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

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Abstract

Derivatives often have real effects on the underlying assets. 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.

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Abstract

Derivatives often have real effects on the underlying assets. 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. Introduction

The derivatives market plays an important role in today's financial world. Financial intermediaries allocate substantial resources as dealer and market makers for various types of derivatives. Moreover, the derivatives markets are becoming increasingly complex. Given the many options on the same underlying firm, a recent addition to the derivatives market is credit default swaps (CDS). 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 with both institutional and retail demand and supply, 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 Dodd-Frank, 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 can 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, option value can be higher as option prices are positively related to 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, allocation of resources to CDS trading may reduce dealers ability to profit from options (given the same information advantages). In such case, dealers may charge higher option premiums. Option prices can also go down if now dealers can use

[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.

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 would have no effect 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 asset class level or individual name level (or trading desk risk limit). If the bank coordinates the trading book of all various 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 inventory risk for both CDS and option 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 CDS trading on the same underlying firm. This finding is statistically significant and economically meaningful. In univariate comparison, option premium increase 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, with higher realized volatility, after CDS trading. However, delta-hedged option returns, which are option prices adjusted by firm fundamentals and realized volatilities, are lower after CDS trading. This result is robust to various controls for firm characteristics and market conditions. We further account for the selection of firms into CDS trading, following Saretto and Tookes (2013) and Subrahmanyam, Tang, and Wang (2014). The findings from propensity score matching and 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 CDS market instead of option market. Therefore, option market makers need to charge higher premium, but also lower bid-ask spread. However, the information story applies to both call and put options, probably even more so for put options. But we find the results concentrate on call options rather than put options. Second, CDS are more similar to put options than call options. Therefore, CDS provide more effective substitute for put option but not for call options. If the market is in net demand of insurance, then CDS can alleviate some of the demand pressure for put

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

options (and should not negatively impact put option prices).[4] Indeed, we find that there is no effect on put option prices. The result that the CDS effect 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 other hand, now that option traders can use information from CDS price, they themselves may not collect information. In such case, information quality may reduce. Moreover, the firm may disclose more information after CDS trading (Kim, et al. (2014)). Batta, Qiu, and Yu (2014) find that information quality is higher after CDS trading as analysts make more accurate forecasts. Hence, option bid-ask spreads are lower after CDS trading. The introduction of CDS enlarges the set of trading strategies insiders can follow. This can make it more difficult for market makers to interpret 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 dealers are exposed to more potential information disadvantage. Therefore, they 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) point out 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 option is immune to such consideration. But for call option, there is a more serious concern. That means, CDS trading will affect put-call parity.)

This study helps understand the linkages between different types of derivatives. Our findings also add to the option return literature. Consistent with Cao and Han (2013), there seems 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.

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[4] 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.

The rest of the paper is organized as follows. Data and sample construction is provided in Section 2. Section 3 reports the main results on option pricing. Section 4 presents the results on option bid-ask spread and trading volume. Section 5 concludes.

2. Data and measures

2.1. Data

We collect the data from the stock, equity option and CDS markets. The data process for 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 obtain stock returns, prices, and trading volume 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. Analyst coverage data 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 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 collected 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 my 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 options return is negative on average, which implies that individual option is overvalued relative to the underlying stock if Black-Scholes model holds.[5]

We measure delta-hedged call option return by following Cao and Han (2013). We first define delta-hedged option gain, which is 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 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

[5] 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."

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

where Δ_{C,t_n} is the delta of the call option on date t_n, r_{t_n} is annualized risk-free rate on date t_n, α_n is the number of calendar days between t_n and t_{n+1}. Definition for the delta-hedged put option gain is the same as (2), except with put option price and delta replacing call option price 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 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. Based on 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 the 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% and -0.586% for call and put options. The days to maturity are around 50, and the moneyness is around 1, both with very small standard deviations. The relative quoted option bid-ask spreads are around 3% and 2% for call and put options, varying across different options. Moreover, the call option has a higher option open interest to stock volume ratio as well as option volume to stock volume ratio than the put option.

Panel C reports the summary statistics for stock level variables. The underlying stocks have an average annualized volatility 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. Put-Call ratio is less than 0.5, which implies that the investor prefer to trade in call options and this finding is consistent with the findings in 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.

Panel D 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-varaite 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. Therefore, we first divide all option observations into quintiles each month based on the firms' market capitalization, to control for the size effect. Within each size quintile, we examine three sub-groups: option observations which never have the associated CDS (group A); option observations whose underlying firms ever have CDS during the sample period (group B); option observations only after the first associated CDS is launched (group C).

Table 2 shows the uni-varaite test results. It is clear that most of the options with associated CDS come from large firms. Within small firms, there is no significant difference on delta-hedged option return between firms with CDS and those without CDS. Within large firms, options with associated CDS tend to have more negative delta-hedged option returns, i.e. these options are more overvalued. This result is meaningful as most firms with CDS are from top size quintiles.

3.3. The impact of CDS introduction on option pricing: time-series event study

To examine how the CDS introduction affects the option mispricing, we conduct a time-series event study. For each event of the first CDS launch, we examine the delta-hedged option returns for 36 months both before and after. Figure 1 plots the cross-sectional average for the 72-month event window. The trend lines in logarithm show that the delta-hedged call return keeps decreasing, while the delta-hedged put return remains stable. After the introduction of CDS, the delta-hedged return of call converges to the delta-hedged returns of put. One possible explanation is that put is already expensive and quite overvalued. However, call is more subject to the increasing hedging demands incurred by the launch of CDS, such that call becomes as expensive as put after certain amount of time.

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

In the second step, we conduct Fama-MacBeth type regressions on how CDS trades affect the cross-section of delta-hedged option returns. We test the following regression:

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

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 (2010). 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 $Ln(BE)$, $Ret_{(-1,0)}$, $Ret_{(-12,-1)}$ 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. $Ret_{(-12,-1)}$ 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 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.

Table 3 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). The coefficients of CDS_{trades} is -0.409 (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 which are associated with CDS, which translates to 34.9% lower in magnitude compared to an average call option delta-hedged portfolio (i.e.-1.172%).

Model 2-5 reports the regression coefficients of CDS_{trades} after controlling for the 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, which suggests that the CDS trading makes option more expensive.

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 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 with different dependent variables. Panel A for call options and Panel B 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 negative significant 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 & 4 use the delta-hedged gain divided by the stock price until maturity and month end as the dependent variables, respectively. Both of the CDS_{trades} coefficients are negative significant with t-statistic 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 different scaled delta-hedged gain and different testing time periods.

3.5. Control for endogeneity of CDS introduction

The presence of endogeneity, if any, will prevent us from concluding that the 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 Saretoo 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 Saretoo 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 / predicted probability of the introduction of CDS trading. We apply the logistic 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 predict the probability of the introduction of CDS for all observations including all the CDS firms and non-CDS firms. After obtaining the implied probability of the introduction of CDS trading ($\widehat{CDS_{trades}}$), we run the empirical model as below to test the robustness of our findings after controlling for the endogeneity:

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

Table 5 reports the coefficients of the Fama-MacBeth Regression of option delta-hedged return until maturity. The coefficients of ($\widehat{CDS_{trades}}$) are negative significant at 1% level, 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.

3.6. Placebo Test

In order to further make sure that our findings is 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 the CDS is introduced in next 36 months, and otherwise 0. We further run the Fama-MacBeth Regression including the new variable $Pre - CDS$:

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

All the other control variables are the same as subsection 4.4. Table 6 reports the monthly Fama-MacBeth regression coefficients of option delta-hedged gain until maturity scaled by (Δ*S-C or P-Δ*S) at the beginning of the period including the new variable $Pre - CDS$. The coefficients of $Pre - CDS$

are all insignificant except Model 2. The results suggest that our findings are not driven by other factors and our findings are very robust.

3.7. Difference-in-Difference (DID) Test

There is a concern that the event study results in subsection 4.2 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:

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

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 9 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 negatively significant. The findings in DID analysis provides further evidence that the CDS trading makes option more expensive.

3.8. Other robustness

We further conduct other robustness tests in using the ratio of at-the-money option implied volatility to realized volatility as the dependent variables. A high implied volatility could indicate the high demand and price of the option. It is a more intuitive measure relative to the delta-hedged option return our study relies on. To compare the implied volatility cross-sectional, we scale it by the historical volatility.[6] We keep the same explanatory variables as Table 3. Table 6 reports the Fama-MacBeth

[6] An equivalent method is to use the difference between implied volatility and historical volatility. The results are consistent.

regression coefficients of the ratio of at-the-money option implied volatility to realized volatility (see Goyal and Saretto (2010)). The coefficients of CDS_{trades} are positive significant at 1% level, which implies that after CDS is introduced, the ratio of at-the-money option implied volatility to realized volatility becomes higher. The results are consistent with our previous finding using the scaled delta-hedged gains: the options become relatively more expensive after the introduction of CDS trading.

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. To address this concern, we repeat tests in the Table 3 by control for volatility risk premium (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.) In the unreported results, the main results are consistent.

4. The impact of CDS on option bid-ask spread and demand pressure

4.1. Impact of CDS on bid-ask spread

In this subsection, we would like to test the impact of CDS trading on the bid ask spread. The relative bid ask spread is defined as the quoted bid ask spread divided by the average of the bid and ask prices at the beginning of the period, which is a measure of information asymmetry. We follow Grundy, Lim, and Verwijmeren (2012) and perform the following empirical models to test the impact of CDS trading on the relative bid ask spread:

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

where CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, otherwise 0. $Moneyness$ 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. $Stock\ Return$ is the current month stock return. And the time, firm and industry fixed effect are controlled.

Table 9 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%.

4.2. 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:

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

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 10 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 univariate comparison, option premium increase 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. These findings are not driven by firm fundamentals. The delta-hedged option returns, which are option prices adjusted by firm fundamentals and realized volatilities, 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 for the effect of CDS on option prices. The information story applies to both call and put options, probably even more so for put options. But we find the results concentrate on call options rather than put options, which is also inconsistent with the substitution story between CDS and put options. Consistent with the improved information quality hypothesis, we find option bid-ask spreads are lower after CDS trading. It is possible that the introduction of CDS enlarges the set of trading strategies insiders can follow. This can make it more difficult for market makers to interpret 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 dealers are exposed to more potential information disadvantage. Therefore, they may want to protect themselves by charging higher option premium while keeping bid-ask spreads narrow.

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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; C 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 beginning of the period. 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(BE) 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

Panel D: Number of CDS Introductions

Year	# of CDS Introductions	Year	# of CDS Introductions
1997	32	2004	61
1998	58	2005	49
1999	48	2006	24
2000	97	2007	12
2001	143	2008	10
2002	183	2009	2
2003	79	Total	798

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 (delta-hedged gain till maturity/stock price) 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. 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; C 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 w/o CDS	Set B w/ CDS	Set C w/CDS & after the first	B-A Diff	C-A Diff	Set A w/o CDS	Set B w/ CDS	Set C w/CDS & after the first	B-A Diff	C-A 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 option delta-hedged gain until maturity scaled by (Δ*S-C or P-Δ*S) 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(BE) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -1)}$ 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 beginning of the period. 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
CDS	-0.409***	-0.371***	-0.250***	-0.305***	-0.207***
	(-5.743)	(-5.291)	(-4.608)	(-4.807)	(-4.005)
Ln(ME)	0.637***	0.147***	0.0260	-0.387***	-0.528***
	(19.59)	(5.299)	(1.025)	(-11.00)	(-12.52)
VOL		-6.841***	-8.382***	-7.726***	-9.275***
		(-25.23)	(-35.44)	(-29.45)	(-39.24)
VOL_deviation		5.762***	6.218***	6.148***	6.604***
		(32.49)	(34.11)	(33.27)	(34.36)
Ln(BM)			-0.127***		-0.114***
			(-3.728)		(-3.384)
$Ret_{(-1,0)}$			-0.242		0.0735
			(-0.886)		(0.283)
$Ret_{(-12,-1)}$			0.464***		0.372***
			(5.954)		(4.968)
Ln(Illiquidity)				-0.342***	-0.363***
				(-8.322)	(-9.069)
(Option open interest / stock volume) *1000				-3.765***	-3.575***
				(-9.773)	(-10.71)
Option bid-ask spread				-2.807***	-2.613***
				(-14.42)	(-14.10)
Constant	-5.795***	1.228***	2.406***	4.211***	5.388***
	(-19.64)	(4.748)	(9.382)	(17.13)	(20.60)
Observations	265,350	265,347	228,794	265,346	228,794
R-squared	0.029	0.096	0.113	0.111	0.127

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 / (Δ^*S – C)	Gain till month-end / (Δ^*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)
$Ret_{(-12,-1)}$	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)
Constant	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
R-squared	0.127	0.152	0.126	0.135

Panel B: Delta-Hedged Put Option Returns

Dependent Variables	Gain till maturity (P – Δ*S)	Gain till month-end (P – Δ*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)
$Ret_{(-12,-1)}$	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)
Constant	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
R-squared	0.120	0.132	0.127	0.121

Table 5: Controlling for Endogeneity, Heckman Two-Stage Test

This table reports the monthly Fama-MacBeth regression coefficients of option delta-hedged gain until maturity scaled by (Δ^*S-C or P-Δ^*S) at the beginning of the period. $\widehat{CDS}$ is the predicted probability that CDS is introduced based on first stage regression as 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 VOLt-1 and IVt-1. Ln(BE) is the natural logarithm of the book-to-market ratio. Ret $_{(-1,\ 0)}$ is the stock return in the prior month. Ret $_{(-12,\ -1)}$ 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 beginning of the period. 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 5.

	Model 1	Model 2	Model 3	Model 4	Model 4
$\widehat{CDS}$	-31.84***	-35.68***	-23.90***	-22.33***	-14.17***
	(-7.155)	(-7.478)	(-6.712)	(-5.341)	(-4.187)
Ln(ME)	0.751***	0.182***	0.0621**	-0.583***	-0.618***
	(16.83)	(4.841)	(2.022)	(-10.40)	(-10.62)
VOL		-8.000***	-9.003***	-9.114***	-9.931***
		(-24.28)	(-29.48)	(-27.74)	(-32.31)
VOL_deviation		6.274***	6.504***	6.786***	6.917***
		(23.58)	(23.30)	(24.20)	(23.90)
Ln(BM)			-0.0134		0.00564
			(-0.341)		(0.147)
Ret $_{(-1,0)}$			-0.390		-0.0160
			(-1.151)		(-0.0490)
Ret $_{(-12,-1)}$			0.423***		0.342***
			(3.550)		(2.967)
Ln(Illiquidity)				-0.476***	-0.433***
				(-7.644)	(-7.278)
(Option open interest / stock volume) *1000				-3.949***	-3.650***
				(-7.949)	(-7.742)
Option bid-ask spread				-2.912***	-2.643***
				(-10.05)	(-10.25)
Constant	-6.588***	1.786***	2.737***	5.704***	6.195***
	(-17.85)	(6.164)	(9.387)	(17.94)	(18.35)
Observations	108,836	108,836	104,878	108,836	104,878
R-squared	0.037	0.106	0.123	0.124	0.139

Table 6: Placebo Test

This table reports the monthly Fama-MacBeth regression coefficients of option delta-hedged gain until maturity scaled by (Δ*S-C or P-Δ*S) at the beginning of the period. Pre-CDS is a dummy that equals to 1 if the CDS is introduced in 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(BE) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -1)}$ 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 beginning of the period. 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 10.

	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)
$Ret_{(-12,-1)}$			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)
Constant	-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
R-squared	0.031	0.097	0.113	0.112	0.127

Table 7: Event Study – Matching Results

This table 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. 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(BE) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -1)}$ 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 beginning of the period. 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. Regression for call option is reported in Panel A. Regression for put option is reported in Panel B.

Panel A: Delta-Hedged Call Option Returns (event study)

	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)
$Ret_{(-12,-1)}$			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)
Constant	-11.92***	-0.0739	0.456	0.0705	0.414
	(-4.777)	(-0.0283)	(0.151)	(0.0273)	(0.137)
Firm Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	10,371	10,371	9,958	10,371	9,958
R-squared	0.006	0.033	0.038	0.034	0.038

Panel B: Delta-Hedged Put Option Returns (event study)

	Model 6	Model 7	Model 8	Model 9	Model 10
CDS*After	-0.0304	-0.00348	0.0184	-0.0189	0.0415
	(-0.289)	(-0.0323)	(0.167)	(-0.176)	(0.378)
Ln(ME)	1.341***	0.587**	0.825***	0.404	1.011***
	(5.053)	(2.224)	(2.775)	(1.281)	(2.807)
VOL		-5.732***	-6.510***	-5.704***	-6.591***
		(-8.394)	(-9.316)	(-8.266)	(-9.265)
VOL_deviation		3.064***	3.537***	3.082***	3.479***
		(9.352)	(10.61)	(9.221)	(10.29)
Ln(BM)			-0.467**		-0.481**
			(-2.442)		(-2.502)
Ret $_{(-1,0)}$			-3.108***		-3.206***
			(-6.946)		(-6.994)
Ret $_{(-12,-1)}$			0.155		0.156
			(1.079)		(1.081)
Ln(Illiquidity)				-0.145	0.200
				(-0.843)	(1.121)
(Option open interest / stock volume) *1000				-1.727	-1.930
				(-1.257)	(-1.376)
Option bid-ask spread				-0.339	-0.261
				(-0.693)	(-0.535)
Constant	-12.10***	-2.908	-5.074**	-2.346	-5.091*
	(-5.320)	(-1.271)	(-1.984)	(-0.996)	(-1.916)
Firm Effect	Yes	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes	Yes
Observations	10,419	10,419	9,987	10,419	9,987
R-squared	0.008	0.030	0.046	0.031	0.046

Table 8: Implied Volatility and CDS Presence

This table reports the monthly Fama-MacBeth regression coefficients of Implied Volatility / Volatility 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(BE) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -1)}$ 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 beginning of the period. 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 6.

	Model 1	Model 2	Model 3	Model 4
CDS	0.0124***	0.0103***	0.0113***	0.00901***
	(3.928)	(3.593)	(3.796)	(3.152)
Ln(ME)	-0.0238***	-0.0265***	-0.0435***	-0.0525***
	(-15.20)	(-16.95)	(-19.81)	(-20.29)
Ln(BM)		-0.00419**		-0.00338*
		(-2.105)		(-1.723)
$Ret_{(-1,0)}$		-0.336***		-0.331***
		(-16.12)		(-16.01)
$Ret_{(-12,-1)}$		-0.0112**		-0.0143***
		(-2.434)		(-3.272)
Ln(Illiquidity)			-0.0223***	-0.0271***
			(-10.51)	(-11.00)
(Option open interest / stock volume) *1000			0.586***	0.568***
			(32.38)	(28.80)
Option bid-ask spread			0.0380***	0.00151
			(3.861)	(0.141)
Constant	1.329***	1.374***	1.301***	1.368***
	(92.73)	(92.86)	(93.62)	(102.0)
Observations	265,347	228,794	265,346	228,794
R-squared	0.018	0.060	0.040	0.083

Table 9: Option Bid-Ask Spread and CDS Presence

This table reports the monthly panel data regression coefficients of option bid ask spread at the beginning of the period. 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. 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 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. All volatility measures are annualized. 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. Stock Return 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. The sample period is from January 1996 to December 2012. Robust t-stat is reported in the brackets. Only Call option is reported in Table 7.

	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	6.12e-05	7.34e-05	4.24e-05	5.69e-05
	(1.089)	(1.285)	(0.302)	(0.357)
1/(Days to Maturity)	1.178***	1.177***	1.170***	1.168***
	(3.740)	(3.738)	(3.761)	(3.756)
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)
Log(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***
	(3.118)	(3.115)	(2.711)	(2.705)
VOL	-0.0151***	-0.0151***	-0.0128***	-0.0129***
	(-11.94)	(-11.96)	(-7.656)	(-7.659)
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)
Institutional Ownership	0.0582***	0.0582***	0.0511***	0.0511***
	(27.65)	(27.63)	(13.05)	(13.02)
Stock Return		0.00288		0.00341
		(1.210)		(0.569)
Constant	0.987***	0.986***	0.892***	0.890***
	(90.64)	(89.92)	(40.14)	(37.28)
Firm Effect	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes
Industry	No	No	Yes	Yes
Observations	253,808	253,808	253,808	253,808
R-squared	0.0859	0.0859	0.086	0.086

Table 10: 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 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 Ratio is defined as institutional holdings divided by the total number of shares outstanding. Stock Return 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. The sample period is from January 1996 to December 2012. Robust t-stat is reported in the brackets. Only Call option is reported in Table 8.

Dependent Variables	Model 1	Model 2	Model 3	Model 4
	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
	(6.627)	(-1.506)	(1.801)	(1.125)
Analyst Dispersion	-1.03e-05	-4.04e-05	-6.04e-05	-4.06e-05
	(-0.0877)	(-0.443)	(-0.504)	(-0.340)
Institutional Ownership	0.847***	-0.521***	0.474***	-0.676***
	(11.44)	(-9.752)	(7.831)	(-12.41)
Constant	1.930***	-8.859***	-4.264***	-0.747***
	(7.092)	(-41.43)	(-20.20)	(-4.061)
Firm Effect	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Time 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 (Δ^*S-C or P-Δ^*S) before and after the CDS is introduced.