Understanding Transactions Prices in the Credit Default Swaps Market*

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ABSTRACT

The price determination of over-the-counter derivatives has become major concerns for market participants and policy makers since the recent global financial crisis, triggering substantial law-making and new regulations. We use a unique, comprehensive dataset to examine the tick-by-tick price changes associated with both trades and quotes on credit default swaps (CDS). We find that, while fundamental factors such as volatility are important drivers of CDS spread changes, especially during the crisis period, CDS spread movements are also affected by supply-demand imbalance and liquidity in the market, reflecting the impact of slow-moving capital and capacity constraints of financial intermediation.

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ABSTRACT

The price determination of over-the-counter derivatives has become major concerns for market participants and policy makers since the recent global financial crisis, triggering substantial law-making and new regulations. We use a unique, comprehensive dataset to examine the tick-by-tick price changes associated with both trades and quotes on credit default swaps (CDS). We find that, while fundamental factors such as volatility are important drivers of CDS spread changes, especially during the crisis period, CDS spread movements are also affected by supply-demand imbalance and liquidity in the market, reflecting the impact of slow-moving capital and capacity constraints of financial intermediation.

I Introduction

Recent studies have raised serious questions about the pricing mechanism of credit default swaps (CDS) despite their popularity as credit risk benchmarks.[1] For instance, Hilscher, Pollet, and Wilson (2015) argue that CDS hardly contribute to price discovery. Understanding better the over-the-counter derivatives markets in general, and the CDS market in particular, is an important task, as it is one of the major responsibilities of the Office of Financial Research at U.S. Treasury, which was set up under the mandate of the Dodd-Frank Act. Most extant studies on CDS pricing, however, are based on dealer quotes rather than actual transactions. In this paper, we analyze tick-by-tick trade and quote data to provide a comprehensive account about the price determinants in the CDS market.

CDS spreads have been increasingly used as a measure of credit risk in practice. For example, Deutsche Bank provides an online mapping from CDS spreads to default probabilities for sovereign entities, and Moody's calculates CDS-implied expected default frequencies for companies. Major media outlets such as Bloomberg have also frequently used CDS spreads as a barometer for the financial health of corporations and sovereign entities. Such interpretations often equate CDS spread increases to higher levels of default risk. However, this usage of CDS spreads has raised concerns about its accuracy as most CDS contracts are sparsely traded.[2] Indeed, the Bank for International Settlements (BIS) cautions that "the same CDS spread in numerical terms may not necessarily imply the same risk" (BIS (2010), page 38). Jarrow (2012) also questions the practice of inferring default probabilities from CDS spreads. In contrast, the International Monetary Fund (IMF) in its 2013 Global Financial Stability Report argues that CDS spreads are an effective gauge of credit risk for sovereign entities (IMF (2013), Chapter 2). This debate calls for a systematic investigation of the relative importance of various determinants that drive the *changes* in CDS spreads.

CDS are insurance-type contracts providing protection against losses of debt instruments in pre-specified credit events. Trading in CDS contracts is done over the counter (OTC), mostly facilitated by inter-dealer brokers. While some contracts have multiple trades in a

[1] Augustin, Subrahmanyam, Tang, and Wang (2014) provide a review of the CDS literature. For example, Stanton and Wallace (2011) find that CDS spreads referencing subprime residential mortgages were "inconsistent with any reasonable assumption for mortgage default rates, and that these price changes are only weakly correlated with observed changes in the credit performance of the underlying loans in the index."

[2] See "A Fear Gauge Comes Up Short – Analysis Shows Credit-Default Swaps, a Popular Indicator of Market Health, Are Thinly Traded" by Carrick Mollenkamp and Serena Ng, *Wall Street Journal*, September 28, 2011. The large trading loss at J.P. Morgan revealed in May 2012 also illustrates liquidity problems in the CDS market.

day, for many contracts the time span between two consecutive trades can be measured in days and weeks. This sparse trading pattern contributes to the concern about the information content of CDS spreads (Hilscher, Pollet, and Wilson (2014), Kapadia and Pu (2012), and Marsh and Wagner (2015)), and highlights the importance of liquidity in CDS pricing (e.g., Bongaerts, de Jong, and Driessen (2011), Tang and Yan (2012)). To properly account for this feature of infrequent trading, we examine the change in CDS spreads between two consecutive trades, based on time-stamped transactions data on North American corporate names from GFI Group. Using both trades and quotes data has the advantage of producing more reliable inferences. Our sample period spans from 2002 to 2009, covering the period of the global credit crisis from late 2007 to early 2009. Our study aims to provide insights into the determinants of short-run price movements in the OTC credit derivatives market.

We find that, consistent with the prior literature on the changes in credit spreads, changes in macroeconomic conditions and firm-level fundamentals are important determinants of CDS spread changes. Among the firm-level fundamental variables, changes in stock return volatility and changes in leverage ratio are the most dominant. Stock returns on their own account for about 6% of the variation in CDS spreads, but that explanatory power is substantially reduced once other firm-level variables are controlled for. Among the market-level variables, changes in VIX, the so-called "fear factor" that proxies for the market-wide risk, have more significant explanatory power than others. The prominent role of stock return volatility, both at the firm level and at the market level, in explaining CDS spreads changes is consistent with the evidence in Ericsson, Jacobs and Oviedo (2009), Zhang, Zhou and Zhu (2009), and Cao, Yu, and Zhong (2010). In general, changes in market-wide and firm-level variables, respectively, have similar levels of explanatory power for changes in CDS spreads in our panel regressions, and altogether they account for over 40% of the variation in CDS spreads.

Collin-Dufresne, Goldstein, and Martin (2001) conjecture that supply-demand imbalances for the bonds being traded may account for the unexplained variations in credit spreads. Using the transaction-level data with trades and binding quotes, we calculate the difference between the number of bids and the number of offers between two consecutive trades to measure the excess demand (or the supply-demand imbalance) for a CDS contract. We find that the excess demand accounts for a notable portion of CDS spread changes. One additional bid between two consecutive trades is associated with a 1.1% increase in CDS spreads in our sample, on average, while controlling for other factors accounting for contemporaneous information flow and liquidity changes. This effect of excess demand is large considering that this is almost half of the magnitude of an average increase between consecutive trades. Indeed, for contracts that experience strong excess demands (three or more bids than offers), the average increase in CDS spreads can be as high as 16%, while for contracts with large excess supply (three or more offers than bids), the average CDS spreads can go down by as much as 10%.

We find that the excess demand can predict not only the concurrent changes but also future changes in CDS spreads over subsequent trades. Following a large excess demand, CDS spreads on average rise another 10% over the next two trades in addition to the initial 16% price increase. In fact, positive demand shocks appear to be informative of changes in credit quality, as contracts with large excess demand and large concomitant stock price changes usually settle into higher CDS spreads after five trades. In contrast, an excess supply of contracts appears to be liquidity-driven with little content of fundamental information and its price impact is reversed quickly. This finding is consistent with informed trading in the CDS market as indicated by Acharya and Johnson (2007), especially for negative news.

We distinguish the sources for supply-demand imbalances from information flow and liquidity changes in the market. We choose the elapsed time duration between two consecutive trades, the total number of quotes between two consecutive trades as well as the change in the bid-ask spreads on one trade from that on the previous trade as our measures for liquidity changes between trades. While they all appear to be statistically significant in determining the changes in CDS spreads, they do not detract from the role of excess demand nor can they match its significance in explaining CDS spread changes in panel regressions.

For a subsample of firms with long data history, we run time-series regressions firm-by-firm so that we can focus on CDS changes over time. Consistent with our panel regression results, firm characteristics and market variables combined explain a substantial amount of CDS spread changes, significant for all firms in the time-series regressions with an average R^2 of 44%, while changes in liquidity measures are significant in 90% of the regressions, with a mean R^2 of 17%, comparable to the explanatory power of stock returns between two consecutive trades. The excess demand variable is significant in two-thirds of the regressions, capturing an average of 8% of the variation in CDS spread changes. Therefore, while we have not uncovered all sources for CDS spread changes, the examined economic factors are significant drivers.

One major event in our sample is the global credit crisis during 2007-2009. We find that the explanatory power of those identified determinants of CDS spread changes rises considerably during the crisis period. There is an apparent increase in the co-movement of CDS spreads during this period with many firms experiencing simultaneous large increases in their CDS spreads. Such a degree of co-movement is rare during normal times. Market-level variables, such as swap rates and term slopes, become substantially more significant in explaining CDS spread changes during the crisis period, so does firm-level stock return volatility. Interestingly, the sensitivity to VIX remains relatively stable before and during the crisis, although the dramatic increase in the level of VIX during this period raises CDS spreads across firms. While the role of excess demand remains stable throughout the sample period, the liquidity measures carry opposite loadings before and during the crisis in which liquidity and credit were both deteriorating.

This study on the determinants of CDS spread changes makes several contributions to the literature. Using unique transactions data from the CDS market, we explicitly take into account the impact of supply-demand imbalances as reflected in excess demand, a factor conjectured by Collin-Dufresne, Goldstein, and Martin (2001) as a potential resolution of the unexplained portion of credit spread movements. We show a significant effect of excess demand between trades on the changes in CDS spreads. While consistent with the evidence from stocks and stock options (e.g., Bollen and Whaley (2004), Garleanu, Pedersen, and Poteshman (2009)), this finding is the first for an OTC derivative market. Comparing the economic magnitudes of price pressure, fundamental variables and liquidity factors, we find that the impact of excess demand on CDS spread changes is on par with the effect of common liquidity measures. Among the 40% identified variations in CDS spread changes, price impact and liquidity variables contribute to roughly one-third while changes in fundamental factors explain the other two-thirds.

The amount of the explained portion of CDS spread changes in our study is substantially higher than that of bond yield spread changes examined by Collin-Dufresne, Goldstein, and Martin (2001). We note differences in sample periods, data type and empirical approaches between our study and theirs. We also document significant differences in our model's explanatory power in tranquil times and during the credit crisis of 2007-2009, with heightened co-movements in CDS spreads during the turbulent period. Moreover, we do not find significant common components for the remaining unexplained portion of CDS spread changes. Bao and Pan (2013) show that CDS spreads are too volatile relative to firm fundamental volatility due to illiquidity in the CDS market, our paper corroborates with that finding and provides a quantitative dissection of different determinants of CDS spread changes. Moreover, this study is related to, but distinguished from, Tang and Yan (2012), who analyze firm-month panel data to investigate the cross-sectional effect of liquidity measures on CDS spreads. In contrast, this study analyzes transactions prices using trade-by-trade data to focus on CDS spread changes from one trade to the next with a novel measure of excess demand in the CDS market.

Our findings have implications for recent proposals of using CDS spreads for regulation and estimation of systemic risk (e.g., Flannery, Houston, and Partnoy (2011), Hart and Zingales (2011), Giglio (2012), Knaup and Wagner (2012)). We show that a non-trivial portion of the movement in CDS spreads is driven by excess demand and liquidity changes in the market. Such demand-driven price fluctuations are asymmetric, i.e., more pronounced and persistent for excess demand than excess supply. Although this temporary component is useful for liquidity providers and traders, it is important to filter out the temporary component of CDS spread movements for long-term investors and policy applications. Such filtrations can be a difficult task, however. Thus, our findings caution the implementation of rules based on CDS spreads, in the spirit of Stulz (2010), as changes in CDS spreads are not always associated with changes in credit quality.

The rest of the paper is organized as follows: Section II describes our data and empirical approach. We examine the determinants of CDS spread changes in Section III, including fundamental variables, supply-demand imbalance and liquidity variable. Section IV discusses the relative explanatory power of different sets of variables, cross-sectional and time-series variations, and predictability of CDS spread changes. Section V concludes.

II Market, Data, and Background

A The CDS Market

The invention of credit default swaps is commonly attributed to J.P. Morgan which in 1994 contracted with the European Bank of Reconstruction and Development (EBRD) on a $4.8 billion credit line to Exxon Mobile. J.P. Morgan would pay a periodic fee to EBRD until the contract expires or Exxon defaults. In the latter event EBRD would cover J.P. Morgan's loss.[3] In this case, J.P. Morgan is the buyer of CDS protection, and EBRD is the protection seller. Exxon is the reference entity, and the reference issue is the credit line. The notional amount of the contract is $4.8 billion. Another important milestone for CDS is the creation of synthetic collateralized debt obligation (CDO) called BISTRO by J.P.Morgain in 1997.

[3] See Tett (2006) for more details about this event. Longstaff, Mithal, and Neis (2005) provide a good introduction of the CDS market.

The standardization of CDS contracts was stipulated by the 1999 International Swaps and Derivatives Association (ISDA) Master Agreement. Those developments helped the CDS market grow dramatically until the credit crisis in 2007.[4] According to the ISDA market survey, the total notional amount of outstanding CDS contracts peaked at $62 trillion by the end of 2007, but it dropped to $30 trillion by the end of 2009.[5]

Until recently, the CDS market was largely unregulated and CDS transactions were conducted mostly over-the-counter. Market participants are almost entirely institutions, including many financial conglomerates. In the aftermath of the financial crisis of 2007-2008, new rules and regulations are being introduced to improve the functioning of the CDS market in the U.S. and Europe. For example, the U.S. Dodd-Frank Act (Title VII) enacted in July 2010 regulates both CDS contracts and CDS market participants in order to improve market transparency and accountability. These new rules, however, are in place after the end of our data series, so they are not applicable to the analysis in this paper.

Most CDS contracts are traded through dealers. Dealers either trade with other dealers directly or trade through an interdealer broker. Flow traders fill orders for their clients. Proprietary trading desks buy and sell CDS contracts for profits like hedge funds. For the market-making purpose, a flow trader may warehouse certain positions of outstanding CDS contracts. Most dealers and traders use a hybrid trading system. A dealer may call a broker to place an order or execute a trade. She may also simply trade at an acceptable price displayed by an online quoting system such as MarketAxess, RealTime, or CreditMatch. Dealers can also enter their quotes into the system and wait for them to be hit. When anonymity is not essential, a trader may directly communicate with a counterparty to execute a trade.

B Data Description

Our dataset comes from the GFI Group, which is the leading CDS market interdealer broker and has been ranked as top credit broker by the Risk magazine every year since 2002. The CDS transaction data are captured by GFI's CreditMatch electronic and voice hybrid trading system, which allows traders to enter, amend and remove their own quotes and prices and

[4] In addition to single-name CDS and basket products, index and CDS derivatives started trading in 2004.

[5] The BIS estimates the total 2009 year-end CDS notional amount outstanding to be $32.7 trillion with market value of $1.8 trillion ($21.9 trillion and $1.2 trillion, respectively, for single-name CDS contracts only). DTCC reports outstanding amount $14.6 trillion for single-name contracts and $25 trillion for all credit products as of May 7, 2010. OCC statistics for U.S. insured commercial banks by year-end 2009 is $14 trillion.

search historical prices. A trader's screen displays the order book which includes all tradable bid and offer prices and corresponding trade sizes for a reference name and the length of a contract. Relevant bond prices are also provided on the same screen for reference. Only dealers can trade on the CreditMatch platform which is also connected with voice brokers. Transaction data are disseminated to the public after one hour. Unlike other data sources, the GFI dataset consists of only market prices, tradable quotes and transaction information.

Our dataset covers all intra-day quotes and trades on North American corporate names crossing GFI's trading platform from January 1, 2002 to April 30, 2009. Because of the over-the-counter market structure and the lack of a central clearing mechanism, there is no single comprehensive data source for CDS transactions. Therefore, our findings and conclusions could be undermined by this data constraint. To mitigate the concern about the representativeness of our sample, we aggregate our firm-level observations to obtain a market-level summary and then compare it with the market survey summary statistics from ISDA and the Office of the Comptroller of the Currency (OCC) which collect data from their respective member dealers and banks. The ISDA survey is conducted semiannually with dealers all over the world. The OCC report is released quarterly containing information from American commercial banks regulated by OCC. Tang and Yan (2012) conduct a detailed study on CDS transactions and data sources. Overall, trading activities recorded in our sample correlate well with those in the ISDA data with a correlation coefficient of 0.75. As expected, our data sample matches even better with the OCC reports with a correlation coefficient of 0.82, as both focus on market participants in the US. Therefore, if we assume that trades are not biased towards this platform, then the general statistical patterns should be representative of the whole market.[6]

Our main analysis uses trades and quotes directly. In order to isolate the effects of contractual terms and term structure, we only use five-year corporate CDS contracts on North American senior unsecured reference issues with modified restructuring (MR) in the settlement clause. To illustrate the transaction data in our analysis, we plot in Figure 1 the quotes and traded prices for five-year CDS contracts on *Yum! Brands* in 2006. At the beginning of the year, a trade was executed at 60 basis points while the offer price was at about 75 basis points and the bid price at about 55 basis points. After that trade, there were 13 bids and 15 offers before the next trade was executed at 45 basis points in April. Although the CDS

[6]The CDS market has recently experienced several major new developments such as central clearing (studied by Loon and Zhong (2014)) and new contract standardization. We restrict the discussion of the findings to our sample and the given period. Future studies with new data can provide new insights from the new market environment.

spread had fallen 25% during this period, the stock price had not changed much. Starting in August, stock prices started to rise substantially and the CDS spread kept dropping down to 23 basis points before it went back up to 42 basis points in December. During this late-year run-up, there were 8 bids and 4 offers. Stock price went up from about 45 in August to the peak of 63 in November. CDS spread reached the lowest level at 25 basis points in late October. At the end of the year when CDS spreads were going up, stock price dropped from around 63 to 59.

Our overall sample consists of 55,358 trades and 608,524 quotes from 861 corporate entities with appropriate financial and accounting data. After taking first differences, we end up with 35,981 observations of CDS spread changes between two consecutive trades. We summarize our trade-level data in Table I. Panel A shows the summary statistics of main variables and control variables. The average 5-year CDS spread is about 223 basis points, the average bid-ask spread is 14 basis points. On average, CDS spread increases by 2.3% between consecutive trades. When we use the logarithm of CDS spread to calculate the percentage changes, the change from one trade to the next is 0.18%. Those numbers suggest that CDS spread changes are skewed but there is no overall credit deterioration for our sample firms during the examined period. Between two consecutive trades, there is about half bid more than ask quotes (5.7 bids and 5.2 offers). The average time duration between two consecutive trades is 0.24 (=exp(-1.423)) days or 5.8 hours.

We consider a comprehensive list of determinants of CDS spread changes including accounting-based and market-based variables. While some of the variables are also used in other studies on the determinants of the level of CDS spreads such as Ericsson, Jacobs, and Oviedo (2009), our comprehensive study allows us to distinguish the differential effects of these determinants on CDS spread changes. We categorize those variables as the following:

- *Firm-specific fundamental variables*: stock volatility, leverage, total asset size, profitability and cash ratio. Asset volatility and leverage are the key determinants of credit risk according to structural models of the Merton (1974)-type. We use stock volatility in place of asset volatility. Cao, Yu, and Zhong (2010), among others, discuss the role of volatility in explaining CDS spreads. We use realized volatility instead of option implied volatility due to data constraint (some firms in our sample do not have publicly traded options). Other three variables are associated with credit quality according to Altman's (1968) Z-score calculation.
- *Market conditions*: swap rate and term slope. These market variables are used by

Collin-Dufresne, Goldstein, and Martin (2001) in the study of credit spread changes using corporate bonds.[7]

- *Market sentiment*: VIX. VIX is often referred to as the "fear factor." We use VIX as a proxy for market sentiment or average investor risk aversion in the market. VIX is also often used as market-wide forward-looking volatility measure.
- *Stock price change*: stock return between CDS trades, which is used as a summary measure of all public information in the stock market.
- *CDS liquidity*: bid-ask spread, the time duration and the total number of quotes between two consecutive trades. CDS liquidity is shown to affect CDS spreads by Bongaerts, de Jong, and Driesson (2011), Tang and Yan (2012).
- *Bond turnover*: the ratio of bond trading volume over all bonds outstanding for the same issuer. We aggregate all bonds from the issuer which is used as the CDS reference entity. Bond turnover is a measure of bond market liquidity and activity.

We do not control for maturity as all contracts are for five years. All above variables enter the CDS spread change specifications in a linear fashion.

In all of the existing CDS studies, one important aspect of market trading activity is always missing. That is the latent trading demand which would lead to the next trade and the associated price change. While this trading demand may be related to changes in fundamental variables as described above, it could also be an indicator of permanent or temporary shifts in the market that evades the variables used before. We take advantage of the availability of binding quotes in our dataset and estimate *CDS Excess Demand* for each CDS contract as:

$$\text{CDS Excess Demand} = \text{Number of Bids} - \text{Number of Offers}, \tag{1}$$

where the numbers of bids and offers are recorded between two consecutive trades. This measure captures the latent trading demand between consecutive transactions and can be used as a proxy for supply-demand imbalances, consistent with the notion of order imbalance in Chordia and Subrahmanyam (2004).

Among the summary statistics presented in Panel A of Table I, the average value of the excess demand between two consecutive trades is 0.516, while the median is zero. Panel B

[7] We do not include direct proxies for recovery rate. However, recovery rate is highly related to market condition. Therefore, our market condition variables also to some extent control for expected recovery rate. Note that we investigate trade level changes and recovery rate may not significantly change over short time period.

of Table I reports the correlations between the variables discussed above. The variables with relatively higher correlations with CDS spread changes are stock volatility change, change in VIX, change in leverage, change in swap rate, change in stock price, excess demand, and change in asset size. The correlation among our explanatory variables are generally low except the correlation between time duration and number of quotes (0.65), changes in stock price and asset size (0.48), changes in stock volatility and VIX (0.47), changes in stock price and leverage (-0.42).

C Fundamental Drivers of Tick-by-Tick CDS Price Changes

We first investigate fundamental determinants of CDS spread changes. According to the structural model of Merton (1974) and its extensions, credit spreads are determined mostly by leverage, asset volatility, and market condition such as interest rates. The accounting based approach along the line of Altman (1968) employs firm conditions such as cash holdings and profitability. Das, Hanouna, and Sarin (2009) discuss those different approaches and suggest that a hybrid model combining the accounting-based and market-based approaches is best in explaining the level of CDS spreads. Therefore, we examine those variables separately as well as jointly. We regress 5-year CDS spread changes between two consecutive trades on firm-level fundamental variables and market condition measures in a panel data analysis. Regression results are reported in Table II.

The first three columns of Table II examine the effect of changes in five independent variables for firm-level fundamentals: stock volatility, leverage, size, profitability, and cash ratio. Among those five firm characteristics, the change in stock volatility is the most significant determinant of CDS spread changes with an adjusted R^2 of 25% and a large t-statistic. This is consistent with previous findings that stock volatility is a key determinant of the *level* of credit spreads (Campbell and Tasler (2003), Ericsson, Jacobs and Oviedo (2009), Zhang, Zhou and Zhu (2009), and Tang and Yan (2010)). The magnitude of this effect remains robust even with the control of other firm-level determinants. As we discussed before, individual equity option implied volatility is a forward-looking volatility measure, which could have even stronger explanatory power for CDS spread changes. The second most significant firm-level determinant is the change in leverage, which alone accounts for roughly 13% of the variations in CDS spreads. Other fundamental variables dwarf in their explanatory power, although changes in asset size and cash ratio are statistically significant determinants of CDS spread changes. CDS spread increases when cash ratio increases, consistent with the precautionary motive of cash holdings. The effects of volatility and leverage are also economically large. Based on the regression result in column 3, one standard deviation increase in the change of stock volatility results in a 12.5% increase in CDS spreads. Changes in all five firm-level variables lead to an adjusted R^2 of 31%, as shown in column 3, in explaining CDS spread changes.

We measure market conditions by the 5-year swap rate (*Swap Rate*) and the term premium (yield difference between 5-year and 2-year Treasury notes, *Term Slope*) and examine how they affect the changes in CDS spreads. Column 4 of Table II shows that changes in the market interest rate level are much more significant than changes in the term premium even though the latter is also statistically significant. CDS spreads decrease by about 1.3% when the 5-year swap rate increases by 1%. The R^2 is about 7%, suggesting that market conditions have smaller explanatory power than firm-level fundamentals, consistent with the findings in Tang and Yan (2010) on the determinants of CDS spread levels. We also note that the expected recovery rate also changes with economic states and may affect CDS spreads.

Another potentially important factor for CDS spread changes is the change in investor sentiment or risk aversion in the market. Even if actual default risk stays the same, CDS spreads may increase when investors become more pessimistic or more risk averse. The VIX index is often used to measure market sentiment or average investor risk aversion or market-wide forward-looking volatility. In column 5 of Table II, we regress CDS spread changes on the change in the VIX index. The high t-statistic and adjusted R^2 show that the change in market sentiment indeed is a significant determinant of CDS spread changes. The coefficient estimate of 1.014 for the change in VIX index suggests that a 10% increase in the VIX index is associated with about 10% increase in CDS spreads. Comparing the adjusted R^2s, VIX has similar explanatory power as that of individual stock volatility.

We jointly evaluate the explanatory power of those three market condition variables in column 6. The effect of 5-year swap rate, our measure of market interest rate, is attenuated once VIX is controlled for as shown by the decreases in t-statistic and coefficient estimate. In aggregate, those macroeconomic variables produce a R^2 of 0.27, which is slightly lower than the R^2 of 0.31 in column 3 with firm characteristics.

Stock price changes are often used as a sufficient statistics for public information flow. However, there is a debate on how much CDS spreads co-move with stock prices (Hilscher, Pollet, and Wilson (2015), Kapadia and Pu (2012), and Marsh and Wagner (2015)). We regress CDS spread changes on stock price changes in column 7 of Table II. The statistical significance of stock price changes as measured by t-statistic is similar to that of the change in leverage in column 3. This is intuitive as one way for stock price to affect CDS spreads is by affecting firm leverage. The adjusted R^2 of about 6% shows substantial yet limited explanatory power of stock price changes for CDS spread changes. Also, the coefficient estimate -0.713 suggests that one percentage increase in stock price is accompanied by 0.7% decrease in CDS spreads. We note that the relationship between stock price changes and CDS spread changes is generally non-linear (there may also be asymmetry), and much of the nonlinearity may be picked up by other fundamental variables.

Indeed, the effect of stock price change on CDS spread changes appears significant attenuated as shown in column 8 for the regression that includes all firm-level variables. While all significant variables in the separate analysis remain so in this multi-variate regression, remarkably, the significance of stock price change is most affected by the inclusion of other variables. The magnitude of coefficient estimates for change in stock price drops from -0.713 to -0.166. Changes in stock volatility and leverage remain the most significant firm-level fundamental variables that drive CDS spread changes. This finding is consistent and substantiate the approach by Bai and Wu (2015).

Market condition variables absorb part of the impact of firm-level variable as shown in column 9 of Table II. The total adjusted R^2 increases to about 0.38 from 0.31 for firm-level variables alone in column 3 and from 0.27 for market variables alone in column 6. We further include year and firm fixed effects in column 10, and the adjusted R^2 reaches 0.40. Such a level of R^2 is relatively high for an analysis of trade-by-trade price changes. The adjusted R^2 is about 0.2 in Collin-Dufresne, Goldstein, and Martin (2001).

III Slow-Moving Capital and Intermediation Capacity

In this section we provide evidence that CDS prices respond to supply or demand shocks, consistent with the slow-moving capital theory of Duffie (2010). This is plausible especially as buyers and sellers bargain over prices while new traders may arrive, as modeled by Fuchs and Skrzypacz (2010). Moreover, investors could be inattentive and financial intermediaries can be capital constrained. We characterize the price movements over time and across firms, as well as before and during the credit crisis.

A Supply-Demand Imbalance

CDS contracts are derivatives. In a complete and frictionless market, trading should have no impact on CDS spreads. However, if the CDS market is not frictionless, motivations to trade may determine whether trading causes prices to move. Moreover, when dealers provide liquidity to market by accepting bids or offers, their own inventories may be unbalanced. They may need to be compensated for such service.

Prior studies suggest that the market structure for CDS may have implications for price movements. Sellers worry about dealing with informationally advantaged buyers and vice versa. Funding constraints faced by dealers may prevent them from meeting the surging demand. Shachar (2012) shows limited market making capacity by CDS dealers, along the line of Froot (2001) for insurance sellers. When the market is one-sided, prices need to adjust significantly to attract more participants to take the opposite side of the trade. Therefore, as found in the literature, trade imbalance may lead to the movement of market prices. In the opaque OTC market, search for the best price may generate a relationship between search intensity and prices and a wedge between quotes and the transacted price, as modeled by Zhu (2012). Motivated by these considerations, we investigate the effect of supply-demand imbalances in CDS contracts on CDS spread changes.

The demand and supply for CDS protection may fluctuate over time and across firms. Because of the insurance nature of CDS contracts, trades are more likely driven by the demand side as there is natural net exposure to credit risk. In order to delineate the price impact of CDS trading activities, we link changes in CDS spreads to our measure of excess demand for CDS contracts as specified in (1). Figure 2 plots average CDS spread changes against CDS excess demand. The percentage change in CDS spreads is averaged for each level of the excess demand.[8] The figure shows a clear positive relationship between CDS spread change and excess demand. There are no observations in the second and fourth quadrants.

The univariate relation between excess demand and CDS spread changes is confirmed by the regression analysis in column 1 of Table III. The coefficient estimate of 0.018 indicates that when there is one more bid than offer for CDS contracts from one trade to the very next trade, CDS spread increases by 1.8% on average, all else equal. When the excess demand increases by one standard deviation, i.e., with 2.7 more bids than offers, CDS spread increases by 4.9%. This effect is large considering that the sample average of CDS spread changes between two

[8]We depict only those averages with more than ten observations to assure reliable inference. The general patterns remain the same if we keep all data points and do not take average.

consecutive trades is 2.3%. The adjusted R^2 of 3% is on the same order of magnitude as that of the change in stock prices in column 7 of Table II and that of the change in market credit conditions in column 4 of Table II. Therefore, the explanatory power of excess demand for CDS spread change is economically meaningful.

The magnitude and significance of excess demand effect in explaining CDS spread changes hold up in column 2 and column 3 of Table III when the fundamental variables and fixed effects examined in Table II are included. The t-statistic for the coefficient estimate of excess demand in column 3 is higher than the t-statistic of stock price changes and market credit condition. One additional bid would on average increase the CDS spread by 1.1%, holding other control variables fixed.

Financial firms are important part of the CDS market. They are both major CDS buyers and sellers as well as reference entities. To further understand the effect of the supply-demand imbalance, we interact the excess demand variable with a financial firm dummy. The result in column 4 shows that the effect of excess demand on CDS spread changes is about one-third weaker for financial firms. Given that CDS sellers are conceivably affiliated with financial firms (Arora, Longstaff and Gandhi (2012)), the credit risk of financial reference entities and the credit risk of CDS sellers are likely correlated. Our finding suggests that buyers are not willing to pay as much when they demand more CDS contracts referencing financial firms. Therefore, while the excess demand effect in general indicates a limited intermediary capacity for CDS sellers (Shachar (2012)), the CDS spread reduction for financial firms suggests that counterparty risk figures prominently in this effect.

Besides counterparty risk, another source of the excess demand effect could be the insufficient liquidity provision by dealers. Such a conjecture would suggest that the effect of supply-demand imbalance should be short-lived. If excess demand is not persistent, the impact of high level of demand or supply will attenuate over time. We plot CDS spread changes subsequent to the large (three or more in net absolute value) positive and negative excess demand in Figure 3. We observe asymmetry in terms of positive excess demand versus negative excess demand. Excess demand has a stronger effect (16% initial response) than excess supply (10% initial response). More important, the supply-demand effect is transitory and dissipates after three trades. After five trades (or even two trades), the price movements following large buy or large sell would not be distinguishable.

B CDS Liquidity

The last set of determinants for CDS spread changes that we examine is direct measures of liquidity in the CDS market. Changes in CDS market liquidity, potentially due to changes in funding cost of CDS dealers, may affect CDS spreads. There could also be a spillover effect from corporate bond trading, as the bond market and the CDS market are both linked to firms' credit risk. CDS spread changes may also be related to bond trading due to capital structure arbitrage and CDS-bond basis trade. We regress the change in CDS spreads on measures of CDS liquidity, liquidity changes, and bond trading activities. Results are reported in Table IV. To isolate the effect of liquidity, we control for changes in fundamental variables and the excess demand between two consecutive trades.

We first examine the time duration between two trades measured by days, which indicates the depth of the market and the ease of trade. We take the logarithm of duration as our independent variable in response to the skewness in the distribution of this measure. Column 1 of Table IV shows that CDS spreads increase more with longer time duration between two trades, *ceteris paribus*. Compared to two trades that take place within the same day, CDS spreads increase by 0.2% more if two trades are one week apart, holding fundamentals and excess demand fixed. Comparing column 1 and column 6 with all controls, the effect of time duration is robust, even stronger in the presence of other liquidity controls. Hence, as CDS trading is sparse, when there is a long elapse of time, then CDS spreads tend to spike up for the next trade, all else equal.

CDS contracts are traded over-the-counter, therefore it is hard to conceptualize trading volume. We calculate the number of quotes between trades to measure trading interest. Column 2 shows that there is no significant relation between the number of quotes between consecutive trades and CDS spread changes between trades. Nevertheless, the effect becomes significant in column 6 in the presence of other liquidity controls. When there are more quotes, holding other liquidity variables such as bid-ask spread fixed, CDS spread decreases as number of quotes increases. The difference between column 2 and column 6 is likely due to the negative correlation between number of quotes and bid-ask spreads. Intuitively, for a given level of bid-ask spreads, a larger number of quotes indicates better liquidity. If liquidity premium is captured by CDS sellers on average, then CDS spreads should decrease with the number of quotes between trades. We note that the inclusion of number of quotes in the regression does not affect the coefficient estimate and statistical significance of excess demand.

We directly examine the effect of changes in bid-ask spreads on CDS spread changes in column 3 and column 4. We consider two measures, one is the difference in bid price and ask price, which factors in the spread or return nature of CDS spreads, the other is to scale the difference by mid-price to make a percentage measure. Column 3 shows a positive relationship between the change in bid-ask spread measured by difference and CDS spread changes, which is robust with other controls as shown in Column 6. Column 4 shows that CDS spread decreases when the percentage change in bid-ask spreads increases. The effect is stronger in column 6 when we control for the number of quotes and other liquidity variables, consistent with our previous discussion on the number of quotes. The economic magnitude of the effect due to the percentage change of bid-ask spreads is also large. When bid-ask spreads increase by 6% (about one standard deviation), CDS spreads decrease by about 0.3%–0.8%.

Lastly, we link bond trading to CDS spread changes.[9] We calculate bond turnover using TRACE data. Column 5 and column 6 show a positive relation between change in bond turnover and CDS spread changes. When bond turnover increases by 10%, CDS spreads increase by about 1.1%. This result could be due to hedging across these two markets. Increase in bond turnover may suggest potential demand for CDS and therefore increase CDS spreads.

Overall, we find that CDS liquidity and bond trading affect CDS spread changes. Comparing the adjusted R^2 from column 6 of Table IV (0.4187) and that from column 3 in Panel A of Table III (0.4138), we find that incremental R^2 due to liquidity measures is somewhat limited in the panel data analysis. In the next section, we show that the effect of liquidity is much more significant in time-series regressions.

C Comparative Explanatory Power in Time Series

To better understand the relative explanatory power of the determinants for CDS spread changes, we also conduct time-series regression analysis, following Collin-Dufresne, Goldstein, and Martin (2001) in this exercise. We choose 171 firms with at least 20 weeks of trading data for a sufficient length of time series, and consider five groups of determinants as discussed before: (1) change in firm and market fundamentals; (2) stock price change; (3) CDS excess demand; (4) change in bond turnover; (5) change in CDS liquidity. In Table V we first report the percentage of those 171 firm-level time-series regressions have significant coefficient

[9] A growing literature examining the CDS-bond basis and interaction between CDS and bond markets includes Bai and Collin-Dufresne (2012), Li, Zhang, and Kim (2012), Das, Kalimipalli, and Nayak (2014).

estimates in terms of t-test or F-test. The other columns report the distribution of the adjusted R^2s from these individual firm-level time-series regressions.

The first row shows that for all 171 firms, fundamental variables (all variables analyzed in Table II except for stock price change) jointly are significant determinants of CDS spread changes. Average R^2 from the time-series regression on CDS spread changes is 0.437, with median 0.415 and maximum 0.961. The explanatory power of stock price change alone is much weaker, as shown in the second row. The average R^2 in regressing CDS spread changes on stock price changes is 0.165 with median 0.143. However, we find that for 83% (142 out of 171) firms, CDS spread changes move significantly with stock price changes.[10]

CDS excess demand is significant in explaining CDS spread changes in 66% of the firm-level time-series regressions. The average R^2 is 0.078 and median is 0.041. The effect of bond trading is significant for 32% of the regressions but median R^2 is about zero (average is 0.035). However, the maximum R^2 is 0.614, suggesting some occasions with strong CDS-bond trading integration. Lastly, CDS liquidity is significant for 90% of the regressions. Average R^2 is 0.174 (median 0.154). Therefore, the explanatory power of CDS liquidity looks on par with stock price changes. Such a level of explanatory power is substantial given the significant amount of attention to the relation between movements in stock prices and CDS spreads in the literature. This finding further underscores the importance of CDS liquidity analysis (Bongaerts, de Jong, and Driessen (2011), Tang and Yan (2012)).

In the overall analysis with all above determinants, average R^2 is 0.581 (median 0.591) for the 171 time-series regressions on CDS spread changes. Given that we run firm-level regressions on the transaction-based data, we do not expect to explain 100% of the time-series variations as some noise not captured by fundamentals, excess demand, and liquidity will remain. Nevertheless, such a level of R^2 compares favorably with the findings in Collin-Dufresne, Goldstein and Martin (2001) on bond credit spreads. They find R^2 to be around 0.2 for changes in credit spreads based on corporate bond yields using monthly observations. Two factors could contribute to the improved explanatory power by the determinants of CDS spread changes. First, CDS trading is more active and arguably more liquid than corporate bonds. Prior studies find that CDS trading is more efficient than bond trading (e.g., Blanco, Brennan, and Marsh (2005)). Second, we use a more recent sample. Recent studies show that bond trading also improves in terms of price efficiency and liquidity after TRACE is im-

[10]Most regressions produce negative coefficient estimates for the CDS spread change and stock price change regression as expected. The coefficient estimates sometime are positive. We do not differentiate the positive and negative significant relations as done by Kapadia and Pu (2012).

plemented (see, among others, Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), Goldstein, Hotchkiss, and Sirri (2007)). Our sample also includes the credit crisis period which contains more variations in CDS spreads. As we will see later, the explanatory power of our CDS spread change determinants during the crisis period is much larger.

D Cross-sectional Variation

For the practice of risk management, it is useful to see cross-sectional heterogeneity in the patterns of CDS spread changes. If there are significant differences across different types of firms, risk management policies should factor that into the system. We analyze potential cross-sectional variations in credit quality, financial versus non-financial firms, and market activities. Results are reported in Table VI.

We first separate firms by their credit ratings. Investment grade (IG) firms with ratings BBB and above can behave differently from junk rating or high yield (HY) firms with ratings BB and below. The gap between BBB and BB ratings is a significant demarcation in credit quality. Many pension funds and other institutional investors are restricted from buying junk grade bonds by regulation or by-laws. This may impact CDS spread changes differently as fund managers could use CDS contracts as an alternative to bypass the regulations (Adam and Guettler, 2015). We find that CDS spread changes for investment grade firms are better explained by these determinants as indicated by higher t-statistics and adjusted R^2. The R^2 is 0.431 for investment grade firms but 0.355 for high yield firms. The difference may appear modest at a glance, but we note that there are about four times more observations in the high grade group that would make the higher R^2 more difficult to attain. The effect of the number of quotes between trades is only significant for high grade firms. The coefficient estimates for volatility and leverage are much larger for investment grade firms than high yield firms. Increase in profitability helps reduce CDS spreads for high yield firms but not for investment grade firms. Lastly, change in size (measured by total assets) is positively related to CDS spread changes for investment grade firms but has a negative coefficient for high yield firms. In other words, the increase in asset size helps reduce CDS spreads for high yield firms but CDS spreads increase when investment grade firms bloat their balance sheets.

Financial firms are unique in the sense that many CDS dealers are financial firms themselves. Also, financial firms engage in financial markets frequently. Their capital structures are quite different from non-financial firms. We find that the explanatory power of the determinants for CDS spread changes is weaker for financial firms. However, there is a significant negative relationship between CDS spread changes and stock price changes for financial firms. There is no significant relationship between CDS spread changes and stock price changes for non-financial firms in the presence of controls for other determinants. This finding suggests additional information content in stock price changes for CDS spread changes for financial firms.

Volatility is more powerful in explaining CDS spread changes for non-financial firms. Leverage is more important for financial firms, consistent with the intuition that financial firms often use the market to manage leverage. Relatedly, increasing asset size on balance sheets for financial firms raises their CDS spreads, all else equal, but has no effect on non-financial firms. This is consistent with the result for investment grade firms above as higher levels of financial assets on the balance sheet may indicate heightened levels of credit risk.

Changes in profitability, cash ratios, and are related to CDS spread changes for financial firms but not non-financial firms. Furthermore, CDS spreads decrease when bond turnover increases for financial firms, the relationship is the opposite for non-financial firms. Therefore, the CDS-bond trading integration could be different for financial firms versus non-financial firms. For financial firms, bonds can be a substitute for CDS trading, but for non-financial firms, bond and CDS may be complements. The significant effect of the number of CDS quotes for non-financial firms can further support this conjecture.

Surprisingly, variables for market conditions appear to have stronger effects on CDS spread changes for non-financial firms than financial firms, as term slope explains CDS spread changes for non-financial firms but not so much for financial firms. The significance levels of changes in swap rates and VIX are much lower for financial firms than for non-financial firms. This may be the consequence of more active hedging policies adopted by financial firms.

In addition, we separate CDS-active firms from firms with only occasional CDS trading. CDS trading concentrates on a few active names. In our sample, there are 87 firms with 100 or more trades, making up the 28175 CDS change observations, while the other 308 firms contribute 7369 CDS change observations. The adjusted R^2 is higher for infrequently traded CDS names than for actively traded CDS names, partly due to the larger sample for the actively traded CDS contracts. For the same reason, t-statistics are usually larger for the active CDS group. Similar to the partition by financial versus non-financial firms, CDS spreads decrease with stock returns only for the actively traded CDS group. For this group the integration between CDS and stock markets is significant.

The effect of excess demand is stable over our cross-sectional analysis. Both the economic magnitude and statistical significance are high in all sub-samples. Excess demand effect in driving CDS spread changes is even more persistent than some firm characteristics such as stock price and profitability. Therefore, we conclude that excess demand has a pervasive impact on CDS spread changes.

E Time Variation: Before and During Credit Crisis

Although the CDS market has grown rapidly since its emergence in the 90's, it had stayed away from public attention and media coverage until the onset of the global financial crisis in 2007. CDS trading has become controversial and under regulatory scrutiny around the world. Many blame CDS trading for its role in the crisis. We examine CDS spread changes before and during the crisis period, which is defined as from July 2007 to March 2009, to shed more light on the time variation in the effect of CDS spread change determinants.

The co-movement among CDS spreads becomes much more pronounced during the crisis period when CDS spreads mostly increase.[11] We plot the number of firms with big CDS increases (up more than 50%) and big CDS spread decreases (down more than 50%) in a given month in Figure 4. Overall, there are more correlated increases than decreases. In other words, CDS spreads are more likely to go up together than go down together. For example, in the middle of 2002 around the Argentina default, about 25 firms experienced CDS spread increase by 50% or more (and only two firms experienced CDS spread dropping more than 50%). Same phenomenon occurred when GM and Ford were downgraded to junk ratings in May 2005. In any given month, the number of firms with more than 50% CDS spread decreases is no more than 10. Correlated CDS spread increases are particularly prevalent in the crisis period after July 2007. For instance, about 50 firms had CDS spread increases by more than 50% in August 2007.

We examine the differential impact of determinants of CDS spread changes before and during the credit crisis. Table VII reports our regression results. In Panel A, we separate our sample into the normal period (January 2002 to June 2007) and the crisis period (July 2007 to March 2009). During the normal period, CDS liquidity variables and excess demand each contribute marginally about 3% or 4% of R^2 to the total of 24% in model 3 compared

[11] Credit contagion is also examined by Jorion and Zhang (2007) and Yang and Zhou (2013).

to model 1 and model 2. In contrast, during the crisis period, the marginal contribution to R^2 from excess demand and liquidity measures is minimal. Moreover, the effects of the number of quotes and bid-ask spreads are different in the normal time versus in the crisis period. For example, CDS spreads increase with percentage changes in bid-ask spreads in the normal period but decrease in the crisis period. Bond turnover is positively related to CDS spread changes in the normal time but negative in the crisis period. Increases in asset size are associated with a drop in CDS spreads in the normal period but positive in the crisis period. The crisis is characterized by the failure of Lehman Brothers and bailout of AIG. Both were major CDS market participants. Hence, the deterioration of CDS and bond liquidity was concurrently accompanied by overall increase of CDS spreads. Before the crisis, there was no trend in the overall CDS spread movements and there was ample liquidity, especially for the A/BBB names. Such differences could generate the flipping signs in the liquidity coefficients.

Market conditions as measured by swap rate and term slope are significantly related to CDS spread changes in the crisis period but much less significant in the normal period. This is consistent with the observation that during the crisis period, security movements become much more correlated and hence more sensitive to macro variables. Interestingly, the sensitivity to VIX remains stable before and during the crisis period, although VIX shot up to an extremely high level, raising CDS spreads with it. The increased level of the co-movement in CDS spreads changes and its heightened sensitivities to changes in macroeconomic variables also contribute to the much-higher R^2 in column 6 for the crisis period than that in column (3) for the pre-crisis period.

As an alternative way to examine the influence of the credit crisis, we interact all the determinants with the crisis period indicator and present the results in Panel B of Table VII. Consistent with those in Panel A, the significant results for swap rate and term slope mostly come from the crisis period. The impact of excess demand is pervasive and consistent before and during the crisis period. This contrasts the observation that the effect of liquidity variables flips from one period to the other. Furthermore, the crisis dummy itself is insignificant in model 5, suggesting the crisis effect on CDS spread movements is well-captured by their changing sensitivities to the determinants. Therefore, the determinants affect CDS spreads differently during the crisis period and taking this into account helps explain CDS spread changes.

F Predictability

Previous analysis shows significant role of excess demand and liquidity for CDS spread changes. Therefore, market makers would be interested in knowing the dynamics of CDS spread changes for better management of inventory and other strategies. For our trade level analysis, one straightforward analysis is to examine whether CDS spread changes are positively or negatively autocorrelated over time. The investigation of path-dependence for CDS spread changes can also shed light on the predictability and efficiency of CDS spreads.

We examine two aspects of CDS spread history. One is the lagged CDS spread change. The other is the lagged CDS spread level. Return reversal is a common measure of illiquidity. If CDS market is illiquid due to dealer risk capacity constraints, CDS spread changes will be negatively auto-correlated. We regress CDS spread changes on lagged CDS spread changes and the lagged CDS spread level with other controls. Regression results are reported in Table VIII.

The first model of Table VIII shows that CDS spread changes are mean-reverting. CDS spread increases are followed by decreases and vice versa. The speed of mean reversion is measured by the coefficient estimate of -0.055. That is, about 5.5% of previous change will be corrected in the next trade, while controlling for other factors. This kind of mean reversion can be related to price impact of trade. The adjusted R^2 in column 1 of Table VIII is 0.4552, which is higher than 0.4187 in column 6 of Table IV with all previously analyzed determinants of CDS spread changes.

The second model of Table VIII shows that high CDS spreads tend to be reduced over the next trade. For two CDS contracts, one with spread of 100 bps and the other at 200 bps. The contract with a high CDS spread is likely to have about 0.7% additional decrease than one with a low CDS spread. Results are similar when we jointly consider last CDS spread change and last CDS spread price in model 3. The inclusion of past CDS spread change and past CDS spread level has little effect on the other variables, suggesting the path-dependence in CDS spread change is inherent to the market rather than correlation with other determinants.

The results in Table VIII suggest that CDS spread changes can be predicted by their last change and level. We emphasize that such predictability may not be tradable if it is purely due to liquidity. It is a consequence of market friction rather than a cause and may serve as a compensation for CDS liquidity providers. However, when CDS market becomes more liquid, such predictability may be attenuated.

G Results over Different Sampling Frequencies

We have examined CDS spread changes from one trade to the very next trade our main analysis. We are interested in discovering whether the frequency of observations would make any difference for our results. Such analysis can also serve as robustness check of our main findings. Therefore, we examine different sampling frequencies to understand CDS spread dynamics. We consider trades within one day and day-to-day, as well as week-end and month-end CDS spread changes. Regression results are reported in Table IX.

The first specification restricts the time duration between the two trades within one day. For such high-frequency transactions, fundamentals (especially firm fundamentals resulting from operations) are likely to stay the same. We only examine the effect of liquidity and CDS spread history. The results show that last CDS spread change and last CDS spread level continue to be significant and negatively correlated with CDS spread changes. Nevertheless, the effects of last CDS spread change and last CDS price are much smaller in terms of coefficient estimate or economic magnitude than low-frequency estimates in specifications 2-4. CDS excess demand is also positive and significant. CDS spreads increase as the time between the two trades increase, although they happen within one day. Such trade price differences within short time are also often used as a measure of liquidity (Feldhutter (2012), Jankowitsch, Nashikkar, and Subrahmanyam (2011)). The adjusted R^2 is 0.0328 for specification 1. It is low as we analyze intraday data which likely contain more noise than data from lower frequency.

In the second specification, we examine trades across days (so the price changes are over at least one day). The adjusted R^2 is 0.4684. The coefficient estimates are consistent with our previous estimations. Change in term slope is significantly negatively related to CDS spread change. We then examine week end trades and month end data in specifications 3 and 4. The results are similar to the the results from over day observations. R^2s from columns 2-4 (0.4684, 0.4268, and 0.4314) are close. In summary, results from Table IX show that our findings on the CDS spread change determinants are consistent over different sampling frequencies.

IV Conclusion

The movements of credit default swaps (CDS) spreads are topical issues especially since the credit crisis in 2007-2009 and the European sovereign crisis in 2010-2012. After the explosive growth of the CDS market in the decade before the credit crisis, many are now concerned of the role of CDS spreads in financial markets. As CDS trading figured prominently in the collapse of AIG in 2008 and in the European sovereign debt crisis since 2010, there have been calls for tougher regulations and even an outright ban on certain types of CDS transactions.[12] Yet, systematic evidence on the determinants of CDS spread changes is lacking. This study provides a comprehensive examination of factors that impact the changes in CDS spreads based on transactions prices in the CDS market.

We find that CDS spreads are mostly driven by fundamental variables such as firm volatility and leverage, market conditions, and investor risk aversion. However, excess demand and liquidity are important additional factors. The average R^2 in individual-firm time-series regressions is around 0.6, an impressive level in light of the relatively low explained portion of bond spread changes documented by Collin-Dufresne, Goldstein, and Martin (2001). We also find that CDS spreads move together much more during the credit crisis than during normal times. Moreover, CDS spread changes are accounted for substantially by firm fundamentals during the credit crisis. Nevertheless, there could be some unique risk factors driving CDS market movements, such as dealer risk bearing capacity constraint and counterparty risk. In addition, we show that CDS spread changes are path-dependent, suggesting that the CDS market is not fully efficient, although such inefficiency may not imply arbitrage opportunity, as it can be the consequence of trading frictions.

Our findings have implications for improving credit risk modeling and hedging strategies. Moreover, our work provides a basis for regulatory discussions such as banning naked CDS. Because banning naked CDS buying will effectively reduce the net CDS buying interest due to limited supply of reference bonds, our analysis implies that such action may not be necessary because the informationless price impact identified in our study is short lived as long as there is adequate supply of liquidity. A ban may actually hamper information production in the market and reduce market liquidity and efficiency. Even though it appears that large net buying interests are associated with large increases in CDS spreads, our analysis further illustrates that fundamentals are still the main driving force as only issuers of deteriorating credit risk are susceptible to a significant price pressure effect.

A caveat is that our empirical findings are drawn from one dataset which may not reflect

[12]For instance, in summer 2009, influential investor George Soros proposed to ban CDS contracts altogether. In March 2010, the Prime Minister of Greece blamed the CDS market for his country's soaring CDS spreads and borrowing costs, and solicited an international coalition to curb CDS trading. In May 2010, Germany banned naked CDS buying which is regarded as creating "excessive price movements" and endangering financial stability.

features of some other data sources. It is possible that different marketplaces may generate different price patterns, even though the aggregate statistics from our dataset closely resemble those from the overall market. Recently, the CDS market is going through several major new developments such as central clearing and standardized trading disclosure procedures. ISDA also implemented new credit derivatives definitions and master agreements in September 2014. Future studies using different datasets, especially those from the post Dodd-Frank era, may yield further useful insights into the pricing mechanisms in the CDS market.

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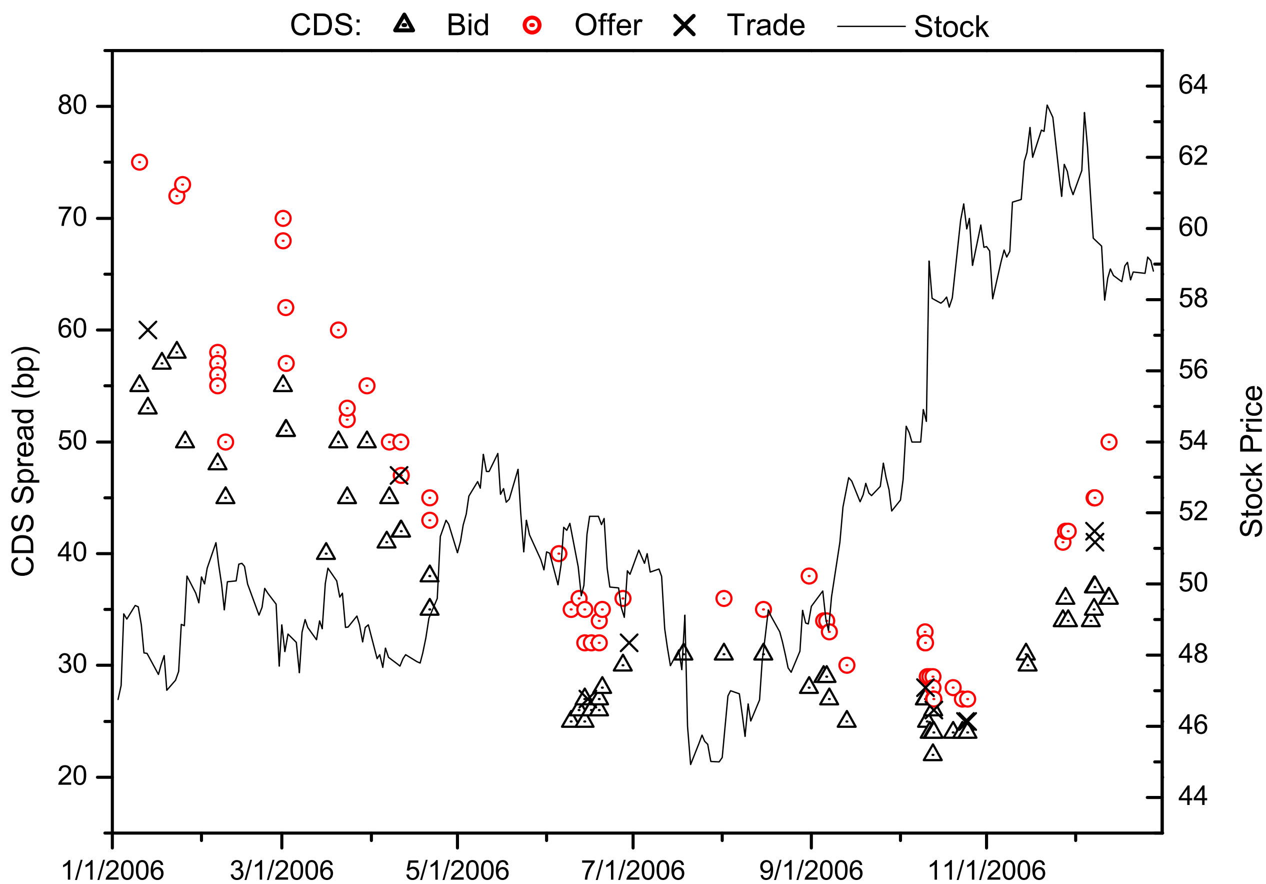

Figure 1: **Trading and Quoting Activities for Yum! Brands 5-year CDS in 2006.** This figure plots all the 5-year quotes and trades recorded in our dataset for Yum! Brands over the year 2006. All contracts are on senior unsecured bonds denominated in U.S. Dollar.

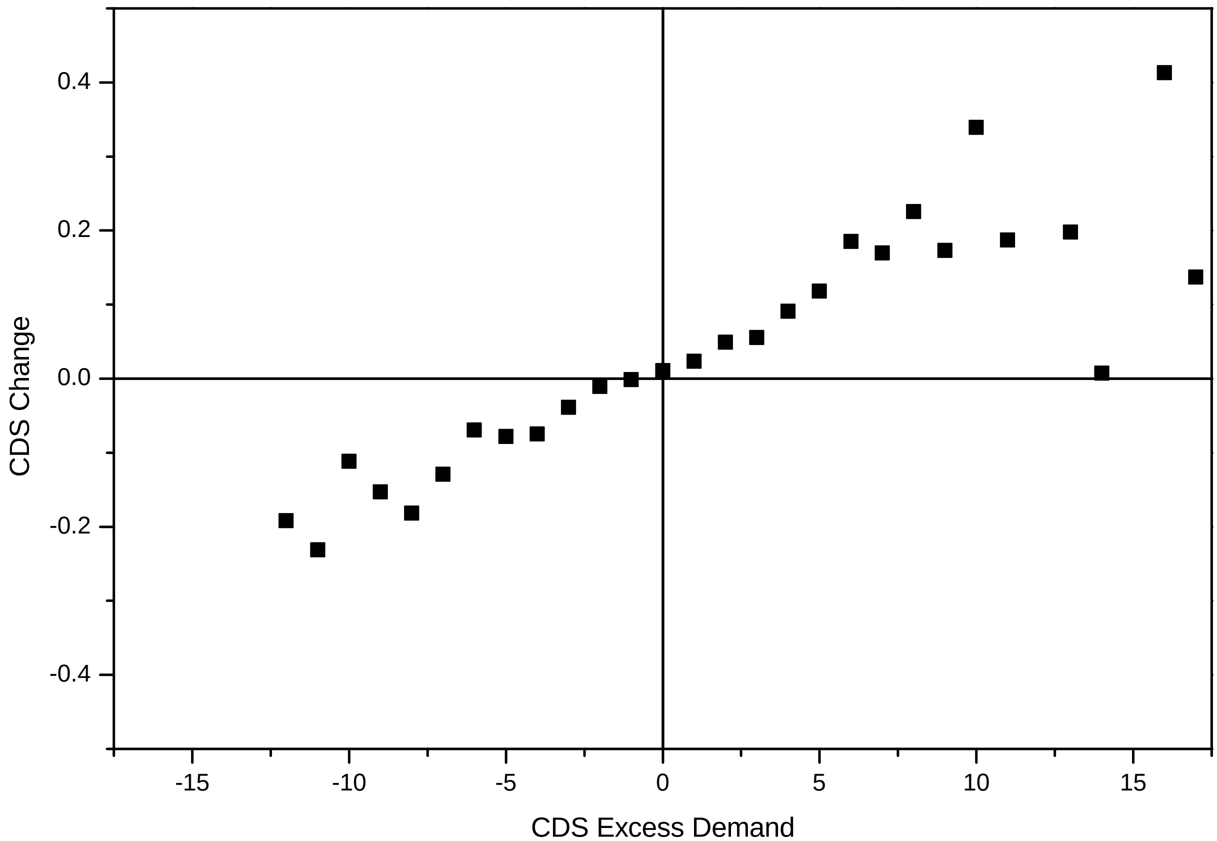

Figure 2: **CDS Spread Changes and CDS Supply-Demand Imbalance.** This figure plots the average CDS spread changes versus CDS supply-demand imbalance, or excess demand, which is defined as the number of bids minus number of offers between consecutive trades.

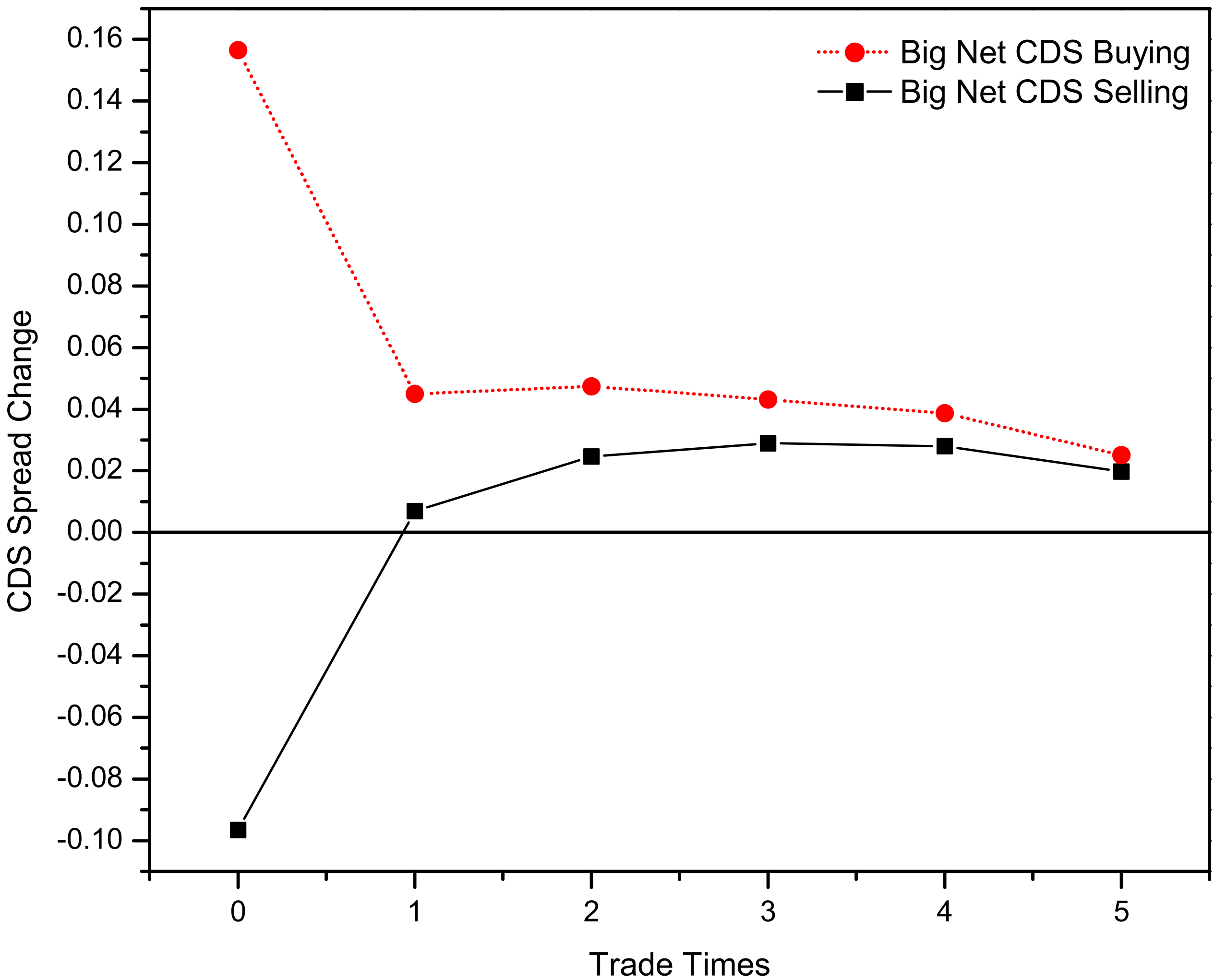

Figure 3: **CDS Spread Changes Following Big CDS Excess Demand or Excess Supply.** This figure plots the changes in CDS spreads for the subsequent five trades following the initial big CDS excess demand or big excess supply. Big CDS excess demand (*big net CDS buying*) refers to when the number of bids minus number of offers is bigger than three. Big CDS excess supply (*big net CDS selling*) refers to when the number of offers minus number of bids is bigger than three.

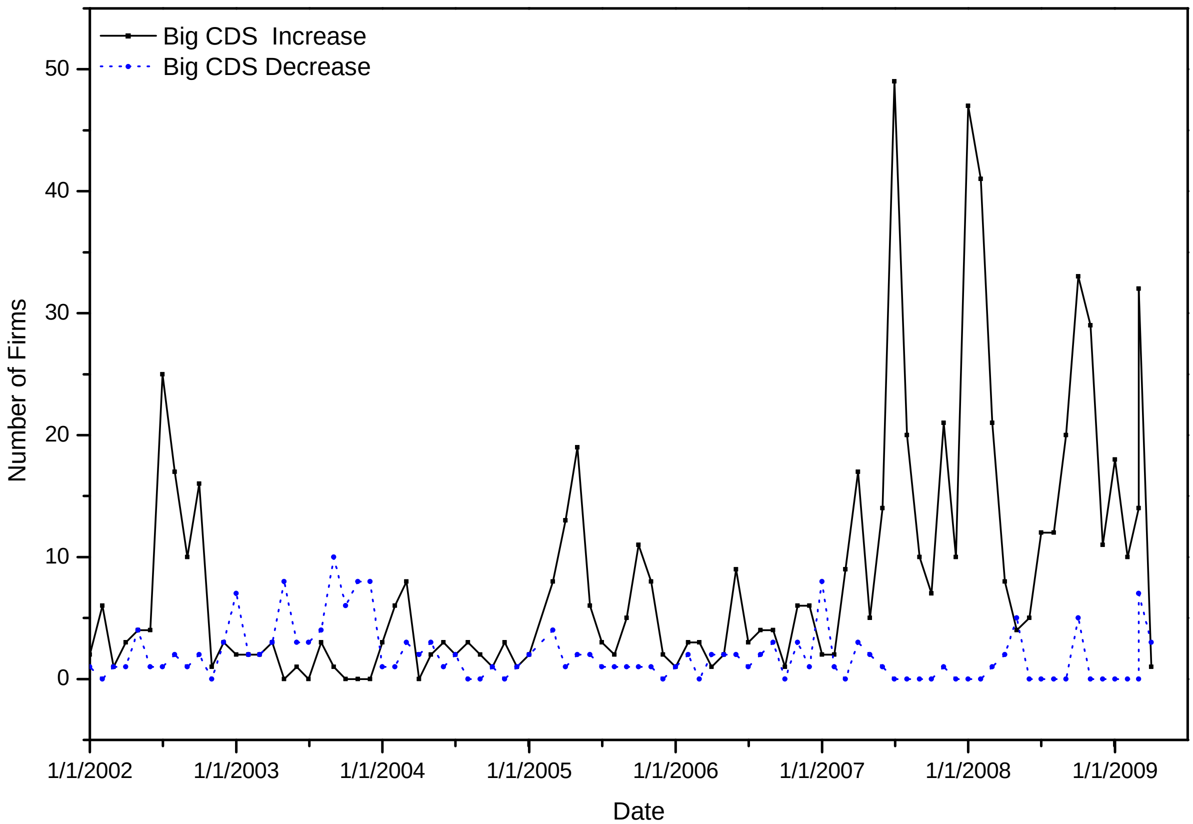

Figure 4: **Number of Firms with Big CDS Spread Changes over Time.** This figure plots monthly total number of firms with big CDS increase and decrease, respectively. Big CDS increase refers to CDS spread changes equal to or greater than 50%, and big CDS decrease refers to CDS spread changes equal to or less than -50%.

Table I
Data Summary Statistics

This table reports summary of the entire sample used in the analysis. Panel A reports the summary statistics of CDS key variables and firm fundamentals. Panel B reports the Pearson correlation coefficients of variables used in the regression. CDS spread change is defined as the percentage change of CDS spread between consecutive CDS trades. CDS excess demand is defined as the difference between number of bid and number of ask between trades. Ln(Time Duration) is the logarithm of time duration (days) between CDS trades. Ln(1+#Quotes) is the logarithm of number of quotes between CDS trades plus 1. BAS(Difference) is the difference between bid spread and offer spread at the same time. BAS(%) is the difference between bid spread and offer spread at the same time, and then divided by average bid and offer spread. Bond Turnover is defined as total bond trading volume divided by total offering amount for all the bonds traded within last month of CDS trade. ΔStock Price is defined as the percentage change of stock price between CDS trading days. Stock volatility is defined as standard deviation of stock daily return within the last one year before CDS trades. Leverage is defined as long-term debt over market value of total assets. Size is defined as logarithmic market value of total assets. Profitability is defined as net income over market value of total assets. Cash ratio is defined as cash and cash equivalent over market value of total assets. 5-Year Swap Rate is the monthly 5-year swap rate at the month of CDS trades. Term Slope is the 10-year Maturity-Constant Treasury Rate minus 2-year Maturity-Constant Treasury Rate at the month of CDS trading. VIX is CBOE Volatility Index at the month of CDS trading. Δ denotes the percentage change except for BAS(Difference), BAS(%) and Bond Turnover, whose Δs are just the change between CDS trades.

Panel A. Summary Statistics

Variable	N	Mean	StdDev	Min	Max
CDS Spread	35981	222.9	289.8	4.000	7058
BAS(Difference)	35943	13.98	30.96	-286.9	2057
BAS(%)	35943	0.102	0.084	-0.190	1.111
Bond Turnover	35981	0.091	0.135	0	1.601
CDS Spread Changes	35981	0.023	0.289	-0.922	18.286
CDS Excess Demand	35981	0.516	2.721	-54.000	59.000
Ln(Time Duration)	35884	-1.423	4.038	-11.367	7.626
Ln(1+#Quotes)	35981	1.616	1.337	0.000	5.889
ΔBAS(Difference)	35875	0.087	21.436	-1291.8	1962.1
ΔBAS(%)	35875	-0.001	0.061	-0.998	1.047
ΔBond Turnover	35981	0.000	0.031	-1.328	1.086
ΔStock Price	35981	0.001	0.097	-0.892	8.896
ΔStock Volatility	35981	0.004	0.080	-0.690	3.550
ΔLeverage	35981	0.002	0.057	-0.696	3.280
ΔSize	35981	0.000	0.005	-0.114	0.230
ΔProfitability	35981	-0.092	7.190	-780.0	241.7
ΔCash Ratio	35981	0.047	1.139	-1.000	126.7
ΔSwap Rate	35974	-0.001	0.058	-0.650	1.016
ΔTerm Slope	35747	-0.039	2.519	-177.0	228.0
ΔVIX	35981	0.009	0.141	-0.664	4.673

Table I
Continued

Panel B. Pearson Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)CDS Spread Changes	1	0.17	0.10	0.04	0.09	-0.02	0.00	-0.24
(2)CDS Excess Demand	0.17	1	0.19	0.23	0.04	-0.00	0.01	-0.04
(3)Ln(Time Duration)	0.10	0.19	1	0.65	0.02	0.01	-0.00	0.03
(4)Ln(1+#Quotes)	0.04	0.23	0.65	1	0.01	-0.00	-0.00	0.05
(5)ΔBAS(Difference)	0.09	0.04	0.02	0.01	1	0.39	-0.01	-0.09
(6)ΔBAS(%)	-0.02	-0.00	0.01	-0.00	0.39	1	-0.01	0.01
(7)ΔBond Turnover	0.00	0.01	-0.00	-0.00	-0.01	-0.01	1	0.01
(8)ΔStock Price	-0.24	-0.04	0.03	0.05	-0.09	0.01	0.01	1
(9)ΔStock Volatility	0.51	0.08	0.07	-0.00	0.08	-0.01	0.01	-0.21
(10)ΔLeverage	0.36	0.07	0.05	0.01	0.03	-0.02	-0.01	-0.42
(11)ΔSize	-0.16	-0.00	0.07	0.09	-0.05	-0.00	0.02	0.48
(12)ΔProfitability	-0.00	-0.00	-0.01	-0.01	-0.00	-0.00	-0.01	0.00
(13)ΔCash Ratio	0.03	0.03	0.06	0.06	-0.00	-0.01	0.00	0.00
(14)ΔSwap Rate	-0.27	-0.07	-0.00	0.04	-0.05	0.00	-0.01	0.18
(15)ΔTerm Slope	-0.04	-0.02	-0.02	-0.02	0.00	-0.01	-0.01	-0.01
(16)ΔVIX	0.50	0.09	0.09	0.05	0.07	-0.00	-0.04	-0.22

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)CDS Spread Changes	0.51	0.36	-0.16	-0.00	0.03	-0.27	-0.04	0.50
(2)CDS Excess Demand	0.08	0.07	-0.00	-0.00	0.03	-0.07	-0.02	0.09
(3)Ln(Time Duration)	0.07	0.05	0.07	-0.01	0.06	-0.00	-0.02	0.09
(4)Ln(1+# of Quotes)	-0.00	0.01	0.09	-0.01	0.06	0.04	-0.02	0.05
(5)ΔBAS(Difference)	0.08	0.03	-0.05	-0.00	-0.00	-0.05	0.00	0.07
(6)ΔBAS(%)	-0.01	-0.02	-0.00	-0.00	-0.01	0.00	-0.01	-0.00
(7)ΔBond Turnover	0.01	-0.01	0.02	-0.01	0.00	-0.01	-0.01	-0.04
(8)ΔStock Price	-0.21	-0.42	0.48	0.00	0.00	0.18	-0.01	-0.22
(9)ΔStock Volatility	1	0.28	-0.14	-0.01	0.01	-0.35	0.05	0.47
(10)ΔLeverage	0.28	1	-0.37	-0.01	0.03	-0.19	-0.04	0.28
(11)ΔSize	-0.14	-0.37	1	-0.01	0.01	0.23	-0.02	-0.20
(12)ΔProfitability	-0.01	-0.01	-0.01	1	-0.01	-0.01	0.00	0.00
(13)ΔCash Ratio	0.01	0.03	0.01	-0.01	1	0.01	-0.00	0.04
(14)ΔSwap Rate	-0.35	-0.19	0.23	-0.01	0.01	1	-0.01	-0.28
(15)ΔTerm Slope	0.05	-0.04	-0.02	0.00	-0.00	-0.01	1	0.02
(16)ΔVIX	0.47	0.28	-0.20	0.00	0.04	-0.28	0.02	1

Table II
CDS Spread Changes and Fundamentals

This table reports the regression result of CDS spread changes on firm fundamental variables. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	0.015***	0.018***	0.013***	0.021***	0.013***	0.013***	0.023***	0.013***	0.010***	0.231*
	(11.18)	(12.82)	(10.37)	(14.42)	(10.07)	(10.23)	(15.40)	(10.51)	(8.23)	(1.79)
ΔStock Price	.	.	.	.	.	.	-0.713***	-0.166***	-0.120***	-0.118***
	.	.	.	.	.	.	(-46.84)	(-10.60)	(-8.04)	(-8.02)
ΔStock Volatility	1.811***	.	1.566***	.	.	.	.	1.548***	1.078***	1.067***
	(110.31)	.	(94.79)	.	.	.	.	(93.36)	(60.33)	(58.97)
ΔLeverage	.	1.821***	1.151***	.	.	.	.	1.078***	0.891***	0.891***
	.	(73.07)	(46.55)	.	.	.	.	(42.06)	(36.34)	(36.03)
ΔSize	.	.	-1.321***	.	.	.	.	-0.138	1.660***	0.941***
	.	.	(-4.91)	.	.	.	.	(-0.47)	(5.93)	(3.30)
ΔROA	.	.	-0.000	.	.	.	.	-0.000	-0.000	-0.000
	.	.	(-0.28)	.	.	.	.	(-0.25)	(-0.75)	(-0.85)
ΔCash Ratio	.	.	0.006***	.	.	.	.	0.006***	0.003***	0.003***
	.	.	(5.23)	.	.	.	.	(5.30)	(3.05)	(3.19)
ΔSwap Rate	.	.	.	-1.331***	.	-0.691***	.	.	-0.239***	-0.254***
	.	.	.	(-52.42)	.	(-29.34)	.	.	(-10.47)	(-11.19)
ΔTerm Slope	.	.	.	-0.005***	.	-0.006***	.	.	-0.006***	-0.006***
	.	.	.	(-8.13)	.	(-11.03)	.	.	(-12.68)	(-12.63)
ΔVIX	.	.	.	.	1.014***	0.936***	.	.	0.591***	0.563***
	.	.	.	.	(107.80)	(96.83)	.	.	(59.30)	(56.01)
Year Fixed Effect	No	No	No	No	No	No	No	No	No	Yes
Firm Fixed Effect	No	No	No	No	No	No	No	No	No	Yes
N	35747	35747	35747	35747	35747	35747	35747	35747	35747	35747
Adj R-Sq	0.2539	0.1299	0.3065	0.0727	0.2453	0.2654	0.0578	0.3086	0.3776	0.4032

Table III
CDS Spread Changes and CDS Supply-Demand Imbalance

This table reports the regression result of CDS spread changes on CDS excess demand and other control variables, as well as the interaction between excess demand and financial firm dummy. Financial firm dummy is 1 if the CDS firm belongs to financial industry (the first two digits of SIC code are from 60 to 70), otherwise 0. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

Variable	(1)	(2)	(3)	(4)
Intercept	0.013***	0.004***	0.225*	-0.010
	(8.27)	(3.65)	(1.76)	(-0.43)
CDS Excess Demand	0.018***	0.011***	0.011***	0.012***
	(33.63)	(25.59)	(25.02)	(24.52)
Financial Firm Dummy	.	.	.	0.235*
	.	.	.	(1.82)
CDS Excess Demand	.	.	.	-0.004***
x Financial Firm Dummy	.	.	.	(-3.48)
ΔStock Price	.	-0.114***	-0.112***	-0.113***
	.	(-7.71)	(-7.67)	(-7.74)
ΔStock Volatility	.	1.064***	1.058***	1.059***
	.	(60.10)	(58.97)	(59.03)
ΔLeverage	.	0.867***	0.867***	0.865***
	.	(35.64)	(35.33)	(35.25)
ΔSize	.	1.392***	0.722**	0.736***
	.	(5.01)	(2.56)	(2.61)
ΔProfitability	.	-0.000	-0.000	-0.000
	.	(-0.61)	(-0.74)	(-0.74)
ΔCash Ratio	.	0.003**	0.003***	0.003***
	.	(2.48)	(2.77)	(2.76)
ΔSwap Rate	.	-0.215***	-0.230***	-0.231***
	.	(-9.51)	(-10.22)	(-10.26)
ΔTerm Slope	.	-0.006***	-0.006***	-0.006***
	.	(-12.31)	(-12.18)	(-12.16)
ΔVIX	.	0.580***	0.552***	0.552***
	.	(58.62)	(55.32)	(55.34)
Year Fixed Effect	No	No	Yes	Yes
Firm Fixed Effect	No	No	Yes	Yes
N	35747	35747	35747	35747
Adj R-Sq	0.0306	0.3887	0.4136	0.4138

Table IV
CDS Spread Changes and CDS Liquidity

This table reports the regression results of CDS spread changes on CDS excess demand, other liquidity measures and control variables. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.005	-0.008	-0.010	-0.009	-0.009	0.010
	(-0.22)	(-0.31)	(-0.41)	(-0.36)	(-0.36)	(0.41)
CDS Excess Demand	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(24.18)	(24.71)	(24.97)	(25.18)	(25.14)	(24.44)
Ln(Time Duration)	0.001***	.	.	.	.	0.003***
	(4.39)	.	.	.	.	(6.86)
Ln(1+#Quotes)	.	-0.001	.	.	.	-0.008***
	.	(-0.84)	.	.	.	(-5.33)
ΔBAS(Difference)	.	.	0.000***	.	.	0.001***
	.	.	(7.07)	.	.	(8.89)
ΔBAS(%)	.	.	.	-0.053***	.	-0.129***
	.	.	.	(-2.76)	.	(-6.16)
ΔBond Turnover	.	.	.	.	0.110***	0.111***
	.	.	.	.	(2.88)	(2.92)
ΔStock Price	-0.115***	-0.113***	-0.106***	-0.113***	-0.113***	-0.102***
	(-7.84)	(-7.70)	(-7.27)	(-7.72)	(-7.73)	(-6.99)
ΔStock Volatility	1.063***	1.065***	1.061***	1.065***	1.063***	1.052***
	(59.12)	(59.26)	(59.01)	(59.25)	(59.12)	(58.48)
ΔLeverage	0.871***	0.875***	0.880***	0.873***	0.875***	0.875***
	(35.31)	(35.49)	(35.69)	(35.42)	(35.50)	(35.54)
ΔSize	0.646**	0.740***	0.723**	0.714**	0.720**	0.679**
	(2.26)	(2.59)	(2.54)	(2.50)	(2.53)	(2.38)
ΔProfitability	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(-0.82)	(-0.87)	(-0.86)	(-0.87)	(-0.82)	(-0.84)
ΔCash Ratio	0.003**	0.003***	0.003***	0.003***	0.003***	0.003**
	(2.44)	(2.66)	(2.65)	(2.60)	(2.61)	(2.53)
ΔSwap Rate	-0.251***	-0.248***	-0.246***	-0.249***	-0.248***	-0.242***
	(-11.11)	(-10.96)	(-10.92)	(-11.02)	(-10.98)	(-10.72)
ΔTerm Slope	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(-12.12)	(-12.21)	(-12.17)	(-12.21)	(-12.16)	(-12.16)
ΔVIX	0.546***	0.549***	0.546***	0.549***	0.550***	0.548***
	(54.57)	(54.76)	(54.67)	(54.95)	(55.00)	(54.68)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N	35544	35544	35544	35544	35544	35544
Adj R-Sq	0.4167	0.4164	0.4172	0.4165	0.4165	0.4187

Table V
Distribution of R^2s from Time-Series Regressions of CDS Spread Changes

This table reports summary statistics for the adjusted R^2s of firm-level time-series regressions of CDS spread changes on firm fundamentals, CDS excess demand, ΔStock Price, change in bond turnover, and CDS liquidity measures for each firm. CDS liquidity measures include Ln(Time Duration), Ln(1+#Quotes), ΔBAS(Difference) and ΔBAS(%). All variables are described in Table I. The sample includes 171 CDS firms with CDS trading over 20 weeks during sample period. The column %Significant reports the percentage of significant key variables at 10% level.

Independent Variables	Significant(%)	Mean	Min	P25	Median	P75	Max
Fundematals	100.00	0.437	-0.072	0.221	0.415	0.612	0.961
ΔStock Price	83.04	0.165	-0.032	0.048	0.143	0.247	0.708
CDS Excess Demand	66.08	0.078	-0.032	0.006	0.041	0.113	0.587
ΔBond Turnover	32.16	0.035	-0.032	-0.003	0.001	0.036	0.614
CDS Liquidity Measures	90.06	0.174	-0.088	0.039	0.154	0.260	0.790
All Above	100.00	0.581	-0.189	0.377	0.591	0.779	0.972

Table VI
CDS Spread Changes by Rating, Industry and Trading Frequency

This table reports the regression result of CDS spread changes on CDS excess demand, ΔStock Price, bond trading volume, bond turnover, and control variables by credit rating, industry, and trading frequency. IG denotes to those CDS firms' credit rating of BBB- and higher, and HY is BB+ and lower. Financial firms are those firms with first two digits of SIC code from 60 to 69. Others are non-financial firms. Active trading firms are those with over 100 trades during the whole sample period. Inactive trading firms are those with less than 100 trades. There are 87 active firms and 308 inactive firms. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

	Credit Rating		Industry		Trading Frequency	
Variable	IG	HY	Financial	Non-Fin	Active	Inactive
Intercept	0.008	0.114	-0.118	0.052*	0.013	-0.018
	(0.15)	(1.10)	(-0.95)	(1.72)	(0.83)	(-0.19)
CDS Excess Demand	0.011***	0.008***	0.007***	0.012***	0.011***	0.012***
	(20.74)	(14.64)	(6.72)	(22.51)	(30.09)	(9.04)
Ln(Time Duration)	0.004***	0.001***	0.002***	0.003***	0.001***	0.010***
	(6.77)	(3.06)	(3.39)	(5.48)	(4.95)	(5.69)
Ln(1+#Quotes)	-0.009***	-0.001	-0.001	-0.009***	-0.005***	-0.026***
	(-5.00)	(-0.94)	(-0.47)	(-4.61)	(-4.64)	(-4.21)
ΔBAS(Difference)	0.002***	0.000***	0.001***	0.001***	0.001***	0.001***
	(13.22)	(9.70)	(5.41)	(7.37)	(15.94)	(4.24)
ΔBAS(%)	-0.249***	-0.126***	-0.170***	-0.128***	-0.148***	-0.169***
	(-9.64)	(-2.86)	(-3.99)	(-5.32)	(-8.53)	(-2.95)
ΔBond Turnover	0.090*	0.163***	-0.257**	0.151***	0.059**	0.235**
	(1.90)	(4.36)	(-2.12)	(3.63)	(2.08)	(2.07)
ΔStock Price	-0.218***	-0.369***	-0.287***	-0.009	-0.182***	0.013
	(-9.75)	(-18.08)	(-12.86)	(-0.47)	(-17.32)	(0.26)
ΔStock Volatility	1.081***	0.355***	0.563***	1.111***	0.353***	1.148***
	(52.79)	(10.75)	(19.38)	(46.65)	(15.61)	(29.19)
ΔLeverage	0.845***	0.235***	3.340***	0.769***	0.764***	0.867***
	(29.78)	(5.01)	(31.91)	(28.64)	(22.15)	(16.76)
ΔSize	2.153***	-2.643***	8.374***	-0.292	-1.048***	-0.019
	(6.17)	(-6.69)	(10.77)	(-0.91)	(-3.33)	(-0.03)
ΔProfitability	-0.000	-0.001***	-0.006***	-0.000	-0.000*	0.000
	(-0.23)	(-2.62)	(-3.98)	(-0.37)	(-1.94)	(0.12)
ΔCash Ratio	0.002*	0.003**	0.018***	0.001	-0.001	0.003
	(1.82)	(2.10)	(5.52)	(0.99)	(-0.99)	(1.45)
ΔSwap Rate	-0.238***	-0.239***	-0.123***	-0.235***	-0.310***	-0.152***
	(-9.25)	(-6.55)	(-2.87)	(-8.89)	(-15.64)	(-2.68)
ΔTerm Slope	-0.006***	-0.005***	0.003*	-0.006***	-0.007***	-0.006***
	(-10.52)	(-3.88)	(1.90)	(-10.96)	(-7.66)	(-6.56)
ΔVIX	0.569***	0.202***	0.349***	0.612***	0.311***	0.645***
	(49.46)	(12.61)	(19.81)	(50.69)	(31.42)	(27.26)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N	28028	7309	10425	25119	28175	7369
Adj R-Sq	0.4313	0.3554	0.4034	0.4401	0.2134	0.4753

Table VII
CDS Spread Changes Before and During the Credit Crisis

This table reports the regression results of CDS spread changes for crisis period and interaction with crisis period. Panel A reports the regression result of CDS spread changes on CDS excess demand, ΔStock Price, liquidity measures, and control variables before and during financial crisis period. Financial crisis period started from July, 2007. Panel B reports the regression result of CDS spread changes on CDS excess demand and other control variables interacted with crisis dummy. Crisis dummy is 1 when the time of CDS trade is after July 2007, otherwise 0. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

Panel A. Subperiod Analysis

	Before Crisis			During Crisis		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	0.008	0.021	0.026*	-0.071	-0.075	-0.077
	(0.57)	(1.47)	(1.85)	(-1.04)	(-1.10)	(-1.13)
CDS Excess Demand	0.011***	.	0.011***	0.012***	.	0.011***
	(37.35)	.	(37.02)	(6.17)	.	(5.17)
Ln(Time Duration)	.	0.002***	0.002***	.	0.003***	0.003***
	.	(5.32)	(5.53)	.	(2.84)	(2.67)
Ln(1+#Quotes)	.	-0.005***	-0.011***	.	0.009**	0.002
	.	(-4.56)	(-9.30)	.	(2.33)	(0.40)
ΔBAS(Difference)	.	0.002***	0.002***	.	-0.000***	-0.000***
	.	(30.73)	(29.31)	.	(-2.69)	(-2.70)
ΔBAS(%)	.	-0.372***	-0.354***	.	0.818***	0.821***
	.	(-23.63)	(-23.05)	.	(8.67)	(8.71)
ΔBond Turnover	.	0.285***	0.267***	.	-0.477***	-0.469***
	.	(11.02)	(10.58)	.	(-2.67)	(-2.63)
ΔStock Price	-0.142***	-0.127***	-0.119***	-0.222***	-0.224***	-0.219***
	(-12.28)	(-10.91)	(-10.45)	(-6.46)	(-6.51)	(-6.39)
ΔStock Volatility	0.360***	0.331***	0.316***	1.095***	1.107***	1.104***
	(19.32)	(17.57)	(17.26)	(30.42)	(30.55)	(30.51)
ΔLeverage	0.396***	0.418***	0.383***	1.466***	1.449***	1.457***
	(20.50)	(21.55)	(20.24)	(22.13)	(21.91)	(22.06)
ΔSize	-2.737***	-2.489***	-2.627***	6.522***	6.611***	6.480***
	(-12.75)	(-11.51)	(-12.47)	(8.01)	(8.14)	(7.99)
ΔProfitability	0.000	0.000	0.000	-0.001	-0.001	-0.001
	(1.26)	(1.25)	(1.30)	(-1.34)	(-1.42)	(-1.35)
ΔCash Ratio	0.001	0.001*	0.001*	0.007**	0.008**	0.007**
	(1.24)	(1.66)	(1.66)	(2.38)	(2.56)	(2.46)
ΔSwap Rate	0.031*	0.009	0.030*	-1.021***	-1.045***	-1.002***
	(1.85)	(0.56)	(1.82)	(-16.19)	(-16.67)	(-15.88)
ΔTerm Slope	-0.000	-0.002**	-0.001	-0.005***	-0.006***	-0.006***
	(-0.41)	(-2.15)	(-1.26)	(-5.80)	(-6.27)	(-6.06)
ΔVIX	0.329***	0.322***	0.322***	0.363***	0.356***	0.347***
	(28.65)	(27.84)	(28.63)	(18.78)	(18.26)	(17.74)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N	25938	25938	25938	9606	9606	9606
Adj R-Sq	0.2037	0.1962	0.2371	0.6142	0.6167	0.6177

Table VII
Continued

Panel B. Interaction with Crisis Period Dummy

Variable	1	2	3	4	5
Intercept	0.004	-0.021	-0.070***	0.004	-0.023
	(0.12)	(-0.71)	(-2.81)	(0.14)	(-0.93)
Crisis Dummy	0.034***	0.046***	0.007	0.001	-0.008
	(5.28)	(6.15)	(1.35)	(0.11)	(-1.32)
CDS Excess Demand	0.012***	0.012***	0.011***	0.012***	0.011***
	(19.93)	(20.43)	(23.00)	(23.31)	(23.60)
CDS Excess Demand	0.045***	0.024***	0.015***	0.002	0.001
x Crisis	(28.21)	(13.41)	(11.04)	(1.61)	(0.75)
Ln(Time Duration)	.	0.000	.	.	0.001***
	.	(0.39)	.	.	(2.86)
Ln(Time Duration)	.	0.018***	.	.	0.000
x Crisis	.	(16.77)	.	.	(0.38)
Ln(1+#Quotes)	.	-0.014***	.	.	-0.010***
	.	(-6.07)	.	.	(-5.69)
Ln(1+#Quotes)	.	0.053***	.	.	0.005*
x Crisis	.	(13.22)	.	.	(1.68)
ΔBAS(Difference)	.	0.003***	.	.	0.002***
	.	(18.88)	.	.	(19.10)
ΔBAS(Difference)	.	-0.002***	.	.	-0.002***
x Crisis	.	(-13.19)	.	.	(-17.88)
ΔBAS(%)	.	-0.417***	.	.	-0.361***
	.	(-14.00)	.	.	(-15.15)
ΔBAS(%)	.	0.485***	.	.	0.775***
x Crisis	.	(5.76)	.	.	(11.53)
ΔBond Turnover	.	0.239***	.	.	0.262***
	.	(4.88)	.	.	(6.71)
ΔBond Turnover	.	-0.850***	.	.	-1.058***
x Crisis	.	(-6.15)	.	.	(-9.58)
Fundemantals	.	.	.	.	.
	No	No	Yes	No	Yes
Fundemantals	.	.	.	.	.
x Crisis	No	No	Yes	No	Yes
ΔSwap Rate	.	.	.	-0.144***	0.019
	.	.	.	(-5.38)	(0.76)
ΔSwap Rate	.	.	.	-1.962***	-1.083***
x Crisis	.	.	.	(-38.45)	(-21.89)
ΔTerm Slope	.	.	.	0.000	-0.001
	.	.	.	(0.27)	(-0.91)
ΔTerm Slope	.	.	.	-0.007***	-0.005***
x Crisis	.	.	.	(-3.65)	(-2.87)
ΔVIX	.	.	.	0.466***	0.322***
	.	.	.	(25.34)	(18.43)
ΔVIX	.	.	.	0.438***	0.175***
x Crisis	.	.	.	(20.11)	(8.24)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes
N	35544	35544	35544	35544	35544
Adj R-Sq	0.1223	0.1609	0.4117	0.3578	0.4682

Table VIII
CDS Spread Changes and CDS Spread History

This table reports the regression result of CDS spread changes on last CDS spread changes, last CDS price, CDS excess demand, CDS liquidity measures, and control variables. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

Variable	(1)	(2)	(3)
Intercept	0.039*	0.075***	0.076***
	(1.73)	(3.33)	(3.40)
Last CDS Spread Changes	-0.055***	.	-0.053***
	(-12.33)	.	(-12.02)
Last CDS Price	.	-0.716***	-0.698***
	.	(-12.59)	(-12.29)
CDS Excess Demand	0.011***	0.011***	0.011***
	(26.57)	(26.29)	(26.45)
Ln(Time Duration)	0.003***	0.002***	0.002***
	(6.56)	(6.00)	(5.94)
Ln(1+#Quotes)	-0.007***	-0.006***	-0.006***
	(-4.97)	(-4.49)	(-4.65)
ΔBAS(Difference)	0.001***	0.001***	0.001***
	(11.09)	(11.42)	(11.39)
ΔBAS(%)	-0.219***	-0.218***	-0.221***
	(-11.29)	(-11.22)	(-11.38)
ΔBond Turnover	0.048	0.047	0.051
	(1.38)	(1.35)	(1.47)
ΔStock Price	-0.123***	-0.120***	-0.122***
	(-9.15)	(-8.93)	(-9.10)
ΔStock Volatility	1.020***	1.002***	1.016***
	(61.29)	(60.35)	(61.17)
ΔLeverage	0.918***	0.914***	0.912***
	(39.47)	(39.29)	(39.26)
ΔSize	0.052	0.091	0.061
	(0.20)	(0.35)	(0.23)
ΔProfitability	-0.000	-0.000	-0.000
	(-1.06)	(-1.05)	(-1.06)
ΔCash Ratio	0.003***	0.003***	0.003***
	(3.37)	(3.37)	(3.35)
ΔSwap Rate	-0.275***	-0.272***	-0.275***
	(-13.16)	(-13.07)	(-13.23)
ΔTerm Slope	-0.004***	-0.004***	-0.004***
	(-10.19)	(-10.23)	(-10.22)
ΔVIX	0.501***	0.502***	0.497***
	(54.23)	(54.37)	(53.96)
Year Fixed Effect	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes
N	35223	35223	35223
Adj R-Sq	0.4552	0.4553	0.4576

Table IX
CDS Spread Changes over Different Sampling Frequencies

This table reports the regression result of CDS spread changes on last CDS spread changes, last CDS price, CDS excess demand, CDS liquidity measures, and control variables within one day, over one day, week end and month end transactions. In the regression of over one day transactions, the CDS spread changes are the changes from the CDS trades at the end of last day. In the regression of week end and month end transactions, the CDS spread, stock price and stock volatility are the last CDS trade during the week or month, and other variables are aggregated to week or month respectively. The dependent variable is percentage change in CDS spreads between two consecutive trades. The variables are described in Table I. t-statistics are in the parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels.

	Same Day	Over Day	Week End	Month End
Variable	(1)	(2)	(3)	(4)
Intercept	0.010	0.138***	-0.006	-0.117***
	(1.48)	(3.08)	(-0.63)	(-4.07)
Last CDS Spread Changes	-0.008***	-0.074***	-0.079***	-0.102***
	(-4.59)	(-9.93)	(-8.96)	(-8.73)
Last CDS Price	-0.060***	-1.375***	-0.967***	-1.741***
	(-3.61)	(-12.26)	(-7.46)	(-6.64)
CDS Excess Demand	0.004***	0.011***	0.011***	0.011***
	(11.12)	(18.72)	(15.95)	(12.41)
Ln(Time Duration)	0.001***	0.010***	0.025***	0.067***
	(7.13)	(5.26)	(8.08)	(9.84)
Ln(1+#Quotes)	0.000	-0.012***	-0.010***	-0.023***
	(0.31)	(-4.88)	(-4.00)	(-4.70)
ΔBAS(Difference)	0.000	0.001***	0.001***	0.002***
	(0.38)	(9.20)	(10.33)	(7.92)
ΔBAS(%)	0.010	-0.240***	-0.376***	-0.522***
	(0.69)	(-8.60)	(-9.14)	(-7.72)
ΔBond Turnover	.	0.080*	0.058	0.114
	.	(1.67)	(0.96)	(1.29)
ΔStock Price	.	-0.121***	-0.141***	-0.083**
	.	(-6.59)	(-6.02)	(-2.46)
ΔStock Volatility	.	1.001***	0.989***	0.997***
	.	(43.18)	(32.94)	(24.04)
ΔLeverage	.	0.894***	0.881***	0.908***
	.	(27.80)	(21.79)	(16.00)
ΔSize	.	-0.216	-0.314	-1.573**
	.	(-0.59)	(-0.67)	(-2.32)
ΔProfitability	.	-0.000	-0.000	-0.000
	.	(-0.80)	(-0.63)	(-0.50)
ΔCash Ratio	.	0.003**	0.002	0.001
	.	(2.25)	(0.94)	(0.48)
ΔSwap Rate	.	-0.281***	-0.284***	-0.271***
	.	(-9.78)	(-7.72)	(-5.17)
ΔTerm Slope	.	-0.004***	-0.000	0.000
	.	(-7.37)	(-0.10)	(0.47)
ΔVIX	.	0.485***	0.546***	0.528***
	.	(37.78)	(33.80)	(23.23)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
N	17220	18107	12007	6609
Adj R-Sq	0.0328	0.4684	0.4268	0.4314