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Does the Introduction of One Derivative Affect Another Derivative? The Effect of Credit Default Swaps Trading on Equity Options*

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Abstract

Although the impact of derivatives trading on underlying firms' securities is extensively examined, the interactions between different types of derivatives remain underexplored. In this study, we show that options on the stocks of companies with credit default swaps (CDS) are more expensive, as indicated by lower delta-hedged option returns. This result is consistent with the view that option premiums are influenced by dealers' intermediation capacity, which is adversely impacted by CDS trading. Nevertheless, options associated with CDS exhibit improved market quality (e.g., higher liquidity, lower pricing error), suggesting cross-market information spillover from CDS to options.

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Abstract

Although the impact of derivatives trading on underlying firms' securities is extensively examined, the interactions between different types of derivatives remain underexplored. In this study, we show that options on the stocks of companies with credit default swaps (CDS) are more expensive, as indicated by lower delta-hedged option returns. This result is consistent with the view that option premiums are influenced by dealers' intermediation capacity, which is adversely impacted by CDS trading. Nevertheless, options associated with CDS exhibit improved market quality (e.g., higher liquidity, lower pricing error), suggesting cross-market information spillover from CDS to options.

Keywords: CDS, delta-hedged option return, financial intermediation capacity, option market quality, information spillover

JEL Classification: G12; G14

1. Introduction

The impact of derivatives trading on other related assets has been an important issue since the exchange trading of financial options began in 1973. Early studies have shown the impact of futures and option trading on underlying asset markets.[1] More recently, a burgeoning literature explores the impact of credit default swaps (CDS) trading on markets for various assets.[2] CDS are an important innovation that not only significantly affect investors' ability to both hedge and take exposure to credit risk, but also provide a channel through which more information about firm fundamentals and risks can be impounded into asset prices. As a result, they plausibly have important impacts on the market quality of other assets, such as corporate bonds (Das, Kalimipalli, and Nayak (2014)) and equity (Boehmer, Chava, and Tookes (2015)).

Many different types of derivatives exist in the market, even for the same underlying firm. Derivatives trading requires that dealers have access to both economic and human capital; if dealers' intermediation capacity is limited, then the different financial derivatives may interact with one another. In this paper, we provide evidence that the inception of single-name CDS trading has important impacts on both the pricing and market quality of the same underlying firms' other derivatives, i.e., exchange-traded equity options. Specifically, using CDS introduction and equity option data from 1996 to 2012, we show that options on the stocks of companies with CDS are more expensive, as indicated by lower delta-hedged option returns. On the other hand, options associated with CDS exhibit improved market quality, as indicated by better liquidity and lower pricing error.

There are three potential channels through which CDS trading can impact the markets for other derivatives, including options. First, a financial institution's aggregate exposure to a firm can be limited by its overall risk-bearing capacity. Consequently, a financial intermediary's positions in one market can affect its ability to bear risk in a different market. For example, a bank's position in CDS based on the default of a publicly traded firm might limit the size of the options positions on the firm's stock that the same bank is willing to take. CDS positions can

[1] Ni, Pearson, and Poteshman (2005) and Ni, Pearson, Poteshman, and White (2018) briefly survey this literature.
[2] CDS contracts are traded over the counter. The CDS market has grown rapidly in the last two decades with multi-trillion dollar contracts outstanding. The market reached $62 trillion in notional value in 2007 and the market size is about $10 trillion as of mid-2017. Tett (2009) documents the invention and growth of the CDS market. Augustin, Subrahmanyam, Tang, and Wang (2016) review the studies on CDS.

have important impacts on financial intermediaries' ability to bear risk in other instruments because they require considerable capital (see, e.g., Siriwardane (2018)).[3]

Second, CDS are closely related to deep out-of-the-money put options, which suggests that there is potential substitutability between investors' demands for CDS and out-of-the-money put options (e.g., Carr and Wu (2011)).[4] Because demand for puts gets passed through to calls through the put-call parity relation and because demand at one strike prices and expiration dates gets passed through to other strikes and expiration dates (e.g., Garleneau, Pedersen, and Poteshman (2009)), this channel implies that the availability of CDS will impact the prices of all options based on the same underlying firm. This channel does not require that financial intermediaries impose position limits that take account of their overall exposure to firms.

A third channel by which CDS can impact option markets is that CDS trading can change the information environment of the underlying firm. CDS trading can convey (private) information that is also relevant to other markets (e.g., Acharya and Johnson (2007, 2010)). In addition, firms may produce more valuable information after CDS trading (e.g., Batta, Qiu, and Yu (2016)). Informed traders may trade in multiple marketplaces; thus, when various derivatives markets are channeled through the same dealer, then dealers could be exposed to a lesser information disadvantage. Therefore, dealers in option markets could maintain narrower bid-ask spreads and facilitate more trading activities, which ultimately reduce pricing errors and improve informational efficiency.

We empirically test hypotheses that the inception of CDS trading on a firm affects the pricing and market quality of equity options of the same firm. Analyzing CDS introduction and the equity option data from 1996 to 2012, we first show that options with associated CDS are, on average, relatively more expensive than options without associated CDS, as indicated by lower delta-hedged option returns.[5] This finding of higher premia for options associated with CDS is prevalent for both call and put options. If the CDS and equity option markets are segmented, then there would be no such effect from the trading of CDS on option prices.

[3] Notably, Deutshe Bank in 2014 decided to exit the single-name CDS business due to the capital needs required.

[4] The idea that CDS are related to out-of-the-money put options also appears in the CBOE Reference Guide: "Deep Out-Of-the-Money Put Options: A credit derivative market alternative," March 2009. http://www.cboe.com/institutional/pdf/doom.pdf

[5] Option traders and market makers frequently use delta-hedging to reduce the total risk of option positions. The delta-hedged option position is not influenced by systematic or idiosyncratic shocks to the underlying stock return. Raw option returns or changes in implied volatility could contain risk premium from bearing equity price risk.

Prior studies have shown that CDS trading can directly affect an underlying firm's fundamentals including its default risk (e.g., Subrahmanyam, Tang, and Wang (2014)). However, delta-hedged option returns, thanks to their construction, are insensitive to movements in underlying stock prices. Moreover, the negative impact of CDS trading on delta-hedged option returns is both statistically significant and economically meaningful. We also show that our findings are robust to alternative measures of option returns (e.g., variance risk premium) and cannot be explained by various existing option return determinants.

Our findings could potentially be driven by unobservable firm heterogeneity before the introduction of CDS. The result of a placebo test suggests that our findings are indeed due to the presence of CDS, rather than by potential confounding effects before CDS were introduced. In addition, we also carefully address the concern that the CDS introduction is endogenous. Following Saretto and Tookes (2013) and Subrahmanyam, Tang, and Wang (2014), we account for the selection of firms into CDS trading. Our findings obtained by using propensity score matching and the Heckman selection model are qualitatively similar to our baseline results, which indicates that our findings are robust after we take account of the possible endogeneity. Furthermore, to determine whether any pre-existing differences can potentially explain our documented effects, we conduct a difference-in-difference analysis around the CDS introduction with a matched sample. When we do so, our results show that the main impacts only exist after CDS are introduced.

Although CDS share some similarities with deep out-of-the-money put options, there are some notable differences (e.g., maturity) so that, in practice, they may or may not be substitutes. We find increases in the premiums of both call and put options after CDS trading, which suggests that substitution may not be pervasive. Moreover, we find that the effect of CDS introduction on option prices is stronger when financial intermediaries' risk-bearing capacity is low.[6] This finding is consistent with the hypothesis that the market-making ability of market makers is constrained due to funding liquidity. Our finding is consistent with Chen, Joslin, and Ni (2017). They show that options are more expensive when intermediary constraints are tightened. When option trading firms also need to make a market for CDS, their resources for equity option can be reduced, which thereby affect option prices. This argument is further

[6] We measure aggregate financial intermediary constraints and capacity by using the leverage factor in Adrian, Etula, and Muir (2014) and the intermediary capital risk factor in He, Kelly, and Manela (2017).

supported by the natural experiment provided by the "Big Bang" in the CDS market, when the International Swaps and Derivatives Association (ISDA) increased upfront funding requirements for trading CDS in April 2009.

Consistent with the hypothesis with respect to improved information quality that CDS offers, we also find that options associated with CDS exhibit improved market quality (e.g., lower bid-ask spreads, lower pricing errors), as well as higher trading volume and open interest. This finding suggests positive cross-market information spillover from CDS markets to option markets. Investors intending to trade CDS may acquire information on the reference firm. When there is an additional information source from CDS markets, then option dealers face less adverse selection problems and can subsequently charge lower bid-ask spreads, which facilitate more trading and ultimately improve option market quality.

Prior studies have shown the effect of CDS trading on bond market quality (Das, Kalimipalli, and Nayak (2014)) and equity market quality (Boehmer, Chava, and Tookes (2015)). Although Carr and Wu (2011) identify the pricing linkage between CDS and put options, they do not consider the possibility that CDS trading itself may affect option prices. Thus, to better understand how CDS influence other related markets, our paper presents a comprehensive study of the effects of single-name CDS markets on both the pricing and market quality of equity option markets.

As we examine the linkages between different types of derivatives, our paper also contributes to the growing literature on individual equity options. First, this paper is related to the literature on the cross-sectional determinants of delta-hedged option returns (e.g., Goyal and Saretto (2009); Cao and Han (2013)).[7] We provide new evidence that options associated with CDS are more expensive (i.e., lower delta-hedged option returns). Consistent with Cao and Han (2013), our finding suggests that there are constraints on the capacity of financial intermediaries in making markets for derivatives. Second, our paper explores more fully both market quality and informational efficiency for a large sample of equity options.[8]

[7] Previous studies find that deviation between implied volatility and realized volatility (Goyal and Sarreto (2009)), idiosyncratic volatility (Cao and Han (2013)), and skewness (Bali and Murray (2013), Boyer and Vorkink (2014)) are negatively related to delta-hedged equity option returns. Moreover, Christoffersen et al. (2018) find a positive illiquidity premium in daily option returns. Cao, Han, Tong, and Zhan (2017) find that 8 out of 12 well-known stock market anomalies significantly predict future delta-hedged option returns.

[8] There is relatively little empirical work on this topic. Grundy, Lim, and Verwijmeren (2012) study option bid-ask spreads and volume for banned stocks during the 2008 short-sale ban. Christoffersen et al. (2018) and Goyenko, Ornthanalai, and Tang (2015) examine the illiquidity of equity options by using intra-day option transactions. To the best of our knowledge, our paper is the first to investigate equity option price efficiency by using the Hasbrouck (1993) method and intra-day option trading data.

Furthermore, our paper also offers insight with respect to the potential impact of intermediary constraints on asset prices (e.g., Adrian et al. (2014); Chen et al. (2017); He et al. (2017)). Oehmke and Zawadowski (2017) argue that CDS comprise a marketplace that concentrates credit trading. Thus, dealers need to allocate more capital and resources to CDS markets. We find that the "crowding-out" effect of CDS on equity option prices is more pronounced for periods when a broker-dealer's leverage is high and financial intermediation capacity is constrained. Our empirical evidence helps illustrate how financial intermediation constraints affect asset prices, particularly in equity option markets.

The rest of our paper is organized as follows. In Section 2, we discuss the background and hypotheses. In Section 3, we describe our data and sample constructions. We report our main empirical results on option pricing and further address the possible endogeneity of the presence of CDS in Section 4. In Section 5, we discuss how broker-dealers' capacity affects the impact of CDS on option pricing, and we further examine the effects of CDS on option market quality in Section 6. We conclude our paper with Section 7.

2. Background and Hypotheses

CDS trading, which began in 1994, became common around 1999. Initially, this trading occurred mostly among banks and insurance companies. Later, however, more financial institutions, such as asset management companies, participated in the market, including through capital structure arbitrage. Currently, hedge funds with a focus on derivatives often consider both CDS and options as possible trading instruments.[9]

Financial firms, which deploy substantial capital and manpower to trade derivatives and manage related risks, have recently become subject to heavier capital charges for derivatives market-making. In some cases, banks have found the derivatives business too costly and exited the market.[10] A developing literature (Adrian et al. (2014), Chen et al. (2017), He et al. (2017), and Siriwardane (2018)) provides evidence that limits on financial intermediaries' capital and on risk-bearing capacity significantly impact the prices of financial instruments.

These limits to financial intermediaries' risk-bearing capacity can be a mechanism for CDS trading to impact options trading. For example, a derivatives dealer, hedge fund, or other

[9] Examples include Citadel, Graham Capital, Cornwall Capital, Napier Park, and BlueMountain.
[10] For example, Deutsche Bank exited the market for single-name CDS in the third quarter of 2014, and the CME exited the CDS clearing business in September 2017.

financial institution may place equity options and credit derivatives trading into the same group, or a financial institution may impose risk and capital limits on its overall exposure to an underlying reference entity. In other cases, financial institutions may organize CDS and options trading in separate trading desks, but the overall risk limits and human resource budgets indirectly constraint capital and manpower allocations among equity options and credit derivatives. Derivatives trading also requires considerable human capital, whose expertise is in limited supply; in turn, the growth of derivatives trading roughly coincides with the rise of pay for finance professionals from 1990 to 2006. Philippon and Reshef (2013) find that "workers in finance earn the same education-adjusted wages as other workers until 1990, but by 2006 the premium is 50% on average." Credit derivatives professionals received some of the largest bonuses in investment banking from 2002 until the 2007/2008 crisis, and CDS trading became one of the more lucrative niche professions, which suggests that the necessary expertise is in short supply.[11] Traders' ability to shift across product areas implies that the demand for credit derivatives expertise can impact other areas, including equity options.[12]

CDS and equity options on the same underlying firms are sometimes substitutes in terms of achieving users' trading or hedging purposes. When the CDS of a firm become expensive or difficult to trade, traders may look to equity options as a substitute.[13] The reverse can also be said: traders will consider options when other instruments such as CDS are not readily available.

Our collective observations lead us to hypothesize that CDS trading may affect options markets, as derivatives dealers and other financial institutions face capacity constraints in trading derivatives, including CDS and options. These constraints are likely to be more severe when the derivatives are on the same underlying firm. The effect of CDS can propagate across the maturity and moneyness of options, even though CDS and options differ in several dimensions.

Hypothesis 1 (Capacity Constraint): Options become more expensive when underlying firms also have CDS contracts referencing their debt.

[11] https://www.nytimes.com/2014/01/19/opinion/sunday/for-the-love-of-money.html

[12] For example, a trader was hired by Deutsche Bank as a credit index trader after that individual worked as an option market maker at Bank of America Merrill Lynch for six years (https://www.bloomberg.com/news/articles/2015-07-28/deutsche-bank-said-to-hire-delaville-as-london-cds-index-trader). When Citadel started its CDS business in 2015, it hired market veterans from Citigroup and elsewhere. (https://www.ft.com/content/eb5cce62-2835-11e6-8b18-91555f2f4fde?mhq5j=e5).

[13] https://www.ft.com/content/eb5cce62-2835-11e6-8b18-91555f2f4fde?mhq5j=e5

On the other hand, derivatives dealers or other financial institutions may use CDS to hedge and offset their exposures from option positions. In such cases, CDS would attenuate rather than worsen capacity constraints, and we should see the opposite. Moreover, this capacity constraint can depend on the market environment and a dealer's capital positions. When funding liquidity is high or when dealers have abundant capital, then capacity issues are less pronounced. The 2009 CDS Big Bang provides a quasi-natural experiment to further test this hypothesis, as greater capital requirements were imposed on less standard CDS contracts after the CDS Big Bang.

Our key proxy for option expensiveness is delta-hedged option returns (see, e.g., Bakshi and Kapadia (2003a and 2003b); Goyal and Saretto (2009); Cao and Han (2013)). Under the Black-Scholes model, the option can be replicated by continuously trading the underlying stock and risk-free bond. A more negative delta-hedged option return would indicate a higher (more expensive) option price, relative to its underlying stock under the Black-Scholes model. We also examine the volatility risk premium as an alternative measure for option expensiveness.

Only institutional investors satisfying certain criteria imposed by ISDA can trade CDS. Hence, CDS market participants can be viewed as relatively sophisticated, and CDS trading may generate useful information for other markets. Acharya and Johnson (2007, 2010) show that insider trading in CDS market exists, and information about negative news flows from CDS to the equity market.[14] Further, Han, Subrahmanyam, and Zhou (2017) show that differences between long-term and short-term CDS spreads can predict future stock returns; in fact, firms may produce more valuable information after CDS trading. For example, Batta et al. (2016) find that information quality is higher after CDS trading, as analysts make more accurate forecasts. Therefore, when additional information sources from CDS markets exist, option dealers face lesser adverse selection problems, and they may better serve markets by charging lower bid-ask spreads, facilitating more option trading, and ultimately improving option price efficiency.[15]

Hypothesis 2 (Information Spillover): Option market quality is better when an underlying firm also has CDS contracts referencing its debt.

[14] Other studies have explored this issue as well. For example, Kapadia and Pu (2012) show that CDS and stock prices often move independently, which suggests that CDS have no impact on stocks and options.

[15] The liquidity and quality of trading have improved in the option market over time (see Figures 1–3 of Goyenko et al. (2015). We control for such time trends by using a time fixed effect in our analysis.

We look at two aspects of option market quality: liquidity and price efficiency. For option liquidity, we look at option bid-ask spreads, option trading volume, and open interest (see e.g., Grundy et al. (2012)).[16] The option price efficiency measure is based on Hasbrouck (1993). Prior studies have also examined the effect of CDS trading on bond market price efficiency (Das, Kalimipalli, and Nayak (2014)) and equity market price efficiency (Boehmer, Chava, and Tookes (2015)). Both studies use the Hasbrouck (1993) measure as a proxy for pricing error.

The initiation of CDS trading is not random. A growing literature is devoted to understanding the determinants of CDS trading. Oehmke and Zawadowski (2015, 2017) argue that CDS is an alternative trading venue for credit investors. Prior empirical studies have identified firm characteristics (e.g., size, credit rating) that serve as determinants of CDS trading. To establish the causal impact of CDS trading on option markets, we use standard methods to address the selection issue.

3. Data and Measures

3.1. Data and sample coverage

We collect the data from the stock, equity option, and CDS markets. The data process for the option market follows Cao and Han (2013). We obtain data on U.S. individual stock options from OptionMetrics from January 1996 to December 2012. The dataset includes daily closing bid and ask quotes, trading volume, and open interest of each option. Option implied volatility, delta, and vega are computed by OptionMetrics, based on standard market conventions. We also obtain stock returns, prices, and trading volumes from the Center for Research on Security Prices (CRSP). The common risk factors and risk-free rate are taken from Kenneth French's website. The annual accounting data are obtained from Compustat. The quarterly institutional holding data are from the Thomson Reuters (13F) database. The analyst coverage data are from I/B/E/S. The stock intra-day quotes and trades data are from Trade and Quote (TAQ) database. The option intra-day trades data are from the Options Price Reporting Authority (OPRA) database and start from 2004.

At the end of each month and for each optionable stock, we extract from the OptionMetrics Ivy DB database a pair of options (one call and one put) that are closest to being

[16] Grundy et al. (2012) also use option volume and bid-ask spread as proxies for market quality. They find a significant decrease in option volumes and a significant increase in option bid-ask spreads for banned stock during the September 2008 short-sale ban.

at-the-money and have the shortest time to expiration among those with more than one month remaining to expiration. Several filters are applied to the extracted option data. First, U.S. individual stock options are of the American type: we exclude an option if the underlying stock paid a dividend during the remaining life of the option. Thus, the call options we analyze are effectively European. Second, to avoid microstructure-related biases, we only retain options that have positive trading volume (i.e., positive bid quotes for which the bid price is strictly smaller than the ask price), and the mid-point of the bid and ask quotes is at least $1/8. Third, most of the options selected each month have the same expiration date. We drop the options whose time to expiration is longer than that of the majority of options.

The CDS data come from the GFI Group, which is a leading CDS market interdealer broker. The sample covers all intra-day quotes and trades on North American single name CDS from GFI's trading platform between January 1, 1997 and April 30, 2009. Due to the over-the-counter market structure and lack of central clearing, there is no comprehensive data source for CDS transactions. To guard against concerns that the data may not be representative, we compare the data aggregated from the firm level to market survey summary results from ISDA and OCC, who both collect data from their member dealers/banks. The ISDA survey is conducted semi-annually with dealers all over the world. The OCC report is released quarterly, containing information from American commercial banks regulated by the OCC. Overall, the trading activity recorded in our sample correlates well with the ISDA data.

Appendix Table A1 reports the year-by-year sample coverage, including the number of stocks with options, the number of CDS introductions, and the number of stocks with CDS. The average number of stocks with options in our sample ranges between 1,300 and 1,900. There are a total of 798 North American firms with CDS inceptions during the 1996-2009 sample period in our merged database. Both the firms with options and the subset of firms with CDS in our sample are quite diverse in terms of industry distribution.[17]

[Insert Table A1 about here]

In our merged dataset, there are 265,369 option-month observations for delta-hedged call returns and 247,632 observations for delta-hedged put returns, respectively. Table 1 shows that

[17] All firms with CDS in our sample already had traded options before CDS are introduced. Hence, firms with CDS are a subset of firms with options.

the average moneyness of the chosen options is one, with a small standard deviation of 0.05. The time to maturity averages 50 days, with a small standard deviation of only 2 days. These relatively short-term options are actively traded, have a relatively smaller bid-ask spread, and provide more reliable pricing information. We utilize this set of option data to study how option returns and market quality are affected by the presence of CDS.

[Insert Table 1 about here]

3.2. Delta-hedged option returns

If options can be perfectly replicated by the underlying stock (e.g., under the Black-Scholes model), then the delta-hedged option position is riskless and should earn zero return on average. Cao and Han (2013) find that the delta-hedged individual stock option return is, on average, negative, which implies that individual options are overvalued, relative to the underlying stock if the Black-Scholes model holds.[18] Therefore, a more negative delta-hedged option return would indicate a higher (more expensive) option price, relative to its underlying stock under the Black-Scholes model.

We measure the delta-hedged call option return following Cao and Han (2013). We first define the delta-hedged option gain, which is the change in the value of a self-financing portfolio that consists of a long call position, hedged by a short position in the underlying stock such that the portfolio is not sensitive to stock price movement, with the net investment earning risk-free rate. Following Bakshi and Kapadia (2003a) and Cao and Han (2013), we define the delta-hedged gain for a call option portfolio over a period $[t, t+\tau]$ as:

$$\widehat{\prod}(t, t+\tau) = C_{t+\tau} - C_t - \int_t^{t+\tau} \Delta_u \, dS_u - \int_t^{t+\tau} r_u \, (C_u - \Delta_u S_u) du, \qquad (1)$$

for which C_t is the call option price, $\Delta_t = \partial C_t / \partial S_t$ is the delta of the call option, and r is the risk-free rate. The empirical analysis uses a discretized version of the above equation. Specifically,

[18] Bakshi and Kapadia (2003a) find similar results of negative delta-hedged gains for index options, and explain these as evidence of a negative price of volatility risk under a stochastic volatility model.

consider a portfolio of a call option that is hedged discretely N times over a period $[t,, t+\tau]$, where the hedge is rebalanced at each of the dates t_n (where we define $t_0 = t, t_N = t+\tau$).

The discrete delta-hedged call option gain is:

$$\prod(t, t+\tau) = C_{t+\tau} - C_t - \sum_{n=0}^{N-1} \Delta_{C,t_n} [S(t_{n+1}) - S(t_n)] - \sum_{n=0}^{N-1} \frac{\alpha_n r_{t_n}}{365} [C(t_n) - \Delta_{C,t_n} S(t_n)], \qquad (2)$$

for which Δ_{C,t_n} is the delta of the call option on date t_n, r_{t_n} is the annualized risk-free rate on date t_n, and α_n is the number of calendar days between t_n and t_{n+1}. The definition for the delta-hedged put option gain is the same as (2), except that put option price and delta replace call option price and delta, respectively.

With a zero-net investment initial position, the delta-hedged option gain $\prod(\mathrm{t}, \mathrm{t}+\tau)$ in Eq. (2) is the excess dollar return of the delta-hedged call option. Because the option price is homogeneous of degree one in the stock price and the strike price, $\prod(\mathrm{t}, \mathrm{t}+\tau)$, is proportional to the initial stock price. To make it comparable across stocks with different market prices, we scale the dollar return $\prod(\mathrm{t}, \mathrm{t}+\tau)$ by the absolute value of the securities involved (i.e., $(\Delta_t * S_t - C_t)$ for call options and $(P_t - \Delta_t * S_t)$ for puts).[19]

In Table 1, we report the descriptive statistics of the delta-hedged option returns for the pooled data. In Panels A and B, we report the summary statistics for call and put options, respectively. Consistent with previous studies, the average delta-hedged returns through maturity are negative for both call and put options. For example, the average delta-hedged option gain of at-the-money call options is –1.172% over the next month and –0.864% if held through maturity (approximately 50 calendar days). This indicates that options are, on average, more expensive than the underlying stocks, under the Black-Scholes model. A more negative delta-hedged option return indicates a more expensive option price.

Panel C of Table 1 reports the summary statistics for stock-level variables. The underlying stocks have an average annualized volatility of 0.478, and the VOL deviation ($Ln(VOL/IV)$) is around –0.10, which shows that, on average, the implied volatility is greater

[19] We obtain similar results when we scale the delta-hedged option gains by the initial price of the underlying stocks or options.

than the realized volatility. The average natural logarithm of the Amihud (2002) illiquidity measure is around –6.6, and the average natural logarithm of the market capitalization is 7.4.

3.3. Option market quality measures

We examine two aspects of option market quality: liquidity and price efficiency. For option liquidity, we look at bid-ask spreads, option trading volume, and option open interest. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point at the daily level and averaged over the current month. Option trading volume is proxied by the total trading volume of the current month. Option open interest is the daily average open interest of the current month.

For option price efficiency, we focus on the pricing error, which captures temporary deviations from the efficient price, and which could come from the non-information-related portion of transactions costs, uninformed order imbalances, price discreteness, and/or dealer inventory effects. A high σ_s suggests a large pricing error and, hence, worse informational efficiency.

The option pricing error measure is based on Hasbrouck (1993) and calculated using the OPRA intra-day option trades data over the current month. Specifically, we decompose the log transaction price, p_t, , as the combination of an unobservable efficient price, m_t, which follows a random walk and reflects the true expected value, and a transitory pricing error, s_t which captures the temporary deviations from the true expected value, at transaction t:

$$p_t = m_t + s_t, \tag{3}$$

The pricing error is assumed to follow a zero mean covariance stationary process. Its standard deviation, σ_s, measures the deviation of the observed transaction price from the underlying efficient price, and gives an inverse measure of price efficiency. Following Hasbrouck (1993), we estimate a lower bound for σ_s using a vector autoregressive (VAR) model with five lags:

$$\mathrm{y_t} = \sum_{\mathrm{i}=1}^{5} \Theta_{\mathrm{i}} \mathrm{y}_{\mathrm{t-i}} + \varepsilon_{\mathrm{t}}, \tag{4}$$

where y_t is a 4×1 matrix containing (i) r_t, the first difference of p_t, (ii) an indicator of the trade sign, (iii) signed trading volume, and (iv) the signed square root of trading volume. Θ_i are the estimated coefficients. A trade is signed +1 if it is buyer initiated with the transaction price above the prevailing quote midpoint, and signed −1 if it is seller initiated with the price below the midpoint. Transactions with prices falling exactly on the midpoint are signed 0. Including the signed square root of trading volume captures the concave relationship between prices and the trade series. Under the identification restriction on the correlation between s_t and y_t, the estimate of σ_s is derived from the vector moving average (VMA) representation of the VAR model. To make cross-sectional comparisons, the pricing error σ_t is normalized by the standard deviation of the log transaction prices of the respective stocks. In Table 1, we report the summary statistics of the option market quality measures.

4. The Impact of CDS on the Option Premium

This section documents the empirical findings regarding the effects of the presence of CDS on corresponding option prices and delta-hedged returns. In Section 4.1, we present the baseline analysis based on univariate analysis and Fama-MacBeth (1973) regressions. In Section 4.2, we conduct the robustness checks using alternative measures of option return (expensiveness). Further, we implement a Placebo test (Section 4.3), a Heckman two-stage analysis (Section 4.4), and difference-in-difference analyses (Section 4.5) to address the issue of selection bias and possible endogeneity of CDS trading.

4.1. The impact of CDS on delta-hedged option returns: Baseline analysis

In Section 4.1, we study the cross-sectional determinants of delta-hedged option returns using univariate tests and Fama-MacBeth type regressions, and focus on how the presence of CDS affects the cross-section of delta-hedged option returns, while controlling for other option return predictors.

We first compare the average delta-hedged option returns (option expensiveness) for firms with and without CDS. Cao and Han (2013) and Cao et al. (2017) find that the magnitude of the delta-hedged option return is negatively correlated with the size of underlying stock. Hence, options of small stocks tend to be more overvalued (expensive) relative to their underlying stocks. Meanwhile, large companies are more likely to have CDS available than small companies. In order to control for the effect of size, we first divide all option observations into quintiles for each month, based on the firms' market capitalization. Within each size quintile, we examine three sub-groups: option observations in which CDS trading is never available in our sample (group A), option observations in which underlying firms have CDS trading at any point during the sample period (group B), and observations that correspond to the period only after the launch of the first CDS (group C).

In Appendix, Table A2, we show the univariate test results. It is clear that most of the options associated with CDS presence are on large firms. Within small firms, there is no significant difference in the delta-hedged option return of firms with and without CDS. Within large firms, options with a CDS presence tend to have a more negative delta-hedged option return (i.e., prices of these options are more expensive). This result is meaningful, as most firms with CDS are from the top size quintiles.

[Insert Table A2 about here]

In the second step, we conduct Fama-MacBeth (1973) regressions to examine how CDS presence affects the cross-section of delta-hedged option returns. Specifically, we estimate the following regression:

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS_{trades})_{i,t-1} + d_t^2 \cdot Ln(ME)_{i,t-1} + d_t^3 \cdot Volatility_{i,t-1} + d_t^4 \cdot (Stock\ chracteristics)_{i,t-1} + d_t^5 \cdot (Option\ demand\ pressure)_{i,t-1} + d_t^6 \cdot (Option\ transaction\ cost)_{i,t-1} + e_{it}$$

where CDS_{trades} is a dummy variable that equals 1 if the option observation is associated with CDS presence in a given month, and 0 otherwise. $Ln(ME)$ is the natural logarithm of the market capital at the previous month end. All volatility measures are annualized. $Volatility$ include total volatility (VOL) and volatility mispricing (VOL_deviation) used in Goyal and Saretto (2009). *Total volatility* (VOL) is the standard deviation of daily stock returns over the previous month. *VOL_deviation* is the log difference between VOL_{t-1} and IV_{t-1}, where IV is the implied volatility of corresponding option. Stock characteristics include $Ln(BE)$, $Ret_{(-1,0)}$, $Ret_{(-12,-2)}$ and $Ln(Illiquidity)$. $Ln(BE)$ is the natural logarithm of the book-to-market ratio. $Ret_{(-1,0)}$ is the stock return in the prior month. $Ret_{(-12,-2)}$ is the cumulative stock return from the prior 2nd through 12th month. $Illiquidity$ is the average of the daily Amihud (2002) illiquidity measure over the previous month. $Option\ demand\ pressure$ is measured as the option open interest to stock volume ratio. Option transaction cost is measured as the quoted option relative bid-ask spread, which is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the beginning of the period.

[Insert Table 2 about here]

In Table 2, we report the monthly Fama-MacBeth regression coefficients, where the option delta-hedged return (i.e., delta-hedged gain till maturity scaled by ($\Delta * S - C$) for call or by ($P - \Delta * S$) for put at the beginning of the period) is used as the dependent variable. In all the of models, we control for other factors, such as volatility related measures, stock price characteristics, and option demand pressure.

In Model 1, we present the results based on the full sample, which consists of all the call and put options in our sample. The key explanatory variable is CDS_{trades}, which is a dummy that equals 1 if the option observation is associated with CDS presence, and 0 otherwise. The coefficient estimate of CDS_{trades}in Model 1 is –0.168, with a significant *t*-statistic of –4.08. Models 2 and 3 present similar patterns, based on the call options sample and put options sample, respectively. For example, the coefficient of CDS_{trades} in Model 2 is –0.207. It indicates that the delta-hedged call option return till maturity is –0.207% lower for those call options having associated CDS, which translates to 17.6% lower in magnitude compared to an average delta-hedged call option return (i.e., –1.172% as we show in Table 1). Similarly, the results in Model 3 indicate that for put options with associated CDS, the delta-hedged return till maturity is 15.4% lower in magnitude compared to an average return of delta-hedged put.

The results cannot be explained by volatility level or volatility-related mispricing in the option markets, since we have controlled for total volatility (Cao and Han (2013)) and volatility mispricing (Goyal and Saretto (2009)). We also control for firm size, the book-to-market ratio, and past stock returns, so the results cannot be explained by stock characteristics. Furthermore, it is unlikely that the results are explained by option demand pressure and liquidity, since we have controlled for the option open interest to stock volume ratio, the option bid-ask spread, and stock illiquidity (Amihud (2002)). [20]

Therefore, the negative relationship between CDS presence and the cross-section of delta-hedged option returns are very robust and consistent for both call and put options, suggesting that the options associated with CDS are relatively more expensive than those without associated CDS.

4.2. Further robustness checks

Merton (1973) shows that the option price is homogeneous of degree one in the stock price and the strike price. Hence in the robustness check section, we first scale delta-hedged option gains by the prices of the underlying stocks as the alternative measures because they are comparable across stocks. We also use the delta-hedged gain until the current month end to construct the other measures of option expensiveness and examine the robustness of our findings.

[Insert Table 3 about here]

In Table 3, we report the coefficients from monthly Fama-MacBeth cross-sectional regressions, based on a set of alternative dependent variables. In Panels A and B, we show the estimates for call and put options, respectively. Model 1 uses the delta-hedged return till maturity, and Model 2 uses the delta-hedged return till month end as their dependent variables, respectively. In both cases, the delta-hedged gain is scaled by $(\Delta * S - C)$ for call options, or $(P - \Delta * S)$ for put options. The coefficients on CDS_{trades} are both significantly negative at the 1% level, and the magnitude is larger in Model 1 with a longer horizon, because the average time to maturity is around one and a half months.

[20] Our results are robust after further controlling for: 1) volatility risk premium: the difference between the square root of a model-free estimate of the risk-neutral expected variance implied from stock options at the end of the month and the square root of realized variance estimated from intra-daily stock returns over the previous month; 2) volatility uncertainty: the standard deviation of the percent change in daily realized (or implied) stock volatility over the previous month (Cao, Vasquez, Xiao, and Zhan (2018)); 3) jump risks: option implied skewness and kurtosis, as defined in Bakshi, Kapadia, and Madan (2003); 4) the total market value of all options in the previous month as an alternative proxy for option demand pressure; 5) additional stock characteristics predicting option returns, including cash-to-asset ratio, new issues, analyst forecast diversion, and profitability (Cao et al. (2017)); and 6) analyst coverage as the proxy for stock information uncertainty, and Easley, Hvidkjaer, and O'hara (2002) PIN measure as the proxy for information asymmetry.

In Models 3 and 4, we use the delta-hedged gain divided by the stock price till maturity and till month end as the dependent variables, respectively. Both CDS_{trades} coefficient estimates are significantly negative. The magnitudes are smaller because of the larger denominator (stock price). These empirical results suggest that our finding is robust to different ways to scale delta-hedged gains and different option return horizons.

Under the Black-Scholes model, the option can be replicated by trading the underlying stock and risk-free bond. When volatility is stochastic and volatility risk is priced, the mean of the delta-hedged option gain would be different from zero, reflecting the volatility risk premium (VRP). Hence, the negative delta-hedged equity option return is also consistent with the negative volatility risk premium explanation (see e.g., Coval and Shumway (2001), Bakshi and Kapadia (2003a and 2003b)). Therefore, the expensiveness of equity options could also be measured by the contemporaneous individual VRP.

Following Bollerslev, Tauchen, and Zhou (2009), we measure individual VRP as the difference between the square root of a model-free estimate of the risk-neutral expected variance implied from stock options at the end of the current month, and the square root of realized variance estimated from intra-daily stock returns over the current month.[21]

[Insert Table 4 about here]

In Table 4, we report the Fama-MacBeth regression coefficients using individual VRP as a dependent variable. The coefficients of CDS_{trades} are significantly negative, which implies that with CDS presence, the volatility risk premium becomes even more negative. The results are consistent with our previous findings using the scaled delta-hedged option gains: the options are relatively more expensive when the observations are associated with the presence of CDS.

4.3. Placebo test

In our baseline regressions and robustness checks sections, we have already included many control variables following the literature. However, one could still argue that our findings might be caused by unobservable ex-ante heterogeneity before the introduction of associated CDS. To further address this concern and capture the causal effect of CDS introduction, we run a

[21] Chen et al. (2017) measure the expensiveness of SPX options by using variance premium, as defined in Bekaert and Hoerova (2014).

placebo test in this subsection. Specifically, we define a new variable, Pre_CDS, which equals 1 in a given month, if the underlying stock introduced CDS within the next 36 months, and 0 otherwise. We re-run the Fama-MacBeth Regression including the new variable Pre_CDS. If the previous results are driven by ex-ante heterogeneity before the introduction of CDS, then we would expect the coefficient estimates of $Pre_CDS$to be significant.

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS_{trades})_{i,t-1} + d_t^2 \cdot (Pre\_CDS)_{i,t-1} + other\ controls + e_{it}$$

In Table 5, we report the monthly Fama-MacBeth regression coefficients for call options,[22] for which delta-hedged option return is used as the dependent variable. The coefficients of $Pre_CDS$are all insignificant across different models. The coefficients of the estimate of CDS_{trades} are always negatively significant and even become stronger (the result of Model 3 in Table 5 is comparable to that of Model 2 in Table 2). It suggests that our findings are indeed driven by the presence of CDS, rather than by potential confounding effects before the introduction of CDS.

[Insert Table 5 about here]

4.4. Controlling for the endogeneity of CDS introduction

The introduction of CDS is endogenous and not random. This may prevent us from concluding that CDS has a casual effect on option pricing. To explore this issue, we employ the Heckman two-stage selection model to examine the relation between the option price and the presence of CDS. Subrahmanyam et al. (2014) and Saretto and Tookes (2013) face similar endogeneity issues in the specification of their CDS selection models, so we follow their approach.

Specifically, we keep the data from 1996 until the CDS introduction month and all other observations for non-CDS firms, to estimate the inverse mills ratio of the introduction of CDS. We apply the Probit regression with the following settings: the dependent variable equals one

[22] To save space, we only report the results of call options for further analyses. The same pattern holds for put options, and the results are available upon request.

after the CDS trading starts, and zero otherwise. The control variables are the same as those in Subrahmanyam et al. (2014). We also control for industry effect and time effects. The results suggest that large firms, firms with high leverage, high tangibility, or high credit quality are more likely to have corresponding CDS.

[Insert Table A3 about here]

Then, we implement the first-stage model to calculate the inverse mills ratio (IMR) of the introduction of CDS for all observations, including all CDS firms and non-CDS firms (in Appendix Table 3, we report the first stage regression result). After obtaining the inverse mills ratio, we run the empirical model as below to examine the robustness of our findings after taking account of the endogeneity:

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS_{trades})_{i,t-1} + d_t^2 \cdot Inverse\ Mills\ Ratio + other\ controls + e_{it}$$

In Table 6, we report the coefficients of Fama-MacBeth regressions of delta-hedged return until maturity for call options. The coefficients of CDS_{trades} are still negatively significant at the 1% level after controlling for the selection bias (inverse mills ratio). It indicates that the relationship between the presence of CDS and the delta-hedged option return is robust even after taking account of the endogeneity. The coefficient estimates of all the other control variables are consistent with the findings in Table 2.

[Insert Table 6 about here]

4.5. Difference-in-difference (DID) tests

We further examine whether any pre-existing differences can potentially explain our documented effects. To address this concern, we conduct a difference in difference (DID) analysis around the introduction of CDS, using a matched sample to test the robustness. First of all, we match the sample by the nearest implied probabilities method at the month that CDS is introduced, and then keep both the treatment group and control group (matching sample) delta-hedged return 12 months before and after the events that accompany the introduction of CDS. Next, we run the following empirical model:

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS\ * After)_{i,t-1} + other\ constrols + e_{it}$$

where $CDS * After$is a dummy that equals 1 if the option is associated with CDS and the date is after the CDS introduction, and 0 otherwise.

[Insert Table 7 about here]

In Table 7, we report the monthly panel data regression coefficients of the delta-hedged call option return till maturity, during the event window of [–12, 12] for the matching sample. The coefficient estimates of $CDS * After$ are the DID test statistics, which are consistently negative and significant. The results of our DID analysis provide further evidence that the options are more expensive only after the introduction of associated CDS, rather than because of any pre-existing differences.

5. Does Broker-Dealer Capacity Affect How CDS Impact Option Premia?

In this section, we explore the possible explanations of CDS impacts on the exchange-traded options market, especially with respect to pricing. Since CDS and options have different characteristics and are traded in different marketplaces, CDS should have no impact on the exchange-traded options market if the financial intermediaries are unconstrained in terms of human and financial capital.

5.1. The role of broker-dealers' capacity

In reality, financial intermediaries have constraints with respect to human capital (Philippon and Reshef (2013)) and financial capital (Adrian et al. (2014)). CDS trading may crowd out the human and financial capital available for option trading. The financial intermediaries may or may not arrange the equity options and credit derivatives in the same trading group; however, they share the overall risk limits and human resources budgets, which indirectly constrain human and financial capital allocations between the equity option and credit derivatives.

Recent literature argues that constraints in financial intermediaries' capacity play a central role in asset pricing, and Adrian et al. (2014) propose the leverage of security broker-dealers as an empirical proxy for the marginal value of the capital of financial intermediaries. For example, when broker-dealer leverage is high (i.e., funding conditions are tight and the financial intermediaries are forced to deleverage), then the marginal value of capital becomes high. As a result, the impacts of the presence of CDS on option pricing can be quite different when dealers' funding conditions and capacity vary over time. Specifically, when dealers encounter higher leverage or tighter funding conditions (i.e., the dealers' capacity become more limited), we would expect that the presence of CDS has a stronger effect on option expensiveness of the same underlying stock.

We empirically investigate whether financial intermediaries or dealers' capacity affect the impact of CDS on option pricing or not. Following Adrian et al. (2014), we employ the leverage factor, which captures the seasonally adjusted changes in log leverage of security broker-dealers using quarterly Flow of Funds data.[23] We define that month t is within $High$ dealer's capacity period if the quarter's leverage factor at time *t* is below the median, and otherwise within Low dealer's capacity period. Next, we estimate the following Fama-MacBeth regression for $High$ dealer's capacity periods and Low dealer's capacity periods, respectively. Then, we compare the difference between the two coefficients on CDS_{trades}in the two Fama-MacBeth Regressions.

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS_{trades})_{i,t-1} + other\ controls + e_{it}$$

In Columns (1) and (2) of Table 8, we report the monthly Fama-MacBeth regression coefficients in the regressions explaining the call option's delta-hedged return (i.e., delta hedged gain till maturity scaled by $(\Delta * S - C)$ at the beginning of the period) for $High$ dealer's capacity

[23] The broker-dealer quarterly leverage is defined as total financial asset / (total financial asset - total financial liability) in Adrian et al. (2014). The leverage factor is seasonally adjusted log changes in the level of broker-dealer leverage. The data are obtained from Table L.129 of the Federal Reserve. http://www.federalreserve.gov/releases/z1/current/data.htm

periods and Low dealer's capacity periods, respectively. The difference between the two coefficients of CDS_{trades} is 0.207, with a *t*-statistic of 2.151 which is significant at the 5% significant level. This evidence indicates that the delta-hedged option returns are even more negative during the Low dealer's capacity period. In other words, though the options are, on average, more expensive for stocks with associated CDS in all periods, the impact also depends on a dealer's capacity. When the leverage factor becomes higher (i.e., a broker-dealer's leverage becomes greater, and a dealer's capacity is lower), equity options are much more expensive for stocks with associated CDS. This finding is consistent with our hypothesis that option dealers charge a higher option premium due to limited intermediaries' capacity. We also conduct the robustness check using the intermediary capital risk factor (He et al. (2017)) as the alternative measure of a dealer's capacity, and we find evidence (Columns (3) and (4) in Table 8) that supports the limited intermediaries capacity hypothesis.[24]

[Insert Table 8 about here]

One might further argue that the "crowding-out" channel due to dealer's capacity, if it exists, should only emerge as a short-run phenomenon, and vanish in the long run when market players fully anticipate it and adjust accordingly. To verify whether such an effect vanishes in the long run, we also empirically examine the impacts of the CDS on option returns for different subsamples. Specifically, we divide the full sample into two subgroups: within three years and after three years following the inception of CDS, respectively. The empirical results show that the impact of CDS on option returns indeed decays over time, and turns much weaker in the later subsample.[25]

5.2. A natural experiment: the "CDS Big Bang"

On April 8th 2009, ISDA increased the upfront funding requirement for trading CDS, and several trading convention changes were implemented, in what is commonly called the "CDS Big Bang." The changes resulted in a significant increase in the initial funding requirements of trading single-name CDS contracts after the "CDS Big Bang".

[24] We also obtain consistent results when using index option implied funding illiquidity (Golez, Jackwerth, and Slavutskaya (2018)) as the alternative measure of a dealer's capacity.
[25] The results are consistent when implementing 5 years as the alternative threshold. The table is available upon request.

Wang, Wu, Yan and Zhong (2017) suggest that the average size of the upfront fee is quite significant, as it averages 4.07% of the CDS contract notional amount and the aggregate upfront fee for new trades is about 3.87 billion dollars per month. The sudden increase in the upfront fee is a funding shock and expected to have significant effects on the market; therefore, we expect that the "CDS Big Bang" offers a chance to test the impact of funding shocks in the market as a quasi-experiment.

[Insert Table 9 about here]

In Table 9, we present the empirical results of option-month panel regressions for call options, based on the "CDS Big Bang" in the CDS market as a natural experiment (see e.g., Wang et al. (2017)). We examine whether the "CDS Big Bang" in the CDS market has an influence on the CDS's impact on option pricing. The coefficients on the interaction term (the Big Bang dummy* CDS_{trades}) are all negatively significant, which confirms our findings in Table 8 and supports the limited intermediary capacity hypothesis.

To summarize, this section provides empirical evidence that the impact of CDS on option pricing is stronger when the broker-dealer leverage (capacity) is higher (lower). This finding is consistent with the hypothesis that the market-making ability of market makers is constrained. When the market makers need to make a market for CDS products, their resources for equity options can be reduced, hence affecting option prices and returns of similar underlying stocks.

6. The Impact of CDS on Option Market Quality

In this section, we investigate whether option market quality improves when the same underlying firms also have CDS contracts referencing their debt. In Section 6.1, we present the results of option bid-ask spreads. In Section 6.2, we report the results using option trading volume and open interests. Further, in Section 6.3, we look at option price efficiency (pricing error).

6.1. The impact of CDS on option bid-ask spread

In this subsection, we examine the impact of CDS trading on the daily average option relative bid-ask spread of the current month. The relative bid-ask spread is defined as the quoted bid-ask spread divided by the mid-point of the bid and ask prices. We follow Grundy et al.

(2012), performing the following empirical models to test the impact of CDS trading on the relative bid-ask spread:

$$
\begin{aligned}
&Daily\ Average\ Option\ Bid\ Ask\ Spread_{it} \\
&\quad = \beta_0 + \beta_1 \cdot (CDS_{trades})_{i,t-1} + \beta_2 \cdot Moneyness_{i,t-1} + \beta_3 \\
&\quad \cdot \left(\frac{1}{Days\ to\ Maturity}\right)_{i,t-1} + \beta_4 \cdot Ln(Stock\ Volume)_{i,t-1} + \beta_5 \cdot Size_{i,t-1} + \beta_6 \\
&\quad \cdot Ln(BM)_{i,t-1} + \beta_7 \cdot Ln(Price)_{i,t-1} + \beta_8 \cdot Ret_{(-1,0),i,t-1} + \beta_9 \cdot VOL_{i,t-1} \\
&\quad + \beta_{10} Institutional\ Ownership_{i,q-1} + \beta_{11} Op_{skew,it} + \beta_{12} Market\ Return_t \\
&\quad + \beta_{13} Stock\ Return_{it} + Firm\ Effect + Time\ Effect + Industry\ Effect \\
&\quad + \epsilon_{it}
\end{aligned}
$$

where CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. $Moneyness$ and $days\ to\ maturity$ are measured at the end of each month. $Days\ to\ maturity$ is the total number of calendar days till the option expiration. $Ln(ME)$ is the natural logarithm of the market capital at the last month end. $Ln(BE)$ is the natural logarithm of the book-to-market ratio. $Ln(Price)$ is the natural logarithm of the stock price at the last month end. $Ret_{(-1,0)}$ is the stock return in the prior month. *Total volatility* (VOL) is the standard deviation of daily stock returns over the previous month. Op_{skew} is the empirical skewness of daily option raw return of current month. $Market\ Return$ is current month return of S&P 500 index. $Institutional\ Ownership$ is defined as institutional holdings divided by the total number of shares outstanding in the previous quarter. $Stock\ Return$ is the current month stock return. Finally, we control the time, firm, and industry fixed effects.

[Insert Table 10 about here]

In Table 10, we report the coefficients of the option-month panel regression on the daily average relative bid-ask spread of call options. The coefficients of CDS_{trades} are always significantly negative, suggesting that the information asymmetry faced by option market makers is mitigated by the introduction of CDS. Hence, market makers tend to charge a smaller big-ask spread. Given that the average magnitude of the relative bid-ask spread is 21.5% and the coefficient of CDS_{trades} is -0.018 in Model 4, the relative bid-ask spread decreases by 8.4% after various controls.

6.2. The impact of CDS on option trading volume and open interest

The introduction of CDS may also increase option trading volume and open interest, if there is information spillover from the CDS market. In this subsection, we further examine option liquidity using four different measures: $Ln(Option\,Volume)$, $Ln\left(\frac{Option\,Volume}{Stock\,Volume}\right)$, $Ln\left(\frac{open\,interest}{stock\,total\,shares}\right)$, and $Ln\left(\frac{open\,interest}{stock\,volume}\right)$. The following empirical model is performed in studying the relationship between CDS presence and option liquidity:

$$\begin{aligned} Ln(Option\,Volume)_{it} &= \beta_0 + \beta_1 \cdot (CDS_{trades})_{i,t-1} + \beta_2 \cdot Ln(ME)_{it} + \beta_3 \\ &\cdot Option\,Bid\,Ask\,Spread_{i,t-1} + \beta_4 \cdot Implied\,Volatility_{i,t-1} + \beta_5 \cdot Delta_{i,t-1} \\ &+ \beta_6 \cdot Analyst\,Coverage_{i,t-1} + \beta_7 \cdot Analyst\,Dispersion_{i,t-1} + \beta_8 \\ &\cdot Institutional\,Ownership_{i,t-1} + Firm\,Effect + Time\,Effect \\ &+ Industry\,Effect + \epsilon_{it} \end{aligned}$$

where CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. $Ln(ME)$ is the natural logarithm of the market capital at the last month end. $Option\ bid - ask\ spread$ is the ratio of the bid-ask spread of option quotes over the mid-point of the bid and ask quotes at the end of the last month. $Implied\,Volatility$ is the implied volatility of the option at the last month end. $Delta$ is the delta of the option at the last month end. $Analyst\,Coverage$ is the number of analysts covering the underlying stock of the last month. $Analyst\,Dispersion$ is the analyst dispersion scaled by the mean estimate of the last month. $Institutional\,Ownership$ is defined as institutional holdings divided by the total number of shares outstanding in the previous quarter. Finally we include time, firm, and industry fixed effects.

[Insert Table 11 about here]

In Table 11, we report the panel data regression results using different option liquidity measures for call options. The coefficients of CDS_{trades} are all positive and significant at the 1% level. The results demonstrate that the option liquidity improves after the introduction of CDS. Specifically, in Model 2, our results suggest that after CDS introduction, the option volumes increases by 20.5% relative to the stock volume, and in Model 4, our results suggest that after CDS introductioni, the option open interest increases by 13.3% relative to stock volume. Using different liquidity measures provide robust and consistent empirical evidence that CDS trading has a positive effect on option liquidity. We also find the same results in the put options data sample.

6.3. The impacts of CDS on option pricing error

We further implement the Hasbrouck (1993) measure to investigate the impact of CDS on option market quality. It helps identify the option pricing error using the option intra-day trades and quotes data. The pricing error, σ_s, which captures temporary deviations from the efficient price, could come from the non-information-related portion of transactions costs, uninformed order imbalances, price discreteness, and dealer inventory effects. A high σ_s suggests a large pricing error and, hence, worse informational efficiency.

The following empirical model is performed in studying the relationship between CDS trading and the option market quality measure:

$$\begin{aligned} Hasbrouck\ (1993) \\ &= \beta_0 + \beta_1 \cdot (CDS_{trades})_{i,t-1} + Other\ Controls + Firm\ Effect \\ &+ Time\ Effect + Industry\ Effect + \epsilon_{it} \end{aligned}$$

for which CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Other control variables are the same as those in Table 11, and we include time, firm, and industry fixed effects.

[Insert Table 12 about here]

In Table 12, we report the panel data regression results when using the option Hasbrouck (1993) measures as the dependent variables. The coefficient of CDS_{trades} is −1.347 in Model 2 and significant at the 1% level. The results suggest that option price becomes more efficient after the CDS of the same underlying firm is traded in the market, because the Hasbrouck (1993) measure is smaller for options with associated CDS. The empirical evidence in Table 12 shows that the CDS trading actually improves the option market informational efficiency.

7. Conclusion

This paper provides a comprehensive examination of the effect of single-name credit default swaps (CDS) on the equity option market. We first document that options associated with CDS are more expensive, as indicated by lower delta-hedged option returns. This finding is statistically significant and economically meaningful. If the CDS and equity option markets are segmented, there should be no effect from the trading of CDS on option prices. We have also shown that our findings are prevalent for both call and put, not driven by underlying firm fundamentals, and are robust to various controls, such as existing option return predictors and sample selection bias, among others.

This result is consistent with the view that option premiums are influenced by dealers' intermediation capacity, which is adversely impacted by CDS trading. We find consistent evidence that when a broker-dealer's leverage is high, options with associated CDS are even more expensive. Our paper suggests that it is important to consider the constraints and capacity of financial intermediaries and their impact on option prices. In our case, the introduction of a new derivative security, CDS, makes the existing derivative (equity option) more expensive.

In line with the hypothesis of improved information quality brought by CDS, we also find that options associated with CDS exhibit improved market quality, suggesting cross-market information spillover from CDS to options. Informed traders may trade in multiple marketplaces. When various derivatives markets are channeled through the same dealer, then the dealer could be exposed to less information disadvantage. Therefore, these dealers in option markets could keep narrower bid-ask spreads, facilitate more trading activities, and ultimately reduce pricing errors and improve informational efficiency.

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Appendix: Variable Definitions

Option Variables	
Delta-hedged option return	Delta-hedged gain, as in Bakshi and Kapadia (2003a), defined as the change (over the next month or till option maturity) in the value of a portfolio consisting of one contract of long option position and a proper amount of the underlying stock, re-hedged daily so that the portfolio is not sensitive to stock price movement. As in Cao and Han (2013), the call option delta-hedged gain is scaled by ($\Delta \cdot S - C$), for which Δ is the Black-Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged gain is scaled by ($P - \Delta \cdot S$), for which P is the price of put option. The options are assumed to be bought or sold at the midpoint of the bid and ask price quotes.
Implied volatility	The Black-Scholes option implied volatility at the end of the last month.
Delta	The Black-Scholes option delta at the end of the last month.
Moneyness	The ratio of stock price over option strike price at the end of the last month.
Days to maturity	The total number of calendar days till the option expiration at the end of the last month.
Option bid-ask spread	The ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month (as a control variable). The ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the daily level and averaged over the current month (as a measure of option market quality).
Option open interest	The open interest at the end of the last month (as a control variable). The daily average open interest of the current month (as a measure of option market quality).
Option volume	The total option trading volume during the previous month (as a control variable). The total option trading volume of the current month (as a measure of option market quality).
Option Hasbrouck measure	The option pricing error measure based on Hasbrouck (1993) and calculated using the OPRA intra-day option trades data over the current month.
Op_skew	The empirical skewness of daily option raw return within a month.
CDS Variables	
CDS_{trades}	A dummy that equals 1 if the option observation is associated CDS, and 0 otherwise.
Pre-CDS	A dummy that equals to 1 if the CDS is introduced within next 36 months, and 0 otherwise.
CDS*After	A dummy that equals 1 if the option is associated CDS and within the 12 months after CDS introduction, and 0 otherwise.

Stock Variables	
Ln(ME)	The natural logarithm of the market capital at the end of the last month.
VOL	Annualized standard deviation of daily stock returns over the previous month.
VOL_deviation	Volatility mispricing, as in Goyal and Saretto (2009), calculated as the log difference between realized volatility and Black-Scholes implied volatility for at-the-money options at the end of the last month.
Ln(BM)	The natural logarithm of book equity for the fiscal year-end in a calendar year divided by market equity at the end of December of that year, as in Fama and French (1992).
$RET_{(-1,0)}$	The stock return in the prior month
$RET_{(-12,-2)}$	The cumulative stock return from the prior 2^{nd} through 12^{th} months.
Illiquidity	The average of the daily Amihud (2002) illiquidity measure over the previous month.
Volatility risk premium	The difference between the square root of a model-free estimate of the risk-neutral expected variance implied from stock options at the end of the given month, and the square root of realized variance estimated from intra-daily stock returns over the entire month.
Stock volume	Total stock trading volume over the previous month.
Analyst coverage	The number of the analysts covering the underlying stock at the last month.
Analyst dispersion	The standard deviation of annual earnings-per-share forecasts scaled by the absolute value of the average outstanding forecast at the last month.
Institutional ownership	The percentage of common stocks owned by institutions in the previous quarter.
Broker-Dealer's Capacity Measures	
AME	The security broker-dealers quarter's leverage factor (Adrian et al. (2014))
HKM	The intermediary capital risk factor (He et al. (2017))

Table 1: Summary Statistics

This table reports the descriptive statistics of delta-hedged option returns and stock characteristics. The sample period is 1996-2012. At the end of each month, we extract from the Ivy DB database of Optionmetrics one call and one put on each optionable stock. The selected options are approximately at-the-money with a common maturity of about one and a half months. We exclude the following option observations: (1) moneyness is lower than 0.8 or higher than 1.2; (2) option price violates obvious no-arbitrage option bounds; (3) reported option trading volume is zero; (4) option bid quote is zero or mid-point of bid and ask quotes is less than $1/8; (5) the underlying stock paid a dividend during the remaining life of the option. Delta-hedged gain is the change in the value of a portfolio consisting of one contract of long option position and a proper amount of the underlying stock, re-hedged daily so that the portfolio is not sensitive to stock price movement. The call option delta-hedged gain is scaled by ($\Delta \cdot S-C$), for which Δ is the Black-Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged gain is scaled by ($P-\Delta \cdot S$), for which P is the price of call option. The pooled data has 265,369 observations for delta-hedged call returns and 247,632 observations for delta-hedged put returns. Days to maturity is the total number of calendar days until the option expiration. Moneyness is the ratio of stock price over option strike price. Moneyness and days to maturity are measured at the end of the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. Option open interest is the total number of option contracts that are open at the beginning of the period. Stock volume is the stock trading volume over the previous month. Option Hasbrouck (1993) measure is the option price efficiency measure calculated using the Options Price Reporting Authority (OPRA) intra-day option trades data over the current month. The OPRA data starts from January 2004. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOL_{t-1} and IV_{t-1}. All volatility measures are annualized. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Ln(ME) is the natural logarithm of the market capital at the last month's end. Ln(BM) is the natural logarithm of the book-to-market ratio.

Table 1—*Continued*

Panel A: Call Options		All (265,369 obs)				
		Mean	StDev	Q1	Median	Q3
Delta-hedged gain till maturity / (Δ·S – C)	(%)	-1.172	7.778	-3.905	-1.315	0.932
Delta-hedged gain till month-end / (Δ·S – C)	(%)	-0.876	4.969	-2.809	-0.967	0.757
Days to maturity		50	2	50	50	51
Moneyness = S/K	(%)	100.532	4.930	97.543	100.171	103.130
Option bid-ask spread		0.215	0.181	0.094	0.158	0.275
(Option open interest / stock volume) ×1000		0.031	0.111	0.001	0.005	0.024
		OPRA Data from January 2004 (62,616 obs)				
Option Hasbrouck (1993) measure		7.070	5.248	3.336	5.682	9.291

Panel B: Put Options		All (247,632obs)				
		Mean	StDev	Q1	Median	Q3
Delta-hedged gain till maturity / (P - Δ·S)	(%)	-0.864	7.187	-3.461	-1.219	0.993
Delta-hedged gain till month-end / (P - Δ·S)	(%)	-0.484	4.466	-2.433	-0.805	0.871
Days to maturity		50	2	50	50	51
Moneyness = S/K	(%)	99.822	4.703	97.083	99.775	102.467
Option bid-ask spread		0.212	0.177	0.094	0.157	0.271
(Option open interest / stock volume) ×1000		0.020	0.095	0.000	0.003	0.013
		OPRA Data from January 2004 (47,527 obs)				
Option Hasbrouck (1993) measure		6.829	5.174	3.175	5.465	8.965

Panel C: Stock Level Variables					
	Mean	StDev	Q1	Median	Q3
Total volatility: VOL	0.478	0.317	0.270	0.398	0.593
VOL deviation: Ln (VOL / IV)	-0.103	0.321	-0.306	-0.106	0.098
Ln (Illiquidity)	-6.611	1.844	-7.879	-6.595	-5.329
Ln (ME)	7.425	1.525	6.337	7.287	8.380
Ln (BM)	-0.910	1.053	-1.490	-0.913	-0.378

Table 2: Delta-Hedged Option Returns and CDS Presence

This table reports the monthly Fama-MacBeth regression coefficients of all the option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) for call or scaled by (P - Δ·S) for put, at the beginning of the period. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1,\ 0)}$ is the stock return in the prior month. $Ret_{(-12,\ -2)}$ is the cumulative stock return from the prior 2^{nd} through 12^{th} months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. The results of all the call and put options are reported in Model 1, the results of call option only are reported in Model 2, and the results of put option only are reported in Model 3. The sample period is from January 1996 to December 2012. Robust Newey-West (1987) t-statistics are reported in brackets.

	Model 1	Model 2	Model 3
CDS_{trades}	-0.168***	-0.207***	-0.133***
	(-4.08)	(-4.01)	(-2.96)
Ln(ME)	-0.515***	-0.528***	-0.489***
	(-13.36)	(-12.52)	(-12.22)
VOL	-7.914***	-9.275***	-6.599***
	(-39.72)	(-39.24)	(-29.98)
VOL_deviation	5.825***	6.604***	5.062***
	(35.99)	(34.36)	(33.98)
Ln(BM)	-0.129***	-0.114***	-0.154***
	(-4.29)	(-3.38)	(-5.61)
$Ret_{(-1,0)}$	-0.380*	0.0735	-0.873***
	(-1.70)	(0.28)	(-4.19)
$Ret_{(-12,-2)}$	0.297***	0.372***	0.252***
	(5.31)	(4.97)	(5.49)
Ln(Illiquidity)	-0.371***	-0.363***	-0.384***
	(-9.49)	(-9.07)	(-9.51)
(Option open interest / stock volume) ×1000	-3.294***	-3.575***	-3.076***
	(-13.15)	(-10.71)	(-7.87)
Option bid-ask spread	-1.765***	-2.613***	-0.589**
	(-12.97)	(-14.10)	(-2.57)
Intercept	4.539***	5.388***	3.420***
	(19.84)	(20.60)	(15.62)
Observations	442,793	228,787	214,006
Average adj. R^2	0.106	0.127	0.120

Table 3: Alternative Measures of Delta-Hedged Option Returns

This table reports the average coefficients from monthly Fama-MacBeth cross-sectional regressions, using alternative measures of delta-hedged option returns as the dependent variable, for both call options (Panel A) and put options (Panel B). The first model uses delta-hedged option gain till maturity defined in Equation (2) scaled by (Δ·S - C) for call, or scaled by (P - Δ·S) for put. In the second model, delta-hedged option positions are held for one month rather than till option maturity. The third model uses delta-hedged option gain till maturity defined in Equation (2) scaled by the stock price. In the fourth model, delta-hedged option positions are held for one month rather than till stock maturity. All independent variables are the same as defined in Table 3, and winsorized each month at the 1% level. The sample period is from January 1996 to December 2012. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

Panel A: Delta-Hedged Call Option Returns (%)

Dependent Variables	$\frac{\text{Gain till maturity}}{(\Delta\cdot S - C)}$	$\frac{\text{Gain till monthend}}{(\Delta\cdot S - C)}$	$\frac{\text{Gain till maturity}}{\text{Stock Price}}$	$\frac{\text{Gain till monthend}}{\text{Stock Price}}$
CDS_{trades}	-0.207***	-0.100***	-0.0819***	-0.0332**
	(-4.01)	(-3.33)	(-3.82)	(-2.31)
Ln(ME)	-0.528***	-0.361***	-0.233***	-0.175***
	(-12.52)	(-13.62)	(-14.09)	(-14.02)
VOL	-9.275***	-7.061***	-4.037***	-3.198***
	(-39.24)	(-36.26)	(-37.78)	(-36.33)
VOL_deviation	6.604***	5.197***	2.908***	2.391***
	(34.36)	(32.51)	(34.04)	(34.30)
Ln(BM)	-0.114***	-0.0798***	-0.0561***	-0.0413***
	(-3.38)	(-3.96)	(-4.31)	(-4.36)
Ret $_{(-1,0)}$	0.0735	-0.0107	-0.00337	-0.0323
	(0.28)	(-0.05)	(-0.03)	(-0.36)
Ret $_{(-12,-2)}$	0.372***	0.164***	0.177***	0.0760***
	(4.97)	(3.42)	(5.04)	(3.45)
Ln(Illiquidity)	-0.363***	-0.129***	-0.170***	-0.0646***
	(-9.07)	(-5.23)	(-10.16)	(-5.67)
(Option open interest / stock volume) ×1000	-3.575***	-2.455***	-1.380***	-1.012***
	(-10.71)	(-9.45)	(-9.08)	(-8.06)
Option bid-ask spread	-2.613***	-1.889***	-0.791***	-0.602***
	(-14.10)	(-13.45)	(-10.20)	(-10.32)
Intercept	5.388***	4.786***	2.201***	2.176***
	(20.60)	(23.74)	(19.83)	(22.68)
Observations	228,787	228,787	228,787	228,787
Average adj. R^2	0.127	0.152	0.126	0.135

Table 3—*Continued*

Panel B: Delta-Hedged Put Option Returns (%)

Dependent Variables	$\frac{\text{Gain till maturity}}{(\Delta \cdot S - C)}$	$\frac{\text{Gain till monthend}}{(\Delta \cdot S - C)}$	$\frac{\text{Gain till maturity}}{\text{Stock Price}}$	$\frac{\text{Gain till monthend}}{\text{Stock Price}}$
CDS_{trades}	-0.133***	-0.0775**	-0.0894***	-0.0553***
	(-2.96)	(-2.58)	(-3.90)	(-3.56)
Ln(ME)	-0.489***	-0.312***	-0.265***	-0.180***
	(-12.22)	(-11.43)	(-14.51)	(-12.46)
VOL	-6.599***	-5.420***	-3.459***	-2.962***
	(-29.98)	(-30.94)	(-26.58)	(-28.52)
VOL_deviation	5.062***	4.049***	2.678***	2.233***
	(33.98)	(31.94)	(29.74)	(30.18)
Ln(BM)	-0.154***	-0.107***	-0.0848***	-0.0651***
	(-5.61)	(-5.59)	(-6.50)	(-6.33)
$Ret_{(-1,0)}$	-0.873***	-0.654***	-0.373***	-0.340***
	(-4.19)	(-3.62)	(-3.16)	(-3.30)
$Ret_{(-12,-2)}$	0.252***	0.191***	0.134***	0.101***
	(5.49)	(5.02)	(4.59)	(4.61)
Ln(Illiquidity)	-0.384***	-0.155***	-0.239***	-0.105***
	(-9.51)	(-6.75)	(-12.77)	(-8.56)
(Option open interest / stock volume) ×1000	-3.076***	-2.098***	-1.354***	-0.962***
	(-7.87)	(-6.42)	(-6.54)	(-5.25)
Option bid-ask spread	-0.589**	-0.720***	0.171*	-0.155**
	(-2.57)	(-4.78)	(1.82)	(-2.15)
Intercept	3.420***	3.471***	1.471***	1.779***
	(15.62)	(19.47)	(12.97)	(17.70)
Observations	214,006	214,006	214,006	214,006
Average adj. R^2	0.120	0.132	0.127	0.121

Table 4: Individual Volatility Risk Premium and CDS Presence

This table reports the monthly Fama-MacBeth regression coefficients of individual volatility risk premium (×100). Individual VRP is the difference between the square root of a model-free estimate of the risk-neutral expected variance implied from stock options at the end of the current month, and the square root of realized variance estimated from intra-daily stock returns over the current month. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1,\ 0)}$ is the stock return in the prior month. $Ret_{(-12,\ -2)}$ is the cumulative stock return from the prior 2nd through 12th months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. The sample period is from January 1996 to December 2012. Robust Newey-West (1987) t-statistics are reported in brackets.

	Model 1	Model 2	Model 3
CDS_{trades}	-0.480**	-0.680***	-0.697***
	(-2.34)	(-3.18)	(-3.33)
Ln(ME)	-0.658***	-0.498***	-0.839***
	(-8.41)	(-6.35)	(-7.56)
Ln(BM)		0.722***	0.737***
		(9.75)	(9.93)
$Ret_{(-1,0)}$		-6.144***	-6.245***
		(-12.16)	(-12.30)
$Ret_{(-12,-2)}$		-0.273**	-0.350***
		(-2.26)	(-2.93)
Ln(Illiquidity)			-0.248***
			(-2.74)
(Option open interest / stock volume) ×1000			7.921***
			(7.69)
Option bid-ask spread			-6.629***
			(-8.84)
Intercept	11.309***	10.721***	12.301***
	(14.82)	(14.46)	(16.62)
Observations	51,282	46,717	46,717
Average adj. R^2	0.056	0.096	0.124

Table 5: Placebo Test

This table reports the monthly Fama-MacBeth regression coefficients of call option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) at the beginning of the period. Pre_CDS is a dummy that equals 1 if the CDS is introduced within the next 36 months, and 0 otherwise. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -2)}$ is the cumulative stock return from the prior 2^{nd} through 12^{th} months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Robust Newey-West (1987) t-statistics are reported in brackets.

	Model 1	Model 2	Model 3
CDS_{trades}	-0.485***	-0.348***	-0.298***
	(-5.94)	(-5.69)	(-5.10)
Pre_CDS	-0.110	-0.159	-0.119
	(-0.79)	(-1.40)	(-1.07)
Ln(ME)	0.658***	0.050**	-0.506***
	(20.80)	(2.10)	(-14.06)
VOL		-8.409***	-9.300***
		(-34.29)	(-37.75)
VOL_deviation		6.226***	6.611***
		(31.21)	(32.00)
Ln(BM)		-0.120***	-0.108***
		(-4.23)	(-3.84)
$Ret_{(-1,0)}$		-0.251	0.066
		(-0.88)	(0.24)
$Ret_{(-12,-2)}$		0.458***	0.368***
		(5.66)	(4.67)
Ln(Illiquidity)			-0.363***
			(-9.51)
(Option open interest / stock volume) ×1000			-3.549***
			(-10.10)
Option bid-ask spread			-2.595***
			(-14.03)
Intercept	-5.913***	2.306***	5.292***
	(-20.87)	(10.09)	(21.67)
Observations	265,342	228,787	228,787
Average adj. R^2	0.031	0.113	0.127

Table 6: Accounting for Endogeneity – Heckman Two-Stage Test

This table reports the monthly Fama-MacBeth regression coefficients of call option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) at the beginning of the period. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. IMR is the inverse mills ratio based on the first stage regression as in Subrahmanyam et al. (2014). Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOL_{t-1} and IV_{t-1}. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1,\ 0)}$ is the stock return in the prior month. $Ret_{(-12,\ -2)}$ is the cumulative stock return from the prior 2^{nd} through 12^{th} months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Robust Newey-West (1987) t-statistics are reported in brackets. First stage regression (Table A3) is reported in the Appendix.

	Model 1	Model 2	Model 3
CDS_{trades}	-0.654***	-0.273***	-0.193***
	(-8.84)	(-3.96)	(-2.82)
IMR	-0.246**	0.326***	0.306***
	(-2.58)	(3.84)	(3.80)
Ln(ME)	0.626***	0.135***	-0.531***
	(11.25)	(3.35)	(-9.12)
VOL		-9.223***	-10.120***
		(-30.14)	(-32.91)
VOL_deviation		6.575***	6.969***
		(23.38)	(23.98)
Ln(BM)		0.069*	0.096***
		(1.94)	(2.75)
$Ret_{(-1,0)}$		-0.421	-0.032
		(-1.24)	(-0.10)
$Ret_{(-12,-2)}$		0.408***	0.320***
		(3.82)	(3.12)
Ln(Illiquidity)			-0.443***
			(-7.24)
(Option open interest / stock volume) ×1000			-3.599***
			(-7.75)
Option bid-ask spread			-2.459***
			(-10.01)
Intercept	-4.798***	1.190**	4.544***
	(-6.92)	(2.29)	(8.89)
Observations	108,836	104,878	104,878
Average adj. R^2	0.045	0.126	0.142

Table 7: Difference-In-Difference Tests

This table reports the monthly panel data regression coefficients of call option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) during time period [-12, 12] for the matching sample. We match the sample at the month that CDS is introduced, and keep the both treatment group and control group (matching sample) delta-hedged returns 12 months before and after the CDS introduction events. CDS*After is a dummy that equals 1 if the option is associated CDS and remains so after CDS is introduced, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -2)}$ is the cumulative stock return from the prior 2^{nd} through 12^{th} months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Firm and time fixed effects are controlled. Robust t-statistics based on clustered standard errors are reported in brackets.

	Model 1	Model 2	Model 3
CDS*After	-0.340***	-0.248**	-0.247**
	(-2.99)	(-2.07)	(-1.98)
Ln(ME)	1.326***	0.207	0.183
	(4.53)	(0.59)	(0.46)
VOL		-7.904***	-7.884***
		(-8.39)	(-8.12)
VOL_deviation		3.734***	3.705***
		(8.94)	(8.70)
Ln(BM)		-0.727***	-0.723***
		(-3.14)	(-3.13)
$Ret_{(-1,0)}$		-2.561***	-2.479***
		(-4.40)	(-4.16)
$Ret_{(-12,-2)}$		0.393*	0.392*
		(1.89)	(1.89)
Ln(Illiquidity)			-0.0292
			(-0.15)
(Option open interest / stock volume) ×1000			-1.602*
			(-1.71)
Option bid-ask spread			0.356
			(0.67)
Intercept	-11.92***	0.456	0.414
	(-4.78)	(0.15)	(0.14)
Firm Fixed Effect	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	10,371	9,958	9,958
Adj. R^2	0.006	0.038	0.038

Table 8: Dealer's Capacity and the Impact of CDS Presence on Option Returns

This table reports the monthly Fama-MacBeth regression coefficients of call option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) at the beginning of the period. High (Low) dealer's capacity period is defined as the period of time when the corresponding quarter's leverage factor (Adrian, Etula, and Muir (2014), AEM hereafter) is below (above) the median of full sample period (Columns (1) and (2)), or when the intermediary capital risk factor (He, Kelly, and Manela (2017), HKM hereafter) is above (below) the median of the full sample period (Columns (3) and (4). CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -2)}$ is the cumulative stock return from the prior 2nd through 12th months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Robust Newey-West (1987) t-statistics are reported in brackets.

	(1)	(2)	(3)	(4)
	High periods of Dealer's Capacity based on AEM	**Low** periods of Dealer's Capacity based on AEM	**High** periods of Dealer's Capacity based on HKM	**Low** periods of Dealer's Capacity based on HKM
CDS_{trades}	-0.121**	-0.328***	-0.0646	-0.350***
	(-2.09)	(-4.27)	(-1.01)	(-5.30)
Ln(ME)	-0.510***	-0.554***	-0.504***	-0.552***
	(-12.13)	(-8.41)	(-12.32)	(-9.032)
VOL	-9.839***	-8.485***	-9.495***	-9.055***
	(-31.89)	(-21.54)	(-29.78)	(-23.90)
VOL_deviation	6.690***	6.485***	6.273***	6.937***
	(23.08)	(22.53)	(24.99)	(21.21)
Ln(BM)	-0.0636**	-0.185***	-0.0915***	-0.137***
	(-2.00)	(-3.54)	(-2.46)	(-3.10)
$Ret_{(-1,0)}$	0.631**	-0.707	0.883***	-0.736*
	(2.05)	(-1.47)	(2.75)	(-1.72)
$Ret_{(-12,-2)}$	0.186	0.633***	0.376***	0.368***
	(1.56)	(7.53)	(4.27)	(2.79)
Ln(Illiquidity)	-0.287***	-0.470***	-0.355***	-0.372***
	(-5.96)	(-7.80)	(-7.48)	(-6.21)
(Option open interest /	-3.478***	-3.690***	-3.068***	-4.065***
stock volume)×1000	(-7.61)	(-6.56)	(-6.27)	(-7.97)
Option bid-ask spread	-2.682***	-2.516***	-2.721***	-2.505***
	(-12.76)	(-7.51)	(-10.93)	(-9.09)
Intercept	5.661***	5.007***	5.082***	5.695***
	(21.71)	(10.93)	(16.07)	(15.31)
t-stat ($H_0: \beta_{CDS,high} > \beta_{CDS,low}$)	2.151**		3.10***	
Observations	137,552	91,235	113,592	115,195
Average adj. R^2	0.127	0.126	0.129	0.124

Table 9: The Impact of CDS Presence on Delta-Hedged Option Return - Big Bang Period

This table reports the monthly panel data regression coefficients of call option returns (%): delta-hedged gain till maturity scaled by ($\Delta \cdot S-C$) at the beginning of the period. "Big Bang" equals 1 if the month is after April 2009, and 0 otherwise. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1,0)}$ is the stock return in the prior month. $Ret_{(-12,-2)}$ is the cumulative stock return from the prior 2nd through 12th months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Firm and time fixed effects are controlled for. Robust t-statistics based on clustered standard errors are reported in brackets.

	Model 1	Model 2	Model 3
Big Bang* CDS_{trades}	-0.720***	-0.456***	-0.459***
	(-13.09)	(-8.48)	(-8.32)
CDS_{trades}	-0.738***	-0.347***	-0.285***
	(-10.51)	(-4.96)	(-3.97)
Ln(ME)	0.887***	0.0886**	0.190***
	(23.89)	(2.08)	(3.03)
VOL		-4.989***	-5.124***
		(-32.07)	(-32.23)
VOL_deviation		3.880***	3.877***
		(43.37)	(43.01)
Ln(BM)		-0.607***	-0.594***
		(-15.58)	(-15.33)
$Ret_{(-1,0)}$		-1.078***	-1.072***
		(-8.00)	(-7.86)
$Ret_{(-12,-2)}$		0.691***	0.684***
		(21.62)	(21.42)
Ln(Illiquidity)			0.0954***
			(2.81)
(Option open interest / stock volume) $\times$1000			-2.393***
			(-11.94)
Option bid-ask spread			-0.349***
			(-3.21)
Intercept	-7.644***	0.236	0.313
	(-28.16)	(0.70)	(0.88)
Firm Fixed Effect	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	265,342	228,787	228,787
Adj. R^2	0.007	0.034	0.034

Table 10: The Impact of CDS Presence on Option Bid-Ask Spreads

This table reports the monthly panel data regression coefficients of the average daily option bid-ask spreads of the current month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Moneyness and days to maturity are measured at the end of the last month. Days to maturity is the total number of calendar days until the option expiration. Ln(ME) is the natural logarithm of the market capital at the last month's end. Ln(BM) is the natural logarithm of the book-to-market ratio. Ln(Price) is the natural logarithm of the stock price at the last month's end. $Ret_{(-1,0)}$ is the stock return in the prior month. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. Institutional Ownership is defined as institutional holdings divided by the total number of shares outstanding in the previous quarter. Op_{skew} is the empirical skewness of daily option raw returns of the current month. Market Return is the current month S&P 500 index return. $Ret_{(0,1)}$ is the current month stock return. Time, firm, and industry fixed effects are controlled for. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Robust t-statistics based on clustered standard errors are reported in brackets.

Table 10—*Continued*

	Model 1	Model 2	Model 3	Model 4
CDS_{trades}	-0.081***	-0.017***	-0.031***	-0.018***
	(-108.4)	(-17.6)	(-9.989)	(-6.671)
Moneyness*100	-0.684***	-0.926***	-0.751***	-0.933***
	(-88.44)	(-101.3)	(-77.59)	(-79.11)
1/(Days to Maturity)	0.510	2.500***	0.649**	2.275***
	(1.30)	(6.01)	(2.02)	(6.05)
Ln(Stock Volume)		-0.058***		-0.041***
		(-99.01)		(-31.90)
Ln(ME)		0.026***		0.021***
		(40.65)		(9.24)
Ln(BM)*100		1.390***		0.959***
		(28.83)		(8.46)
Ln(Price)		-0.114***		-0.102***
		(-117.3)		(-38.81)
$Ret_{(-1,0)}$		0.000971		-0.000916
		(0.409)		(-0.406)
VOL		-0.012***		-0.000
		(-11.25)		(-0.11)
Institutional ownership		0.014***		0.015***
		(35.17)		(36.57)
Op_{skew}		-0.144***		-0.144***
		(-14.09)		(-15.55)
Market return		0.074***		0.077***
		(37.18)		(13.81)
$Ret_{(0,1)}$		-0.396***		-0.383***
		(-77.41)		(-57.48)
Intercept	0.905***	2.194***	0.921***	1.868***
	(81.33)	(148.7)	(45.48)	(68.55)
Firm Fixed Effect	No	No	Yes	Yes
Time Fixed Effect	No	No	Yes	Yes
Industry Fixed Effect	No	No	Yes	Yes
Observations	270,151	131,049	219,932	131,053
Adj. R^2	0.063	0.374	0.073	0.263

Table 11: The Impact of CDS Presence on Option Volume and Open Interest

This table reports the monthly panel data regression coefficients of the current month option total trading volume or daily average open interest. The dependent variables are Ln(Option Volume), Ln(Option Volume / Stock Volume), Ln(Open Interest / Stock Total Shares) and Ln(Open Interest / Stock Volume). CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. Implied Volatility is the implied volatility of the option at the last month's end. Delta is the delta of the option at the last month's end. Analyst coverage is the number of the analysts covering the underlying stock at the last month. Analyst Dispersion is the analyst dispersion scaled by the absolute mean estimate at the end of the last month. Institutional Ownership is defined as institutional holdings divided by the total number of shares outstanding in the previous quarter. Time, firm and industry fixed effects are controlled for. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Robust t-statistics based on clustered standard errors are reported in brackets.

	Model 1	Model 2	Model 3	Model 4
Dependent Variables	Ln(Option Volume)	Ln(Option Volume/ Stock Volume)	Ln(Open Interest / Stock Total Shares)	Ln(Open Interest/ Stock Volume)
CDS_{trades}	1.031***	0.205***	0.533***	0.133***
	(24.63)	(6.306)	(15.14)	(4.183)
Ln(ME)	0.619***	0.132***	-0.140***	-0.228***
	(31.49)	(9.426)	(-8.862)	(-16.11)
Option bid-ask spread	-1.235***	-1.149***	-1.299***	-0.824***
	(-31.40)	(-31.13)	(-28.76)	(-18.78)
Implied volatility	0.928***	-0.563***	-0.606***	-1.810***
	(17.90)	(-14.85)	(-13.26)	(-41.98)
Delta	-3.301***	-3.213***	-1.919***	-1.723***
	(-74.67)	(-75.71)	(-34.33)	(-30.93)
Analyst coverage	0.0176***	-0.00278	0.00380*	0.00210
	(6.63)	(-1.51)	(1.80)	(1.13)
Analyst dispersion	-1.03e-05	-4.04e-05	-6.04e-05	-4.06e-05
	(-0.09)	(-0.44)	(-0.50)	(-0.34)
Institutional ownership	0.847***	-0.521***	0.474***	-0.676***
	(11.44)	(-9.75)	(7.83)	(-12.41)
Intercept	1.930***	-8.859***	-4.264***	-0.747***
	(7.092)	(-41.43)	(-20.20)	(-4.061)
Firm Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Observations	139,794	139,794	116,568	116,568
Adj. R^2	0.165	0.067	0.031	0.043

Table 12: The Impact of CDS Presence on Option Pricing Error

This table reports the monthly panel data regression coefficients using the Hasbrouck (1993) option measure of the current month. Hasbrouck (1993) is the option pricing error measure calculated using the Options Price Reporting Authority (OPRA) data over the current month. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Moneyness and days to maturity are measured at the end of the last month. Days to maturity is the total number of calendar days until the option expiration. Ln(ME) is the natural logarithm of the market capital at the last month's end. Ln(BM) is the natural logarithm of the book-to-market ratio. Ln(Price) is the natural logarithm of the stock price at the last month's end. $Ret_{(-1,0)}$ is the stock return in the prior month. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. Institutional Ownership is defined as institutional holdings divided by the total number of shares outstanding in the previous quarter. Op_{skew} is the empirical skewness of the daily option raw return of the current month. Market Return is the current month's S&P 500 index return. $Ret_{(0,1)}$ is the current month's stock return. Time, firm and industry fixed effects are controlled for. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 2004 to December 2012. Robust t-statistics based on clustered standard errors are reported in brackets.

Table 12—*Continued*

Dependent Variables	Model 1	Model 2
$\mathbf{CDS_{trades}}$	-1.337***	-1.347***
	(-4.99)	(-4.80)
Moneyness*100	-0.169	1.030
	(-0.27)	(1.21)
1/(Days to Maturity)	56.86**	101.9***
	(2.16)	(2.79)
Ln(Stock Volume)		-1.416***
		(-15.82)
Ln(ME)		0.077
		(0.45)
Ln(BM)		-0.030
		(-0.41)
Ln(Price)		-1.372***
		(-7.157)
Ret $_{(-1,0)}$		-0.121
		(-0.59)
VOL		0.422**
		(2.52)
Institutional ownership		-0.280***
		(-10.23)
Op_{skew}		0.349
		(0.50)
Market return $_{(0,1)}$		-1.799***
		(-5.03)
Ret $_{(0,1)}$		0.572*
		(1.71)
Intercept	5.933***	35.63***
	(3.28)	(14.16)
Firm Fixed Effect	Yes	Yes
Time Fixed Effect	Yes	Yes
Industry Fixed Effect	Yes	Yes
Observations	49,253	30,802
Adj. R^2	0.002	0.035

Internet Appendix for
"Does the Introduction of One Derivative Affect Another Derivative? The Effect of Credit Default Swaps Trading on Equity Options"

Jie Cao, Jin Yong, Neil D. Pearson, and Dragon Yongjun Tang

Table A1: Sample Coverage

Table A1 reports the coverage of underlying stocks with call options in our sample and the numbers of the CDS introduction for each year. We further report the percentage of the stocks with CDS within all the (Call) optionable stocks universe. The sample period is 1996-2012. At the end of each month, we extract from the Ivy DB database of OptionMetrics one call and one put on each optionable stock. The selected options are approximately at-the-money with a common maturity of about one and a half months. We exclude the following option observations: (1) moneyness is lower than 0.8 or higher than 1.2; (2) option price violates obvious no-arbitrage option bounds; (3) reported option trading volume is zero; (4) option bid quote is zero or mid-point of bid and ask quotes is less than $1/8; (5) the underlying stock paid a dividend during the remaining life of the option.

Year	# of average monthly optionable stocks	# of CDS introductions	# of stocks with CDS in total	# of stocks with CDS / # of optionable stocks
1996	1,373	0	0	0.0%
1997	1,387	32	32	2.3%
1998	1,549	58	90	5.8%
1999	1,622	48	138	8.5%
2000	1,525	97	235	15.4%
2001	1,447	143	378	26.1%
2002	1,393	183	561	40.3%
2003	1,382	79	640	46.3%
2004	1,534	61	701	45.7%
2005	1,573	49	750	47.7%
2006	1,799	24	774	43.0%
2007	1,945	12	786	40.4%
2008	1,825	10	796	43.6%
2009	1,843	2	798	43.3%
2010	1,909	n.a.	798	41.8%
2011	1,822	n.a.	798	43.8%
2012	1,752	n.a.	798	45.5%

Table A2: Delta-Hedged Option Returns and CDS Presence across Size Quintiles

This table reports the impact of CDS presence on delta-hedged option returns (%) after controlling for the size effect. The sample period is 1996-2012. At the end of each month, we extract from the Ivy DB database of Optionmetrics one call and one put on each optionable stock. The selected options are approximately at-the-money with a common maturity of about one and a half month. Delta-hedged gain is the change in the value of a portfolio consisting of one contract of long option position and a proper amount of the underlying stock, re-hedged daily so that the portfolio is not sensitive to stock price movement. The call option delta-hedged gain is scaled by ($\Delta \cdot S - C$), for which Δ is the Black-Scholes option delta, S is the underlying stock price, and C is the price of call option. The put option delta-hedged gain is scaled by ($P - \Delta \cdot S$), for which P is the price of call option. Column A includes option observations that never have the associated CDS; Column B includes option observations whose underlying firms ever had CDS during our sample period; Column C includes option observations only after the first associated CDS is launched.

	Call					Put				
	Set A	Set B	Set C	B-A	C-A	Set A	Set B	Set C	B-A	C-A
	w/o CDS	w/ CDS	w/CDS & after the first	Diff	Diff	w/o CDS	w/ CDS	w/CDS & after the first	Diff	Diff
Size Q1	-0.820	-0.584	-0.621	0.235	0.199	-0.732	-0.599	-0.728	0.133	0.004
	(-65.769)	(-6.267)	(-3.649)	(2.503)	(1.166)	(-49.085)	(-4.887)	(-3.812)	(1.073)	(0.022)
Obs	54,657	1,003	424			46,110	823	452		
Size Q2	-0.410	-0.480	-0.508	-0.070	-0.098	-0.299	-0.378	-0.405	-0.079	-0.106
	(-40.764)	(-12.987)	(-8.633)	(-1.816)	(-1.642)	(-25.453)	(-8.334)	(-5.827)	(-1.688)	(-1.509)
Obs	50,439	3,430	1,687			45,820	2,905	1,548		
Size Q3	-0.277	-0.318	-0.369	-0.041	-0.092	-0.179	-0.197	-0.243	-0.017	-0.064
	(-30.781)	(-16.517)	(-13.556)	(-1.942)	(-3.210)	(-17.388)	(-8.141)	(-7.406)	(-0.663)	(-1.848)
Obs	44,877	8,134	4,426			42,324	7,257	4,223		
Size Q4	-0.211	-0.261	-0.289	-0.051	-0.078	-0.112	-0.174	-0.206	-0.062	-0.094
	(-23.271)	(-24.795)	(-21.909)	(-3.642)	(-4.891)	(-10.805)	(-14.620)	(-14.113)	(-3.917)	(-5.251)
Obs	33,975	18,122	11,583			33,146	17,350	11,508		
Size Q5	-0.088	-0.161	-0.215	-0.073	-0.127	0.007	-0.061	-0.112	-0.068	-0.119
	(-7.794)	(-25.045)	(-30.735)	(-5.660)	(-9.579)	(0.543)	(-8.625)	(-14.536)	(-4.665)	(-7.995)
Obs	17,657	33,056	25,123			17,985	33,895	25,967		

Table A3: Probability of Credit Default Swaps Trading

This table reports the probit regression coefficients of the probabilities of CDS trading. Ln(Assets) is the quarterly logarithm of the firm's total assets. Leverage is the ratio of book debt to the sum of book debt and market equity. ROA is the quarterly firm's return on assets. $r_{it-1} - r_{mt-1}$ is the firm's excess return over the past year. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. PPENT/Total Asset is the quarterly ratio of property, plant and equipment to total assets. EBIT/Total Asset is the quarterly ratio of earnings before interest and tax to total assets. Sales/Total Asset is the quarterly ratio of total sales to the total assets. WCAP/Total Asset is the quarterly ratio of the working capital to total assets. RE/Total Asset is the quarterly ratio of retained earnings to total assets. CAPX/Total Asset is the quarterly ratio of capital expenditure to total assets. Rated is a dummy variable which equals 1 if the firm is rated and otherwise 0. The sample period is from January 1996 to December 2012. Robust z-stat is reported.

	CDS Prediction Model	z-stat
Ln(Assets)	0.291***	15.13
Leverage	0.353**	2.21
$r_{it-1} - r_{mt-1}$	0.162	0.86
ROA	-2.266***	-3.41
VOL	0.003	0.03
PPENT/Total Asset	0.362**	2.54
Sales/Total Asset	-0.070	-0.23
EBIT/Total Asset	-0.262	-0.84
WCAP/Total Asset	-0.074	-0.41
RE/Total Asset	0.209**	2.29
CAPX/Total Asset	-2.633***	-3.12
Rated	0.725***	8.11
Constant	-5.669***	-26.17
Industry Fixed Effect	Yes	
Time Fixed Effect	Yes	
Clustered standard error	Yes	
Pseudo R^2	0.201	
Observations	168,336	