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

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Abstract

While prior studies have shown pervasive impact of derivatives trading on underlying firms' securities, little is known about the interactions between different types of derivatives. We examine the impact of credit derivatives, represented by credit default swaps (CDS), on equity derivatives. We show that options on the stocks of CDS-referenced firms are more expensive (i.e., lower delta-hedged option returns). The CDS effect on options is robust to different measurement and sample period and is stronger after the 2009 CDS Big Bang when the funding cost for CDS dealers increased. This result is consistent with the view that option premiums are influenced by dealers' intermediation capacity, which is adversely impacted by CDS trading.

Keywords: CDS, delta-hedged option return, demand-based option pricing, financial intermediation capacity

JEL Classifications: G13, G14

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While prior studies have shown pervasive impact of derivatives trading on underlying firms' securities, little is known about the interactions between different types of derivatives. We examine the impact of credit derivatives, represented by credit default swaps (CDS), on equity derivatives. We show that options on the stocks of CDS-referenced firms are more expensive (i.e., lower delta-hedged option returns). The CDS effect on options is robust to different measurement and sample period and is stronger after the 2009 CDS Big Bang when the funding cost for CDS dealers increased. This result is consistent with the view that option premiums are influenced by dealers' intermediation capacity, which is adversely impacted by CDS trading.

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1. Introduction

The impact of derivatives trading on other related assets has been an important issue since the exchange trading of equity options began in 1973. Early studies have shown the impact of futures and option trading on underlying asset markets.[1] More recently, a burgeoning literature explores the impact of credit default swap (CDS) trading on markets for various assets.[2] CDS are an important innovation that increases investors' ability to both hedge and take exposure to credit risk, but also provide a channel through which more information about firm fundamentals and risks can be impounded into asset prices. As a result, they have been shown to impact the financial structure of the firm (Saretto and Tookes (2013)), the market quality of other assets (Das, Kalimipalli, and Nayak (2014), Boehmer, Chava, and Tookes (2015)), bankruptcy risk (Subrahmanyam, Tang, and Wang, 2014), and debt restructuring (Danis (2017). We use CDS introduction and equity option data to show that options on the stocks of CDS-referenced firms are more expensive, that is they have lower delta-hedged returns. We also present evidence that the results are not driven by the endogeneity of CDS introductions. These results are consistent with the predictions of the literature on financial intermediary asset pricing and the demand-based option pricing theory of Gârleanu, Pedersen, and Poteshman (2009).

The conceptual framework that underlies our empirical analysis is provided by the literature on financial intermediary asset pricing, which recognizes that large financial intermediaries play a central role in the financial markets and are likely to be the price setting agents. The idea that financial intermediary's risk bearing capacity can impact the pricing of financial contracts dates back at least to Froot, Scharfstein, and Stein (1993). More recently, Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), Gromb and Vayanos (2010), Duffie (2010), Duffie and Strulovici (2012), He and Krishnamurthy (2012, 2013), Adrian, Etula, and Muir (2014), and He, Kelley, and Manela (2017) present models in which the limited risk bearing capacity of intermediaries affects the risk premia on and the pricing of financial assets.[3] As pointed out by He, Kelly, and Manela (2017, p. 1), "financial intermediaries are in the advantageous position of trading

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[1] Ni, Pearson, and Poteshman (2005) and Ni, Pearson, Poteshman, and White (2018) briefly survey this literature.

[2] CDS contracts are traded over the counter. The CDS market has grown rapidly in the last two decades with multi-trillion dollar contracts outstanding. The market reached $62 trillion in notional value in 2007 and the market size is about $10 trillion as of mid-2017. Tett (2009) documents the invention and growth of the CDS market. Augustin, Subrahmanyam, Tang, and Wang (2016) review the studies on CDS. corporate investment (Bolton and Oehmke (2011), Danis and Gamba (2018)), cash holdings (Subrahmanyam, Tang, and Wang, 2017), innovation (Chang, Chen, Wang, Zhang, and Zhang, 2018), and firm value (Narayanan and Uzmanoglu, 2018). Ashcroft and Santos (2009) also investigate whether CDS impact credit spreads.

[3] He and Krishnamurthy (2018) provide a recent survey of the literature. Gromb and Vayanos (2010) is an earlier survey.

almost all asset classes, anytime and everywhere… and that their marginal value of wealth is a plausible pricing kernel for a broad cross-section of securities." The largest and most important of these financial intermediaries are central to many markets: they are dealers in credit default swaps (CDS) and other OTC derivatives markets, including the OTC options markets; they make markets in corporate bonds, they are active in issuing and hedging structured notes that include embedded options on individual equities and stock indexes, and they participate in the markets for exchange traded options.

A developing empirical literature provides evidence about the importance of this channel. For example, He, Kelly, and Manela (2017) show that aggregate capital positions affect the prices of many financial instruments, including those of index options. Turning to the impact of CDS, Siriwardane (2018) shows that a dealer's capital position affects CDS pricing as CDS consume substantial capital.[4] Chen, Joslin, and Ni (2017) find that the pricing of index options is affected by dealer's capital capacity.

In addition, we draw on the related demand-based option pricing theory due to Gârleanu, Pedersen, and Poteshman (2009). In that theory, financial intermediaries accommodate the demands of end users of derivatives, and optimally hedge the resulting exposures by trading the underlying asset, for example the underlying stock. Derivatives' equilibrium prices are determined by the risks that cannot be hedged by a position in the underlying asset, and end user demand for one derivative (e.g., a call with strike K_1) impacts the equilibrium price of another derivative with correlated risks (e.g, a call or put with strike K_2). A key implication of the theory is that the sensitivity of the price of one security or financial instrument to demand pressure in another is proportional to the covariance of their unhedgeable risks. While the focus of the Gârleanu, Pedersen, and Poteshman (2009) is the pricing of stock options and how demand for one option series may impact the pricing of other series, the theory also applies to other non-option derivatives. In fact, the Gârleanu, Pedersen, and Poteshman (2009) theory implies that end user demand for one derivative instrument will impact the pricing of all other derivatives with correlated unhedgeable risks.

The linear or "delta" exposures of both options and CDS can easily be hedged with stock. For both kinds of instruments, the important unhedgeable risks are the risk of sudden large changes in stock prices, that is "jumps" in stock prices, and changes in volatility. As we explain in Section 2

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

below, the exposures of delta-hedged positions in options and CDS are qualitatively similar. As a result, a straightforward and immediate implication of the Gârleanu, Pedersen, and Poteshman (2009) demand-based option pricing theory is that end-user demand for CDS (options) will impact financial institutions' pricing of options (CDS). The direction of the impact, for example whether end-user demand for CDS increases or decreases options prices, depends upon whether end users buy or sell protection via CDS. It is known in the literature that CDS dealers were net sellers of protection (and therefore CDS end users were net buyers) during our sample period (Choi and Sachar (2013), Siriwadne (2018). As a result, dealers' CDS positions provided exposures to unhedgeable risks similar to the exposures provided by written options positions, and the dealers would experience losses of if stock prices jumped or volatilities increased. The demand-based option pricing theory then implies that the prices at which the financial intermediaries would be willing to trade options would increase, that is they would be willing to pay more the buy options and would require higher prices to sell options.

This leads us to predict that the inception of CDS trading on a reference entity will be associated with higher prices for options on the reference entity's stock. The demand-based option pricing theory implies that the impacts on option prices should be greatest for at-the-money options, as these are the options with the greatest exposure to the risks of stock price "jumps" and changes in volatility.[5]

A second channel through which CDS trading can impact the pricing of options is that CDS may provide a substitute for certain options positions. CDS closely resemble deep out-of-the-money put options (JP Morgan 2007, Carr and Wu 2011).[6] Therefore, investors' demands for CDS might influence the pricing of out-of-the-money put options. Then, demand for put options can get passed through to calls through the put-call parity relation and demand in one option series gets passed through to others through the impact on dealers' pricing kernels as in Garleneau, Pedersen, and Poteshman (2009). Consequently, the availability of CDS can impact the prices of all options based on the same underlying firm. This channel does not involve constraints on financial intermediaries' financial capacity. It predicts that options become cheaper after CDS trading as demand for some positions migrates to the CDS market.

[5] In the terminology of option pricing, the gammas and vegas of at-the-money options are larger than those of in- and out-of-the-money options.

[6] The idea that CDS and out-of-the-money put options are substitutes has been in the practitioner literature since at least 2007 (JP Morgan 2007), and appears in the CBOE Reference Guide: "Deep Out-Of-the-Money Put Options: A credit derivative market alternative," March 2009. http://www.cboe.com/institutional/pdf/doom.pdf.

We empirically test hypotheses that the inception of CDS trading on a firm affects the pricing of equity options of the same firm. Analyzing CDS introduction and the equity option data from 1996 to 2012, we first show that options with associated CDS are, on average, relatively more expensive than options without associated CDS, as indicated by lower delta-hedged option returns constructed by Bakshi and Kapadia (2003a).[7] This finding of higher premia for options associated with CDS is prevalent for both call and put options. In addition to being statistically significant, the negative impact of CDS trading on delta-hedged option returns is economically meaningful. Delta-hedged option returns by construction are insensitive to movements in underlying stock prices. Therefore, our result is distinct from prior finding that CDS trading can directly affect an underlying firm's fundamentals including its default risk (e.g., Subrahmanyam, Tang, and Wang (2014)).

The CDS effect on option prices are prevalent: it is significant for both calls and puts and for alternative measures of option pricing. We also examine other outcome measures and find that CDS trading affects volatility risk premium. This is also consistent with CDS trading affecting option prices through a different channel than through firm fundamentals. We also show that our findings are robust to alternative measures of option prices (e.g., the variance risk premium) and cannot be explained by various existing determinants of option returns.

We also conduct a comprehensive analysis to address the concerns about the endogeneity of CDS introduction. The evidence is consistent with a causal interpretation of CDS effect on option prices. We conduct a placebo test and the results suggest that our findings are indeed due to the presence of CDS, rather than by potential confounding effects before CDS were introduced. Moreover, we also formally address the concern that the CDS introduction is endogenous. Following Saretto and Tookes (2013) and other prior studies, we account for the selection of firms into CDS trading using multiple approaches. Our findings obtained by using propensity score matching and the Heckman selection model are consistent with our baseline results, suggesting that the CDS effects on option prices are likely causal. Furthermore, to control for pre-trends in the data, we conduct a difference-in-difference analysis around the CDS introduction with a matched sample and continue to find significant CDS effect on option prices.

Our finding of a positive impact of CDS trading on option prices is consistent with the the implications of the theory of intermediary asset pricing (e.g., He, Kelly, and Manela (2017)). We

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

further explore the implications of this channel, we use measures of financial intermediary constraints constructed by Adrian, Etula, and Muir (2014) and He, Kelly, and Manela (2017) to show that the effect of CDS introduction on option prices is stronger when financial intermediaries' risk-bearing capacity is low. This result is also consistent with the findings in Chen, Joslin, and Ni (2017), who show that options are more expensive when intermediary constraints are tightened.

However, a major event occurred after the 2008 credit crisis. Specifically, the International Swaps and Derivatives Association (ISDA) changed the CDS trading convention by using upfront fees and fixed coupons in April 2009, the so-called "CDS Big Bang" (see Danis (2017)). As a result, the funding requirement for most CDS transactions increased after the Big Bang. Indeed, we find that the CDS effect on option prices is stronger after the Big Bang. This finding provides additional evidence consistent with the importance of financial intermediaries' risk-bearing capacity.

We find that the CDS effects attenuate over time after the initial introduction period. This finding suggests that dealers adjust their strategy and adapt to the new environment of making market for multiple derivatives (Mitchell, Pedersen, Pulvino (2007), Duffie (2010)). This is also consistent with limits to financial intermediaries; risk bearing capacity.

Our results are not consistent with the substitution hypothesis.

Our findings also add to growing literature on the real effects of CDS trading (e.g., Danis and Gamba (2018)). Closed related studies include Das, Kalimipalli, and Nayak (2014) on the effect of CDS trading on bond market quality and Boehmer, Chava, and Tookes (2015) on the effect of CDS trading on equity market quality. We propose a new mechanism of financial intermediation capacity constraint to explain the effect of CDS on options. While Carr and Wu (2011) consider CDS and put options in a joint pricing framework, they do not consider the possibility that CDS trading itself may affect option prices, which is the focus of our paper.

Our findings help improve the understanding of option pricing, especially the order flow or inventory effects on option pricing (e.g., Bollen and Whaley (2004), Muravyev (2016)), by adding new evidence on the cross-sectional determinants of delta-hedged option returns (e.g., Goyal and Saretto (2009)).[8] Cao and Han (2013) show that options are more expensive when stock

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

idiosyncratic volatility is higher. Intuitively, it is more difficult for dealers to make market during volatile markets. In this sense, our finding of expensive options associated with CDS trading due to dealer capacity constraint is consistent with theirs.

The rest of our paper is organized as follows. In Section 2, we discuss the background and hypotheses. In Section 3, we describe our data and sample construction. We report our baseline results and address the endogeneity concerns in Section 4. Section 5 presents the evidence about how broker-dealers' capacity affects the impact of CDS on option pricing. Section 6 briefly concludes.

2. Hypotheses

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

As indicated above, a developing literature on financial intermediary asset pricing recognizes that large financial intermediaries play a central role in the financial markets and are likely to be the price setting agents. For example, Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), Gromb and Vayanos (2010), Duffie (2010), Duffie and Strulovici (2012), He and Krishnamurthy (2012, 2013), Adrian, Etula, and Muir (2014), and He, Kelley, and Manela (2017) present models in which the limited capacity of intermediaries affects the risk premia on and the pricing of financial assets.[10] As pointed out by He, Kelly, and Manela (2017, p. 1), "financial intermediaries are in the advantageous position of trading almost all asset classes, anytime and everywhere… and that their marginal value of wealth is a plausible pricing kernel for a broad cross-section of securities." The largest and most central of these financial intermediaries are central to many markets: they are dealers in credit default swaps (CDS) and other OTC derivatives markets, including the OTC options markets; they make markets in corporate bonds, they are active in issuing and hedging structured notes that include embedded options on individual equities and stock indexes, and they participate in the markets for exchange traded options. A growing empirical literature including He and Krishnamurthy (2013), Adrian, Tula, and Muir (2014), Chen, Joslin, and

[9] Examples include Citadel, Graham Capital, Cornwall Capital, Napier Park, and BlueMountain.

[10] He and Krishnamurthy (2018) provide a recent survey of the literature. Gromb and Vayanos (2010) is an earlier survey.

Ni (2017), He, Kelly, and Manela (2017), and Siriwardane (2018) provides evidence that limits on financial intermediaries' capital and on risk-bearing capacity significantly impact the prices of financial instruments.

These limits can be particularly important in the case of CDS. In some cases, financial institutions have found the derivatives business too costly and exited the market. [11]

These limits to financial intermediaries' risk-bearing capacity can be a mechanism for CDS trading to impact options trading. In fact, the closely related demand-based option pricing theory provides a particular mechanism. In that theory, financial intermediaries accommodate the demands of end users of derivatives, and optimally hedge the resulting exposures using the underlying asset, for example the underlying stock. Derivatives' equilibrium prices are determined by the risks that cannot be hedged by a position in the underlying asset, and end user demand for one derivative (e.g., a call with strike K_1) can impact the equilibrium price of another derivative with correlated risks (e.g, a call with strike K_2). In particular, a key result is that "[t]he sensitivity of the price of security *i* to demand pressure in security *j* is proportional to the covariance of their unhedgeable risks" (Gârleanu, Pedersen, and Poteshman 2009, Theorem 2 on p. 4268). For options, the risk of sudden large changes in stock prices, i.e. "jumps," is an important unhedgeable risk. This risk is large when the curvature of the option value function is large, which is the case for option that are at- or near-the-money.[12] Gârleanu, Pedersen, and Poteshman (2009) present evidence that jump risk is the most important unhedgeable risk, and that it has important impacts on the prices of at and near-the-money options[13]. This explains our focus on close to at-the-money options in the empirical analysis below.

While the focus of the Gârleanu, Pedersen, and Poteshman (2009) is the pricing of stock options and how demand for one option series may impact the pricing of other series, as they point out the theory also applies to other non-option derivatives (p. 4262). In fact, an important implication of the Gârleanu, Pedersen, and Poteshman (2009) theory is that end user demand for one derivative instrument will impact the pricing of all other derivatives with correlated unhedgeable risks. For example, the risks of a CDS on a reference entity are similar to the risks of options based on the stock of the reference entity.

[11] For example, Deutsche Bank exited the market for single-name CDS in the third quarter of 2014, and the CME exited the CDS clearing business in September 2017.

[12] See the analysis of jump risk on p. 4272 Gârleanu, Pedersen, and Poteshman (2009).

[13] See Gârleanu, Pedersen, and Poteshman (2009) Table 2 and Figure 3, and the associated discussion on pp. 4286-4289.

To illustrate this, we consider a simple structural credit risk model, the Black and Cox (1976) model. In that model a defaultable bond can be interpreted as a default-free bond and a written barrier put option on the underlying firm asset value, and a CDS with tenor equal to the time-to-maturity of the defaultable bond is equivalent to a levered position in the defaultable bond. The stock value is the firm's asset value less the value of the defaultable bond. An option on the firm's stock is a compound option on the firm's asset value, and is straightforward to value. Figures 1 and 2 illustrate that selling protection via CDS and writing options create similar exposures to the underlying asset value. Figure 1 shows the market value of a five-year CDS as a function of the underlying firm asset value V, where the CDS is used to sell protection and the position is delta-hedged using the stock so that at the current asset value $V_0 = 165$ the derivative of the market value of the CDS with respect to the underlying firm asset value is zero. Figure 2 shows the market value of a similarly delta-hedged written position in a six-month at-the-money call option on the firm's stock. The two panels illustrate that the exposure to jump risk created by selling protection via a CDS is similar to the exposure created by writing options in that both positions suffer losses if there is a jump in the underlying asset value. The two positions also have similar exposures to changes in volatility. Given the similarities in the exposures of the two positions, the Gârleanu, Pedersen, and Poteshman (2009) theory implies that the CDS positions of the large financial intermediaries who play a crucial role in price setting will impact the equilibrium prices of options on the reference entities stocks, and vice-versa.

Whether the financial intermediaries CDS positions increase or decrease equilibrium option prices depends on whether they write or buy credit protection using CDS. The evidence in the literature is that CDS dealers were net sellers of protection. Figure 1 in Sirawradane (2018) shows that the leading CDS dealers were net protection sellers of single name CDS during his sample period of 2010-2017. Figure 6.6 of Choi and Shachar (2013) shows that dealers were net sellers during their sample period of January 2007 through June 2009. These two sample periods together cover most of our sample period, and cover the periods of the vast majority of CDS inceptions in our sample.[14] In the case in which the large financial intermediaries sell protection via CDS and end users buy protection, demand-based option pricing theory implies that changes in end-user demand

[14] Consistent with the results for the aggregate market in Choi and Shachar (2013),, Figure 2 of Shachar (2012) shows that dealers were selling protection on the sample of 35 financial firms used in that paper throughout that paper's sample period of January 2007 through June 2009.

for CDS, for example following CDS inception, will increase option prices. The effect is predicted to be particularly large for at- and near-the-money options.

This leads to our main hypothesis that CDS inceptions cause increases in option prices:

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

A second channel through which CDS trading can impact the pricing of options is that CDS may provide a substitute for certain options positions for either speculative or hedging purposes. CDS closely resemble deep out-of-the-money put options (JP Morgan 2007, Carr and Wu 2011).[15] Therefore, investors' demands for CDS might influence the pricing of out-of-the-money put options. Then, demand for put options can get passed through to calls through the put-call parity relation and demand in one option series gets passed through to others through the impact on dealers' pricing kernels as in Garleneau, Pedersen, and Poteshman (2009). Consequently, the availability of CDS can impact the prices of all options based on the same underlying firm.

CDS and equity options on the same underlying firms are sometimes substitutes in terms of achieving users' trading or hedging purposes. When the CDS of a firm become expensive or difficult to trade, traders may look to equity options as a substitute.[16] The reverse can also be said: traders will consider options when other instruments such as CDS are not readily available.

This substitution channel predicts that options become cheaper after CDS trading as demand for some positions migrates to the CDS market.

> **Hypothesis 2 (Substitution)**: Options become less expensive when underlying firms also have CDS contracts referencing their debt for put options.

Derivatives dealers or other financial institutions may use CDS to hedge and offset their exposures from option positions. In such cases, CDS would attenuate rather than worsen capacity constraints, and we should see the opposite. However, the evidence in Choi and Sachar (2011) and Siriwadne (2018) is that CDS dealers are net sellers of protection, suggesting that this mechanism cannot explain our results.

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[15] The idea that CDS and out-of-the-money put options are substitutes has been in the practitioner literature since at least 2007 (JP Morgan 2007), and appears in the CBOE Reference Guide: "Deep Out-Of-the-Money Put Options: A credit derivative market alternative," March 2009. http://www.cboe.com/institutional/pdf/doom.pdf.

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

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

The 2009 CDS Big Bang provides a quasi-natural experiment to further test this hypothesis, as greater capital requirements were imposed on less standard CDS contracts after the CDS Big Bang.

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

3. Data and Measures

3.1. Data and sample coverage

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

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

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

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

In our merged dataset, there are 265,369 option-month observations for delta-hedged call returns and 247,632 observations for delta-hedged put returns, respectively. Table 1 shows that the average moneyness of the chosen options is one, with a small standard deviation of 0.05. The time to maturity averages 50 days, with a small standard deviation of only 2 days. These relatively short-term options are actively traded, have a relatively smaller bid-ask spread, and provide more reliable pricing information. We utilize this set of option data to study how option returns are affected by the presence of CDS.

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

[Insert Table 1 about here]

3.2. Delta-hedged option returns

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

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

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

for which C_t is the call option price, $\Delta_t = \partial C_t / \partial S_t$ is the delta of the call option, and r is the risk-free rate. The empirical analysis uses a discretized version of the above equation. Specifically, consider a portfolio of a call option that is hedged discretely *N* times over a period [t, , $t+\tau$], where the hedge is rebalanced at each of the dates t_n (where we define $t_0 = t, t_N = t+\tau$).

The discrete delta-hedged call option gain is:

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

for which Δ_{C,t_n} is the delta of the call option on date t_n, r_{t_n} is the annualized risk-free rate on date t_n, and α_n is the number of calendar days between t_n and t_{n+1}. The definition for the delta-hedged

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

put option gain is the same as (2), except that put option price and delta replace call option price and delta, respectively.

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

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

Panel C of Table 1 reports the summary statistics for stock-level variables. The underlying stocks have an average annualized volatility of 0.478, and the VOL deviation ($Ln(VOL/IV)$) is around −0.10, which shows that, on average, the implied volatility is greater than the realized volatility. The average natural logarithm of the Amihud (2002) illiquidity measure is around −6.6, and the average natural logarithm of the market capitalization is 7.4.

4. The Impact of CDS on the Option Premium

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

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

difference-in-difference analyses (Section 4.5) to address the issue of selection bias and possible endogeneity of CDS trading.

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

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

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

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

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

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

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

[Insert Table 2 about here]

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

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

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

In appendix Table A3, we repeat the baseline regressions using panel data regression with fixed effects, and the empirical findings are consistent with Table 2 using alternative methodology. To further study the time varying CDSs' impacts on option pricing, we divide the sample periods into three sub-periods: January 1996 to December 2002, January 2003 to December 2006, January 2007 to December 2012. Table A4 shows that the CDSs' impacts on delta-hedged option returns are all significant in three different sub-periods, which provides evidence that the effects are quite persistent over time.

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

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

4.2. Alternative outcome variables

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

[Insert Table 3 about here]

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

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

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

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

[Insert Table 4 about here]

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

4.3. Addressing endogeneity concerns

CDS trading may be initiated by financial institutions for particular reasons. In this subsection we use multiple approaches to address the endogeneity concerns on the selection of firms into CDS trading.

4.3.1. Placebo test

In our baseline regressions and robustness checks sections, we have already included many control variables following the literature. However, one could still argue that our findings might be caused by unobservable ex-ante heterogeneity before the introduction of associated CDS. To further address this concern and capture the causal effect of CDS introduction, we run a placebo test in this subsection. Specifically, we define a new variable, Pre_CDS, which equals 1 in a given month, if the underlying stock introduced CDS within the next 36 months, and 0 otherwise. We re-run the Fama-MacBeth Regression including the new variable Pre_CDS. If the previous results are driven by ex-ante heterogeneity before the introduction of CDS, then we would expect the coefficient estimates of $Pre_CDS$to be significant.

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

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

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

[Insert Table 5 about here]

4.3.2. Heckman's two-stage regressions

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

Specifically, we keep the data from 1996 until the CDS introduction month and all other observations for non-CDS firms, to estimate the inverse mills ratio of the introduction of CDS. We apply the Probit regression with the following settings: the dependent variable equals one after the CDS trading starts, and zero otherwise. The control variables are the same as those in Subrahmanyam et al. (2014). We also control for industry effect and time effects. The results suggest that large firms, firms with high leverage, high tangibility, or high credit quality are more likely to have corresponding CDS.

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

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

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

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

[Insert Table 6 about here]

4.3.3. Difference-in-difference (DID) tests

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

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

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

[Insert Table 7 about here]

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

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

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

5.1. The role of broker-dealers' capacity

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

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

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

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

In Columns (1) and (2) of Table 8, we report the monthly Fama-MacBeth regression coefficients in the regressions explaining the call option's delta-hedged return (i.e., delta hedged gain till maturity scaled by $(\Delta * S - C)$ at the beginning of the period) for $High$ dealer's capacity periods and Low dealer's capacity periods, respectively. The difference between the two coefficients of CDS_{trades} is 0.207, with a *t*-statistic of 2.151 which is significant at the 5% significant level. This evidence indicates that the delta-hedged option returns are even more negative during the Low dealer's capacity period. In other words, though the options are, on average, more expensive for stocks with associated CDS in all periods, the impact also depends on a dealer's capacity. When the leverage factor becomes higher (i.e., a broker-dealer's leverage becomes greater, and a dealer's capacity is lower), equity options are much more expensive for stocks with associated CDS. This finding is consistent with our hypothesis that option dealers charge a higher option premium due to limited intermediaries' capacity. We also conduct the robustness check using the intermediary capital risk factor (He et al. (2017)) as the alternative measure of a dealer's capacity, and we find evidence (Columns (3) and (4) in Table 8) that supports the limited intermediaries capacity hypothesis.[24]

[Insert Table 8 about here]

5.2. Time decay in CDS effect

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

[24] We also obtain consistent results when using index option implied funding illiquidity (Golez, Jackwerth, and Slavutskaya (2018)) as the alternative measure of a dealer's capacity.

Duffie (2009) argues that financial institutions may face frictions in allocating capital efficiently. Consequently, such "slow-moving capital" can cause the CDS introduction effect on option prices. In this subsection we examine the CDS trading effect over time.

One might further argue that the "crowding-out" channel due to dealer's capacity, if it exists, should only emerge as a short-run phenomenon, and vanish in the long run when market players fully anticipate it and adjust accordingly. To verify whether such an effect decreases as time goes by, we study the impact of CDS after three or five years following the inception of CDS, respectively. Table 9 shows that the impact of CDS on option returns indeed decays over time. After three years of CDS inception, the coefficient of CDS presence drops to -0.111, as shown in Model 2. The number further decreases to -0.082 after five years of CDS inception.

[Insert Table 9 about here]

5.3. The "CDS Big Bang" as shock to dealing funding

The ISDA increased the upfront funding requirement for trading CDS in April 2009. Several other trading convention changes were also implemented. This is commonly referred as the "CDS Big Bang" (see Danis (2017)). The changes resulted in a significant increase in the initial funding requirements of trading single-name CDS contracts after the "CDS Big Bang".

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

[Insert Table 10 about here]

In Table 10, we present the empirical results of option-month panel regressions for call options, based on the "CDS Big Bang" in the CDS market as a natural experiment (see e.g., Wang et al. (2017)). We examine whether the "CDS Big Bang" in the CDS market has an influence on the CDS's impact on option pricing. The coefficients on the interaction term (the Big Bang dummy* CDS_{trades}) are all negatively significant, which confirms our findings in Table 8 and supports the limited intermediary capacity hypothesis.

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

6. Conclusion

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

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

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Appendix: Variable Definitions

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

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

Figure 1
Profit or loss on a 5-year CDS delta-hedged with stock as a function of the firm asset value V. The CDS value is computed using the Black-Cox (1976) model of the value of a defaultable bond, and then exploiting the relation between the bond price and the CDS. The CDS is then delta-hedged using the stock, and the position in the risk-free asset is chosen so that the net value of the position of CDS, stock, and risk-free asset is zero at the assumed current asset value $V_0 = 165$. Firm asset value volatility is $\sigma = 0.30$, the payout rate is $a = 0.04$, the interest rate is $r = 0.02$, the growth rate of the default boundary is $\gamma = 0.02$, the face value of the bond is $P = 100$, and the initial value of the default boundary is $C = 80$. Using these parameters at the assumed current asset value of $V_0 = 165$ the ratio of the market value of the debt to firm value is 0.5 and the credit spread on the debt is 0.01837.

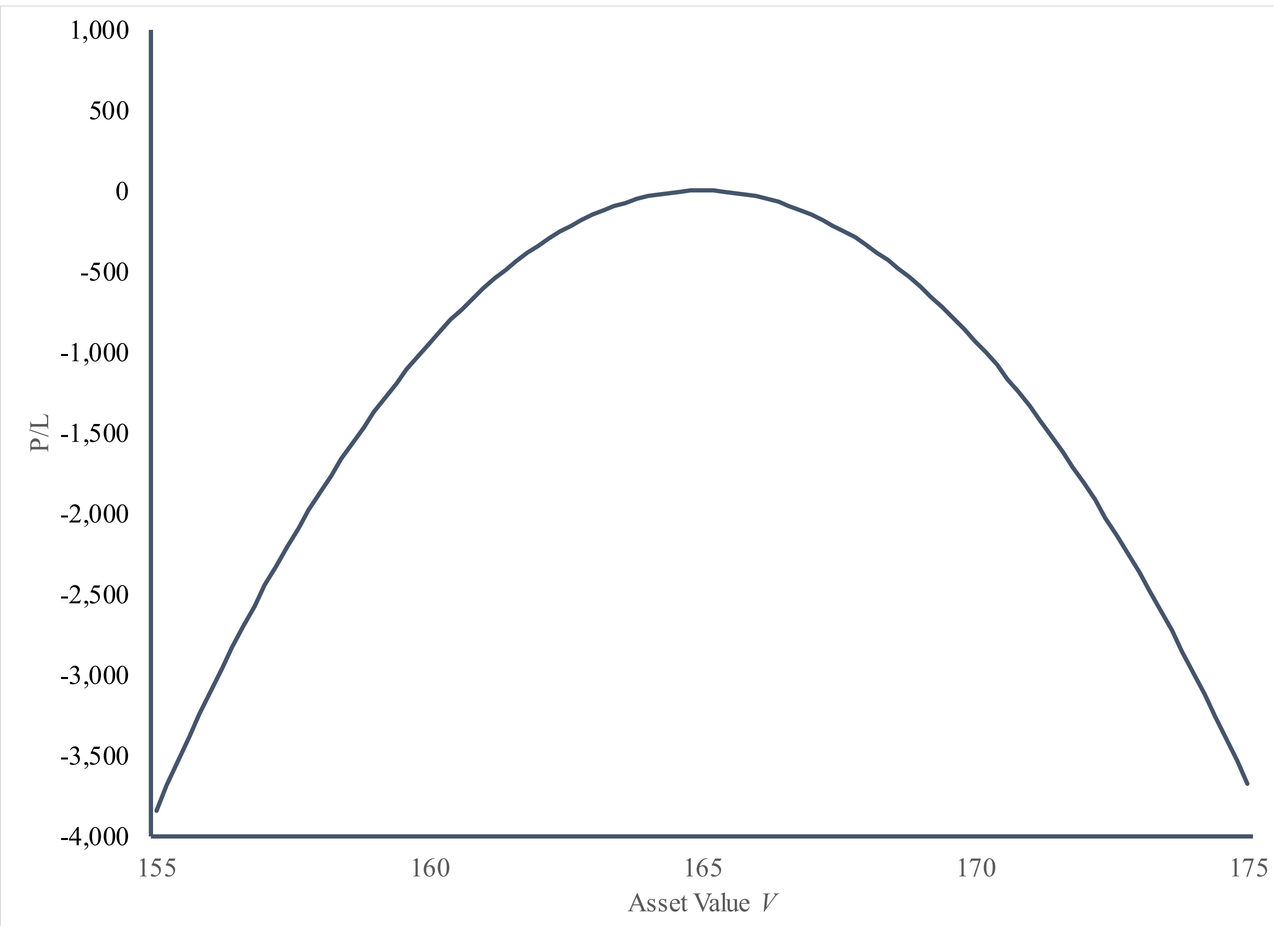

Figure 2
Profit or loss on a 6-month written call option delta-hedged with stock as a function of the stock price *S*. The option value is computed using the Black-Scholes-Merton formula. The option is then delta-hedged using the stock, and the position in the risk-free asset is chosen so that the net value of the position of CDS, stock, and risk-free asset is zero at the assumed current stock price of $S_0 = 165$. The stock volatility is $\sigma = 0.30$, the dividend yield is $q = 0.02$, the interest rate is $r = 0.02$, and the strike price of call is $K = 165$.

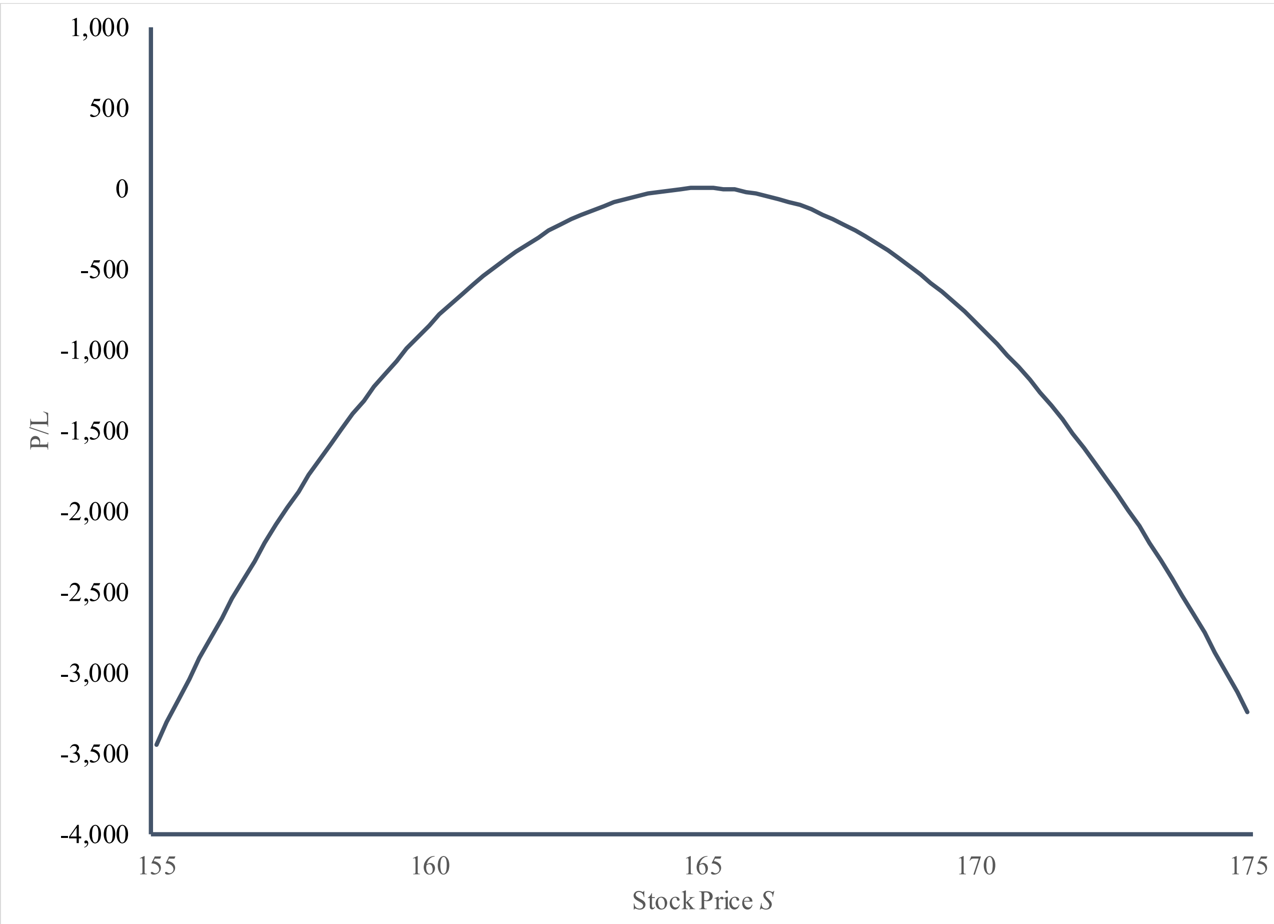

Table 1: Summary Statistics

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

Table 1—*Continued*

Panel A: Call Options

		All (265,369 obs)				
		Mean	StDev	Q1	Median	Q3
Delta-hedged gain till maturity / (Δ·S – C)	(%)	-1.172	7.778	-3.905	-1.315	0.932
Delta-hedged gain till month-end / (Δ·S – C)	(%)	-0.876	4.969	-2.809	-0.967	0.757
Days to maturity		50	2	50	50	51
Moneyness = S/K	(%)	100.532	4.930	97.543	100.171	103.130
Option bid-ask spread		0.215	0.181	0.094	0.158	0.275
(Option open interest / stock volume) ×1000		0.031	0.111	0.001	0.005	0.024

Panel B: Put Options

		All (247,632obs)				
		Mean	StDev	Q1	Median	Q3
Delta-hedged gain till maturity / (P - Δ·S)	(%)	-0.864	7.187	-3.461	-1.219	0.993
Delta-hedged gain till month-end / (P - Δ·S)	(%)	-0.484	4.466	-2.433	-0.805	0.871
Days to maturity		50	2	50	50	51
Moneyness = S/K	(%)	99.822	4.703	97.083	99.775	102.467
Option bid-ask spread		0.212	0.177	0.094	0.157	0.271
(Option open interest / stock volume) ×1000		0.020	0.095	0.000	0.003	0.013

Panel C: Stock Level Variables

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

Table 2: Delta-Hedged Option Returns and CDS Presence

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

	Model 1	Model 2	Model 3
$\mathbf{CDS_{trades}}$	-0.168***	-0.207***	-0.133***
	(-4.08)	(-4.00)	(-2.96)
Ln(ME)	-0.515***	-0.528***	-0.489***
	(-13.36)	(-12.53)	(-12.22)
VOL	-7.914***	-9.275***	-6.599***
	(-39.72)	(-39.24)	(-29.98)
VOL_deviation	5.825***	6.605***	5.062***
	(35.99)	(34.36)	(33.98)
Ln(BM)	-0.129***	-0.114***	-0.154***
	(-4.29)	(-3.380)	(-5.61)
$Ret_{(-1,0)}$	-0.380*	0.0732	-0.873***
	(-1.70)	(0.282)	(-4.19)
$Ret_{(-12,-2)}$	0.297***	0.372***	0.252***
	(5.31)	(4.962)	(5.49)
Ln(Illiquidity)	-0.371***	-0.363***	-0.384***
	(-9.49)	(-9.073)	(-9.51)
(Option open interest / stock volume) ×1000	-3.294***	-3.566***	-3.076***
	(-13.15)	(-10.66)	(-7.87)
Option bid-ask spread	-1.765***	-2.613***	-0.589**
	(-12.97)	(-14.10)	(-2.57)
Intercept	4.539***	5.388***	3.420***
	(19.84)	(20.60)	(15.62)
Observations	442,793	228,787	214,006
Average adj. R^2	0.106	0.127	0.120

Table 3: Alternative Measures of Delta-Hedged Option Returns

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

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

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

Table 3—*Continued*

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

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

Table 4: Individual Volatility Risk Premium and CDS Presence

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

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

Table 5: Placebo Test

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

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

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

This table reports the monthly Fama-MacBeth regression coefficients of call option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) at the beginning of the period. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. IMR is the inverse mills ratio based on the first stage regression as in Subrahmanyam et al. (2014). Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOL_{t-1} and IV_{t-1}. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -2)}$ is the cumulative stock return from the prior 2nd through 12th months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. The sample period is from January 1996 to December 2012. Robust Newey-West (1987) t-statistics are reported in brackets. First stage regression (Table A5) is reported in the Appendix.

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

Table 7: Difference-In-Difference Tests

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

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

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

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

	(1)	(2)	(3)	(4)
	High AEM Dealer Capacity	**Low** AEM Dealer Capacity	**High** HKM Dealer Capacity	**Low** HKM Dealer Capacity
$\mathbf{CDS_{trades}}$	-0.121**	-0.328***	-0.0646	-0.350***
	(-2.09)	(-4.27)	(-1.01)	(-5.30)
Ln(ME)	-0.510***	-0.554***	-0.504***	-0.552***
	(-12.13)	(-8.41)	(-12.32)	(-9.032)
VOL	-9.839***	-8.485***	-9.495***	-9.055***
	(-31.89)	(-21.54)	(-29.78)	(-23.90)
VOL_deviation	6.690***	6.485***	6.273***	6.937***
	(23.08)	(22.53)	(24.99)	(21.21)
Ln(BM)	-0.0636**	-0.185***	-0.0915***	-0.137***
	(-2.00)	(-3.54)	(-2.46)	(-3.10)
$Ret_{(-1,0)}$	0.631**	-0.707	0.883***	-0.736*
	(2.05)	(-1.47)	(2.75)	(-1.72)
$Ret_{(-12,-2)}$	0.186	0.633***	0.376***	0.368***
	(1.56)	(7.53)	(4.27)	(2.79)
Ln(Illiquidity)	-0.287***	-0.470***	-0.355***	-0.372***
	(-5.96)	(-7.80)	(-7.48)	(-6.21)
(Option open interest /	-3.478***	-3.690***	-3.068***	-4.065***
stock volume)×1000	(-7.61)	(-6.56)	(-6.27)	(-7.97)
Option bid-ask spread	-2.682***	-2.516***	-2.721***	-2.505***
	(-12.76)	(-7.51)	(-10.93)	(-9.09)
Intercept	5.661***	5.007***	5.082***	5.695***
	(21.71)	(10.93)	(16.07)	(15.31)
t-stat (H_0: $\beta_{CDS,high} > \beta_{CDS,low}$)	2.151**		3.10***	
Observations	137,552	91,235	113,592	115,195
Average adj. R^2	0.127	0.126	0.129	0.124

Table 9: Delta-Hedged Option Returns and CDS Presence – Time Decay

This table reports the monthly Fama-MacBeth regression coefficients of all the option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) for call or scaled by (P - Δ·S) for put, at the beginning of the period. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. CDS_3Y_after (CDS_5Y_after) is a dummy that equals 1 if the option observation is 36 months (60 months) or more after the CDS inception, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1, 0)}$ is the stock return in the prior month. $Ret_{(-12, -2)}$ is the cumulative stock return from the prior 2nd through 12th months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. Only call option results are reported. Robust Newey-West (1987) t-statistics are reported in brackets.

	Model 1	Model 2	Model 3
CDS_{trades}	-0.207***		
	(-4.003)		
CDS_3Y_after		-0.111***	
		(-2.662)	
CDS_5Y_after			-0.0820*
			(-1.803)
Ln(ME)	-0.528***	-0.545***	-0.548***
	(-12.53)	(-12.91)	(-13.00)
VOL	-9.275***	-9.275***	-9.277***
	(-39.24)	(-39.15)	(-39.09)
VOL_deviation	6.605***	6.605***	6.607***
	(34.36)	(34.32)	(34.33)
Ln(BM)	-0.114***	-0.119***	-0.120***
	(-3.380)	(-3.509)	(-3.529)
$Ret_{(-1,0)}$	0.0732	0.0755	0.0774
	(0.282)	(0.291)	(0.299)
$Ret_{(-12,-2)}$	0.372***	0.376***	0.376***
	(4.962)	(4.975)	(4.986)
Ln(Illiquidity)	-0.363***	-0.364***	-0.364***
	(-9.073)	(-9.069)	(-9.064)
(Option open interest / stock volume) ×1000	-3.566***	-3.580***	-3.583***
	(-10.66)	(-10.75)	(-10.73)
Option bid-ask spread	-2.613***	-2.620***	-2.622***
	(-14.10)	(-14.17)	(-14.19)
Intercept	5.388***	5.482***	-0.548***
	(20.60)	(20.99)	(-13.00)
Observations	228,787	228,787	228,787
Average adj. R^2	0.127	0.126	0.126

Table 10: The Impact of CDS Presence on Delta-Hedged Option Return - Big Bang Period

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

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

Internet Appendix for

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

Table A1: Sample Coverage

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

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

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

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

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

Table A3: Delta-Hedged Option Returns and CDS Presence – Panel Data Regressions

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

	Model 1	Model 2	Model 3
CDS_{trades}	-0.268^{***}	-0.406^{***}	-0.120^{**}
	(-6.38)	(-6.428)	(-2.19)
Ln(ME)	0.442^{***}	0.208^{***}	0.681^{***}
	(15.30)	(4.810)	(18.00)
VOL	-4.282^{***}	-5.150^{***}	-3.384^{***}
	(-80.82)	(-64.11)	(-49.45)
VOL_deviation	3.512^{***}	3.890^{***}	3.087^{***}
	(87.93)	(65.24)	(58.80)
Ln(BM)	-0.530^{***}	-0.612^{***}	-0.443^{***}
	(-30.42)	(-23.35)	(-19.59)
$Ret_{(-1,0)}$	-1.604^{***}	-1.101^{***}	-2.104^{***}
	(-26.42)	(-11.99)	(-26.72)
$Ret_{(-12,-2)}$	0.523^{***}	0.686^{***}	0.355^{***}
	(42.49)	(36.86)	(22.25)
Ln(Illiquidity)	0.128^{***}	0.115^{***}	0.129^{***}
	(7.506)	(4.53)	(5.712)
(Option open interest / stock volume) ×1000	-2.112^{***}	-2.357^{***}	-2.204^{***}
	(-13.25)	(-11.39)	(-8.44)
Option bid-ask spread	-0.628^{***}	-0.327^{***}	-0.876^{***}
	(-9.662)	(-3.38)	(-10.24)
Intercept	-1.501^{***}	0.295	-3.458^{***}
	(-9.66)	(1.28)	(-16.79)
Firm Fixed Effect	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	442,793	228,787	214,006
Adj. R^2	0.032	0.034	0.033

Table A4: Delta-Hedged Option Returns and CDS Presence – Subperiods

This table reports the monthly Fama-MacBeth regression coefficients of all the option returns (%): delta-hedged gain till maturity scaled by (Δ·S-C) for call or scaled by (P - Δ·S) for put, at the beginning of the period. Column (1) covers the sample from January 1996 to December 2002, Column (2) covers the sample from January 2003 to December 2006, and Column (3) covers the sample from January 2007 to December 2012. CDS_{trades} is a dummy that equals 1 if the option observation is associated CDS, and 0 otherwise. Ln(ME) is the natural logarithm of the market capital at the last month's end. All volatility measures are annualized. Total volatility (VOL) is the standard deviation of daily stock returns over the previous month. VOL_deviation is the log difference between VOLt-1 and IVt-1. Ln(BM) is the natural logarithm of the book-to-market ratio. $Ret_{(-1,0)}$ is the stock return in the prior month. $Ret_{(-12,-2)}$ is the cumulative stock return from the prior 2nd through 12th months. Illiquidity is the average of the daily Amihud (2002) illiquidity measure over the previous month. Option bid-ask spread is the ratio of the bid-ask spread of option quotes over the mid-point of bid and ask quotes at the end of the last month. All independent variables are winsorized each month at the 1% level. The results of all the call and put options are reported. The results of all the call and put options are reported. Robust Newey-West (1987) t-statistics are reported in brackets.

Both Calls and Puts	(1) 1996-2002	(2) 2003-2006	(3) 2007-2012
CDS_{trades}	-0.197**	-0.187***	-0.122**
	(-2.336)	(-4.129)	(-2.309)
Ln(ME)	-0.766***	-0.414***	-0.288***
	(-13.31)	(-11.51)	(-5.601)
VOL	-7.478***	-9.061***	-7.656***
	(-23.81)	(-22.71)	(-18.48)
VOL_deviation	7.163***	4.267***	5.302***
	(27.56)	(23.92)	(17.97)
Ln(BM)	-0.351***	-0.0862***	0.101***
	(-7.970)	(-3.104)	(3.106)
$Ret_{(-1,0)}$	-1.042**	0.736**	-0.353
	(-2.367)	(2.361)	(-1.002)
$Ret_{(-12,-2)}$	0.412***	0.555***	-0.0104
	(5.616)	(7.505)	(-0.0738)
Ln(Illiquidity)	-0.717***	-0.150***	-0.116**
	(-12.94)	(-4.176)	(-2.396)
(Option open interest / stock volume) ×1000	-3.927***	-1.553***	-3.696***
	(-8.291)	(-4.686)	(-7.444)
Option bid-ask spread	-1.400***	-2.282***	-1.847***
	(-6.337)	(-14.68)	(-10.66)
Intercept	4.634***	4.807***	4.248***
	(13.13)	(15.92)	(11.20)
Observations	157,736	103,125	181,932
Average adj. R^2	0.110	0.098	0.108

Table A5: Probability of Credit Default Swaps Trading

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

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