Does the Introduction of One Derivative Affect Another Derivative? The Effect of Credit Default Swaps Trading on Equity Options[1]

Jie Cao
The Chinese University of Hong Kong
E-mail: jiecao@cuhk.edu.hk

Yong Jin
University of Florida
E-mail: yong.jin@warrington.ufl.edu

Neil D. Pearson
University of Illinois at Urbana Champaign
E-mail: pearson2@illinois.edu

Dragon Yongjun Tang
The University of Hong Kong
E-mail: yjtang@hku.hk

February 14, 2016

Abstract

There are numerous derivatives, often on the same underlying firms, in the financial markets. However, little is known about the interactions between different types of derivatives. In this paper, we show that the inception of credit derivatives, represented by credit default swaps (CDS), makes the equity options on the same underlying firm more expensive. The expensiveness of option due to CDS trading is not completely driven by the increased riskiness of the firm because the delta-hedged equity option returns, which account for underlying stock price movement, are lower. The effect of CDS trading is more pronounced for call options than put options. The evidence is consistent with the view that CDS trading crowds out option trading, option dealers charge higher option premiums due to limited intermediation capacity.

[1] We thank Hendrik Bessembinder, Charles Cao, Peter Carr, Sujung Choi, Bing Han, Siyang Huang, Jae Ha Lee, Tse-Chun Lin, Mahendrarajah Nimalendran, Andy Naranjo, Sheridan Titman, Cristian Tiu, Yihui Wang, Liuren Wu, Yan Xu, and seminar participants at Chinese University of Hong Kong, Morgan Stanley (New York) and University of Hong Kong for helpful discussions and useful suggestions. We have benefited from the comments of participants at the 11th Annual Conference of the Asia-Pacific Association of Derivatives (2015). The work described in this paper was fully supported by a grant from the Research Grant Council of the Hong Kong Special Administrative Region, China (Project No. CUHK 458212). All errors are our own.

Does the Introduction of One Derivative Affect Another Derivative?

The Effect of Credit Default Swaps Trading on Equity Options

Abstract

There are numerous derivatives, often on the same underlying firms, in the financial markets. However, little is known about the interactions between different types of derivatives. In this paper, we show that the inception of credit derivatives, represented by credit default swaps (CDS), makes the equity options on the same underlying firm more expensive. The expensiveness of option due to CDS trading is not completely driven by the increased riskiness of the firm because the delta-hedged equity option returns, which account for underlying stock price movement, are lower. The effect of CDS trading is more pronounced for call options than put options. The evidence is consistent with the view that CDS trading crowds out option trading, option dealers charge higher option premiums due to limited intermediation capacity.

JEL Classification: G12; G14

Keywords: CDS; Option return; Delta-hedges; Option market efficiency

1. Introduction

The derivatives market plays an important role in today's financial world. Financial intermediaries allocate substantial resources as dealers and market makers for various types of derivatives. Moreover, the derivatives market is becoming increasingly complex. Given the many options on the same underlying firm, a recent addition to the derivatives market is credit default swaps (CDS). The CDS market has grown rapidly in the last two decades and stands as a multi-trillion dollar over-the-counter business.[2]

Although CDS and options are both derivatives, they have distinct characteristics and are traded in different market segments. In this paper, we examine whether the inception of over-the-counter CDS trading has any impact on the exchange-traded option market especially with respect to option pricing.

Financial firms deploy substantial capital and manpower for the trading and risk management of derivatives. Option trading is human capital intensive, even arguably more so for credit derivatives trading. Unlike exchange-traded options where both institutional and retail demand and supply forces are present, CDS trading is almost purely institutional. CDS trading may crowd out the available human and financial capital for option trading. Philippon and Reshef (2013) examine the skill intensity, job complexity and high pay for finance employees over the past century. They 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." Notably, the period of high financial pay coincides with the growth of the credit derivatives market. Market-making for derivatives, especially credit derivatives, has become more burdensome after the recent crisis and post the Dodd-Frank Act. Many banks are subject to heavier capital charge and exit the complex derivatives market.

If derivatives are redundant securities and their prices are only determined by the underlying asset dynamics, then we do not expect any effect from CDS trading on option prices. However, it is well accepted that derivatives can often have real effects and alter the dynamics of the underlying asset value. In such case, the trading of CDS may exert material impact on option prices. For example, Subrahmanyam, Tang, and Wang (2014) show that firms' default risk increases after CDS trading. Consequently, the option value can be higher as the option price is

[2] The market reached $62 trillion in notional value in 2007 and most recent market size is about $15-20 trillion. Tett (2009) documents the invention and growth of the CDS market. Augustin, Subrahmanyam, Tang, and Wang (2014) review the studies on CDS.

positively related to the underlying risk. Moreover, there could be competition between CDS and option in terms of liquidity provision. When dealers have capacity constraints for making derivatives market, the allocation of resources to CDS trading may reduce their ability to profit from options (given the same information advantages). In such case, dealers may charge higher option premiums and cause lower delta-hedged option returns. On the other hand, option prices may also go down if now dealers use CDS to hedge their exposures in the option positions. Additionally, Kapadia and Pu (2012) show that CDS and stock prices often move independently, implying that CDS have no impact on stock and options. Ultimately, the effect of CDS trading on option prices remains an empirical question.

Traders' performance is often evaluated based on risk-adjusted return on capital. Banks may impose combined limits on derivatives positions, either at the asset class level or individual name level (or trading desk risk limit). If a bank coordinates the trading book of all trading activities, it is possible that there will be some implicit limit at the individual name level. For example, when a single-name CDS trader takes over a $500 million book, the option trader may be allocated less, especially if the CDS trading is more profitable than option trading (both for raw returns and for risk-adjusted return on capital). Also, dealers may need to manage the inventory risk for both CDS and options simultaneously. In this sense, CDS and options can compete for market making resources.[3]

Using CDS and option data from 1996 to 2012 covering 798 CDS firms, we find that option prices increase after the inception of CDS trading on the same underlying firm. This finding is statistically significant and economically meaningful. In the univariate comparison, option premium (proxied by delta-hedged option return)[4] increases (decreases) by 0.409% after CDS trading, compared to non-CDS options. If the CDS and equity option markets are segmented, then there would be no effect from the trading of CDS on option prices.

We next examine whether the effect of CDS on option pricing is through their impact on firm fundamentals. We find that, firms indeed become riskier, i.e., with higher realized volatility, after CDS trading. However, the delta-hedged option return, which is the option price adjusted by firm fundamentals and the realized volatility, is lower after CDS trading. This result is

---

[3] Napier Park, the best hedge fund in 2014 according to *Risk Magazine*, traded both CDS and options.

[4] Delta-hedging is frequently used by option traders and market makers to reduce the total risk of the 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 stock markets.

robust to various controls for firm characteristics and market conditions. Following Saretto and Tookes (2013) and Subrahmanyam, Tang, and Wang (2014), we further account for the selection of firms into CDS trading. The findings from propensity score matching and the Heckman selection model are qualitatively similar to our baseline results.

We explore several channels and mechanisms for the effect of CDS on option prices. First, informed trading may now take place in the CDS market instead of the option market. Therefore, option market makers not only need to charge higher premium, but also lower the bid-ask spread. We expect the information story to be relevant for both call and put options, probably even more so for the latter. But we find that the results concentrate on call options rather than put options. Second, CDS are more similar to put options than call options, which implies that CDS are relatively more effective substitutes for put options than call options. If the market is in net demand for insurance, then CDS can alleviate some of the demand pressure for put options (and should not negatively impact put option prices).[5] Indeed, we find that there is no effect on put option prices in an event study around CDS introductions. The result that the impact of CDS on call options is stronger suggests that the CDS firms have more upside volatility after CDS trading.

Investors intending to trade CDS may acquire information on the reference firm. Consequently, there could be more information for option pricing. If information quality is improved, then option prices should be lower. Vanden (2009) shows that information quality affects option prices. On the contrary, if option traders solely rely on information from CDS price and stop collecting information from other data sources, information quality may actually reduce. Moreover, the firm may disclose more information after CDS trading (e.g., Kim et al. (2014)). Batta, Qiu, and Yu (2014) find that information quality is higher after CDS trading as analysts make more accurate forecasts, resulting in lower option bid-ask spreads. The introduction of CDS enlarges the set of trading strategies insiders can follow. This can make it more difficult for market makers to interpret the information content of trades and reduce market efficiency. Informed traders may trade in multiple marketplaces. When the various derivatives markets are channeled through the same dealers, then the dealers are exposed to greater potential

[5] Jurek and Stafford (2015) characterize hedge fund business as writing put options. Hedge funds are also active CDS market participants. Siriwardane (2015) documents that in recent years hedge funds are CDS sellers in aggregate. Chen, Joslin, and Ni (2014) construct a measure of intermediary constraints based on put options and link it to crash insurance.

information disadvantage. Therefore, dealers may want to protect themselves by charging higher option premium (while keeping bid-ask spreads narrow).

Oehmke and Zawadowski (2014) argue that CDS can concentrate the trading for various types of securities into one marketplace. In their analysis, they compare CDS with corporate bonds. Our study makes similar arguments when comparing CDS with options. Prior studies have also examined the effect of CDS trading on bond market (Das, Kalimipalli, and Nayak (2014)) and equity market (Boehmer, Chava, and Tookes (2014)). Carr and Wu (2009) identify the linkage between CDS and put options but do not consider the possibility that CDS may affect option prices. (Our finding shows that their analysis on put options is immune to such consideration but not for call options, implying that CDS trading will affect put-call parity.)

This study adds to the option return literature through examining the linkages between different types of derivatives. Consistent with Cao and Han (2013), there seem to be constraints on the capacity of financial intermediaries in making market for derivatives. Derivatives are under scrutiny during the implementation of the Dodd Frank Act. In particular, CDS clearing is required to go through central counterparties. Central clearing may attenuate the pressure on financial intermediaries. Therefore, post Dodd-Frank, the effect of CDS on option pricing may be weaker.

The rest of the paper is organized as follows. Data and sample construction are provided in Section 2. Section 3 reports the main results on option pricing. Section 4 addresses the endogeneity concern of CDS introduction. Section 5 discusses potential explanations. Section 6 concludes.

2. Data and measures

2.1. Data

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. Implied volatility, option's 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 Thomson Reuters (13F) database. The analyst coverage data are from I/B/E/S. The daily quotes and trades data are from Trade and Quote (TAQ) database.

At the end of each month and for each optionable stock, we extract from the Ivy DB database of Option-metrics a pair of options (one call and one put) that are closest to being at-the-money and have the shortest maturity among those with more than 1 month 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. These options we analyze are effectively European type. Second, to avoid microstructure related bias, we only retain options that have positive trading volume, positive bid quotes and where the bid price is strictly smaller than the ask price, and the mid-point of bid and ask quotes is at least $1/8. Third, most of the options selected each month have the same maturity. We drop the options whose maturity is longer than that of the majority of options. The average moneyness of the selected options is 1, with a standard deviation of only 0.05. The time to maturity ranges from 47 to 52 calendar days across different months, with an average of 50 days. These short-term options are the most actively traded, have the smallest bid-ask spread and provide the most reliable pricing information.

The CDS data comes from GFI Group, which is a leading CDS market interdealer broker. The sample covers all intra-day quotes and trades on North American single names 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 data representation concerns, we compare the data aggregated from firm level to market survey summary results from ISDA and OCC who collect data from their member dealers/banks. The ISDA survey is conducted semiannually with dealers all over the world. The OCC report is released quarterly containing information from American commercial banks regulated by OCC. Overall, trading activity recorded in our sample correlates well with the ISDA data.

There are 798 North American firms with CDS inception during the 1997-2009 sample periods in our merged database. The CDS firms in our sample are quite diverse in the industry distribution. We mainly focus on the changes in the delta-hedged option returns upon the onset of CDS trading around the first day of CDS trading.

2.2. Delta-hedged option returns

If options can be perfectly replicated by the underlying stock (e.g., under the Black-Scholes model), delta-hedged option is riskless and should earn zero return on average. Cao and Han (2013) find that the delta-hedged individual stock option return is negative on average, which implies that individual option is overvalued relative to the underlying stock if Black-Scholes model holds.[6]

We measure 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 consisting of a long call position, hedged by a short position in the underlying stock so 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

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

where C_t is the call option price, $\Delta_t = \partial C_t / \partial S_t$ is the delta of the call option, r is the risk-free rate. The empirical analysis uses a discretized version of (1). Specifically, 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

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

where 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, 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 with put option price and delta replacing call option price

[6] Bakshi and Kapadia (2003a and 2003b) find similar results of negative delta-hedged gain, and explain it as evidence of a negative price of volatility risk under stochastic volatility model. Muravyev (2014) argues in paper appendix that "delta-neutral option returns are a better way to measure aggregate option risk premium than raw option returns or changes in implied volatility in a sufficiently large sample. Raw option returns contain risk premiums from both the option and stock markets."

and delta. We define delta-hedged call option return as delta-hedged option gain scaled by the absolute value of the securities involved (i.e. $\Delta * S - C$).

Merton (1973) shows that option price is homogeneous of degree one in the stock price and the strike price. Hence for a fixed moneyness, the option price scales with the price of the underlying stock. We also scale the delta-hedged option gains by the price of the underlying stocks such that they are comparable across stocks.

3. Empirical results

3.1. Summary statistics

Table 1 reports the descriptive statistics of the delta-hedged option returns for the pooled data, stock level variables and CDS information. Panel A and B reports the summary statistics for call and put options, respectively. In our merged dataset, there are 265,369 observations for delta-hedged call returns and 247,632 observations for delta-hedged put returns. And among all observations, 43,243 observations for call and 43,698 observations for put are associated with CDS presence. The average delta-hedged returns till maturity for all options are -1.172% and -0.864% for call and put option, respectively. For those options after CDS introduction, the delta-hedged average returns till maturity are -0.702% for call and -0.586% for put. The days to maturity are around 50, and the moneyness is around 1, both with a very small standard deviation. Moreover, call options have a higher option open interest to stock volume ratio than put options, as well as a higher option volume to stock volume ratio.

Panel C 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 -0.1, which shows that, on average, the implied volatility is greater than the realized volatility. The put-call ratio is less than 0.5, which implies that investors prefer to trade in call options and this finding is consistent with the option volume to stock volume ratio in Panel A and B. The average Amihud (2002) illiquidity measure is around -6.6 and the natural logarithm of the market capital is 7.4.

Appendix Table A1 reports the year by year number of new CDS firms, with a total 798 North American firms with CDS inception during the 1997-2009 sample periods in our merged database.

3.2. The impact of CDS presence on option pricing: uni-variate tests

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

Table 2 shows the univariate test results. It is clear that most of the options associated with CDS presence come from 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 CDS presence tend to have a more negative delta-hedged option return, i.e. these options are more overvalued. This result is meaningful as most firms with CDS are from top size quintiles.

3.3. Option pricing and CDS trading: cross-sectional analysis

We then conduct Fama-MacBeth type regressions on how CDS trades affect the cross-section of delta-hedged option returns. Specifically, we run 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 that equals 1 if the option observation is associated with CDS presence, and 0 otherwise. $Ln(ME)$ is the natural logarithm of the market capital at the last 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 2^{nd} through 12^{th} 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 bid-ask spread, which is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the beginning of the period.

Table 3 reports the monthly Fama-MacBeth regression coefficients where the call option delta-hedged return until maturity (i.e. delta hedged gain until maturity scaled by ($\Delta * S - C$ or $P - \Delta * S$) at the beginning of the period) is used as dependent variable. The coefficient of CDS_{trades} is -0.409 in Model 1, with a significant t-statistic of -5.743. In other words, the option delta-hedged return until maturity is -0.409% lower for those option observations that are associated with CDS presence, which translates to 34.9% lower in magnitude compared to an average call option delta-hedged portfolio (i.e.-1.172%).

Model 2-5 report the regression coefficients of CDS_{trades} after controlling for other factors including the volatility, stock price characteristics and option demand pressure. The negative relationship between CDS trades and cross-section of delta-hedged option returns are robust and consistent across the different models, suggesting that the CDS trading does make options more expensive.

Merton (1973) shows that the option price is homogeneous of degree one in the stock price and the strike price. Hence for a fixed moneyness, the option price scales with the price of the underlying stock. We also scale delta-hedged option gains by the prices of the underlying stocks so that they are comparable across stocks. We also use the delta-hedged gain till month end as another alternative measures.

Table 4 reports the coefficients from monthly Fama-MacBeth cross-sectional regressions based on a set dependent variables. Panel A shows the estimates for call options while Panel B shows that for put options. Model 1 is using the delta-hedged return (which is defined as delta-hedged gain divided by $\Delta * S - C$ or $P - \Delta * S$) until maturity, and Model 2 is using the delta-hedged return until month end as their dependent variables, respectively. The coefficients on CDS_{trades} are both significantly negative at 1% level, and the magnitude is larger for Model 1, because the average of the days to maturity is around one and half month.

Model 3 and 4 use the delta-hedged gain divided by the stock price until maturity and month end as the dependent variable, respectively. Both CDS_{trades} coefficients are significantly negative with t-statistics of around 3. The magnitudes are smaller because usually the denominator is larger for the stock price than the delta-hedged portfolio at last month end. The above mentioned empirical results suggest that our finding is robust for differently scaled delta-hedged gain and different testing time periods.

3.4. Further robustness checks

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 delta-hedged option gain would be different from zero, reflecting the volatility risk premium. Hence the negative delta-hedged option return is also consistent with the negative volatility risk premium explanation (see Coval and Shumway (2001), and Bakshi and Kapadia (2003a and 2003b)). Therefore, it is possible that we actually test the impact of CDS on volatility risk premium, rather than on the option mispricing. Table 5 reports the Fama-MacBeth regression coefficients of volatility risk premium as a depdend variable (Bollerslev, Tauchen, and Zhou (2009) and similar to Buraschi, Trojani, and Vedolin (2009), i.e. the difference between a model-free measure of risk-neutral expected volatility and the expected volatility under the physical measure computed from high frequency return data.)

The coefficients of CDS_{trades} are significantly negative, which implies that after CDS is introduced, the variance risk premium becomes even more negative. The results are consistent with our previous finding using the scaled delta-hedged option gains: the options become relatively more expensive after the introduction of CDS trading.

4. Control for Endogeneity of CDS introduction

4.1. Placebo test

In order to ensure that our findings are not driven by other factors but the introduction of CDS trading, we run a Placebo test to examine the robustness of our previous findings. We define a new variable, $Pre - CDS$, which equals to 1 if CDS is introduced in the next 36 months, and 0 otherwise. We re-run the Fama-MacBeth Regression including the new variable $Pre - CDS$:

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

Table 6 reports the monthly Fama-MacBeth regression coefficients where delta-hedged option until maturity scaled by (Δ*S-C) or (P-Δ*S) at the beginning of the period is used as the dependent variable. The coefficients of $Pre - CDS$ are all insignificant except in Model 2. This suggests that our findings are indeed not driven by other factors.

4.2. Control for endogeneity of CDS introduction

The presence of endogeneity, if any, will prevent us from concluding that CDS trading has an effect on option pricing. To use an appropriate model for selection of CDS trading on firms is an important endogeneity concern. To explore this issue, we will employ the Heckman two-stage selection model to examine the relations among option price and CDS trades. Following Subrahmanyam, Tang, and Wang (2014) and Saretto and Tookes (2013), which have similar endogeneity issues in the specification of their CDS selection models, we adjust the selectivity concern of the previous cross-section empirical results.

Following Subrahmanyam, Tang, and Wang (2014) and Saretto and Tookes (2013), we keep the data from 1996 until the first months of CDS trading firms and all the other observations for non-CDS firms to estimate the inverse mills ratio of the introduction of CDS trading. We apply the Probit regression with the following settings: the dependent variable equals to one after the CDS firms start the trading of CDS and zero otherwise. The control variables are the same as Subrahmanyam, Tang, and Wang (2014). The industry effect and time effect are also controlled. The results suggest that the large, high leverage, tangibility, and high credit quality firms are more likely to have CDS trading.

Then we use the first-stage model to calculate the inverse mills ratio (IMR) of the introduction of CDS for all observations including all the CDS firms and non-CDS firms. After obtaining the inverse mills ratio, we run the empirical model as below to test the robustness of our findings after controlling for the endogeneity:

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS_{trades})_{i,t-1} + d_t^2 \cdot Inverse\ Mills\ Ratio + d_t^3 \cdot Size_{i,t-1} + d_t^4 \cdot Volatility_{i,t-1} + d_t^5 \cdot (Stock\ price\ chracteristics)_{i,t-1} + d_t^6 \cdot (Option\ demand\ pressure)_{i,t-1} + d_t^7 \cdot (Option\ transaction\ cost)_{i,t-1} + e_{it}$$

Table 7 reports the coefficients of the Fama-MacBeth Regression of option delta-hedged return until maturity. The coefficients of $(CDS_{trades})_{it}$ are still negative significant at 1% level after controlling for the selection bias (inverse mills ratio), with a very high t-statistic in absolute value, which suggests that the relationship between CDS trading and option delta-hedged return is very robust after controlling for endogeneity. All the other coefficients of other control variables are consistent with the findings in Table 3.

4.3. Difference-in-difference (DID) test

There is a concern that the event study results in subsection 3.3 could be due to the evolution of market trend. To address this concern, we further conduct a difference in difference (DID) analysis around the CDS introduction 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 the both treatment group and control group (matching sample) delta-hedged return 12 months before and after the CDS introduction event. Next we run the following empirical model:

$$\left(\frac{Delta - hedged\ gain\ till\ matuirty}{\Delta * S - C}\right)_{it} = d_t^0 + d_t^1 \cdot (CDS\ * After)_{i,t-1} + d_t^2 \cdot Size_{i,t-1} + d_t^3 \cdot Volatility_{i,t-1} + d_t^4 \cdot (Stock\ price\ chracteristics)_{i,t-1} + d_t^5 \cdot (Option\ demand\ pressure)_{i,t-1} + d_t^6 \cdot (Option\ transaction\ cost)_{i,t-1} + Firm\ Effect + Time\ Effect + Industry\ Effect + e_{it}$$

where $CDS * After$ is a dummy that equals 1 if the option is associated CDS and it is after CDS is introduced, otherwise 0. Table 8 reports the monthly panel data regression coefficients of option delta-hedged gain until maturity scaled by (Δ*S-C) or (P-Δ*S) during time period [-12, 12] for the matching sample. The coefficients of $CDS * After$ are the DID test statistics, which are consistently negative and significant. The findings in DID analysis provides further evidence that the CDS trading makes option more expensive.

5. Potential Explanations

5.1. Does broker-dealer's leverage affect the CDS impacts on option pricing?

We further investigate that whether broker-dealers' leverage will affect the CDS's impacts on option price or not. Adrian, Etula, and Muir (2014) define the leverage factor, which captures the seasonally adjusted changes in log leverage of security broker-dealers using quarterly Flow of Funds data. We define that month i is within $High_i$ period when the quarter's leverage factor is above the median at time i, and otherwise within Low period. Next we test the following regression for $High$ periods and Low periods respectively:

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

where CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. $Ln(ME)$ is the natural logarithm of the market capital at the last 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 2^{nd} through 12^{th} 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 bid ask spread, the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the beginning of the period. Then we compare the difference between the two coefficients of CDS_{trades} in the two Fama MacBeth Regressions, with a t-test statistic.

Table 9 reports the monthly Fama-MacBeth regression coefficients of the call option delta-hedged return until maturity (i.e. delta hedged gain until maturity scaled by $(\Delta * S - C)$ or $(P - \Delta * S)$ at the beginning of the period) for $High$ periods and Low periods respectively. The third column reports the difference between the two coefficients of CDS_{trades} is -0.207, with a t-statistic -2.151 at 5% significant level. The empirical evidence suggests that the delta-hedged option returns are even lower during the $High$ period. In other word, though in all periods, the options become more expensive after the inception of CDS, the effects are not the same for different broker-dealer's leverages. When the leverage factor becomes higher (lower), which is, the broker-dealer's leverage becomes greater (smaller) in the quarter, the options become more expensive (cheaper). This finding is consistent with our hypothesis that option dealers charge higher option premiums due to limited intermediation capacity.

5.2. Call vs Put

We further investigate that whether the CDS's impacts on option price are the different for Call and Put options. Figure 1 demonstrates the time series of the average monthly delta-hedged option returns till maturity before and after the CDS introduction for call and put options, respectively. The time series is adjusted for the time trend. From these two plots, we find that on average the monthly delta hedged returns are negative for both call and put. The trend for call option is way stronger before and after the CDS inception than the put option, which suggests the CDS impacts' on options are different for call and put options; particularly, the impacts are stronger for call options. The findings are consistent with the story that the substitution between put options and CDS might dilute the demand for put options to protect the downside.

Figure 2 plots the time-series of the monthly put-call ratio for 18-month before and 18-month after the month of CDS introduction (t=0). Put-call ratio is the number of put contracts divided by the sum of the put and call contracts in Pan and Poteshman (2006) at the end of each month. The time series is adjusted for the time trend and re-based on time 0 level. The put-call ratio decreases therefore the volume for call options increases more than the volume for put options, which supports the substitution effect between put option and CDS.

5.3. Impact of CDS on option liquidity

5.3.1 Impact of CDS on option bid-ask spread

In this subsection, we would like to test the impact of CDS trading on the daily average option relative bid ask spread of the current month, which is a measure of information asymmetry. 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, Lim, and Verwijmeren (2012) and Lin and Lu (2014), 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. $Log(Price)$ 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 S&P 500 return. $Institutional\ Ownership$ 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. And the time, firm and industry fixed effect are controlled.

Table 10 reports the coefficients of the panel data regression of the option relative bid ask spread at the beginning of the period. The coefficients of CDS_{trades} are significantly negative (t-statistic=-20.54 in Model 1), which provides empirical evidence that the information asymmetry is mitigated after the CDS is introduced. Given the average magnitude of the relative bid ask spread is 21.5%, the relative bid ask spread decreases by 11.6%.

5.3.2. Impact of CDS on option volume

The introduction of CDS trading may affect the option liquidity and demand pressure. In this subsection, we further examine the option liquidity using four different volume measures: $Ln(Option\ Volume)$, $Ln(\frac{Option\ Volume}{Stock\ Volume})$, $Ln(\frac{open\ interest}{stock\ total\ shares})$ and $Ln(\frac{open\ interest}{stock\ volume})$. The following empirical model is performed in studying the relationship between CDS trading and the 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, otherwise 0. $Ln(ME)$ is the natural logarithm of the market capital at the last month end. $Option\ bid - ask\ spread$ is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the beginning of the period. $Implied\ Volatility$ is the implied volatility of the option. $Delta$ is the delta of the option at the last month end. $Analyst\ Coverage$ is the number of the analysts covering the underlying stock. $Analyst\ Dispersion$ is the analyst dispersion scaled by the mean estimate last month. $Institutional\ Ownership$ is defined as institutional holdings divided by the total number of shares outstanding. And further time, firm and industry fixed effect are controlled.

Table 11 reports the panel data regression results when using different option liquidity measures for call options. The coefficients of CDS_{trades} are all positively significant, at 1% level. The results demonstrate that the option liquidity improves after CDS is introduced. Specifically, Model 2 suggests that after CDS is introduced, the option volumes increases by 22.8% relatively to the stock volume and Model 4 suggests that after CDS is introduced, the option open interest increases by 14% relatively to stock volume. Using different liquidity measures provide robust and consistent empirical evidences that CDS trading has a positive effect on the option liquidity. And the same results are found in the put options data sample.

5. Conclusion

This paper documents that the inception of credit derivatives, represented by credit default swaps (CDS), makes the equity options on the same underlying firm more expensive. This finding is statistically significant and economically meaningful. In the univariate comparison, the option premium (delta-hedged option return) increases (decreases) by 0.409% after CDS trading, compared to non-CDS options. 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 not driven by firm fundamentals. The delta-hedged option returns, which are option prices adjusted by firm fundamentals, are lower after CDS trading. This result is robust to various controls for firm characteristics, market conditions, and sample selection bias.

We explore several channels and mechanisms through which CDS impact option prices. For both call and put options, limited intermediation capacity gives a coherent explanation for the higher option premium. We find consistent evidence that in quarters where the broker-dealer's leverage is greater (smaller), options are more expensive (cheaper). We also find that the relationship is stronger for call options than put options, which also agrees with the substitution story between CDS and put options. In line with the hypothesis of improved information quality brought by CDS, we find that option bid-ask spreads are lower after CDS trading. On the other hand, it is possible that the introduction of CDS enlarges the set of trading strategies insiders can follow which leads to greater difficulties for market makers in interpreting the information content of trades and thus reduced market efficiency. In addition, informed traders may trade in multiple marketplaces. When various derivatives markets are channeled through the same dealer, then the dealer is exposed to a severe information disadvantage. Therefore, dealers who find themselves in such situation may protect themselves by charging higher option premiums while keeping bid-ask spreads narrow.

Our study shows that the capacity of financial intermediaries has strong impact on securities pricing. In our case, the introduction of a new derivative security, CDS, makes the other, existing derivative (option) more expensive. This finding also adds to the growing literature on the various effects of CDS trading on stocks and bonds. Hence, combining all evidence presents a complete picture of CDS influence in financial markets.

References

Acharya, Viral V., and Timothy C. Johnson, 2007, Insider trading in credit derivatives, *Journal of Financial Economics* 84, 110-141.

Amihud, Yakov, 2002, Illiquidity and stock returns: Cross-section and time-series effects, *Journal of Financial Markets* 5, 31-56.

Amin, Kaushik, Joshua D. Coval, and H. Nejat Seyhun, 2004, Index option prices and stock market momentum, *Journal of Business* 77, 835-873.

Ashcraft, A. B., and J. A. C. Santos, 2009, Has the CDS market lowered the cost of corporate debt? *Journal of Monetary Economics* 56, 514–23.

Batta, George E., Jiaping Qiu, and Fan Yu, 2014, Credit derivatives and earnings announcements, Working Paper.

Bakshi, Gurdip, and Nikunj Kapadia, 2003a, Delta-hedged gains and the negative market volatility risk premium, *Review of Financial Studies* 16, 527-566.

Bakshi, Gurdip, and Nikunj Kapadia, 2003b, Volatility risk premium embedded in individual equity options: Some new insights, *Journal of Derivatives* 11, 45-54.

Berndt, Antje, and Anastasiya Ostrovnaya, 2014, Do equity markets favor credit market news over options market news?, *Quarterly Journal of Finance* 4, 1450006-1-1450006-51.

Bollen, Nicolas, and Robert Whaley, 2004, Does net buying pressure affect the shape of implied volatility functions, *Journal of Finance* 59, 711-753.

Bollerslev, Tim, George Tauchen, and Hao Zhou, 2009, Expected stock return and variance risk premium, *Review of Financial Studies* 22, 4463-4492.

Boehmer, Ekkehart, Sudheer Chava, and Heather E. Tookes, 2014, Related securities and equity market quality: The case of CDS, *Journal of Financial and Quantitative Analysis*, forthcoming.

Boehmer, Ekkehart, and Eric K. Kelley, 2009, Institutional investors and the informational efficiency of prices, *Review of Financial Studies* 22, 3563-3594.

Buraschi, Andrea, Fabio Trojani, and Andrea Vedolin, 2014, When uncertainty blows in the orchard: Comovement and equilibrium volatility risk premia, *Journal of Finance* 69, 101-137.

Cao, Jie and Bing Han, 2013, Cross-section of option returns and idiosyncratic stock volatility, *Journal of Financial Economics* 108, 231-249.

Cao, Charles, Fan Yu, and Zhaodong Zhong, 2010, The information content of option-implied volatility for credit default swap valuation, *Journal of Financial Markets* 13, 321-343.

Cao, Charles, Fan Yu, and Zhaodong Zhong, 2011, Pricing credit default swaps with option-implied volatility, *Financial Analysts Journal* 67(4), 67-76.

Carr, Peter and Liuren Wu, 2011, Stock options and credit default swaps: A joint framework for valuation and estimation, *Journal of Financial Econometrics* 160, 280-287.

Chan, Kalok, Peter Y. Chung, and Wai-Ming Fong, 2002, The informational role of stock and option volume, *Review of Financial Studies* 15, 1949-1975.

Coval, Joshua D., and Tyler Shumway, 2001, Expected options returns, *Journal of Finance* 56, 983-1009.

Cremers, Martijn, and David Weinbaum, 2010, Deviations from put-call parity and stock return predictability, *Journal of Financial and Quantitative Analysis* 45, 335-367.

Das, Sanjiv, Madhu Kalimipalli, and Subhankar Nayak, 2014, Did CDS trading improve the market for corporate bonds?, *Journal of Financial Economics* 111, 495-525.

Duarte, Jefferson, Francis A. Longstaff, and Fan Yu, 2007, Risk and return in fixed-income arbitrage: Nickels in front of a steamroller? *Review of Financial Studies* 20, 769-811.

Easley, David, Maureen O'Hara, and P.S. Srinivas, 1998, Option volume and stock prices: Evidence on where informed traders trade, *Journal of Finance* 53, 431-465.

Garleanu, Nicolae, Lasse Pedersen, and Allen Poteshman, 2009, Demand-based option pricing, *Review of Financial Studies* 22, 4259-4299.

Goyal, Amit, and Alessio Saretto, 2009, Cross-section of option returns and volatility , *Journal of Financial Economics* 94, 310-326.

Grundy, Bruce, Bryan Lim, and Patrick Verwijmeren, 2012, Do option markets undo restrictions on short sales? Evidence from the 2008 short-sale ban, *Journal of Financial Economics* 106, 331-348.

Han, Bing and Zhou, Yi, 2011, Variance Risk Premium and Cross-Section Stock Returns, Working Paper.

Hasbrouck, Joel, 1993, Assessing the quality of a security market: A new approach to transaction cost measurement, *Review of Financial Studies* 6, 191-212.

Kapadia, Nikunj, and Xiaoling Pu, 2012, Limited arbitrage between equity and credit markets, *Journal of Financial Economics* 105, 542-564.

Kim, J. B., Shroff, P. K., Vyas, D., and Wittenberg Moerman, R. 2014, Active CDS trading and managers' voluntary disclosure. *Chicago Booth Research Paper*, (14-15).

Lin, T. C., and Lu, X., 2014, How do equity lending costs affect put options trading? Evidence from separating hedging and speculative shorting demands, Working Paper.

Merton, Robert C., 1973, An intertemporal capital asset pricing model, *Econometrica* 41,867-887.

Muravyev, Dmitriy, 2014, Order flow and expected option returns, *Journal of Finance*, forthcoming.

Muravyev, Dmitriy, Neil D. Pearson, and John P. Broussard, 2013, Is there price discovery in equity options?, *Journal of Financial Economics* 107, 259-283.

Muravyev, Dmitriy, and Neil D. Pearson, 2014, Option trading costs are lower than you think, Working Paper.

Oehmke, Martin, and Adam Zawadowski. 2014, The anatomy of the CDS market, Working Paper.

Pan, Jun, and Allen M. Poteshman, 2006, The information in option volume for future stock prices, *Review of Financial Studies* 19, 871-908.

Philippon, Thomas, and Ariell Reshef, 2013, An international look at the growth of modern finance, *Journal of Economic Perspectives* 27, 73-96.

Roll, Richard, Eduardo Schwartz, and Avanidhar Subrahmanyam, 2010, O/S: The relative trading activity in options and stock, *Journal of Financial Economics*, 96, 1-17.

Roll, Richard, Eduardo Schwartz, and Avanidhar Subrahmanyam, 2011, Volume in redundant assets, Working Paper.

Saretto, Alessio and Heather Tookes, 2013, Corporate leverage, debt Maturity and Credit Default Swaps: The role of credit supply, *Review of Financial Studies* 26, 1190-1247.

Stulz, Rene M., 2010, Credit default swaps and the credit crisis, *Journal of Economic Perspectives* 24, 73-92.

Subrahmanyam, Marti, Dragon Yongjun Tang, and Sarah Qian Wang, 2014, Does the tail wag the dog? The effect of credit default swaps on credit risk, *Review of Financial Studies* 27, 2927-2960.

Subrahmanyam, Marti, Dragon Yongjun Tang, and Sarah Qian Wang, 2014, Credit Default Swaps and Corporate Cash Holdings, Working Paper.

Tang, Dragon Yongjun, and Hong Yan, 2014, Liquidity and credit default swap spreads, Working Paper.

Vanden, Joel M., 2009, Asset substitution and structured financing, *Journal of Financial and Quantitative Analysis* 44, 911-951.

Wang, Hao, Hao Zhou, and Yi Zhou, 2013, Credit default swap spreads and variance risk premia, *Journal of Banking and Finance* 37, 3733-3746.

Yu, Fan, 2006, How profitable is capital structure arbitrage, *Financial Analysts Journal* 62, 47-62.

Appendix: Variable Definitions

Option Variables	
Delta-hedged option return	Delta-hedged gain, as in Bakshi and Kapadia (2003), defined as the change (over the next month or until 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 (Δ*S-C), where 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-Δ*S), where P is the price of put option.
Implied volatility	The Black-Scholes option implied volatility at the end of last month.
Delta	The Black-Scholes option delta at the end of last month.
Moneyness	The ratio of stock price over option strike price at the end of last month.
Days to maturity	The total number of calendar days till the option expiration at the end of last month.
Option bid-ask spread	The ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of last month.
Option open interest	The total number of option contracts that are open at the end of last month.
Option volume	The total number of option contracts traded during the previous month.
Op_skew	The empirical skewness of daily option raw return within a month.
CDS Variables	
CDS	A dummy that equals 1 if the option observation is associated CDS, otherwise 0.
Pre-CDS	A dummy that equals to 1 if the CDS is introduced within next 36 months, otherwise 0.
Stock Variables	
Ln(ME)	The natural logarithm of the market capital at the end of 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 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 2nd through 12th month.
Illiquidity	The average of the daily Amihud (2002) illiquidity measure over the previous month.
Volatility risk premium	The difference between the square root of realized variance estimated from intra-daily stock returns over the previous month and the square root of a model free estimate of the risk-neutral expected variance implied from stock options at the end of the month.
Stock volume	Total stock trading volume over previous month.
Analyst coverage	The number of the analysts covering the underlying stock at last month.
Analyst dispersion	The standard deviation of annual earnings-per-share forecasts scaled by the absolute value of the average outstanding forecast at last month.
Institutional ownership	The percentage of common stocks owned by institutions in the previous quarter.

Table 1: Summary Statistics

This table reports the descriptive statistics of delta-hedged option returns, stock characteristics, and CDS introductions. 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. 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 (Δ*S-C), where 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-Δ*S), where 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 till 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 each month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of last month. 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}. Put-call ratio is the number of put contracts divided by the sum of the put and call contracts in Pan and Poteshman (2006) at the end of each month. 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 end. Ln(BM) is the natural logarithm of the book-to-market ratio.

Panel A: Call Options		All (265,369 obs)					After CDS Introduction (43,243 obs)				
		Mean	StDev	Q1	Median	Q3	Mean	StDev	Q1	Median	Q3
Delta-hedged gain till maturity / (Δ*S – C)	(%)	-1.172	7.778	-3.905	-1.315	0.932	-0.702	5.566	-2.554	-0.933	0.605
Delta-hedged gain till month-end / (Δ*S – C)	(%)	-0.876	4.969	-2.809	-0.967	0.757	-0.592	3.194	-1.922	-0.726	0.472
Days to maturity		49.991	1.997	50.000	50.000	51.000	49.991	1.969	50.000	50.000	51.000
Moneyness = S/K	(%)	100.532	4.930	97.543	100.171	103.130	100.411	3.655	98.240	100.200	102.343
Option bid-ask spread		0.215	0.181	0.094	0.158	0.275	0.147	0.139	0.061	0.103	0.182
(Option open interest / stock volume) *1000		0.031	0.111	0.001	0.005	0.024	0.030	0.072	0.002	0.007	0.029
(Option volume / stock volume) *1000		0.071	0.182	0.009	0.028	0.077	0.071	0.126	0.011	0.034	0.086

Panel B: Put Options		All (247,632obs)					After CDS Introduction (43,698 obs)				
		Mean	StDev	Q1	Median	Q3	Mean	StDev	Q1	Median	Q3
Delta-hedged gain till maturity / (P - Δ*S)	(%)	-0.864	7.187	-3.461	-1.219	0.993	-0.586	4.303	-2.421	-0.932	0.631
Delta-hedged gain till month-end / (P - Δ*S)	(%)	-0.484	4.466	-2.433	-0.805	0.871	-0.307	3.082	-1.688	-0.580	0.605
Days to maturity		50.015	1.969	50.000	50.000	51.000	50.026	1.923	50.000	50.000	51.000
Moneyness = S/K	(%)	99.822	4.703	97.083	99.775	102.467	99.728	3.550	97.700	99.714	101.720
Option bid-ask spread		0.212	0.177	0.094	0.157	0.271	0.150	0.136	0.065	0.109	0.186
(Option open interest / stock volume) *1000		0.020	0.095	0.000	0.003	0.013	0.019	0.049	0.001	0.004	0.017
(Option volume / stock volume) *1000		0.046	0.139	0.005	0.015	0.045	0.051	0.088	0.007	0.023	0.061

Panel C: Stock Level Variables	Mean	StDev	Q1	Median	Q3	Mean	StDev	Q1	Median	Q3
Total volatility: VOL	0.478	0.317	0.270	0.398	0.593	0.357	0.244	0.206	0.293	0.427
VOL deviation: Ln (VOL / IV)	-0.103	0.321	-0.306	-0.106	0.098	-0.100	0.285	-0.281	-0.107	0.074
Put-Call ratio	0.391	0.268	0.161	0.347	0.591	0.426	0.254	0.216	0.402	0.617
Ln (Illiquidity)	-6.611	1.844	-7.879	-6.595	-5.329	-8.387	1.400	-9.288	-8.426	-7.514
Ln (ME)	7.425	1.525	6.337	7.287	8.380	9.019	1.306	8.114	8.988	9.854
Ln (BM)	-0.910	1.053	-1.490	-0.913	-0.378	-0.741	0.805	-1.194	-0.707	-0.251

Table 2: 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 (Δ*S-C), where 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-Δ*S), where P is the price of call option. Column A includes option observations which never have the associated CDS; Column B includes option observations whose underlying firms have 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 3: Delta-Hedged Option Returns and CDS Presence

This table reports the monthly Fama-MacBeth regression coefficients of call option return (%): delta-hedged gain until maturity scaled by (Δ*S-C) at the beginning of the period. CDS is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. Ln(ME) is the natural logarithm of the market capital at the last month 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} month. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of last month. Volatility risk premium (VRP) is the difference between the square root of realized variance estimated from intra-daily stock returns over the previous month and the square root of a model free estimate of the risk-neutral expected variance implied from stock options at the end of the 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-stat is reported in the brackets. Only Call option is reported in Table 3.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CDS	-0.409***	-0.371***	-0.250***	-0.305***	-0.207***	-0.327***
	(-5.743)	(-5.291)	(-4.608)	(-4.807)	(-4.005)	(-3.936)
Ln(ME)	0.637***	0.147***	0.0260	-0.387***	-0.528***	-0.454***
	(19.59)	(5.299)	(1.025)	(-11.00)	(-12.52)	(-6.528)
VOL		-6.841***	-8.382***	-7.726***	-9.275***	-6.212***
		(-25.23)	(-35.44)	(-29.45)	(-39.24)	(-13.59)
VOL_deviation		5.762***	6.218***	6.148***	6.604***	4.248***
		(32.49)	(34.11)	(33.27)	(34.36)	(17.99)
Ln(BM)			-0.127***		-0.114***	-0.0485
			(-3.728)		(-3.384)	(-1.194)
Ret $_{(-1,0)}$			-0.242		0.0735	0.318
			(-0.886)		(0.283)	(0.732)
Ret $_{(-12,-2)}$			0.464***		0.372***	0.563***
			(5.954)		(4.968)	(5.393)
Ln(Illiquidity)				-0.342***	-0.363***	-0.444***
				(-8.322)	(-9.069)	(-6.860)
(Option open interest / stock volume)*1000				-3.765***	-3.575***	-3.698***
				(-9.773)	(-10.71)	(-6.427)
Option bid-ask spread				-2.807***	-2.613***	-2.293***
				(-14.42)	(-14.10)	(-4.910)
Volatility risk premium						-6.339***
						(-13.45)
Intercept	-5.795***	1.228***	2.406***	4.211***	5.388***	3.149***
	(-19.64)	(4.748)	(9.382)	(17.13)	(20.60)	(7.131)
Observations	265,350	265,347	228,794	265,346	228,794	46,717
Average R^2	0.029	0.096	0.113	0.111	0.127	0.141

Table 4: 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 1% level. The sample period is from January 1996 to October 2009. To adjust for serial correlation, robust Newey-West (1987) t-statistics are reported in brackets.

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

Dependent Variables	Gain till maturity ($\Delta^*S - C$)	Gain till month-end ($\Delta^*S - C$)	Gain till maturity Stock Price	Gain till month-end Stock Price
CDS	-0.207***	-0.100***	-0.0819***	-0.0332**
	(-4.410)	(-3.330)	(-3.823)	(-2.309)
Ln(ME)	-0.528***	-0.361***	-0.233***	-0.175***
	(-14.38)	(-13.62)	(-14.09)	(-14.02)
VOL	-9.275***	-7.061***	-4.037***	-3.198***
	(-37.48)	(-36.26)	(-37.78)	(-36.33)
VOL_deviation	6.605***	5.197***	2.908***	2.391***
	(31.92)	(32.51)	(34.04)	(34.30)
Ln(BM)	-0.114***	-0.0798***	-0.0561***	-0.0413***
	(-3.959)	(-3.963)	(-4.308)	(-4.363)
$Ret_{(-1,0)}$	0.0732	-0.0107	-0.00337	-0.0323
	(0.269)	(-0.0544)	(-0.0284)	(-0.357)
$Ret_{(-12,-2)}$	0.372***	0.164***	0.177***	0.0760***
	(4.702)	(3.424)	(5.035)	(3.447)
Ln(Illiquidity)	-0.363***	-0.129***	-0.170***	-0.0646***
	(-9.528)	(-5.230)	(-10.16)	(-5.668)
(Option open interest /	-3.566***	-2.455***	-1.380***	-1.012***
stock volume) *1000	(-10.07)	(-9.451)	(-9.080)	(-8.057)
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***
	(22.04)	(23.74)	(19.83)	(22.68)
Observations	228,787	228,787	228,787	228,787
Average R^2	0.127	0.152	0.126	0.135

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

Dependent Variables	Gain till maturity $(P - \Delta^* S)$	Gain till month-end $(P - \Delta^* S)$	Gain till maturity Stock Price	Gain till month-end Stock Price
CDS	-0.133***	-0.0775**	-0.0894***	-0.0553***
	(-2.870)	(-2.582)	(-3.899)	(-3.557)
Ln(ME)	-0.489***	-0.312***	-0.265***	-0.180***
	(-13.35)	(-11.43)	(-14.51)	(-12.46)
VOL	-6.600***	-5.420***	-3.459***	-2.962***
	(-27.61)	(-30.94)	(-26.58)	(-28.52)
VOL_deviation	5.062***	4.049***	2.678***	2.233***
	(31.29)	(31.94)	(29.74)	(30.18)
Ln(BM)	-0.154***	-0.107***	-0.0848***	-0.0651***
	(-6.083)	(-5.591)	(-6.499)	(-6.329)
$Ret_{(-1,0)}$	-0.873***	-0.654***	-0.373***	-0.340***
	(-3.972)	(-3.618)	(-3.160)	(-3.298)
$Ret_{(-12,-2)}$	0.252***	0.191***	0.134***	0.101***
	(4.725)	(5.020)	(4.592)	(4.605)
Ln(Illiquidity)	-0.384***	-0.155***	-0.239***	-0.105***
	(-10.71)	(-6.747)	(-12.77)	(-8.560)
(Option open interest /	-3.075***	-2.098***	-1.354***	-0.962***
stock volume) *1000	(-7.842)	(-6.420)	(-6.535)	(-5.245)
Option bid-ask spread	-0.589***	-0.720***	0.171*	-0.155**
	(-2.714)	(-4.775)	(1.817)	(-2.152)
Intercept	3.421***	3.471***	1.471***	1.779***
	(16.51)	(19.47)	(12.97)	(17.70)
Observations	214,006	214,006	214,006	214,006
Average R^2	0.120	0.132	0.127	0.121

Table 5: Variance Risk Premium and CDS Presence

This table reports the monthly Fama-MacBeth regression coefficients of variance risk premium for call options at the beginning of the period. CDS is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. Ln(ME) is the natural logarithm of the market capital at the last month 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 2^{nd} through 12^{th} month. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of 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-stat is reported in the brackets.

	Model 1	Model 2	Model 3	Model 4
CDS	-0.00480**	-0.00680***	-0.00488**	-0.00697***
	(-2.343)	(-3.177)	(-2.412)	(-3.327)
Ln(ME)	-0.00658***	-0.00498***	-0.00861***	-0.00839***
	(-8.405)	(-6.345)	(-7.796)	(-7.560)
Ln(BM)		0.00722***		0.00737***
		(9.750)		(9.933)
$Ret_{(-1,0)}$		-0.0614***		-0.0624***
		(-12.16)		(-12.30)
$Ret_{(-12,-2)}$		-0.00273**		-0.00350***
		(-2.257)		(-2.934)
Ln(Illiquidity)			-0.00106	-0.00248***
			(-1.179)	(-2.738)
(Option open interest / stock volume) *1000			0.0694***	0.0792***
			(6.696)	(7.689)
Option bid-ask spread			-0.0612***	-0.0663***
			(-9.101)	(-8.841)
Intercept	0.113***	0.107***	0.126***	0.123***
	(14.82)	(14.46)	(16.20)	(16.62)
Observations	51,282	46,717	51,282	46,717
Average R^2	0.056	0.096	0.082	0.124

Table 6: Placebo Test

This table reports the monthly Fama-MacBeth regression coefficients of call option return (%): delta-hedged gain until maturity scaled by (Δ*S-C) at the beginning of the period. Pre-CDS is a dummy that equals to 1 if the CDS is introduced within next 36 months, and otherwise 0. CDS is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. Ln(ME) is the natural logarithm of the market capital at the last month 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} month. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of 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-stat is reported in the brackets.

	Model 1	Model 2	Model 3	Model 4	Model 5
CDS	-0.485***	-0.483***	-0.348***	-0.405***	-0.298***
	(-5.941)	(-6.053)	(-5.693)	(-5.576)	(-5.098)
Pre-CDS	-0.110	-0.258**	-0.159	-0.185	-0.119
	(-0.788)	(-1.996)	(-1.400)	(-1.448)	(-1.068)
Ln(ME)	0.658***	0.172***	0.0496**	-0.362***	-0.506***
	(20.80)	(6.275)	(2.098)	(-11.09)	(-14.06)
VOL		-6.905***	-8.409***	-7.778***	-9.300***
		(-25.70)	(-34.29)	(-29.30)	(-37.75)
VOL_deviation		5.787***	6.226***	6.167***	6.611***
		(30.24)	(31.21)	(31.11)	(32.00)
Ln(BM)			-0.120***		-0.108***
			(-4.225)		(-3.837)
$Ret_{(-1,0)}$			-0.251		0.0656
			(-0.881)		(0.241)
$Ret_{(-12,-2)}$			0.458***		0.368***
			(5.656)		(4.673)
Ln(Illiquidity)				-0.339***	-0.363***
				(-8.802)	(-9.514)
(Option open interest / stock volume) *1000				-3.741***	-3.549***
				(-9.333)	(-10.10)
Option bid-ask spread				-2.779***	-2.595***
				(-14.43)	(-14.03)
Intercept	-5.913***	1.141***	2.306***	4.116***	5.292***
	(-20.87)	(4.834)	(10.09)	(17.25)	(21.67)
Observations	265,342	265,339	228,787	265,338	228,787
Average R^2	0.031	0.097	0.113	0.112	0.127

Table 7: Controlling for Endogeneity – Heckman Two-Stage Test

This table reports the monthly Fama-MacBeth regression coefficients of call option return (%): delta-hedged gain until maturity scaled by (Δ^*S-C) at the beginning of the period. CDS is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. IMR is the inverse mills ratio based on the first stage regression as in Subrahmanyam, Tang, and Wang (2014). Ln(ME) is the natural logarithm of the market capital at the last month 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 2nd through 12th month. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of 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-stat is reported in the brackets.

	Model 1	Model 2	Model 3	Model 4	Model 5
CDS	-0.654***	-0.365***	-0.273***	-0.275***	-0.193***
	(-8.838)	(-5.462)	(-3.957)	(-4.177)	(-2.815)
IMR	-0.246**	0.343***	0.326***	0.278***	0.306***
	(-2.580)	(3.368)	(3.825)	(2.947)	(3.797)
Ln(ME)	0.626***	0.205***	0.135***	-0.533***	-0.531***
	(11.25)	(4.164)	(3.345)	(-9.409)	(-9.117)
VOL		-8.472***	-9.223***	-9.497***	-10.12***
		(-26.63)	(-30.14)	(-29.71)	(-32.91)
VOL_deviation		6.448***	6.575***	6.913***	6.969***
		(23.63)	(23.38)	(24.15)	(23.98)
Ln(BM)			0.0690*		0.0957***
			(1.943)		(2.747)
$Ret_{(-1,0)}$			-0.421		-0.0321
			(-1.240)		(-0.0983)
$Ret_{(-12,-2)}$			0.408***		0.320***
			(3.824)		(3.119)
Ln(Illiquidity)				-0.474***	-0.443***
				(-7.423)	(-7.239)
(Option open interest / stock volume) *1000				-3.809***	-3.599***
				(-7.804)	(-7.754)
Option bid-ask spread				-2.618***	-2.459***
				(-9.830)	(-10.01)
Intercept	-4.798***	0.522	1.190**	4.435***	4.544***
	(-6.917)	(0.835)	(2.289)	(7.636)	(8.888)
Observations	108,836	108,836	104,878	108,836	104,878
Average R^2	0.045	0.112	0.126	0.130	0.142

Table 8: Event Study – Matching Results

This table reports the monthly panel data regression coefficients of call option return (%): delta-hedged gain until 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 return 12 months before and after the CDS introduction event. CDS*After is a dummy that equals 1 if the option is associated CDS and it is after CDS is introduced, otherwise 0. Ln(ME) is the natural logarithm of the market capital at the last month 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 month. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of last month. All independent variables are winsorized each month at the 1% level. The sample period is from January 1996 to December 2012. Firm and time fixed effects are controlled. Robust t-stat is reported in the brackets.

	Model 1	Model 2	Model 3	Model 4	Model 5
CDS*After	-0.340***	-0.303***	-0.248**	-0.331***	-0.247**
	(-2.988)	(-2.635)	(-2.071)	(-2.778)	(-1.977)
Ln(ME)	1.326***	0.331	0.207	0.0815	0.183
	(4.534)	(1.122)	(0.586)	(0.255)	(0.458)
VOL		-7.448***	-7.904***	-7.382***	-7.884***
		(-8.497)	(-8.389)	(-8.131)	(-8.115)
VOL_deviation		3.431***	3.734***	3.464***	3.705***
		(8.778)	(8.937)	(8.670)	(8.700)
Ln(BM)			-0.727***		-0.723***
			(-3.144)		(-3.132)
$Ret_{(-1,0)}$			-2.561***		-2.479***
			(-4.396)		(-4.155)
$Ret_{(-12,-2)}$			0.393*		0.392*
			(1.890)		(1.891)
Ln(Illiquidity)				-0.265	-0.0292
				(-1.508)	(-0.151)
(Option open interest / stock volume) *1000				-2.205**	-1.602*
				(-2.305)	(-1.713)
Option bid-ask spread				0.348	0.356
				(0.671)	(0.669)
Intercept	-11.92***	-0.0739	0.456	0.0705	0.414
	(-4.777)	(-0.0283)	(0.151)	(0.0273)	(0.137)
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	10,371	10,371	9,958	10,371	9,958
R^2	0.006	0.033	0.038	0.034	0.038

Table 9: Dealer's Leverage and the Impact of CDS Presence on Delta-Hedged Option Returns

This table reports the monthly Fama MacBeth regression coefficients of call option return (%): delta-hedged gain until maturity scaled by (Δ*S-C) at the beginning of the period. High (low) leverage period is defined as the period of time when the corresponding quarter's leverage factor (Adrian, Etula, and Muir (2014)) is above (below) the median of full sample period. CDS is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. Ln(ME) is the natural logarithm of the market capital at the last month 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} month. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of last month. All independent variables are winsorized each month at the 1% level. The sample period is from January 1996 to December 2012. Robust t-stat is reported in the brackets. Robust Newey-West (1987) t-stat is reported in the brackets.

	Periods of Low Leverage	Periods of High Leverage	High-Low
CDS	-0.121**	-0.328***	-0.207**
	(-2.087)	(-4.271)	(-2.151)
Ln(ME)	-0.510***	-0.554***	-0.044
	(-12.13)	(-8.412)	(-0.563)
VOL	-9.839***	-8.485***	1.354***
	(-31.89)	(-21.54)	(2.706)
VOL_deviation	6.690***	6.485***	-0.205
	(23.08)	(22.53)	(-0.502)
Ln(BM)	-0.0636**	-0.185***	-0.121**
	(-1.998)	(-3.542)	(-1.985)
$Ret_{(-1,0)}$	0.631**	-0.707	-1.338***
	(2.050)	(-1.467)	(-2.340)
$Ret_{(-12,-2)}$	0.186	0.633***	0.447***
	(1.561)	(7.531)	(3.065)
Ln(Illiquidity)	-0.287***	-0.470***	-0.183***
	(-5.957)	(-7.797)	(-2.371)
(Option open interest / stock volume) *1000	-3.478***	-3.690***	-0.212
	(-7.613)	(-6.556)	(-0.292)
Option bid-ask spread	-2.682***	-2.516***	0.166
	(-12.76)	(-7.513)	(0.420)
Intercept	5.661***	5.007***	-0.654
	(21.71)	(10.93)	(-1.241)
Observations	137,552	91,235	
Average R^2	0.127	0.126	

Table 10: Option Bid-Ask Spread and CDS Presence

This table reports the monthly panel data regression coefficients of average daily option bid ask spread of current month. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask. CDS 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 last 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(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 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 return of current month. Market Return is current month S&P 500 return. $Ret_{(0,1)}$ is the current month stock return. Time, firm and industry fixed effect are controlled. All independent variables are winsorized each month at the 1% level. Firm, time, and industry fixed effects are controlled. The sample period is from January 1996 to December 2012. Robust t-stat is reported in the brackets. Only Call option results are reported.

	Model 1	Model 2	Model 3	Model 4
CDS	-0.0251***	-0.0251***	-0.0251***	-0.0251***
	(-20.54)	(-20.55)	(-12.31)	(-12.31)
Moneyness	0.0000	0.0000	0.0000	0.0000
	(1.09)	(1.29)	(0.30)	(0.36)
1/(Days to Maturity)	1.178***	1.177***	1.170***	1.168***
	(3.74)	(3.74)	(3.76)	(3.76)
Ln(Stock Volume)	-0.0400***	-0.0400***	-0.0377***	-0.0377***
	(-69.46)	(-69.44)	(-39.26)	(-39.25)
Ln(ME)	0.0152***	0.0152***	0.0164***	0.0164***
	(17.59)	(17.61)	(9.772)	(9.824)
Ln(BM)	0.0135***	0.0135***	0.0125***	0.0125***
	(26.89)	(26.89)	(14.90)	(14.91)
Ln(Price)	-0.0822***	-0.0822***	-0.0811***	-0.0811***
	(-85.59)	(-85.55)	(-44.43)	(-44.36)
$Ret_{(-1,0)}$	0.00551***	0.00551***	0.00466***	0.00465***
	(3.12)	(3.12)	(2.71)	(2.71)
VOL	-0.0151***	-0.0151***	-0.0128***	-0.0129***
	(-11.94)	(-11.96)	(-7.656)	(-7.659)
Institutional ownership	0.0582***	0.0582***	0.0511***	0.0511***
	(27.65)	(27.63)	(13.05)	(13.02)
Op_{skew}	0.00947***	0.00947***	0.00946***	0.00946***
	(36.81)	(36.83)	(31.52)	(31.64)
Market return	-0.0724***	-0.0751***	-0.0701***	-0.0733***
	(-12.57)	(-12.15)	(-8.333)	(-10.83)
$Ret_{(0,1)}$		0.00288		0.00341
		(1.21)		(0.57)
Intercept	0.987***	0.986***	0.892***	0.890***
	(90.64)	(89.92)	(40.14)	(37.28)
Firm Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	No	No	Yes	Yes
Observations	253,808	253,808	253,808	253,808
R-squared	0.0859	0.0859	0.086	0.086

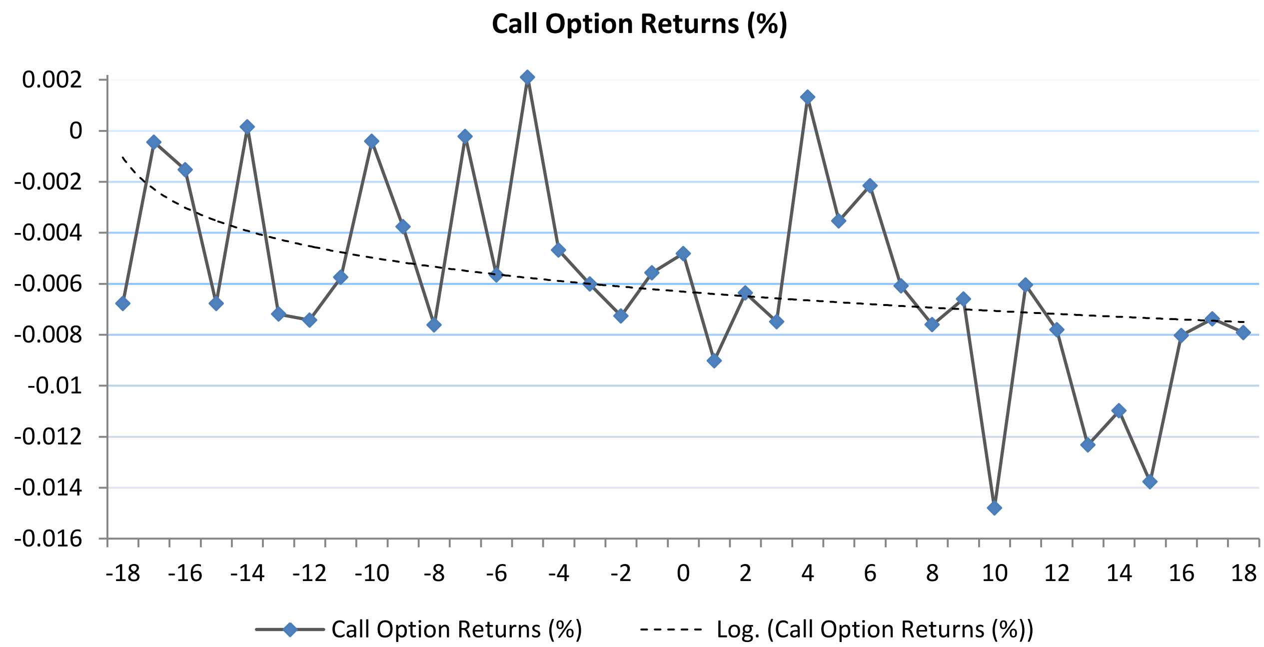
Table 11: Option Volume and CDS Presence

This table reports the monthly panel data regression coefficients of current month option volume. 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 is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. Ln(ME) is the natural logarithm of the market capital at the last month end. Option bid-ask spread is the ratio of bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of 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 the analysts covering the underlying stock at last month. Analyst Dispersion is the analyst dispersion scaled by the absolute mean estimate at the end of 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 effect are controlled. All independent variables are winsorized each month at the 1% level. Firm, time, and industry fixed effects are controlled. The sample period is from January 1996 to December 2012. Robust t-stat is reported in the brackets. Only Call option results are reported.

	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	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
R-squared	0.165	0.067	0.031	0.043

Figure 1: Delta-Hedged Option Returns - Time-Series Analysis

This figure plots the time-series of the monthly option delta-hedged gain until maturity scaled by ($\Delta^{*}S$-C) for call and (P-$\Delta^{*}S$) for put 18-month before and 18-month after the month of CDS introduction (t=0).



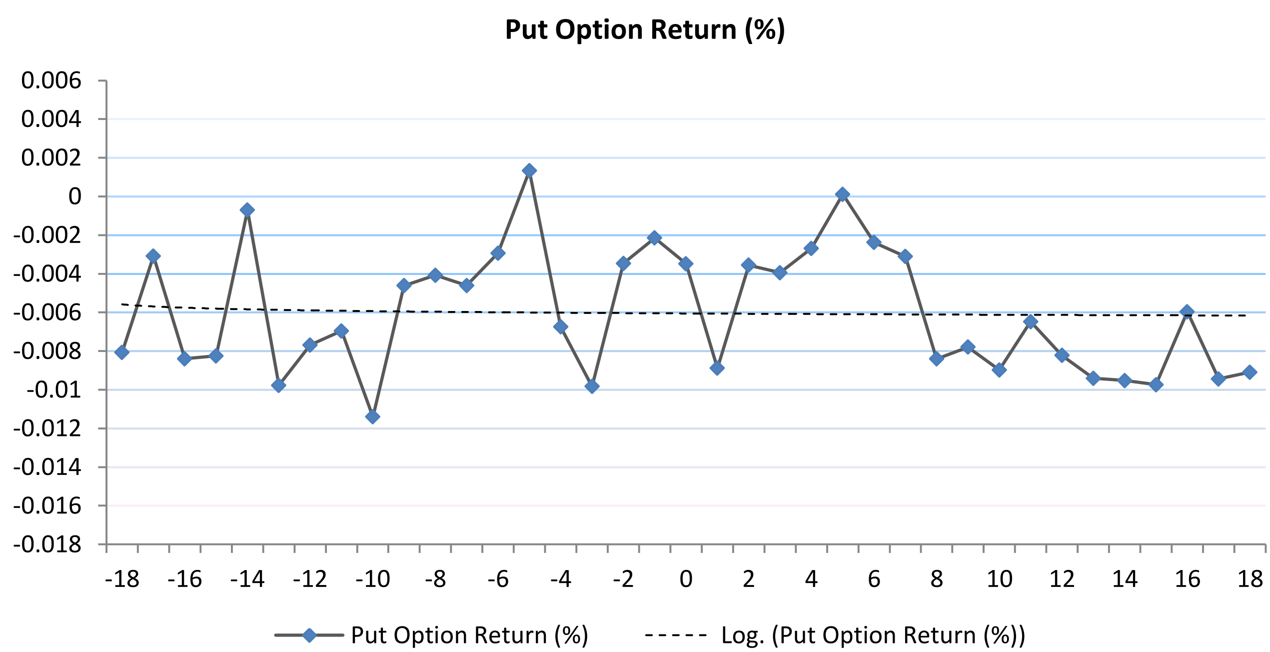


Figure 2: Put-Call Ratio - Time-Series Analysis

This figure plots the time-series of the monthly put-call ratio for 18-month before and 18-month after the month of CDS introduction (t=0). Put-call ratio is the number of put contracts divided by the sum of the put and call contracts in Pan and Poteshman (2006) at the end of each month. The time series is adjusted by the time trend and re-based on time 0 level.

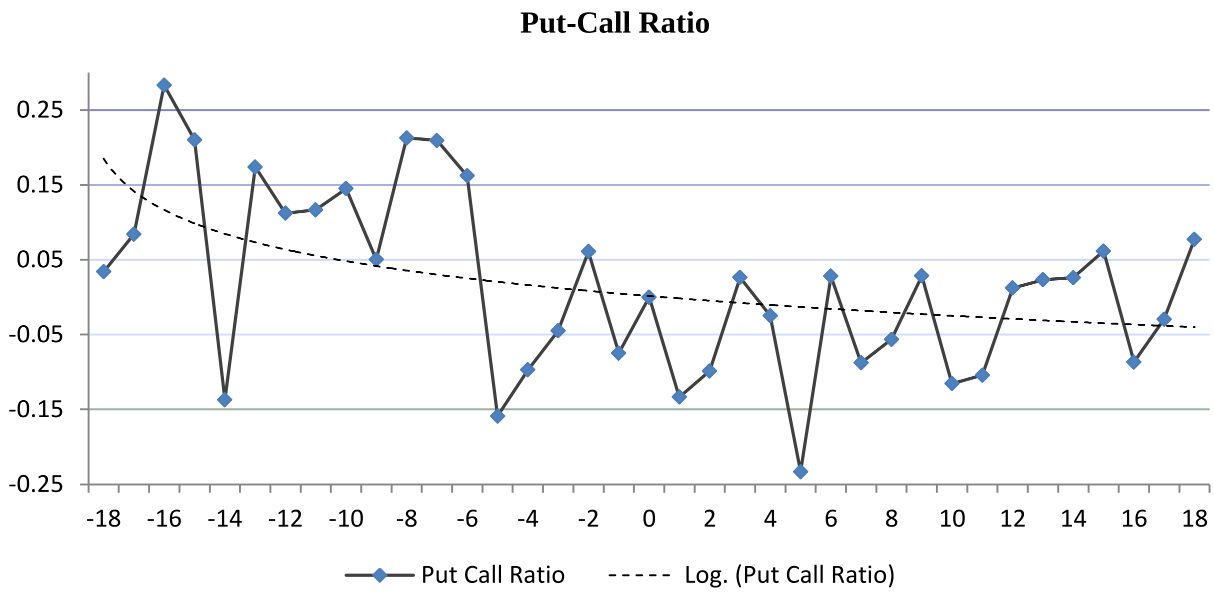


Table A1: Sample Coverage

Table A1 reports the coverage of underlying stocks with 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 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 month. 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 stock with CDS / # of optionable stocks
1997	1,387	32	32	0.023
1998	1,549	58	90	0.058
1999	1,622	48	138	0.085
2000	1,525	97	235	0.154
2001	1,447	143	378	0.261
2002	1,393	183	561	0.403
2003	1,382	79	640	0.463
2004	1,534	61	701	0.457
2005	1,573	49	750	0.477
2006	1,799	24	774	0.430
2007	1,945	12	786	0.404
2008	1,825	10	796	0.436
2009	1,843	2	798	0.433
2010	1,909	n.a.	798	0.418
2011	1,822	n.a.	798	0.438
2012	1,752	n.a.	798	0.455