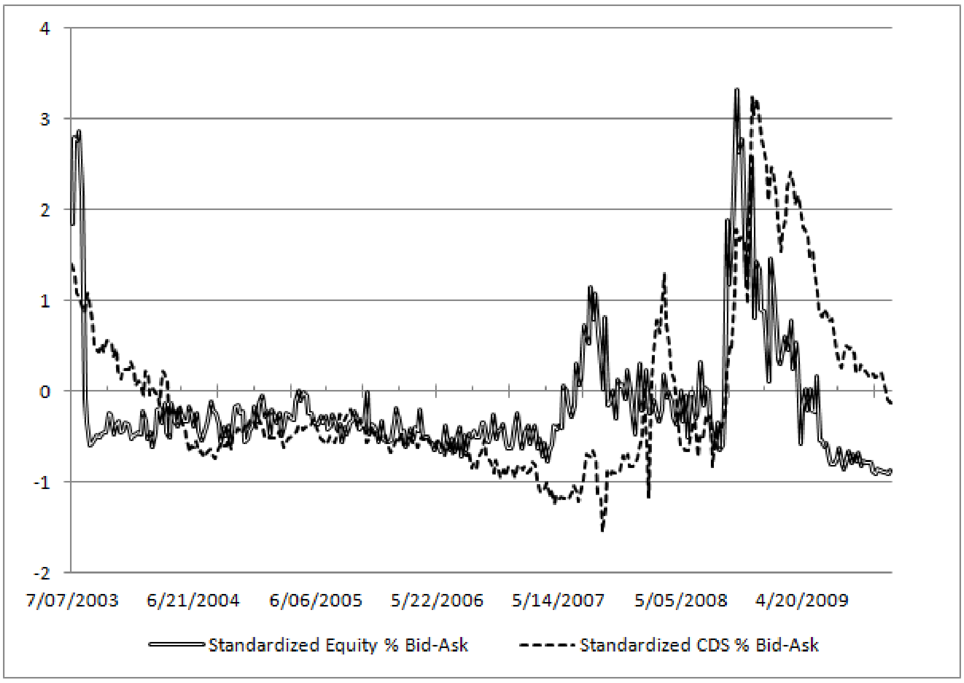


**Figure 1:** Cross-Sectional Value-Weighted Average of CDS and Equity Bid-Ask Spreads - All Sample *(Normalized, Weekly: July 2003 - December 2009, Cross-Section of 45 Firms)*

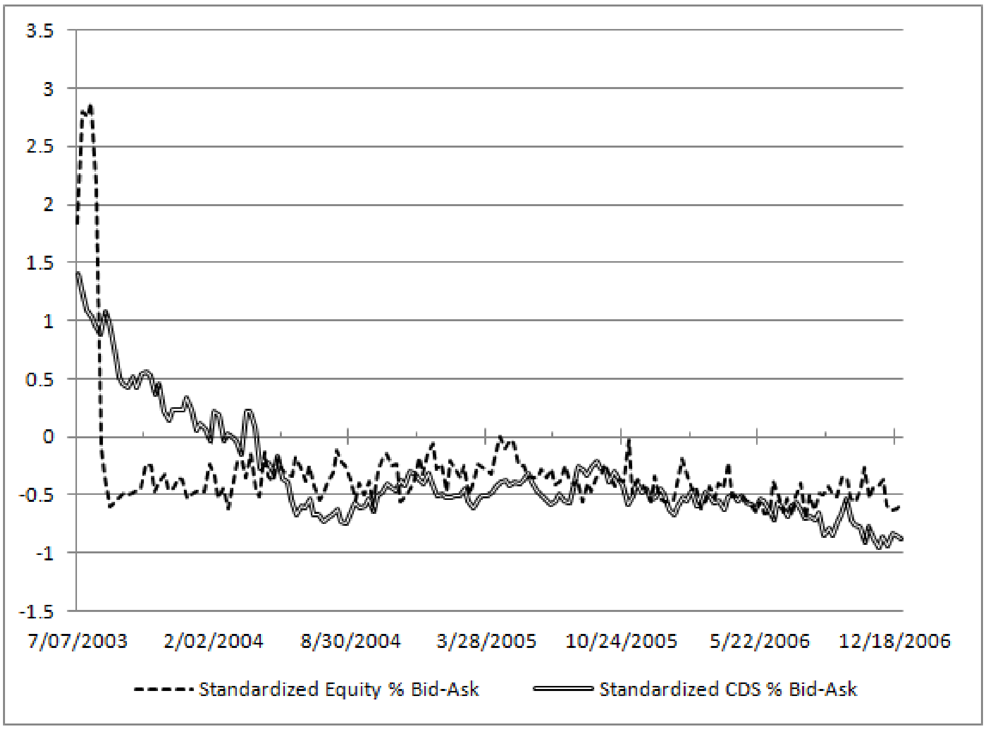


**Figure 2:** Cross-Sectional Value-Weighted Average of CDS and Equity Bid-Ask Spreads - Pre-Crisis Sample *(Normalized, Weekly: July 2003 - December 2006, Cross-Section of 45 Firms)*

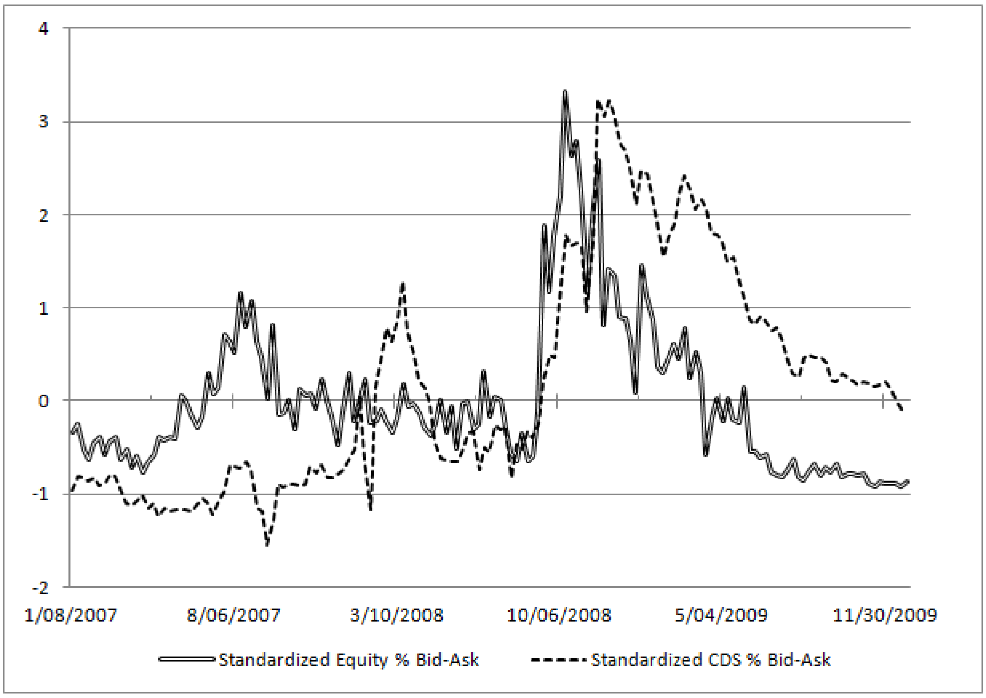


**Figure 3:** Cross-Sectional Value-Weighted Average of CDS and Equity Bid-Ask Spreads - Crisis Sample *(Normalized, Weekly: January 2007 - December 2009, Cross-Section of 45 Firms)*

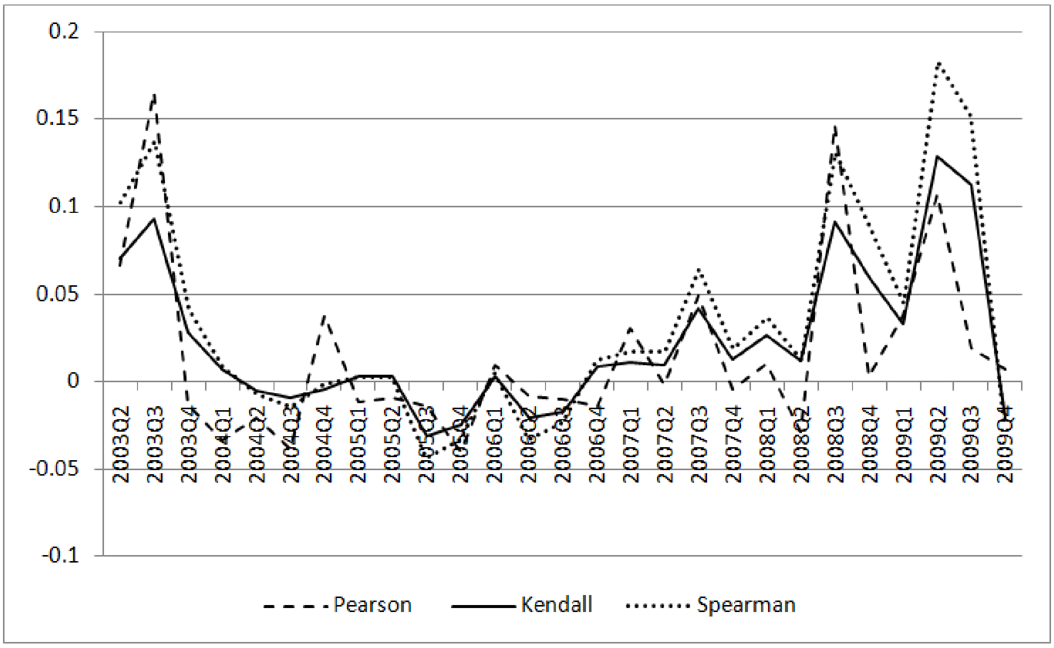


**Figure 4:** Cross-Sectional Value-Weighted Average of Correlation Measures (Pearson, Kendall and Spearman) between CDS and Equity Bid-Ask Spreads

*(Measured in decimals, Quarterly: March 2003 - December 2009, Cross-Section of 45 Firms)*

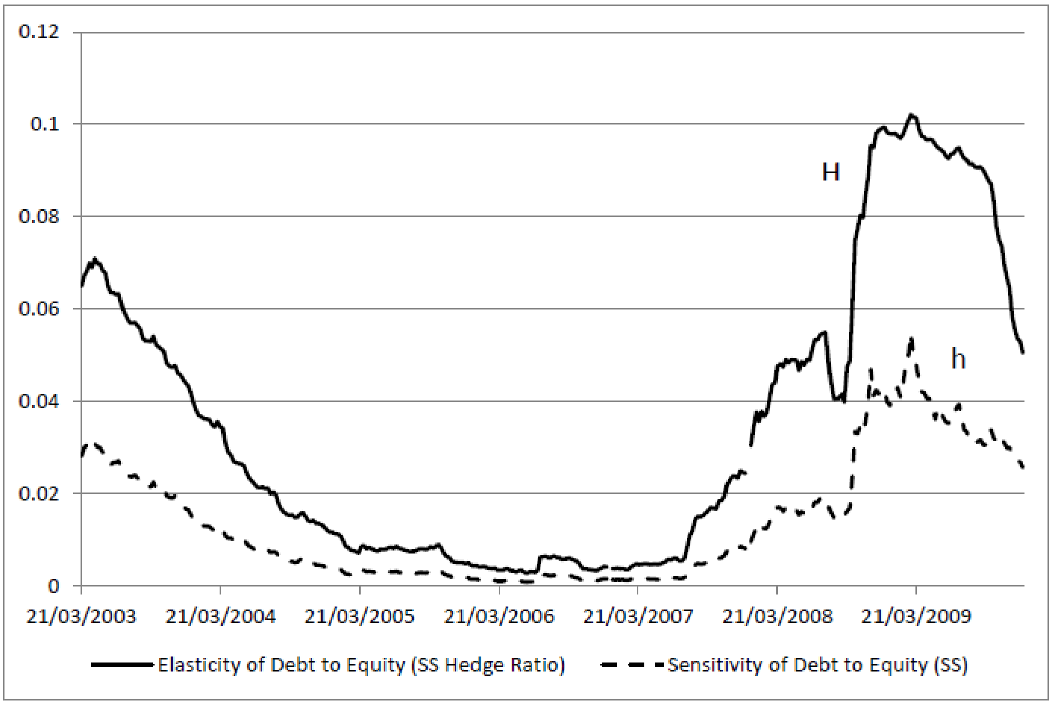


**Figure 5:** Cross-Sectional Value-Weighted Average of Debt-to-Equity Sensitivity $h$ and Hedge Ratio $H$ (Merton Model Calibration - SS Methodology)

*(Measured in decimals, Weekly: March 2003 - December 2009, Cross-Section of 45 firms)*

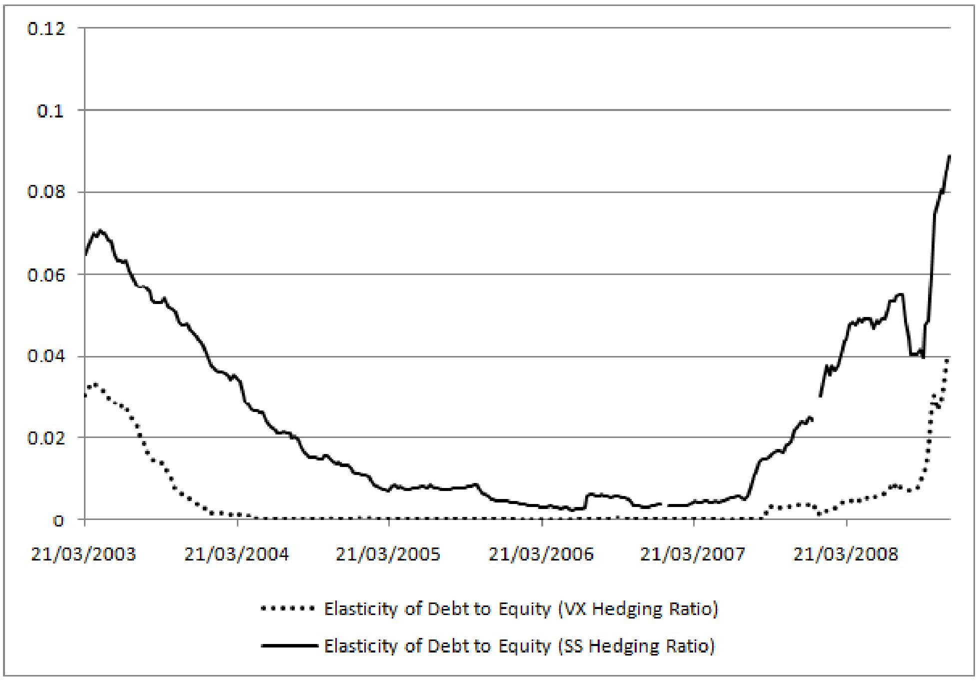


**Figure 6:** Cross-Sectional Value-Weighted Average of Debt-to-Equity Hedge Ratio $H$ (Merton Model Calibration - SS vs VX Methodology)
*(Measured in decimals, Weekly: March 2003 - November 2008, Cross-Section of 45 firms)*

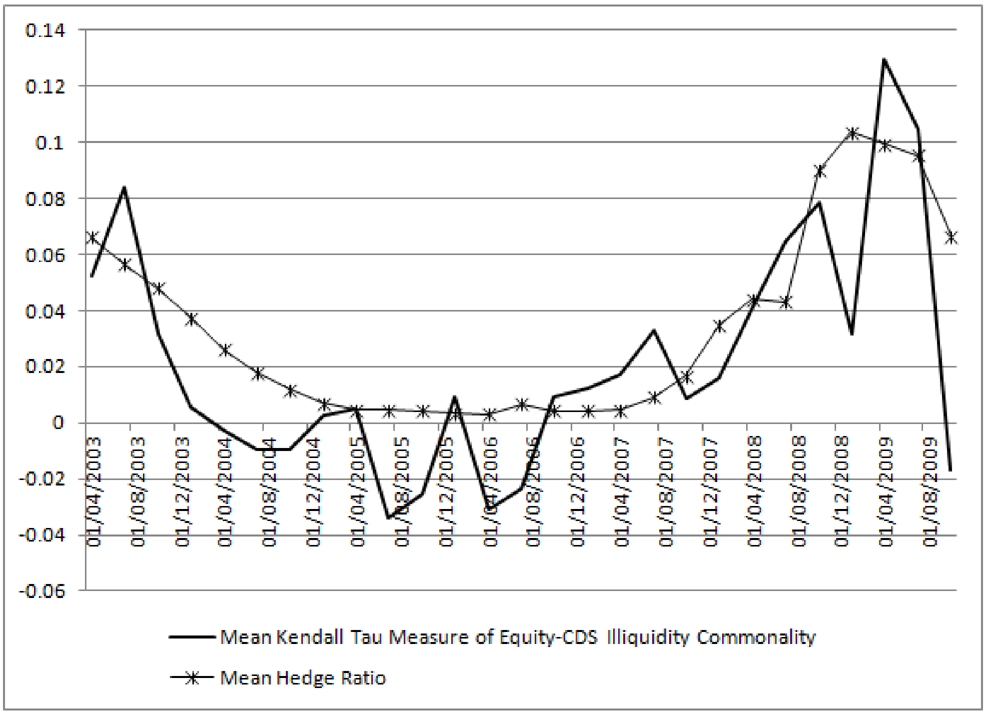


**Figure 7:** Cross-Sectional Value-Weighted Averages of CDS-Equity Illiquidity Correlation (Kendall Measure) and Debt-to-Equity Hedge Ratio (Merton Model Calibration - SS Methodology) *(Measured in decimals, Quarterly: April 2003 - December 2009, Cross-Section of 45 firms)*

Table 1: Distributions of Pearson, Kendall and Spearman Correlations between Equity and CDS Bid-Ask Spreads
(45 Firms; Time-Average Correlations are measured in decimals)

| | **Mean** | **Median** | **Std. Dev.** | **Inter-quartile Range** |
|---|---|---|---|---|
| All Sample: | | | | |
| **Pearson** | 0.4151 | 0.4170 | 0.1675 | 0.2247 |
| **Kendall** | 0.1469 | 0.1431 | 0.1004 | 0.1459 |
| **Spearman** | 0.2188 | 0.2128 | 0.1444 | 0.2071 |
| Year 2003: | | | | |
| **Pearson** | 0.5677 | 0.5867 | 0.1883 | 0.2618 |
| **Kendall** | 0.3830 | 0.3997 | 0.1121 | 0.1328 |
| **Spearman** | 0.5512 | 0.5782 | 0.1575 | 0.1792 |
| Years 2004-2006: | | | | |
| **Pearson** | 0.0144 | 0.0095 | 0.1528 | 0.1412 |
| **Kendall** | 0.0064 | -0.0042 | 0.0931 | 0.1009 |
| **Spearman** | 0.0083 | -0.0079 | 0.1374 | 0.1497 |
| Years 2007-2009: | | | | |
| **Pearson** | 0.2724 | 0.2780 | 0.1710 | 0.1372 |
| **Kendall** | 0.1300 | 0.1322 | 0.1134 | 0.1103 |
| **Spearman** | 0.1945 | 0.1960 | 0.1642 | 0.1578 |

Table 2: Correlation Matrix between Bid-Ask Spread Commonality, Return Commonality, TED, VIX and Market Default Risk
Time Sample: 2003Q2-2009Q4; Number of Cross-section: 45 Firms; Number of Total Quarterly Observations: 1215;
Comm (K) = Fisher transformation of Kendall Tau Measure of Association; Comm (S) = Fisher transformation of Spearman Measure of Association

| | **BA Comm (K)** | **BA Comm (S)** | **Ret.Comm (K)** | **Ret.Comm (S)** | **Hedge Ratio** | **TED** | **VIX** |
|---|---|---|---|---|---|---|---|
| **BA Comm (S)** | 0.995381 | | | | | | |
| *t-Statistic* | *361.1159* | | | | | | |
| *p-value* | *<0.00001* | | | | | | |
| **BA Comm (K)** | -0.068303 | | | | | | |
| *t-Statistic* | *-2.384421* | | | | | | |
| *p-value* | *0.0173* | | | | | | |
| **BA 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 3: Pair-wise Granger Causality Test Matrix between Bid-Ask Spread Commonality, Return Commonality, TED, VIX and Market Default Risk

Null Hypothesis: X does NOT Granger cause Y;

The Granger causality tests include 2 lags; Time Sample: 2003Q2-2009Q4; Number of Cross-sections: 45 Firms; Number of Total Quarterly Observations: 1215;

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

| **X** | **Hedge Ratio** | **BA Comm (K)** | **BA 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* |
| **BA Comm (K)** | **26.3359** | - | - | 4.2486 | - | **29.6549** | **28.3934** |
| | **<0.00001** | - | - | *0.01451* | - | *<0.00001* | *<0.00001* |
| **BA 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 4: Test of Determinants of Commonality between Equity and CDS Bid-Ask Spreads

The panel regressions are estimated with least squares; Panel dataset includes 18 non-financial companies and 27 quarters (from 2003:2 to 2009:4); Specification I is the panel regression for Equation (1) without the VIX Index; Specification II is the panel regression which instead includes also the VIX index on the right-hand side of Equation (1) — this differentiation aims to disentangle the potential effect of TED-VIX collinearity on the estimation results; Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; Likelihood ratio (LR) 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% S.L.; Coefficients marked with ∗ when regressors are significant at 10% S.L.; All variables are measured in decimals; Economic significance (Panel B) is obtained by multiplying the estimated beta by the ratio of the standard deviation of the relative explanatory variable to the standard deviation of the dependent variable.

**Panel A**
**Regression of Equity-CDS Bid-Ask Spread Commonality on Exogenous Risk Factors and Hedge Ratio**

| | **Spec.** | **Int.** | **MktRf** | **Smb** | **Hml** | **TED** | **VIX** | $H^{SS}$ | $H^{SS,ORT}$ | $Adj.R^2$ | **LR Test Firms FE** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dep.Var. Kendall Corr. (CDS-Equity Bid-Ask)** | I | **-0.0435** | **16.3739** | **23.0302** | 10.4497 | **5.8369** | | **0.5434** | | 8.40% | 0.9582 |
| | | *-3.69* | *2.49* | *2.25* | *1.51* | *3.76* | | *3.27* | | | *0.50* |
| | I | **-0.0436** | **16.2548** | **22.8609** | 10.5402* | **5.8073** | | **0.5565** | | 8.53% | No |
| | | *-3.05* | *2.51* | *2.36* | *1.95* | *3.12* | | *4.37* | | | |
| | II | **-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* |
| | II | **-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* | | | |
| | I | **-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* |
| | I | **-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* | | |
| | II | **-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* |
| | II | **-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**

| | **Spec.** | **MktRf** | **Smb** | **Hml** | **TED** | **VIX** | $H^{SS}$ | $H^{SS,ORT}$ | $Adj.R^2$ | **LR Test Firms FE** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dep.Var. Kendall Corr. (CDS-Equity Bid-Ask)** | I | **0.1674** | **0.1049** | **0.0728** | **0.2413** | | **0.1619** | | 8.53% | No |
| | | *2.51* | *2.36* | *1.95* | *3.12* | | *4.37* | | | |
| | II | **0.1674** | **0.1046** | 0.0738* | **0.2368** | 0.0068 | **0.1591** | | 8.34% | No |
| | | *2.51* | *2.33* | *1.75* | *2.36* | *0.08* | *2.87* | | | |
| | I | **0.1798** | **0.1164** | 0.0476 | **0.2959** | | | **0.1113** | 7.21% | No |
| | | *2.90* | *2.51* | *1.27* | *3.87* | | | *2.69* | | |
| | II | **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 5: Test of Determinants of Commonality between Equity and CDS Bid-Ask Spreads - Robustness Check including Time Effects:
Panel Regressions with Time-Interaction Variables (Panel A - Specification III) or Time Dummies (Panel B - Specification IV)

The panel regressions are estimated with least squares; Panel dataset includes 18 non-financial companies and 27 quarters (from 2003:2 to 2009:4). In Specification III we augment the right-hand side of Equation (1) by interacting the hedge ratio variable $H^{SS}_{i,t}$ with $Qtr_{2003:2}, ..., Qtr_{2009:3}$, which represent dummies for each quarter of each year in the sample; in Specification IV we drop all regressors in Equation (1) which vary only over the time-dimension (the three Fama- French factors, TED and VIX) and replace them with the time-dummies and a control variable which proxies firms' exposures to systematic risk $SysRisk_{i,t}$. This variable is obtained for each firm as a Fisher z-transformation of the $R^2$s from the regressions of the firm's daily excess returns on the three Fama-French factors over each quarter. Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; Likelihood ratio (LR) 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% S.L.; Coefficients marked with * when regressors are significant at 10% S.L.; All variables are measured in decimals; For Specification III only the hedge ratio and the statistically significant interaction variables (hedge ratio × time-quarter dummies) are reported in the Table (Panel A) for brevity, however $Hml$ and $VIX$ are also significant resp. at 5% and 10% S.L.

Panel A - Specification III

| | FE | $H^{SS}$ | $H^{SS} \times Qrt_{2003:2}$ | $H^{SS} \times Qrt_{2003:3}$ | $H^{SS} \times Qrt_{2005:3}$ | $H^{SS} \times Qrt_{2007:1}$ | $H^{SS} \times Qrt_{2007:3}$ | $H^{SS} \times Qrt_{2008:3}$ | $H^{SS} \times Qrt_{2009:2}$ | $Adj.R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dep.Var.** | Firm | -0.8482 | 2.1646* | 1.4379* | **-4.5545** | **16.3920** | **5.3435** | 2.6917 | **1.8995** | 6.66% |
| **Kendall** | | *-0.93* | *1.88* | *1.70* | *-2.28* | *4.36* | *2.57* | *1.47* | *2.07* | |
| **Correl.** | | | | | | | | | | |
| **(CDS-Eq.BA)** | No | -0.8861 | 2.2752* | 1.5041* | **-6.2181** | 9.4564* | **5.0820** | 2.7864* | **1.9810** | 6.77% |
| | | *-0.94* | *1.94* | *1.79* | *-3.53* | *1.83* | *3.69* | *1.76* | *2.11* | |

Panel B - Specification IV

| | FE | Int. | $H^{SS}$ | $SysRisk$ | $Adj.R^2$ | LR Test FE |
|---|---|---|---|---|---|---|
| **Dep.Var.** | No | **-0.0099** | **0.8441** | 0.0065 | 5.28% | No |
| **Kendall** | | *-1.91* | *6.20* | *1.59* | | |
| **Correl.** | Time | -0.0069 | **0.6211** | **0.0087** | 16.29% | 3.4279 |
| **(CDS-Eq.BA)** | | *-1.12* | *3.09* | *2.38* | | *<0.0001* |
| | Time | -0.0041 | **0.5770** | 0.0064 | 16.39% | 2.4831 |
| | &Firm | *-0.61* | *2.57* | *1.08* | | *<0.0001* |
| | Time | 0.0015 | **0.5186** | | 15.44% | 2.4195 |
| | &Firm | *0.31* | *2.35* | | | *<0.0001* |

Table 6: Test of Determinants of Commonality between Equity and CDS Bid-Ask Spreads - Robustness Check on Hedge Ratio's Endogeneity

The panel regressions for the Hausmann-Wu Test (Panel A) are estimated with least squares; The variable $\boldsymbol{H^{SS} Fitted}$ corresponds to the fitted values from a regression of the hedge ratio $H^{SS}$ on the equity volatility, the squared equity volatility and the leverage ratio. These three variables are used as instruments in the 2SLS estimation (Panel B). 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 ratio (LR) 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; Yes = FE included; Coefficients in bold when regressors are significant at 1% and 5% S.L.; Coefficients marked with $*$ when regressors are significant at 10% S.L.; All variables are measured in decimals.

| | **Panel A<br>Hausmann-Wu Test of Endogeneity of Hedge Ratio** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Spec.** | **Int.** | **MktRf** | **Smb** | **Hml** | **TED** | $\boldsymbol{H^{SS}}$ | $\boldsymbol{H^{SS} Fitted}$ | $\boldsymbol{Adj.R^2}$ | **LR Test Firms FE** |
| **Dep.Var. Kendall Correlation (CDS-Equity Bid-Ask)** | I | **-0.0415** | **17.2277** | **22.9839** | **11.1920** | **5.8256** | **0.9781** | -0.5443 | 8.76% | No |
| | | *-3.04* | *2.55* | *2.35* | *2.04* | *3.09* | *2.93* | *-1.43* | | |
| | I | **-0.0409** | **17.8008** | **23.5940** | **10.9822** | **5.9316** | **1.0007** | -0.6326 | 8.64% | 0.9622 |
| | | *-3.35* | *2.66* | *2.30* | *1.96* | *3.18* | *2.93* | *-1.54* | | *0.5003* |

| | **Panel B<br>2-Stages Least Squares Estimation of the Model** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Spec.** | **Int.** | **MktRf** | **Smb** | **Hml** | **TED** | $\boldsymbol{H^{SS}}$ | $\boldsymbol{Adj.R^2}$ | **Firms FE** |
| **Dep.Var. Kendall Correlation (CDS-Equity Bid-Ask)** | I | **-0.0430** | **17.4047** | **24.4949** | 9.6667* | **6.0927** | **0.4298** | 8.76% | No |
| | | *-3.07* | *2.55* | *2.51* | *1.84* | *3.10* | *3.04* | | |
| | I | **-0.0430** | **17.5004** | **24.6310** | 9.5940* | **6.1164** | **0.4193** | 8.30% | Yes |
| | | *-3.46* | *2.64* | *2.39* | *1.68* | *3.23* | *2.78* | | |

Table 7: Test of Determinants of Commonality between Equity and CDS Bid-Ask Spreads - Further Robustness Checks

The panel regressions are estimated with least squares; Panel regression includes 18 non-financial companies and 27 quarters (from 2003:2 to 2009:4) when Hedge SS is used; Panel regression 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 fixed effects are included; Coefficients in bold when regressors are significant at 1% and 5% S.L.; Coefficients marked with * when regressors are significant at 10% S.L.; All variables are measured in decimals; Economic significance (Panel B) is obtained by multiplying the estimated beta by the ratio of the standard deviation of the relative explanatory variable to the standard deviation of the dependent variable.

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

| | **Panel B** **Panel Regression - Alternative Hedge Ratio (Vassalou and Xing, 2004)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Specification** | | **Int.** | **MktRf** | **Smb** | **Hml** | **TED** | **VIX** | $\boldsymbol{H^{VX}}$ | ***Adj.R*** $^2$ |
| **Dep.Var. Kendall Correlation** | I | *Coeff* | 0.0090 | -5.7458 | 14.9055 | -9.0884 | 1.5265 | | **1.2799** | 4.73% |
| | | *t-stat* | *1.00* | *-1.05* | *1.52* | *-1.42* | *1.29* | | *2.39* | |
| | | *Econ.Sign.* | | | | | | | **0.1715** | |
| | II | *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 8: Pair-wise Granger Tests of Causality for Equity and CDS Bid-Ask Spreads

(Test at 1% S.L.; 2 Lags included, Daily frequency; ∗ indicates that evidence is stronger for causality running from CDS to Equity than the other way round as the difference between the relative F-stats is > 20)

| | | **Equity BA does not Granger cause CDS BA** | | **CDS BA does not Granger cause Equity BA** | | |
|---|---|---|---|---|---|---|
| **Ticker** | **Obs** | **F-Stat** | **P-value** | **F-Stat** | **P-value** | **Causality Direction** |
| HON | 1477 | 9.65655 | 0.00007 | 72.0589 | 0.00000 | Both directions* |
| DD | 1319 | 0.02757 | 0.97280 | 16.4846 | 0.00000 | CDS to Equity |
| GR | 1470 | 12.9241 | 0.00000 | 94.7041 | 0.00000 | Both directions* |
| IBM | 1402 | 1.31877 | 0.26780 | 0.91107 | 0.40230 | No causality |
| COP | 1293 | 12.8915 | 0.00000 | 13.0634 | 0.00000 | Both directions |
| KR | 1411 | 16.3281 | 0.00000 | 59.1789 | 0.00000 | Both directions* |
| GIS | 1378 | 0.93471 | 0.39290 | 12.8862 | 0.00000 | CDS to Equity |
| CAT | 1426 | 5.26131 | 0.00530 | 8.04736 | 0.00030 | Both directions |
| DE | 1461 | 1.88282 | 0.15250 | 24.2157 | 0.00000 | CDS to Equity |
| BA | 1408 | 3.63554 | 0.02660 | 70.3464 | 0.00000 | CDS to Equity |
| DOW | 1477 | 0.69962 | 0.49690 | 29.8767 | 0.00000 | CDS to Equity |
| LMT | 1357 | 2.85577 | 0.05790 | 22.3741 | 0.00000 | CDS to Equity |
| MOT | 1496 | 6.59504 | 0.00140 | 53.2859 | 0.00000 | Both directions* |
| FE | 1449 | 0.52073 | 0.59420 | 18.9554 | 0.00000 | CDS to Equity |
| PGN | 1438 | 0.45748 | 0.63300 | 3.77172 | 0.02320 | No causality |
| HAL | 1239 | 6.84928 | 0.00110 | 11.58 | 0.00001 | Both directions |
| AA | 1324 | 2.07183 | 0.12640 | 14.6745 | 0.00000 | CDS to Equity |
| NOC | 1502 | 0.40535 | 0.66680 | 16.7724 | 0.00000 | CDS to Equity |
| RTN | 1457 | 4.93599 | 0.00730 | 31.055 | 0.00000 | Both directions* |
| CPB | 1357 | 1.0173 | 0.36180 | 22.762 | 0.00000 | CDS to Equity |
| DIS | 1489 | 1.55099 | 0.21240 | 44.4972 | 0.00000 | CDS to Equity |
| HPQ | 1411 | 4.72621 | 0.00900 | 32.8771 | 0.00000 | Both directions* |
| DUK | 1438 | 11.4569 | 0.00001 | 49.0586 | 0.00000 | Both directions* |
| ARW | 1466 | 9.53989 | 0.00008 | 63.6657 | 0.00000 | Both directions* |
| OMC | 1433 | 7.58392 | 0.00050 | 32.8313 | 0.00000 | Both directions* |
| CSC | 1440 | 6.06369 | 0.00240 | 3.05712 | 0.04730 | Equity to CDS |
| MCD | 1475 | 3.1774 | 0.04200 | 46.7617 | 0.00000 | CDS to Equity |
| TGT | 1273 | 0.18758 | 0.82900 | 14.2473 | 0.00000 | CDS to Equity |
| BNI | 1315 | 2.29332 | 0.10130 | 28.3297 | 0.00000 | CDS to Equity |
| WMT | 1320 | 12.7869 | 0.00000 | 9.35591 | 0.00009 | Both directions |
| CAG | 1400 | 10.2588 | 0.00004 | 46.5928 | 0.00000 | Both directions* |
| JWN | 1412 | 0.55032 | 0.57690 | 5.15584 | 0.00590 | CDS to Equity |
| NSC | 1311 | 2.39611 | 0.09150 | 7.51527 | 0.00060 | CDS to Equity |
| NWL | 944 | 1.82804 | 0.16130 | 11.5742 | 0.00001 | CDS to Equity |
| D | 1465 | 2.38068 | 0.09280 | 28.4344 | 0.00000 | CDS to Equity |
| APC | 1397 | 1.49916 | 0.22370 | 7.01297 | 0.00090 | CDS to Equity |
| CCL | 1551 | 3.98564 | 0.01880 | 6.79041 | 0.00120 | CDS to Equity |
| SWY | 1464 | 8.22348 | 0.00030 | 57.5242 | 0.00000 | Both directions* |
| TWX | 1478 | 1.89036 | 0.15140 | 34.1322 | 0.00000 | CDS to Equity |
| EMN | 1470 | 9.18974 | 0.00010 | 54.5439 | 0.00000 | Both directions* |
| VLO | 1434 | 2.17625 | 0.11380 | 16.0766 | 0.00000 | CDS to Equity |
| MAR | 1492 | 0.49772 | 0.60800 | 19.4288 | 0.00000 | CDS to Equity |
| SRE | 1433 | 7.80696 | 0.00040 | 17.1864 | 0.00000 | Both directions |
| DVN | 1333 | 0.58351 | 0.55810 | 1.06841 | 0.34390 | No causality |
| KFT | 1478 | 2.93716 | 0.05330 | 44.7342 | 0.00000 | CDS to Equity |

Table 9: Pair-wise Granger Tests of Causality for Equity and CDS Returns
(Test at 1% S.L.; 2 Lags included; Daily frequency)

| | | Equity Ret. does not Granger cause CDS Ret. | | CDS Ret. does not Granger cause Equity Ret. | | |
|---|---|---|---|---|---|---|
| **Ticker** | **Obs** | **F-Stat** | **P-value** | **F-Stat** | **P-value** | **Causality Direction** |
| HON | 1476 | 22.5254 | 0.00000 | 0.8284 | 0.43700 | Equity to CDS |
| DD | 1318 | 16.5996 | 0.00000 | 0.0044 | 0.99560 | Equity to CDS |
| GR | 1469 | 12.0712 | 0.00001 | 0.9293 | 0.39510 | Equity to CDS |
| IBM | 1402 | 21.6103 | 0.00000 | 0.7024 | 0.49560 | Equity to CDS |
| COP | 1292 | 16.5660 | 0.00000 | 1.5302 | 0.21690 | Equity to CDS |
| KR | 1410 | 3.5061 | 0.03030 | 1.7045 | 0.18220 | No causality |
| GIS | 1377 | 1.8178 | 0.16280 | 0.8072 | 0.44630 | No causality |
| CAT | 1425 | 35.8506 | 0.00000 | 0.7449 | 0.47500 | Equity to CDS |
| DE | 1460 | 22.8571 | 0.00000 | 2.4517 | 0.08650 | Equity to CDS |
| BA | 1407 | 15.5715 | 0.00000 | 1.1175 | 0.32740 | Equity to CDS |
| DOW | 1476 | 21.8746 | 0.00000 | 4.5982 | 0.01020 | Both directions |
| LMT | 1356 | 1.8347 | 0.16010 | 0.5797 | 0.56020 | No causality |
| MOT | 1495 | 14.8009 | 0.00000 | 3.0415 | 0.04810 | Equity to CDS |
| FE | 1448 | 31.0695 | 0.00000 | 1.0539 | 0.34880 | Equity to CDS |
| PGN | 1437 | 9.9939 | 0.00005 | 2.7832 | 0.06220 | Equity to CDS |
| HAL | 1238 | 16.5024 | 0.00000 | 0.1917 | 0.82560 | Equity to CDS |
| AA | 1323 | 20.5129 | 0.00000 | 0.5764 | 0.56210 | Equity to CDS |
| NOC | 1501 | 11.3915 | 0.00001 | 0.1740 | 0.84030 | Equity to CDS |
| RTN | 1456 | 6.4501 | 0.00160 | 1.7575 | 0.17280 | Equity to CDS |
| CPB | 1356 | 0.7341 | 0.48010 | 1.3428 | 0.26150 | No causality |
| DIS | 1488 | 10.3409 | 0.00003 | 0.6174 | 0.53950 | Equity to CDS |
| HPQ | 1410 | 8.9610 | 0.00010 | 1.2891 | 0.27590 | Equity to CDS |
| DUK | 1437 | 4.2866 | 0.01390 | 0.6868 | 0.50330 | No causality |
| ARW | 1465 | 43.3120 | 0.00000 | 2.2501 | 0.10580 | Equity to CDS |
| OMC | 1432 | 19.7300 | 0.00000 | 0.1598 | 0.85240 | Equity to CDS |
| CSC | 1439 | 5.1909 | 0.00570 | 1.9757 | 0.13900 | Equity to CDS |
| MCD | 1474 | 3.1670 | 0.04240 | 2.3948 | 0.09150 | No causality |
| TGT | 1273 | 8.0365 | 0.00030 | 0.4572 | 0.63320 | Equity to CDS |
| BNI | 1315 | 17.6678 | 0.00000 | 0.1708 | 0.84300 | Equity to CDS |
| WMT | 1320 | 7.2472 | 0.00070 | 4.1119 | 0.01660 | Equity to CDS |
| CAG | 1399 | 6.4537 | 0.00160 | 3.7718 | 0.02320 | Equity to CDS |
| JWN | 1411 | 38.8123 | 0.00000 | 1.6191 | 0.19840 | Equity to CDS |
| NSC | 1310 | 26.8072 | 0.00000 | 0.0170 | 0.98310 | Equity to CDS |
| NWL | 943 | 11.8539 | 0.00001 | 0.9385 | 0.39160 | Equity to CDS |
| D | 1464 | 6.8437 | 0.00110 | 0.6302 | 0.53260 | Equity to CDS |
| APC | 1396 | 20.1116 | 0.00000 | 0.4528 | 0.63600 | Equity to CDS |
| CCL | 1550 | 7.3039 | 0.00070 | 0.0959 | 0.90850 | Equity to CDS |
| SWY | 1463 | 4.3313 | 0.01330 | 0.3468 | 0.70700 | No causality |
| TWX | 1477 | 22.1372 | 0.00000 | 0.8263 | 0.43790 | Equity to CDS |
| EMN | 1469 | 32.2516 | 0.00000 | 0.3471 | 0.70680 | Equity to CDS |
| VLO | 1433 | 30.1477 | 0.00000 | 1.2658 | 0.28230 | Equity to CDS |
| MAR | 1491 | 36.9348 | 0.00000 | 2.0099 | 0.13440 | Equity to CDS |
| SRE | 1432 | 13.6967 | 0.00000 | 1.1088 | 0.33020 | Equity to CDS |
| DVN | 1332 | 10.5095 | 0.00003 | 0.1466 | 0.86360 | Equity to CDS |
| KFT | 1477 | 3.4567 | 0.03180 | 2.7806 | 0.06230 | No causality |

Table 10: Pair-wise Granger Tests of Causality for Equity and CDS Volatility
(Test at 1% S.L.; 2 Lags included; Daily frequency; Volatilities are computed as exponentially-weighted moving averages using a rolling window of 180 days of CDS and equity returns and $\lambda = 0.9$.)

| | | **Equity Vol. does not Granger cause CDS Vol.** | | **CDS Vol. does not Granger cause Equity Vol.** | | |
|---|---|---|---|---|---|---|
| **Ticker** | **Obs** | **F-Stat** | **P-value** | **F-Stat** | **P-value** | **Causality Direction** |
| HON | 1549 | 5.32693 | 0.00490 | 11.9133 | 0.00001 | Both directions |
| DD | 1517 | 0.96815 | 0.38000 | 4.78274 | 0.00850 | CDS to Equity |
| GR | 1563 | 0.19327 | 0.82430 | 0.19562 | 0.82230 | No causality |
| IBM | 1459 | 2.71322 | 0.06670 | 6.13909 | 0.00220 | CDS to Equity |
| COP | 1513 | 1.17301 | 0.30970 | 6.20588 | 0.00210 | CDS to Equity |
| KR | 1539 | 2.02711 | 0.13210 | 5.92694 | 0.00270 | CDS to Equity |
| GIS | 1537 | 0.11188 | 0.89420 | 0.4156 | 0.66000 | No causality |
| CAT | 1505 | 2.24694 | 0.10610 | 9.88471 | 0.00005 | CDS to Equity |
| DE | 1530 | 1.65853 | 0.19080 | 11.2271 | 0.00001 | CDS to Equity |
| BA | 1512 | 2.08635 | 0.12450 | 4.65806 | 0.00960 | CDS to Equity |
| DOW | 1525 | 2.06503 | 0.12720 | 1.66296 | 0.18990 | No causality |
| LMT | 1536 | 0.82183 | 0.43980 | 7.32844 | 0.00070 | CDS to Equity |
| MOT | 1544 | 6.36213 | 0.00180 | 0.34717 | 0.70670 | Equity to CDS |
| FE | 1556 | 3.34316 | 0.03560 | 4.65785 | 0.00960 | CDS to Equity |
| PGN | 1550 | 11.2197 | 0.00001 | 4.79218 | 0.00840 | Both directions |
| HAL | 1509 | 3.28885 | 0.03760 | 13.5669 | 0.00000 | CDS to Equity |
| AA | 1534 | 9.4765 | 0.00008 | 5.42228 | 0.00450 | Both directions |
| NOC | 1563 | 6.53175 | 0.00150 | 11.1753 | 0.00002 | Both directions |
| RTN | 1538 | 2.44959 | 0.08670 | 5.39561 | 0.00460 | CDS to Equity |
| CPB | 1566 | 0.85412 | 0.42590 | 0.76645 | 0.46480 | No causality |
| DIS | 1533 | 9.24651 | 0.00010 | 11.1033 | 0.00002 | Both directions |
| HPQ | 1512 | 4.30404 | 0.01370 | 9.31248 | 0.00010 | CDS to Equity |
| DUK | 1548 | 0.82741 | 0.43740 | 7.40831 | 0.00060 | CDS to Equity |
| ARW | 1564 | 5.72523 | 0.00330 | 15.4489 | 0.00000 | Both directions |
| OMC | 1546 | 0.69593 | 0.49880 | 1.69638 | 0.18370 | No causality |
| CSC | 1536 | 19.9354 | 0.00000 | 2.25889 | 0.10480 | Equity to CDS |
| MCD | 1524 | 8.09558 | 0.00030 | 19.2949 | 0.00000 | Both directions |
| TGT | 1515 | 6.07164 | 0.00240 | 15.4058 | 0.00000 | Both directions |
| BNI | 1536 | 0.11477 | 0.89160 | 0.39538 | 0.67350 | No causality |
| WMT | 1494 | 1.63434 | 0.19540 | 11.0373 | 0.00002 | CDS to Equity |
| CAG | 1549 | 1.6611 | 0.19030 | 1.94036 | 0.14400 | No causality |
| JWN | 1536 | 4.85863 | 0.00790 | 10.4275 | 0.00003 | Both directions |
| NSC | 1531 | 1.22545 | 0.29390 | 0.54135 | 0.58210 | No causality |
| NWL | 1550 | 4.27579 | 0.01410 | 5.76115 | 0.00320 | CDS to Equity |
| D | 1542 | 1.3423 | 0.26160 | 14.1147 | 0.00000 | CDS to Equity |
| APC | 1547 | 4.28249 | 0.01400 | 1.92212 | 0.14660 | No causality |
| CCL | 1538 | 1.69174 | 0.18450 | 2.08267 | 0.12490 | No causality |
| SWY | 1537 | 3.51825 | 0.02990 | 10.3127 | 0.00004 | CDS to Equity |
| TWX | 1544 | 0.71915 | 0.48730 | 2.04066 | 0.13030 | No causality |
| EMN | 1563 | 12.6982 | 0.00000 | 13.3616 | 0.00000 | Both directions |
| VLO | 1539 | 4.76093 | 0.00870 | 0.55913 | 0.57180 | Equity to CDS |
| MAR | 1554 | 4.64991 | 0.00970 | 3.35204 | 0.03530 | Equity to CDS |
| SRE | 1551 | 12.7352 | 0.00000 | 2.25406 | 0.10530 | Equity to CDS |
| DVN | 1514 | 9.70201 | 0.00007 | 17.5007 | 0.00000 | Both directions |
| KFT | 1542 | 0.33171 | 0.71770 | 0.07701 | 0.92590 | No causality |

Table 11: Regressions of CDS and Equity Bid-Ask Spreads on Asset Volatility and Average Market Illiquidity

45 Industrial Firms; Weekly frequency; April 2003 - December 2009; Asset volatility is estimated as in Schaefer and Strebulaev (2008);
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% S.L.) coefficients in bold; Newey-West S.E. are estimated using GMM.

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

Table 12: Test of CDS Bid-Ask Spread Determinants:
Effects of Hedging Costs, Information Risk, CDS Mispricing, and Market Volatility on 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); Estimated standard errors are robust to firm clustering; t-statistics are reported in italic; Economic significance is obtained by multiplying the estimated beta by the ratio of the standard deviation of the relative explanatory variable to the standard deviation of the dependent variable; FE= Fixed Effects included. The economic significance estimates are reported in bold when the corresponding beta coefficient is statistically significant (at a significance level not lower than 10%).

| **Dependent Variable: CDS Bid-Ask Spread ($BA_{it}^{CDS}$)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Int. | $h_{it}^{SS} \times BA_{it}^{E}$ | $(h_{it}^{SS} \times BA_{it}^{E}) \times (\Delta Bond\ Volume_{it})$ | $(h_{it}^{SS} \times BA_{it}^{E}) \times (Asym\ Info_{it-1})$ | $Asym\ Info_{it-1}$ | $CDS\ Mispricing_{it-1}$ | $VIX$ | FE | $Adj.R^2$ |
| *Coeff* | 0.052 | 4.330 | | | | | | *Firms* | *32.98%* |
| *t-stat* | *62.92* | *4.61* | | | | | | | |
| *Econ. Sign.* | | **0.41** | | | | | | | |
| *Coeff* | 0.054 | 2.321 | | | | | | *Firms* | |
| *t-stat* | *79.87* | *3.03* | | | | | | *+ Time* | *49.15%* |
| *Econ. Sign.* | | **0.22** | | | | | | | |
| *Coeff* | 0.039 | 2.756 | 0.006 | 0.163 | | | 0.0007 | *Firms* | *41.70%* |
| *t-stat* | *12.34* | *3.39* | *1.43* | *2.65* | | | *4.32* | | |
| *Econ. Sign.* | | **0.26** | 0.01 | **0.11** | | | **0.23** | | |
| *Coeff* | 0.039 | 2.564 | 0.004 | 0.240 | 0.0005 | 0.022 | 0.0008 | *Firms* | *50.18%* |
| *t-stat* | *15.61* | *3.32* | *0.72* | *3.35* | *1.73* | *5.82* | *5.34* | | |
| *Econ. Sign.* | | **0.24** | 0.01 | **0.17** | **0.08** | **0.32** | **0.24** | | |
| *Coeff* | 0.054 | 1.734 | 0.003 | 0.252 | 0.0005 | 0.027 | | *Firms* | |
| *t-stat* | *17.10* | *2.76* | *0.71* | *4.18* | *2.36* | *5.80* | | *+ Time* | *62.32%* |
| *Econ. Sign.* | | **0.16** | 0.01 | **0.18** | **0.08** | **0.41** | | | |