Funding Liquidity Shocks in a Natural Experiment: Evidence from the CDS Big Bang*

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Abstract

The CDS Big Bang (the protocol changes for the CDS market in April 2009) increased the upfront funding requirements for trading CDS contracts, especially for those with credit spreads further away from 100 and 500 basis points. Exploiting this natural experiment, we document direct evidence that a higher funding cost reduces market liquidity, increases the absolute value of CDS-bond basis, and increases CDS spread volatility. Moreover, the funding cost of basis arbitrageurs reduces their efficacy in pushing the basis towards zero. Finally, an unintended consequence of the standardization of CDS contracts is that it induces upfront payments, which may jeopardize market liquidity especially during periods of financial distress.

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"Liquidity is expected to increase the closer the spread … is to the fixed coupon (100/500 bps)"

J.P. Morgan Worldwide Securities Services[1]

1 Introduction

The theoretical literature has come a long way in analyzing the role of funding liquidity (or capital constraint) in financial markets.[2] On the empirical side, however, existing evidence has mostly been indirect. This is perhaps because, as is clear in Brunnermeier and Pedersen (2009), funding liquidity, market liquidity and asset prices are interdependent with one another, making it difficult to identify the effect of funding liquidity. However, for some issues, it is crucial to isolate and quantify funding liquidity effects. For instance, the interaction between market liquidity and funding liquidity is considered to have played a key role in the recent financial crisis and the ensuing Great Recession (Brunnermeier and Pedersen (2009), Brunnermeier and Sannikov (2014)). To evaluate the policy for funding requirement, it is important to isolate and quantify funding liquidity effects.

We exploit a natural experiment in order to identify the effects of funding liquidity. On April 8th 2009, a collection of trading convention changes in the CDS market took place, which is commonly referred to as the "CDS Big Bang." One important consequence is that it increases the initial funding requirement for trading North American single-name CDS contracts. Before the changes, a CDS contract was traded at a coupon rate that set the contract value to zero on the inception day, and hence no upfront payment was needed. After the CDS Big Bang, however, the coupon rate is restricted to be either 100 basis points or 500 basis points.

The intention of this change is to standardize CDS contracts to facilitate central clearing. However, this trading convention change also induces upfront payments and the size of the payment depends on the CDS spread level. Suppose, for example, a contract has a CDS spread of 400 basis points, i.e., the contract is worth zero to both the protection buyer and seller on the

[1] This quote is from J.P. Morgan Worldwide Securities Services on the potential effect of the CDS Big Bang on market liquidity, *Credit Derivatives Standardization Initiatives, 2009*.

[2] See, for example, Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014).

inception day if the buyer pays a coupon of 400 basis points. After the CDS Big Bang, however, the coupon rate can only be either 100 or 500 basis points. Suppose the coupon rate is set to be 100 basis points. Since the protection buyer pays 300 basis points less than the fair coupon rate (which is 400 basis points), he needs to compensate the protection seller by paying an upfront fee that is the present value of 300 basis points per year. Similarly, if the coupon rate is set to be 500 basis points, since the protection buyer pays 100 basis points more than the fair coupon rate, the protection seller needs to pay the buyer an upfront fee that is the present value of 100 basis points per year. In sum, after the CDS Big Bang, an upfront payment is necessary unless the CDS spread happens to be 100 or 500 basis points. The size of the upfront fee depends on the credit spread level: it is larger if the credit spread is "further away" from 100 and 500 basis points. This upfront fee and its dependence on the credit spread level allow us to identify the effect of funding liquidity through diff-in-diff analysis.

How large is this upfront fee shock? In our sample, the average size of the upfront fee is 3.58% of the notional amount of the CDS contract. For example, according to the DTCC TIW data report, the gross notional value of new single-name CDS trades executed between April and December 2009 is about $10 trillion. Hence, the aggregate size of the upfront fee is on the order of tens of billions of dollar each month.[3] It is only natural to expect this funding requirement to have a sizeable effect on market liquidity and prices. Indeed, this has been recognized by practitioners before the implementation of the CDS Big Bang, as illustrated by the quote from J.P. Morgan Worldwide Securities Services at the beginning of this paper.

Our first hypothesis is that, all else being equal, the funding cost of the upfront payment increases the bid-ask spread in the CDS market. There are two channels. The first one is the *willingness to trade*. For end investors, the benefit from receiving the upfront fee is typically smaller than the cost of paying it. For example, the trader who receives the upfront fee has to post it as collateral, and so earns a return that is lower than her cost of funding. This impediment to trading reduces market activity, leading to higher bid-ask spreads.

The second channel is *dealers' collateral constraint*. Due to upfront fees, dealers incur funding costs when they make markets. Suppose a dealer takes two offsetting positions with two different customers. The dealer receives an upfront fee and pays one with the same size. As will

[3] During April to December 2009, dealer-to-customer trades account for about 29% of all trades. Even if we completely ignore the upfront fee for all inter-dealer trades, the aggregate upfront fee is still 10×29%×3.58%=0.11 trillion dollars.

be explained in detail in Section 3, the dealer cannot net the two payments, and has to post the received fee as collateral and come up funding separately for the other fee. Hence, the funding cost for the upfront fee increases the cost of market making, leading to higher bid-ask spreads. One might expect central clearing to address this netting issue.[4] However, despite the strong push from the Dodd-Frank Act, an overwhelming majority of single-name CDS contracts are still not centrally cleared. As noted in Duffie and Zhu (2011), central clearing is likely to be imperfect in addressing this netting issue. Moreover, central clearing cannot eliminate the effect from the previous "willingness to trade" channel.

Our second hypothesis is on the effect of the upfront funding cost on CDS-bond basis. It has two predictions. First, the upfront funding cost increases the absolute value of the CDS-bond basis. This is because the funding requirement reduces market liquidity, leading to a stronger violation of the law of one price, which is reflected in the absolute value of the CDS-bond basis. The second prediction is that the lower the upfront funding cost for *CDS-bond basis arbitrageurs*, the closer the basis is to 0. That is, the first prediction is due to the market liquidity, while the second prediction takes into account the direction of the upfront payment from the arbitrageur's perspective. If arbitrageurs pay a smaller upfront fee (or even receive one), all else being equal, they would find the arbitrage trade less costly, and push the basis closer towards 0.

Let's first have an "eyeball test" of these two hypotheses. For CDS contracts at each spread level, we compute the change in bid-ask spread as the post-Big-Bang average bid-ask spread minus the pre-Big-Bang average. We then plot this change in bid-ask spread against the CDS spread level. Under the first hypothesis, we should observe a W-shaped pattern, with the two low points at around 100 and 500 basis points. The reason is that, in the post-Big-Bang sample, for CDS contracts with spreads closer to 100 or 500 basis points, the upfront fees are smaller and so the bid-ask spreads are smaller. As shown in Panel A of Figure 1, there is indeed a W-shaped pattern, with the two low points at around 100 and 500 basis points.

Our second hypothesis implies that there should be a similar W-shaped pattern in the change in the absolute value of CDS-bond basis. When CDS spread levels are closer to 100 or 500 basis points, the CDS contracts are more liquid and arbitrage forces are more effective in

[4] A practice known as rehypothecation may also alleviate this netting issue. It allows the receiver of a collateral (usually dealers) to use the collateral for his own purposes upon the permission of the payer of the collateral. Since the onset of the 2008 financial crisis, however, this practice encountered difficulties. The Dodd-Frank Act eventually put restrictions on rehypothecation for derivatives.

reducing the violation of the law of one price, and so reducing the absolute value of the CDS-bond basis. Indeed, this is also confirmed by Panel B in Figure 1. The two low points of the W-shaped pattern are also around 100 and 500 basis points.

To formally test the two hypotheses and their further implications, we need to measure the funding cost of upfront fee, which has two components: the fee size and the funding cost of each unit of payment. We can separately measure both. After the CDS Big Bang, the size of the upfront fee can be constructed from the CDS spread: for each CDS contract *i* on day *t*, we construct a variable DIS_{it} as

$$DIS_{it} = \min(|S_{it} - 100|, |S_{it} - 500|), \quad (1)$$

where S_{it} is the CDS spread. That is, *DIS* is the minimum distance between the CDS spread and the two possible coupon rates (i.e., 100 and 500 basis points). Since the coupon rate is usually chosen to be closer to the CDS spread, the size of the upfront fee is approximately linear in *DIS*.[5] The higher the *DIS*, the larger the upfront fee. Following Garleanu and Pedersen (2011), we use the 3-month Libor-OIS spread as a proxy for the net cost of each unit of funding. Hence, the funding cost for the upfront fee can be measured as

$$F_{it} = DIS_{it} \times LOS_t , \quad (2)$$

where LOS_t is the 3-month Libor-OIS spread on day *t*. After the CDS Big Bang, *F* measures the funding cost of the upfront fee. Before the CDS Big Bang, however, *F* is not related to this cost, since no upfront fee was required then.

To quantify the effects of the upfront funding cost, we run a series of diff-in-diff analyses on a panel dataset on 634 reference entities during 2004-2010. We first regress CDS bid-ask spreads on the interaction term $F \times BB$, where *BB* is a dummy variable that is 0 before the CDS Big Bang, and 1 afterwards. The coefficient of this interaction term is estimated to be 2.79 (t=6.73), suggesting that the upfront fee increases CDS bid-ask spreads. Then, we run similar regressions for the absolute value of CDS-bond basis, and the coefficient of the interaction term is 46.23 (t=4.65), suggesting that a higher funding cost leads to a larger basis in absolute value, i.e., a stronger violation of the law of one price.

What is the economic magnitude of these effects? Let's take a CDS contract with a spread level of 300 basis points as an example. Our estimates imply that when the Libor-OIS

[5] Using a different dataset, we verify in Section 5.5 that the coupon rate is chosen to be closer to the CDS spread for 92% of the observations.

spread is 32 basis points (our sample mean), the upfront fee increases the bid-ask spread by 1.8 basis points and the absolute value of the CDS-bond basis by 30 basis points. These effects are sizable relative to our sample median (mean), which is 5.3 (9.6) basis points for the bid-ask spread, and 24 (54) basis points for the absolute value of CDS-bond basis. Given the size of the CDS market, these effects have enormous economic significance.

Following the logic behind the definition of the funding cost F, we construct the funding cost for a trader who is long in the CDS contract F^l, which reflects the direction of the upfront payment. For instance, $F^l < 0$ implies that the long side of the CDS contract receives the upfront payment. To test the second predict of our second hypothesis, we split our sample based on the sign of CDS-bond basis. In the negative basis subsample, basis arbitrageurs need to long both CDSs and their underlying corporate bonds. Hence, arbitrageurs' upfront funding cost is F^l. Similarly, in the positive basis subsample, arbitrageurs need to short both CDSs and their underlying corporate bonds, and hence their upfront funding cost is $-F^l$. For each subsample, we regress the CDS-bond basis on the interaction term, $F^l \times BB$. The interaction term coefficient is significantly negative for the negative basis subsample. This is consistent with our prediction that when arbitrageurs face a higher funding cost (i.e., a higher F^l), they will be less willing to trade, and so the basis is even more negative. Similarly, since arbitrageurs' funding cost is $-F^l$ for the positive basis sample, consistent with our prediction, the interaction term coefficient is positive for this subsample.

It is worth noting that our focus is the *cross-sectional variation* of the effect of the CDS Big Bang, not its overall effect. This policy change has led to many benefits.[6] Our analysis simply highlights a less-recognized aspect. The standardization induces upfront payments, which reduce market liquidity and are an impediment to the arbitrage mechanism. During normal time, these effects are perhaps not a concern given the potential benefits of standardization. During periods of financial distress, however, these effects are substantially larger. For instance, during the peak of the recent financial crisis, the Libor-OIS spread was around 250 basis points, implying that the upfront payments increases the bid-ask spread by over 10 basis points, and increases the absolute value of CDS-bond basis by 150 basis points. Moreover, some studies suggest that the funding costs were likely to be an order of magnitude higher than what the

[6] For instance, it reinforces the legal framework of CDS contracts and further standardizes CDS contracts. These changes are important for central clearing, and also make CDS trading (e.g. starting new trades, novation and termination of CDS contracts) easier.

Libor-OIS spread suggests (Gârleanu and Pedersen (2011), Gorton and Metrick (2012)). Hence, the effects of upfront payments during a financial crisis are likely to be much more severe. While the intention is to reduce systemic risk, standardization may jeopardize market liquidity precisely during periods of financial distress. This coincidence highlights the importance of accounting for funding cost effects when evaluating the policy.

In addition to several subsample analyses, we also conduct a variety of additional tests. First, given that central clearing affects only 3% of our observations, our results barely change after excluding centrally cleared contracts. Second, we perform diff-in-diff analysis using a sample of reference entities which started central clearing in the period from April 2010 to October 2014. We find that that the effect of funding liquidity is indeed weaker after the initiation of central clearing. Third, we repeat our main analysis on the CDS Small Bang, a similar trading protocol change in the European CDS market, and find similar effects. Finally, to further control for the confounding effects of unobserved shocks to the global CDS market, we conduct diff-in-diff analysis around the CDS Big Bang using a combined sample of both North American and European reference entities, and obtain similar effects.

2 Literature Review

Our paper adds to the large and growing literature on the effects of funding liquidity and arbitrageurs' capital constraint. There has been an extensive theoretical literature. Important contributions include Grossman and Miller (1988), Shleifer and Vishny (1997), Basak and Croitoru (2000), Xiong (2001), Kyle and Xiong (2001), Gromb and Vayanos (2002), Brunnermeier and Pedersen (2009), He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), among others. On the empirical side, the evidence has mostly been indirect. For example, Chordia, Sarkar, and Subrahmanyam (2005) document that the common factors in the shocks to stock and bond market liquidity appear correlated with money flows. Coughenour and Saad (2004) find that the liquidity of stocks handled by the same specialist firm display excess co-movement. Comerton-Forde et al. (2010) find evidence that the market liquidity of a stock decreases when its market maker holds large inventory or has suffered recent trading losses. Mitchell, Pedersen and Pulvino (2007) and Mitchell and Pulvino (2012) provide evidence of capital imoblity. Several studies use major market events as exogenous shocks to the funding condition of financial intermediaries to examine their effects on market liquidity (e.g., Acharya, Schaefer, and Zhang (2015), Aragon and Strahan (2012)). Our paper adds to this literature by using the CDS Big Bang as a natural experiment to provide direct evidence on the effect of funding liquidity on market liquidity and asset prices. The CDS Big Bang has also been exploited to analyze the liquidity spillover by Haas and Reynolds (2015), and test the empty credit hypothesis by Danis (2015).

Our paper is related to the literature on the CDS-bond basis, which attributes the basis to margin requirements (Gârleanu and Pedersen (2011), Mitchell and Pulvino (2012), Shen, Yan, and Zhang (2014)), and liquidity (Nashikkar, Subrahmanyam, and Mahanti (2011), Bai and Collin-Dufresne (2013)). Our evidence shows that that the CDS-bond basis is also determined by the upfront funding cost. More broadly, our paper adds to the large literature on the liquidity in the CDS market. See, for example, Longstaff, Mithal, and Neis (2005), Tang and Yan (2007), Bongaerts, De Jong, and Driessen (2011), Qiu and Yu (2012), Shachar (2011), Chen, Cheng, and Wu (2013), Loon and Zhong (2014). Augustin et al. (2016) provides a recent survey.

Finally, our paper is related to the analysis of the product standardization in the OTC derivative market. Standardization fosters aggregation of information and price discovery (e.g. Augustin et al. (2016)). Chen et al. (2011) document the effects of the CDS Big Bang on the standardization of product and trading convention. Oehmke and Zawadowski (2013) argue that the role of the CDS market is to provide standardization and liquidity as an alternative to the bond market. Despite many benefits of standardization, derivatives end-users face higher costs because they are less likely to find a product that exactly matches their needs (e.g. Stulz (2010) and Duffie, Li, and Lubke (2010)). Our analysis highlights the mechanism through which standardization may jeopardize market liquidity during financial distress.

3 A Natural Experiment: the CDS Big Bang

3.1 Institutional details

On April 8 2009, a collection of trading convention changes in the CDS market took place, which is commonly referred to as the “CDS Big Bang.” The one change that is relevant for our study is the fixed coupon and upfront payment for North American single-name CDS contracts. Before the changes, a single-name CDS contract was traded at a coupon rate that set the contract value to zero on the inception day, and hence no upfront payment was needed. After the CDS

Big Bang, however, the coupon rate is restricted to be either 100 basis points or 500 basis points.[7] The purpose of this convention change is to standardize CDS contracts to facilitate central clearing and reduce the systemic risk.

However, this restriction on the coupon rate induces upfront payments. Suppose, for example, a CDS contract has a spread of 400 basis points, that is, the contract is worth zero on the inception day if the protection buyer pays a coupon rate of 400 basis points. However, after the CDS Big Bang, the coupon rate can only be either 100 or 500 basis points. Suppose the coupon rate is set to be 100 basis points. Since the protection buyer pays 300 basis points less than the fair coupon rate (i.e., 400 basis points), he needs to compensate the protection seller by paying an upfront payment that is the present value of 300 basis points per year. Similarly, if the coupon rate is set to be 500 basis points, since the protection buyer pays 100 basis points more than the fair coupon rate, the protection seller needs to pay an upfront payment that is the present value of 100 basis points per year.

It is important to recognize that if there is a collateral agreement between two parties, a party receiving an upfront payment is not entitled to retain the payment, but must post the payment as collateral to the payer of the upfront payment. According to the 2009 ISDA margin survey, 66 percent of OTC derivatives net credit exposure is covered by collateral. Collateral is usually held either by dealers' internal custody service or by a third agent upon the request of a counterparty. In either case, once upfront payment is transferred to a custody account, neither parties can use the payment for their own purposes. In other words, collateral agreements freeze up upfront payments for both parties.[8] After the inception of a trade, additional collateral may be called or released when the Mark-to-Market value of the trade changes (as the CDS spread changes) with the market. Collateral from the upfront payment is gradually released over time

[7] CDS Indices, such as CDX and iTraxx, have been traded with fixed coupons on the day of issue. To minimize upfront payments, a fixed coupon is traditionally decided to be close to the current index level during each index roll. Upfront payments become large only when the index level significantly deviates from the initial level at index roll. Starting in the first quarter of 2009, CDS indices have been traded with the standard coupon of 100 or 500 basis points. In addition, central clearing of CDS indices was also introduced in the same period. Therefore, upfront payments arising from the standard coupons impose smaller capital constraints for trading CDS indices than for trading single-name CDS.

[8] After the inception of a trade, additional collateral may be called or released when the Mark-to-Market value of the trade changes (as the CDS spread changes) with the market. Collateral from the upfront payment is gradually released over time when the trade approaches maturity. Once a coupon is paid on a scheduled date, a fraction of collateral corresponding to the coupon payment is released.

when the trade approaches maturity. Once a coupon is paid on a scheduled date, a fraction of collateral corresponding to the coupon payment is released.

How are upfront payments handled if trades are centrally cleared? Similar to the case of collateral agreements, a party receiving an upfront payment is not free to use the payment for its own purposes, but must remit the payment as variation margin to the payer of the upfront payment. To guarantee performance under the term of the trade, the upfront payment is immediately collected by the clearing house as variation margin at the inception of the trade. Then the clearing house remits the variation margin to the payer of the upfront payment. Since a CCP serves as the sole counterparty for all parties, central clearing allows a higher degree of netting benefits across trades. We investigate the impact of central clearing on the funding effects in Section 6.

In summary, after the CDS Big Bang, upfront payments are necessary unless the CDS spread happens to be 100 or 500 basis points. The size of the upfront payment depends on the credit spread level: it is larger if the credit spread is "further away" from 100 and 500 basis points. This upfront payment and its dependence on the credit spread level allow us to identify the effect of funding liquidity through diff-in-diff analysis.

3.2 Hypotheses

Our first hypothesis is that the funding cost of the upfront payment increases the bid-ask spread in the CDS market. Intuitively, the upfront payment is an impediment to trading, and so reduces the market liquidity, leading to higher bid-ask spreads. More specifically, the upfront payment for trading CDS contracts can affect their bid-ask spreads in two ways. First, as in Shen, Yan, and Zhang (2014), capital constrained investors are reluctant to trade assets that are capital intensive due to the upfront payments. This impediment to trading makes it difficult for dealers to offset their inventories, leading to higher bid-ask spreads. Second, due to the upfront payments, dealers incur extra funding costs when they take offsetting positions. Suppose a dealer sells a protection on a reference entity to investor A. To offset this exposure, the dealer buys a protection on the same reference entity from investor B. Hence, the dealer needs to pay an upfront payment for one position, and receives an upfront payment of similar size for the other. Let's suppose the dealer receives the upfront fee from A, and pays the upfront fee to B. Although these two offsetting payments are similar in size, the dealer cannot net them unless A and B happen to be the same investor. Specifically, for the trade between the dealer and A, the mark-to-the-market value of the CDS contract for investor A is the size of the upfront payment. Hence, the dealer needs to post the upfront payment, which he just received from A, as collateral for this trade.[9] On the other hand, the dealer has to finance the upfront payment for its trade with investor B. As formalized in Andersen, Duffie, and Song (2016), funding the upfront payments is costly to dealers, and hence they need to increase the bid-ask spreads.

Our second hypothesis is that the funding cost of the upfront payment increases the absolute value of the CDS-bond basis. As noted in the previous hypothesis, the upfront funding requirement reduces market liquidity and makes arbitrage more costly, leading to a stronger violation of the law of one price. Note that the CDS-bond basis measures the magnitude of the violation of the no-arbitrage relation between a CDS and its underlying bond. A higher absolute value of the CDS-bond basis implies a stronger violation of the law of one price. Hence, the funding cost of the upfront payment increases the absolute value of the CDS-bond basis. Similarly, with the upfront payment, the market is less effective is absorbing temporary supply and demand shocks. Hence, an auxiliary of the second hypothesis is that the CDS spread is more volatile when the funding cost of the upfront payment is higher.

Finally, our third hypothesis takes into account the direction of the arbitrageur's position. If the arbitrageur's strategy is such that he pays (receives) the upfront payment, it reduces (increases) his incentive to trade, and hence the CDS-bond basis is further away from (closer to) 0. This is related to the second hypothesis, but has a subtle difference. The second hypothesis focuses on the effect of the upfront payment size *through the market liquidity channel*, regardless of the direction of the payment (i.e., which side pays the upfront payment). In contrast, our third hypothesis focuses on the effect of the *funding cost for arbitrageurs*, and hence takes into account the direction of the upfront payment.

4 Data and Measurement

4.1 Data description

We obtain daily bid and ask quotes for 5-year CDS contracts on North American companies from two sources. Our main analysis is based on the data from Credit Market Analysis Ltd.

[9] For more details on collateral requirements in practice, see "The Standard Credit Support Annex", ISDA, 2011.

(CMA) via Datastream, and we will refer to it as the "CMA sample." It covers 634 North American companies from January 2004 to September 2010.[10] Hence, this sample period includes about 5 years before and 1.5 years after the CDS Big Bang. Our second dataset is from Markit Group Ltd., and we will refer to it as the "Markit sample." It covers 521 North American companies (out of which 319 are also in our CMA sample) from April 1, 2010 to May 30, 2014. That is, the Markit sample only covers the post-Big-Bang period. Nevertheless, it is a nice complement to our CMA sample, because it not only covers a longer post-crisis period, but also includes some important variables that are not in the CMA sample, which will be discussed later.

We apply the following filters to the CDS bid and ask quotes to both samples. We removed observations where the bid quote is greater than or equal to the ask quote, or the quote is indicated as "derived" rather than "observed." We also removed the observations if the mid-point of bid and ask quotes is greater than 750 basis points.[11] After applying these filters, the CMA and Markit samples consist of 633,977 and 400,038 daily observations, respectively.

Table 1 reports the summary statistics. Each variable is pooled over time and across firms. We winsorize all unbounded variables at the 1% and 99% levels. Panel A shows that the mean and median of the bid-ask spread in the CMA sample are 9.61 and 5.30 basis points, respectively. They are slightly higher in the Markit sample in Panel B, where the mean and median are 11.74 and 10.00 basis points, respectively.

The CDS-bond basis is the CDS spread minus the credit spread of the bond issued by the reference entity. The law of one price implies that in a frictionless market, the CDS-bond basis should be close to zero. A negative (positive) CDS-bond basis implies that the bond price is lower (higher) than what is implied by the CDS spread. Following previous studies (e.g., Elizalde, Doctor, and Saltuk (2009) Nashikkar, Subrahmanyam, and Mahanti (2011); Bai and Collin-Dufresne (2013); Choi and Shachar (2014)), we adopt the par equivalent CDS methodology to construct CDS-bond basis. In our CMA sample, the mean and median of CDS-bond basis is -22.47 and -1.63 basis points, respectively, while in Markit sample, the mean and median are -14.25 and -10.74 basis points.

[10] From October 1, 2010, CMA data are not available without a separate license.
[11] This is because that before the CDS Big Bang, some CDS contracts on distressed firms were already traded with a fixed coupon of 500 basis points and upfront payments (The CDS Big Bang: Understanding the Changes to the Global CDS Contract and North American Conventions, Markit 2009). The cutoff of 750 basis points is equivalent to excluding firms with a credit rating below CCC.

The credit ratings of the reference entities in our sample are mostly between A and B, according to S&P long-term issuer credit ratings. The mean and median CDS spread are 137 and 71 basis points, respectively, in our CMA sample, and are 165 and 113 basis points in our Markit sample. For each CDS contract, on each day, we compute the "CDS volatility" as the standard deviation of daily CDS spreads during the previous two weeks. The mean and median of the CDS volatility are 9.86 and 4.24 basis points for the CMA sample, and 7.82 and 3.83 basis points in the Markit sample.

As control variables, we obtain daily close values of the CBOE volatility index (VIX) from Datastream, stock returns, trading volume, and bid-ask spreads from CRSP, transaction prices of bonds issued by the reference entities from TRACE, bond characteristics from Mergent Fixed Income Securities Database (FISD). We construct two bond market liquidity measures. The first is the Amihud (2002) measure, defined as $1/N \sum_{i=1}^{N} |r_i|/v_i$, where N is the number of trades within a given day, r_i and v_i are the percentage price change and the dollar volume of the ith trade respectively. Since there may exist more than one bond for each firm, we aggregate the Amihud measures of all bonds issued by the same firm (identified by 6-digit CUSIP number) by averaging their daily values. The second measure is the trading volume aggregated across daily trading volumes of all bonds issued by the same firm.

4.2 Measure the funding cost of the upfront payment

The funding cost of the upfront payment has two components: the size of the payment and the price of funding, i.e., the funding cost of each unit of the payment. We can separately measure both. In our CMA sample, we cannot observe the upfront payment size or coupon rate directly, but can infer them from the CDS spread. After the CDS Big Bang, when broker-dealers provide their quotes to CMA, they follow a standard procedure convert the coupon rate and the upfront payment into a CDS spread.[12] Our CMA sample reports the CDS spread but not the coupon rate or upfront payment. However, we can easily infer the coupon rate (i.e., 100 or 500 basis points) since it is usually chosen to be closer to the CDS spread. For example, according to our Markit sample, where the coupon rate is directly observable, the "primary coupon rate" is chosen to be the one that is closer to the CDS spread for around 92% of the observations.

[12] The ISDA CDS Standard Model is used to convert coupon rate and upfront payment into CDS spread. The details of the model are available from http://www.cdsmodel.com/cdsmodel/.

As explained in Section 3, the size of the upfront payment is determined by the distance between the CDS spread and the coupon rate. The size of the upfront payment for CDS contract *i* on day *t*, can be measured by DIS_{it} in equation (1), which is the minimum distance between the CDS spread to 100 or 500 basis points. After the CDS Big Bang, the size of the upfront payment is approximately linear in *DIS*.[13] The higher the *DIS*, the larger the upfront payment. For the pre-Big-Bang sample, however, *DIS* is not related to the upfront payment, since no upfront payment was required.

To measure the price of funding, we follow Gârleanu and Pedersen (2011) to use the 3-month Libor-OIS spread, which is the 3-month Libor rate minus the 3-month overnight indexed swap (OIS) rate. The Libor rate is the uncollateralized borrowing rate of large banks and the OIS rate is often considered the risk-free rate. Hence, the spread represents the price of funding for large institutional investors. We obtain daily close values of Libor-OIS spreads from Bloomberg. It has significant variations in our sample period, ranging from less than 5 basis points to over 250 basis points during the recent financial crisis.

Taken together, the funding cost of the upfront payment can be measured as the product of *DIS* and the Libor-OIS spread, as F_{it} in equation (2). After the CDS Big Bang, F measures the funding cost of the upfront payment. Before the CDS Big Bang, however, *F* is not related to this cost, since no upfront payment was required then.

In order to measure arbitrageurs' upfront funding cost, we first construct the upfront funding cost for the investor who is long in the swap contract:

$$F_{it}^{l} = DIS_{it}^{l} \times LOS_t , \tag{3}$$

where

$$DIS_{it}^{l} = \begin{cases} S_{it} - 100, \ if \ S_{it} \leq 300, \\ S_{it} - 500, \ if \ S_{it} > 300. \end{cases}$$

Compare the definitions in (2) and (3), we can see that F_{it}^{l} is the funding cost for the investor on the long side. For example, when the credit spread S_{it} is below 100 basis points, F_{it}^{l} is negative, indicating that the long side is receiving the upfront payment. When the credit spread S_{it} is

[13] The nonlinearity is caused by the possibility of default of the reference entity, but the effect is minor for our sample, where the credit spread is below 750 basis points.

between 100 and 300 basis points, F_{it}^{l} is positive, indicating that the long side is paying the upfront payment.

Consider an environment where the CDS-bond basis is negative, i.e., the CDS spread is lower than the corporate bond spread. In this case, an arbitrageur's position is long in both the CDS and corporate bond. Hence, the arbitrageur's funding cost is captured by F_{it}^{l}. Hence, after the CDS Big Bang, the CDS-bond basis is negatively related to F_{it}^{l}. This is because when F_{it}^{l} is lower, arbitrageurs funding cost is lower and so can trade more aggressively and push up the CDS-bond basis towards 0. Similarly, in an environment where the CDS-bond basis is positive, an arbitrageur's position is short in both the CDS and corporate bond, and hence his funding cost is captured by $-F_{it}^{l}$. Therefore, after the CDS Big Bang, the CDS-bond basis is positively related to F_{it}^{l}.

Finally, in our Markit sample, we can directly observe the size of the upfront payment. As shown in Panel B, the average upfront payment size, *Fee*, is 3.58% of the notional amount of the CDS contract. According to the estimates by the Bank for International Settlements, the net (gross) notional value of the single-name CDS market in 2009, when the CDS Big Bang was introduced, is over \$2.5 (\$24) trillion dollars. Hence, the aggregate size of the upfront payment is 90 (870) billion dollars. It is only natural to expect this funding requirement to have a sizeable effect on market liquidity and prices.

5 Analysis

5.1 Eyeball tests

Before formally testing the hypotheses, we first examine if the effects are detectable visually. Specifically, we divide the interval [0,750] equally into 50 subintervals. Then, for each day, we sort our observations in the CMA sample into the 50 groups according to their CDS spreads. For each group, we compute the change in average bid-ask spread as the post-Big-Bang average bid-ask spread minus the pre-Big-Bang average.[14] We then plot this change in average bid-ask spread against the CDS spread level. Under the hypothesis that the upfront payment increases the bid-ask spread, we should observe a W-shaped pattern, with the two low points at around 100

[14] For each group, we compute average bid-ask spread over firm-date observations for two periods: pre-Big-Bang and post-Big-Bang. Thus for each period, we obtain 50 points of average bid-ask spreads.

and 500 basis points. This is because that, in the post-Big-Bang sample, for CDS contracts with spread levels at around 100 and 500 basis points, the upfront payments are smaller, and hence the market liquidity is better, i.e., the bid-ask spreads are smaller. As shown in Panel A of Figure 1, there is indeed a W-shaped pattern and, as predicted, the two low points are at around 100 and 500 basis points. The plot also suggests that the effect of the upfront payment on the bid-ask spread is a few basis points, which is sizeable as the median bid-ask spread in our sample is around 5 basis points.

We then conduct a similar calculation for the absolute value of the CDS-bond basis and plot the change in the absolute value of the CDS-bond basis against the CDS spread in Panel B. Our hypotheses imply that there should also be a W-shaped pattern. When spread levels are around 100 or 500 basis points, the CDS contracts are more liquid and arbitrage forces are more effective in reducing the violation of the law of one price. Therefore, the absolute value of the CDS-bond bases should be smaller at around 100 or 500 basis points levels. Indeed, this is confirmed by Panel B in Figure 1. The two low points in the W-shaped pattern are also around 100 and 500 basis points. The implied magnitude of the effect is around 30 basis points.

5.2 Diff-in-diff tests of the effect of the cost of upfront payment

To formally test our hypotheses, we first run a panel regression of *CDS bid-ask spread* on *F*. According to our hypothesis, due to the cost of upfront payment, the *CDS bid-ask spread* is *more* positively correlated with *F* in the post-Big-Bang sample than in the pre-Big-Bang one. Note that the *CDS bid-ask spread* can potentially be correlated with *F* in the pre-Big-Bang sample. For example, the CDS market may be more liquid for certain credit spread levels, perhaps due to higher trading activities for those contracts. In this case, the *CDS bid-ask spread* is correlated the CDS spread level, which, as shown in equation (2), is correlated with *F*. The essence of our hypothesis is that after the Big Bang, due to the funding cost of the upfront payment, the *CDS bid-ask spread* becomes *more* correlated with *F*, which can be tested using a diff-in-diff analysis.

Let *BB* be the dummy variable that is 0 before the CDS Big Bang and 1 afterwards. Our interest is the coefficient of the interaction term $BB \times F$, which identifies the effect of the funding cost of the upfront payment, the diff-in-diff effect on the bid-ask spread. Our hypothesis implies that the coefficient for this interaction term should be positive.

The regression results are reported in Table 2. In the first column, the specification includes a firm fixed effect. The coefficient for the interaction term is 2.79, with a *t*-statistic of

6.73. It implies that after the CDS Big Bang, the upfront funding cost increases the bid-ask spread. For a CDS contract with a spread of 300 basis points, for example, this diff-in-diff estimate implies that when the Libor-OIS spread is 32 basis points (our sample mean), the upfront funding cost increases bid-ask spread of this CDS contract by 1.8 basis points. This is sizeable as the mean and median of the bid-ask spread in our sample is 9.6 and 5.3 basis points, respectively. The regression in the second column includes both firm and year-quarter fixed effects, and the results remain similar. The coefficient for the interaction term is 2.35 (t=5.91). It implies that, for a CDS contract with a spread of 300 basis points, when the Libor-OIS spread is 32 basis points, the upfront payment increases bid-ask spread of this CDS contract by 1.5 basis points.

We conduct similar diff-in-diff tests of the hypothesis on the CDS-bond basis. Specifically, we regress *ABS(Basis)*, the absolute value of the CDS-bond basis, on the funding cost F. The coefficient of the interaction term $BB \times F$ measures the effect of the funding requirement on the absolute value of the CDS-bond basis. As shown in column 3, in the specification with firm fixed effects, the coefficient for the interaction term is 46.23 (t=4.65), suggesting that, consistent with our hypothesis, a higher funding cost leads to a larger basis in absolute value, i.e., a stronger violation of the law of one price. For a CDS with a spread of 300 basis points, this estimate implies that when the Libor-OIS spread is 32 basis points, the funding cost of the upfront payment increases the absolute value of the CDS-bond basis by 30 basis points. Column 4 reports the estimates from the regression with both firm and year-quarter fixed effects, and the results remain very similar. The coefficient for the interaction term is 40.60 (t=4.29), suggesting that, for a CDS with a spread of 300 basis points, with a Libor-OIS spread of 32 basis points, the funding cost of the upfront payment increases the absolute value of the CDS-bond basis by 26 basis points. As a comparison, the mean and median of the absolute value of the CDS-bond basis are 54 and 24 basis points, respectively.

To further examine the above limits-to-arbitrage interpretation, we directly analyze the effect of arbitrageurs' funding costs. In particular, we regress the CDS-bond basis on the interaction term $BB \times F^l$ in two separate regressions. In the first one, we only use negative CDS-bond basis observations, while in the second one, we only use positive ones. As noted earlier, when the CDS-bond basis is negative, F^l measures the arbitrageurs' upfront funding cost after the CDS Big Bang. The higher the funding cost, the further away the CDS-bond basis is from 0, i.e., the CDS-bond basis is more negative. Hence, the coefficient for interaction term should be negative. Similarly, in the regression with only positive CDS-bond basis, the coefficient for interaction term should be positive. This is indeed what we find. In Panel B of Table 2, the first two columns report the regression result for negative basis observations. In columns 1, the regression includes firm fixed effects both no quarter-fixed effects, the coefficient for the interaction term is 12.61 (t=2.16). The result gets stronger if we include both firm fixed effects and quarter-fixed effects in column 2, where the coefficient for the interaction term is 14.45 (t=2.75). This coefficient becomes positive for the positive basis sample, although only the statistical significance is much weaker. For instance, for the specification with both firm and quarter fixed effects, the coefficient for the interaction term is 11.55 (t=1.70). One potential reason why the results for positive basis observations are weaker is that, in this case, arbitrageurs need to short CDSs and corporate bonds, and they may be reluctant to execute such trades since shorting corporate bonds is usually very costly. Moreover, in our sample, variations of positive CDS-bond bases are much smaller relative to those for negative ones, and hence the statistical power for this subsample might be weaker.

Finally, we test the effect of the upfront payment on the CDS spread volatility. Columns 5 and 6 in Panel A of Table 2 report the estimates of the regressions of *CDS spread volatility* on *F*. In both specifications, the estimates of the coefficient for the interaction term are around 3.64, with t-statistics 4.9. These results are also consistent with our hypothesis that the upfront funding cost makes the market less effective in absorbing supply and demand shocks, leading to higher volatility. For a CDS with a spread of 300 basis points, this estimate implies that when the Libor-OIS spread is 32 basis points, the upfront funding cost increases the CDS spread volatility by around 2.3 basis points. In comparison, the mean and median of the CDS spread volatility are 9.86 and 4.24 basis points, respectively.

5.3 Unintended consequence

These findings have important implications on the ongoing standardization of the OTC market. One of the main goals for standardization is to reduce the systemic risk by facilitating central clearing. It is natural to expect standardization to increase trading volume and improve market liquidity. However, our evidence highlights a mechanism through which the standardization may jeopardizes market liquidity. This is because the standardization (i.e., restricting the coupon rates to 100 and 500 basis points) induces upfront payments. [15] Our evidence suggests that upfront payments reduce market liquidity and hinder the arbitrage mechanism. During normal times, these effects, while sizeable, are perhaps not concerning. During periods of financial distress, however, these effects are substantially larger and should be considered carefully when evaluating the overall effect of standardization.

For instance, during the peak of the recent financial crisis, the Libor-OIS spread was around 250 basis points. Our estimates suggest that the upfront payment increases the bid-ask spread by over 10 basis points, the absolute value of CDS-bond basis by 150 basis points, and increases the CDS spread volatility by 30 basis points. Moreover, some studies suggest that the price of funding during the recent financial crisis were likely to be an order of magnitude higher than what the Libor-OIS spread suggests. For example, Gârleanu and Pedersen (2011) estimate that the shadow cost of capital is around 10%, Gorton and Metrick (2012) demonstrate that many markets simply shut down during the recent financial crisis, making it impossible to obtain funding for some positions. Hence, the effect of the upfront funding cost during a financial crisis is likely to be significantly larger than our estimates based on the Libor-OIS spread.

That is, while the main purpose of standardization is to reduce systemic risk, our evidence suggests that, due to the upfront funding costs, it may significantly jeopardize market liquidity precisely during periods of financial distress. This coincidence highlights the importance of accounting for the effect of funding costs for the overall evaluation of the policy for standardization.

Essentially, there is a tradeoff between standardization and the upfront payment. When fewer coupon rates are allowed, CDS contracts are more standardized but the average upfront payments are larger. To the extent that the upfront payments can jeopardize market liquidity during financial distress, it should be taken into account when deciding on the optimal level of standardization.

In fact, the practice has been evolving, and responding to the tradeoff between standardization and the upfront payment. Soon after the CDS Big Bang, the trading convention

[15] In principle, one can avoid upfront payments by trading the two contracts at the same time. For instance, if the CDS spread is 300 basis points, one can take half position in the 100-coupon contract and half position in the 500-coupon one, so that the upfront payments of the two contracts cancel out with each other. This is similar to the process known as "portfolio re-couponing", which modifies legacy CDS positions into 100 and 500 fixed coupon positions. However, this strategy is usually infeasible, since many contracts have only one coupon traded. For those with dual coupons, liquidity is typically concentrated in one contract, making it very expensive to trade the less liquid one.

changed in Europe on June 20, 2009, which is commonly referred to as the CDS Small Bang. Interestingly, the standard coupons are chosen to be 25, 100, 500, and 1000 basis points this time. That is, there is less standardization relative to the North American CDS market. This choice appears to reflect the motivation to reduce the size of upfront payments. For example, a Markit technical report states that: "[t]he main reason for the additional strikes is the idea that people have a preference to enter into trades near par…" and that "[t]he additional coupons allow for greater minimization of the upfront fees that will be exchanged."[16]

5.4 Upfront payment size vs. price of funding

Our evidence so far shows that the funding cost of the upfront payment affects liquidity and prices in the CDS market. As is clear in equation (2), the funding cost has two components, the size of the upfront payment *DIS* and the price of funding *LOS*. In this section, we separate the two components in our analysis. Our evidence suggests that both components contribute to the effects of the funding cost in the previous section.

Specifically, we first rerun the regressions in the previous section, using *DIS* to replace *F*. Hence, the effect of the funding cost of the upfront payments is only identified through the variation in the size of the upfront payment. As shown in the first two columns in Panel A of Table 3, the estimate of the coefficient for the interaction term $BB \times DIS$ is 0.844 (t=3.62) for the specification with firm fixed effects only, and is 0.467 (t=2.0) for the specification with both firm and year-quarter fixed effects. These results suggest that after the CDS Big Bang, the bid-ask spread becomes *more* sensitive to *DIS*, the distance between the CDS spread and the coupon rate (100 or 500 basis points). Quantitatively, these two estimates imply that for a CDS contract with a spread of 300 basis points, the upfront payment increases the bid-ask spread by 0.54 to 0.30 basis points, comparable to the estimates in the previous section.

We then include the interaction term with *LOS* to test if the above *DIS* effect is stronger when the price of funding is higher. As shown in columns 3 and 4, the coefficient estimates for the triple interaction term $BB \times DIS \times LOS$ are both positive, although only one is statistically significant. Consistent with our hypothesis, the evidence suggests that when the price of funding is higher, the bid-ask spread is more sensitive to the size of the upfront payment.

[16] For more details, see Markit technical note "CDS Small Bang: Understanding the Global Contract and European Convention Changes" July 20, 2009. Two of coupons (300 and 750) have been implemented to allow more flexibility in recouponing legacy trades.

We run similar regressions for the absolute value of CDS-bond basis and CDS spread volatility. Our results, reported in Panels B and C, show that the evidence is weaker for the payment size *DIS*. As shown in the first two columns of the two panels, although the sign of the interaction terms $BB \times DIS$ is consistent with our hypotheses, only one estimate is statistically significant. Combined with the identification from the price of funding, our evidence becomes much stronger statistically. In the last two columns of the two panels, the coefficients for the interaction term $BB \times DIS \times LOS$ are highly significant for all specifications.

5.5 Robustness analysis

We explore the robustness of our results by analyzing various subsamples. First, we repeat our analysis for the period of April 2008 to April 2010, i.e., one year before to after the CDS Big Bang. The results, reported in Panel A of Table 4, remain similar to those for the overall sample. Consistent with our hypotheses, the coefficients for the interaction term $BB \times F$ are all significantly positive, suggesting that the funding cost of the upfront payment increases the bid-ask spread, the absolute value of the CDS-bond basis, and the CDS spread volatility. Perhaps due to the smaller sample size, the statistical significance for the coefficients in the regressions for ABS(Basis), reported in columns 3 and 4, is somewhat weaker.

Next, we divide our sample into two subsamples according to firm size. Specifically, we identify the median of the reference entities' asset value in our entire sample, and then, on each day, we classify the reference entities into large and small firms according to their asset values relative to this median. We then re-run the regressions on both subsamples, and the results are reported in Panels B and C. Our main results remain similar for both subsamples. Interestingly, the results are stronger in the small firm subsample. For example, the coefficients for the interaction term $BB \times F$ are larger in Panel C than in Panel B, both in their economic magnitude and in statistical significance for all six regressions. This comparison suggests that the funding liquidity effects are stronger for smaller reference entities.

Finally, we conduct our analysis on the Markit sample. For our purpose, the drawback of this sample is that it only covers the post-Big-Bang period, and hence we cannot conduct the diff-in-diff tests. However, the advantage of this dataset is that both the upfront payment size and the coupon rate are directly observable. This allows us to verify the assumption that the coupon rate is usually chosen to be the one that is closer to the CDS spread. Indeed, in our Markit sample, the primary coupon rate is chosen to be the one that is closer to the CDS spread for around 92%

of the observations. Moreover, since we can directly observe the upfront payments size, *Fee*, we can compute the funding cost as $FC=Fee \times LOS$. Then, we run regressions similar to those in Table 2, without the interaction term. The results are reported in Table 5. In all specifications, the coefficients for *FC* are significantly positive. Without the pre-Big-Bang data to compare, this regression does not identify the effect of the funding liquidity shock. Nevertheless, the evidence is consistent with our hypotheses that the funding cost of the upfront payment increases the bid-ask spread, the absolute value of the CDS-bond basis, as well as the CDS spread volatility.

6 Central clearing and European CDS

6.1 Central clearing

The primary reason for the CDS standardization is to facilitate central clearing of CDS contracts. For centrally cleared trades, CDS traders only face a single counterparty – a central counterparty clearing house (CCP). The exposure of a CDS trader can be effectively netted with a CCP across CDS trades. For CDS end users, netting benefit from central clearing may not be significant, since end users typically do not have many offsetting positions. For CDS dealers, however, the netting benefit from central clearing could be considerable since they have a large amount of offsetting positions and thus a significant portion of upfront payments can be netted across trades. Nevertheless, it is very unlikely that dealers can have upfront payments completely netted, since dealers usually hold a certain level of inventory. Therefore we expect that the effect of upfront payments is weaker for centrally cleared trades. We first confirm that our main results are not affected central clearing and next show that the effect of upfront payments is indeed weaker for centrally cleared trades.

We obtain a list of initial clearing dates from the website of ICE Clear Credit.[17] ICECC started to clear CDS trades in December 2009 which is 8 months after the CDS Big Bang. We remove 9950 observations (less than 3% of the total number of observations) of centrally cleared trades from the CMA sample and redo the difference-in-differences regressions in Section 5.2. The results in Table 6 are very similar to the results in Table 2. For example, the interaction term $F \times BB$ for bid-ask spreads is 2.787 and 2.35 in Table 2, and 2.784 and 2.38 in Table 6. This confirms that our main results are not affected by central clearing.

[17] https://www.theice.com/clear_credit.jhtml

Since there are only 9950 observations of centrally cleared trades in the CMA sample, we use the Markit sample to select firms that were initially centrally cleared from April 1, 2010 to October 30, 2014. We conduct difference-in-differences regressions between centrally-cleared observations and non-centrally-cleared observations of the same set of firms during the sample period. We define a dummy variable *cleared* which is a dummy variable that is equal to 1 if a reference entity is centrally cleared at date t, otherwise 0. The results are reported in Table 7. The interaction term $F \times Cleared$ captures the impact of central clearing on the effect of upfront payments. In the first column, the coefficient of the interaction term is -3.2, with a *t*-statistics of -3.29, suggesting that the effect of upfront payments is indeed weaker for centrally cleared trades. The coefficients of $F \times Cleared$ for Abs(Basis) and CDS volatility are negative though not significant. These results show that the effect of upfront payments is indeed weaker for centrally cleared trades.

Although central clearing reduces total amount of upfront payments for CDS dealers through netting, we do not expect that central clearing can perfectly remove upfront payments for CDS dealers. This is because CDS dealers are net protection sellers and hold an inventory of CDS trades. Net upfront payments cannot be zero for CDS dealers. On the other hand, upfront payments are still an impediment for CDS end users even when central clearing is present.

6.2 CDS Small Bang

The CDS Small Bang, implemented on June 20, 2009, provides another opportunity to conduct an event study on the effect of upfront payments. Since CDS traders can choose more standard coupons for European firms to minimize upfront payments, we expect that the effect of upfront payments for European firms may be weaker. We obtain CDS bid-ask spreads for European corporations from Datastream for the period from April 1, 2004 to October 30, 2010. This is the same period as what we used for the North American firms. We apply the same data filters in Section 4.1 to the European sample which consists of 401 European firms and 420,775 firm-date observations. Since trading data for European corporate bonds are not available, we consider only the effects of upfront payments on the bid-ask spread and CDS volatility. We define a time dummy variable SB that equals 1 after June 20 2009, otherwise 0. We conduct the same difference-in-differences regressions as in Section 5.2. The results are presented in Table 8. Similar to the interaction term $F \times BB$ in Table 2, the coefficients of $F \times SB$ for the bid-ask spread are positive and statistically significant, with t-statistics of around 3. The coefficients of $F \times SB$ for CDS volatility are positive but not significant. These results confirm that the effect of upfront payments for European firms is weaker than that for North American firms.

6.3 European vs. North American

For the period between the CDS Big Bang on April 8th 2009 and the CDS Small Bang on June 20th 2009, European CDS was not traded with standard coupons whereas North American CDS was traded with standard coupons. We exploit this time difference to conduct difference-in-differences analysis using a combined sample of European and North American firms from January 25th 2009 to June 20th 2009. January 25th is chosen so that the length of the pre-Big-Bang period is the same as the length of the post-Big-Bang period. We use European firms as the control group and the treatment group is the North American firms. It is expected that there will be no significant change in the funding effect for European firms before and after the Big Bang. We define a dummy variable *NA* which is equal to 1 if an observation is for a North American firm, otherwise 0. The triple interaction term $F \times BB \times NA$ captures the difference in the funding effect between the treatment group and the control group. The results are presented in Table 9. In the first specification, the coefficient for the triple interaction term is 2.095 with *t*-statistics of 3.8. This confirms that the increase in the bid-ask spread as a result of the funding cost of upfront payments for North American firms is significant. Similarly in the third specification the positive and significant coefficient for the triple interaction term confirms the increase in volatility of CDS spreads as a result of the funding cost of upfront payments for North American firms is significant.

7 Conclusion

The CDS Big Bang is a major step towards the standardization of the CDS market. We exploit this historical event to provide direct evidence on the effects of funding liquidity. Using a large sample of North American corporate CDS contracts, we find that the funding cost of the upfront payment increases the CDS bid-ask spread, the absolute value of the CDS-bond basis, and CDS spread volatility. Our findings highlight an unintended consequence of the policy on the standardization of the OTC markets. One main purpose of standardization is to reduce systemic risk. However, our evidence suggests that standardization may jeopardize market liquidity precisely during periods of financial distress. This coincidence highlights the importance of the tradeoff between standardization and the funding cost of upfront payments.

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Table 1. Summary Statistics.

Panel A provides summary statistics of our CMA sample, which contains daily bid and ask quotes for 5-year CDS contracts from Credit Market Analysis Ltd. (CMA) via Datastream. It covers 634 North American companies from January 1, 2004 to September 30, 2010. Panel B provides summary statistics of our Markit sample, which contains daily bid and ask quotes for 5-year CDS contracts from Markit Group Ltd., on 521 North American companies from April 1, 2010 to May 31, 2014. *Bid-ask spread* is the difference between bid and ask quotes on CDS spreads, denominated in basis points. *S* is midpoint of bid and ask quotes on CDS spreads, in basis points. *CDS-bond basis* is the CDS spread minus the bond yield spread of the reference entity, in basis points. *ABS(Basis)* is the absolute value of *CDS-bond basis*. *CDS volatility* is 2 week rolling standard deviations of *CDS spread*. *DIS* is defined in equation (1). *VIX* is the daily close values of the CBOE volatility index expressed in percentage, and is from Datastream. *LOS* is the 3 month Libor rate minus the 3 month Overnight Indexed Swap rate expressed in percentage, and is from Datastream. *Fee* is the size of the upfront payment expressed in percentage of the notional value. *Log(stock volume)* is the logarithm of the daily stock trading volume, in number of shares, of the reference entity. *Stock bid-ask spread* is the ask price minus the bid price divided by the midpoint of the bid and ask price, denoted in basis points, of the stock price of the reference entity. Both *Stock volume* and *Stock bid-ask spread* are from CRSP. *Log(bond volume)* is the logarithm of the daily bond trading volume, in number of bonds, of the reference entity in TRACE. *Log(bond Amihud)* is the logarithm of the Amihud (2002) measure calculated using the reference entity's bonds.

Panel A: CMA sample (January 1, 2004 to September 30, 2010)

Variable	N	Mean	Std Dev	1st Pctl	50th Pctl	99th Pctl
Bid-ask spread	633,977	9.61	8.28	2.00	5.30	40.00
CDS-bond basis	278,446	-22.47	95.42	-380.65	-1.63	172.69
ABS(Basis)	278,446	54.43	81.53	0.34	24.40	385.69
CDS volatility	633,977	9.86	16.94	0.32	4.24	73.75
S	633,977	136.69	152.80	9.00	71.20	681.22
DIS	633,977	0.67	0.45	0.02	0.62	1.98
VIX	633,977	20.44	10.54	10.23	17.18	63.92
Libor-OIS spread	633,975	0.3232	0.4547	0.0515	0.1063	2.5343
Log(stock volume)	541,845	14.70	1.40	10.64	14.70	17.82
Stock bid-ask spread	542,578	9.97	22.55	0.00	5.43	79.09
Log(bond volume)	393,615	15.01	2.14	9.62	15.43	18.84
Log(bond Amihud)	393,615	-15.52	2.22	-22.43	-14.92	-12.00

Panel B: Markit sample (April 1, 2010 to May 31, 2014)

Variable	N	Mean	Std Dev	1st Pctl	50th Pctl	99th Pctl
Bid-ask spread	400,038	11.74	8.04	4.17	10.00	41.72
CDS-bond basis	257,898	-14.28	63.52	-229.44	-10.75	161.67
ABS(CDS-bond basis)	257,898	41.26	50.37	0.45	26.30	243.35
CDS volatility	400,038	7.83	12.53	0.23	3.83	54.60
S	400,038	165.23	149.38	17.91	112.93	678.66
Fee	400,038	3.58	3.53	0.06	2.53	16.75
VIX	400,038	19.21	6.45	11.98	17.31	41.08
Libor-OIS spread	400,038	0.21	0.10	0.08	0.16	0.49
Log(stock volume)	357,673	14.87	1.46	9.70	14.91	18.11
Stock bid-ask spread	357,936	4.69	6.52	0.54	3.02	26.74
Log(bond volume)	308,757	14.95	2.09	9.68	15.29	18.97
Log(bond Amihud)	308,757	-8.69	1.71	-14.48	-8.35	-5.66

Table 2. The effects of the Upfront Payment Cost

Panel A reports the effects of the funding cost of the upfront payment *F*, which is defined in (2), on the bid-ask spread, the absolute value of the CDS-bond basis and the CDS volatility. *BB* is a dummy variable that is 1 if the date is later than April 8, 2009, and 0 otherwise. All other variables are defined in Table 1. Interaction terms between *BB* and control variables are not reported in the table. Panel B reports the effects of the arbitrageur's funding cost of the upfront payment on CDS-bond basis. The dependent variable is the CDS-bond basis. The first two columns are based on the negative CDS-bond basis sample, and the last two columns are based on the positive CDS-bond basis sample. The main independent variable is the funding cost of the long position, F^l, which is defined in (3). All regressions are based on the CMA sample (January 1, 2004 to September 30, 2010). Numbers in parentheses are *t*-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: The effect of the size of upfront funding cost

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	*Bid-ask spread*	*Bid-ask spread*	*ABS(Basis)*	*ABS(Basis)*	*CDS Volatility*	*CDS Volatility*
F	0.58***	0.69***	-7.69**	-7.20*	1.34***	1.24***
	(5.60)	(6.50)	(-2.14)	(-1.94)	(7.66)	(7.32)
F × *BB*	2.79***	2.35***	46.23***	40.60***	3.64***	3.39***
	(6.74)	(5.91)	(4.65)	(4.29)	(4.91)	(4.62)
BB	-0.51	-0.81	75.05**	-18.28	-2.92**	7.84***
	(-0.41)	(-0.63)	(2.44)	(-0.60)	(-2.32)	(5.49)
LOS	-0.43***	0.16	1.56	-0.67	0.69***	1.85***
	(-3.35)	(1.14)	(0.46)	(-0.21)	(3.11)	(6.32)
S	0.03***	0.03***	0.09***	0.07***	0.04***	0.05***
	(32.60)	(29.91)	(4.61)	(2.98)	(37.93)	(38.66)
Log(stock volume)	-0.08	0.12**	-3.08**	-0.14	1.32***	1.31***
	(-1.40)	(2.21)	(-2.30)	(-0.10)	(11.28)	(11.46)
Log(bond volume)	0.01	-0.03**	-0.54	-1.21***	0.13***	0.12***
	(0.48)	(-2.14)	(-1.46)	(-3.28)	(6.99)	(7.01)
Log(bond Amihud)	0.03**	0.01	1.42***	1.00***	-0.01	0.01
	(2.17)	(0.68)	(4.57)	(3.25)	(-0.48)	(1.05)
Stock bid-ask spread	0.01***	0.00**	0.14***	0.15***	0.02***	0.01***
	(2.72)	(2.02)	(2.84)	(3.22)	(7.97)	(4.22)
VIX	0.10***	0.04***	3.24***	0.77***	0.02*	0.11***
	(12.71)	(7.52)	(13.98)	(9.43)	(1.70)	(11.25)
Observations	356,848	356,848	236,112	236,112	356,848	356,848
R-squared	0.654	0.677	0.421	0.467	0.476	0.502
Number of firms	461	461	406	406	461	461
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Panel B: Arbitrageurs' upfront funding cost and CDS-bond basis

	(1)	(2)	(3)	(4)
	basis < 0	basis < 0	basis > 0	basis > 0
F^l	-0.12	0.68	-6.90***	-7.49***
	(-0.09)	(0.48)	(-4.18)	(-4.45)
$F^l \times BB$	-12.61**	-14.45***	10.69	11.55*
	(-2.16)	(-2.75)	(1.54)	(1.70)
BB	-29.30	101.71***	3.05	46.18
	(-0.91)	(3.42)	(0.09)	(1.47)
LOS	-0.45	1.84	-22.82***	-17.18***
	(-0.18)	(0.77)	(-7.86)	(-6.35)
S	0.01	0.08***	0.23***	0.24***
	(0.32)	(3.27)	(18.92)	(17.97)
Log(stock volume)	3.38*	3.24*	-0.04	0.21
	(1.93)	(1.95)	(-0.05)	(0.31)
Log(bond volume)	0.36	1.39***	-0.24	-0.17
	(0.74)	(3.05)	(-1.52)	(-1.15)
Log(bond Amihud)	-2.16***	-1.09***	0.11	0.16
	(-5.80)	(-3.04)	(0.77)	(1.22)
Stock bid-ask spread	-0.17***	-0.25***	0.01	-0.03
	(-2.64)	(-4.42)	(0.34)	(-1.45)
VIX	-4.07***	-1.00***	-0.10	0.06
	(-16.48)	(-11.23)	(-0.61)	(0.74)
Observations	125,443	125,443	110,669	110,669
R-squared	0.486	0.560	0.377	0.398
Number of firms	396	396	391	391
Firm FE	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES

Table 3. Payment Size vs. Price of Funding

This table reports the results of regressions are based on the CMA sample (January 1, 2004 to September 30, 2010). The dependent variables are the *Bid-ask spread* in Panel A, *ABS(basis)* in Panel B and the *CDS volatility* in Panel C. Interaction terms between *BB* and control variables are not reported in the table. Numbers in parentheses are *t*-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Dependent variable: *Bid-ask spread*

	(1)	(2)	(3)	(4)
DIS	0.50***	0.66***	0.20	0.36**
	(4.13)	(5.42)	(1.13)	(2.08)
BB	-0.97	-1.07	-0.79	-0.94
	(-0.78)	(-0.83)	(-0.64)	(-0.73)
BB × DIS	0.84***	0.47**	0.69**	0.27
	(3.62)	(2.00)	(2.23)	(0.85)
LOS	-0.03	0.64***	-0.33**	0.33**
	(-0.24)	(5.85)	(-2.09)	(2.03)
DIS × LOS			0.44***	0.45***
			(2.76)	(2.85)
BB × DIS × LOS			1.28***	1.44***
			(2.65)	(3.00)
S	0.03***	0.03***	0.03***	0.03***
	(33.36)	(30.70)	(32.75)	(29.93)
Log(stock volume)	-0.09	0.12**	-0.08	0.12**
	(-1.54)	(2.12)	(-1.39)	(2.19)
Log(bond volume)	0.01	-0.03**	0.01	-0.03**
	(0.46)	(-2.08)	(0.46)	(-2.06)
Log(bond Amihud)	0.02*	0.01	0.02**	0.01
	(1.95)	(0.47)	(2.10)	(0.60)
Stock bid-ask spread	51.04***	34.03**	50.61***	34.07**
	(2.69)	(1.98)	(2.68)	(2.00)
VIX	0.10***	0.04***	0.10***	0.04***
	(12.70)	(7.80)	(12.76)	(7.68)
Observations	356,848	356,848	356,848	356,848
R-squared	0.654	0.677	0.654	0.678
Number of firms	461	461	461	461
Firm FE	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES

Panel B: Dependent variable: *ABS(basis)*

	(1)	(2)	(3)	(4)
DIS	6.79**	7.25**	23.61***	23.39***
	(2.23)	(2.22)	(7.04)	(6.84)
BB	72.78**	-22.93	80.88***	-11.85
	(2.37)	(-0.76)	(2.68)	(-0.40)
BB × *DIS*	10.29**	6.35	-10.76*	-14.76***
	(2.17)	(1.33)	(-1.92)	(-2.60)
LOS	-2.86	-5.71**	13.79***	10.40***
	(-1.17)	(-2.41)	(3.82)	(3.15)
DIS × *LOS*			-24.25***	-23.35***
			(-6.01)	(-5.88)
BB × *DIS* × *LOS*			38.73***	40.55***
			(3.33)	(3.52)
S	0.06***	0.04*	0.08***	0.05**
	(3.34)	(1.78)	(3.94)	(2.33)
Log(stock volume)	-2.65**	0.10	-3.30**	-0.34
	(-1.98)	(0.07)	(-2.54)	(-0.25)
Log(bond volume)	-0.48	-1.12***	-0.45	-1.11***
	(-1.32)	(-3.14)	(-1.29)	(-3.18)
Log(bond Amihud)	1.42***	0.98***	1.31***	0.89***
	(4.61)	(3.21)	(4.37)	(3.01)
Stock bid-ask spread	1,361.94***	1,507.99***	1,382.62***	1,507.06***
	(2.78)	(3.27)	(2.80)	(3.22)
VIX	3.28***	0.78***	3.27***	0.80***
	(14.23)	(9.72)	(14.14)	(9.90)
Observations	236,112	236,112	236,112	236,112
R-squared	0.421	0.467	0.428	0.473
Number of firms	406	406	406	406
Firm FE	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES

Panel C: Dependent variable: *CDS volatility*

	(1)	(2)	(3)	(4)
DIS	0.87***	0.82***	-0.07	-0.02
	(5.01)	(4.91)	(-0.32)	(-0.11)
BB	-3.38***	7.65***	-2.70**	8.11***
	(-2.70)	(5.37)	(-2.14)	(5.70)
BB × DIS	0.13	0.07	-0.54	-0.64*
	(0.50)	(0.27)	(-1.39)	(-1.66)
Libor-OIS spread	1.60***	2.72***	0.65***	1.84***
	(7.66)	(9.51)	(2.76)	(6.11)
DIS × LOS			1.39***	1.26***
			(5.99)	(5.71)
BB × DIS × LOS			4.72***	4.58***
			(4.54)	(4.43)
S	0.04***	0.05***	0.04***	0.05***
	(38.41)	(39.10)	(37.85)	(38.34)
Log(stock volume)	1.29***	1.30***	1.32***	1.31***
	(11.05)	(11.34)	(11.30)	(11.45)
Log(bond volume)	0.13***	0.12***	0.13***	0.12***
	(6.99)	(6.97)	(7.04)	(7.07)
Log(bond Amihud)	-0.01	0.01	-0.01	0.01
	(-0.79)	(0.77)	(-0.45)	(1.08)
Stock bid-ask spread	187.32***	99.88***	185.95***	100.01***
	(7.88)	(4.11)	(7.96)	(4.20)
VIX	0.02	0.11***	0.02*	0.11***
	(1.60)	(11.39)	(1.70)	(11.21)
Observations	356,848	356,848	356,848	356,848
R-squared	0.473	0.500	0.476	0.502
Number of firms	461	461	461	461
Firm FE	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES

Table 4. Subsample analysis

This table reports the results of the subsample analysis. The regressions are based on the CMA sample (January 1, 2004 to September 30, 2010). Panel A is based on the sample from April 1, 2008 to April 1, 2010. Panel B is based on observations with total asset above the median. Panel C is based on observations with total asset below the median. Interaction terms between *BB* and control variables are not reported in the table. Numbers in parentheses are *t*-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: 1 year before to 1 year after the Big Bang

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	*Bid-ask spread*	*Bid-ask spread*	*ABS(Basis)*	*ABS(Basis)*	*CDS Volatility*	*CDS Volatility*
F	0.54***	0.59***	-4.96*	-3.53	1.64***	1.59***
	(5.54)	(6.23)	(-1.71)	(-1.21)	(9.18)	(9.18)
F × BB	1.98***	1.99***	22.48**	22.39***	2.82***	2.80***
	(5.38)	(5.98)	(2.59)	(2.65)	(3.35)	(3.42)
BB	-4.35***	-2.36	-40.94	-116.13***	2.60	12.70***
	(-2.78)	(-1.50)	(-1.21)	(-3.41)	(1.45)	(6.26)
LOS	-0.79***	0.22	-8.60**	-4.25	2.68***	3.26***
	(-4.73)	(1.42)	(-2.29)	(-1.41)	(9.35)	(8.80)
S	0.03***	0.03***	-0.03	-0.08***	0.04***	0.04***
	(27.55)	(25.40)	(-1.32)	(-2.92)	(26.66)	(27.43)
Log(stock volume)	-0.21**	-0.08	-8.65***	-5.89***	1.00***	1.15***
	(-2.40)	(-0.93)	(-4.26)	(-2.88)	(6.63)	(7.51)
Log(bond volume)	0.03	-0.03	1.56**	0.84	0.21***	0.15***
	(1.18)	(-1.22)	(2.48)	(1.36)	(6.02)	(4.54)
Log(bond Amihud)	0.03	-0.00	1.57***	0.67	0.02	0.05
	(1.38)	(-0.06)	(2.76)	(1.21)	(0.79)	(1.62)
Stock bid-ask spread	0.00**	0.01***	0.28***	0.34***	0.02***	0.02***
	(2.20)	(2.64)	(4.12)	(5.27)	(6.28)	(4.91)
VIX	0.10***	0.01	3.90***	1.17***	0.01	0.06***
	(12.89)	(1.19)	(15.29)	(11.32)	(0.88)	(5.69)
Observations	122,240	122,240	86,187	86,187	122,240	122,240
R-squared	0.629	0.654	0.417	0.449	0.373	0.390
Number of firms	398	398	330	330	398	398
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Panel B: Large firms

Dependent variable	(1) *Bid-ask spread*	(2) *Bid-ask spread*	(3) *ABS(Basis)*	(4) *ABS(Basis)*	(5) *CDS Volatility*	(6) *CDS Volatility*
F	0.59***	0.69***	-11.49**	-10.22**	1.42***	1.27***
	(4.02)	(4.33)	(-2.50)	(-2.19)	(6.07)	(5.30)
F × BB	1.88***	1.62***	30.02**	27.56**	2.42**	2.35**
	(3.24)	(2.78)	(2.45)	(2.29)	(2.15)	(2.16)
BB	0.32	-0.04	68.06*	9.45	0.48	11.13***
	(0.23)	(-0.02)	(1.80)	(0.25)	(0.25)	(5.30)
LOS	-0.06	0.47**	10.97***	7.02*	1.16***	2.56***
	(-0.36)	(2.47)	(2.98)	(1.94)	(4.16)	(6.83)
S	0.03***	0.03***	0.11***	0.09***	0.05***	0.05***
	(24.21)	(21.92)	(4.37)	(2.94)	(29.12)	(29.79)
Log(stock volume)	0.00	0.16**	-3.44*	-0.29	1.43***	1.39***
	(0.05)	(2.22)	(-1.90)	(-0.15)	(8.48)	(8.41)
Log(bond volume)	0.02	-0.01	-0.20	-0.73*	0.07***	0.07***
	(1.08)	(-0.87)	(-0.49)	(-1.88)	(2.89)	(2.79)
Log(bond Amihud)	0.05***	0.04**	1.37***	1.02**	-0.00	0.03*
	(3.23)	(2.27)	(3.26)	(2.51)	(-0.06)	(1.80)
Stock bid-ask spread	0.00	0.00	0.20**	0.21**	0.02***	0.01***
	(0.72)	(0.65)	(2.40)	(2.55)	(5.10)	(2.87)
VIX	0.07***	0.03***	2.27***	0.63***	-0.01	0.09***
	(7.68)	(5.24)	(8.96)	(6.06)	(-0.69)	(7.46)
Observations	192,973	192,973	138,612	138,612	192,973	192,973
R-squared	0.726	0.740	0.420	0.452	0.545	0.565
Number of firms	237	237	200	200	237	237
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Panel C: Small firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	*Bid-ask spread*	*Bid-ask spread*	*ABS(Basis)*	*ABS(Basis)*	*CDS Volatility*	*CDS Volatility*
F	0.55***	0.67***	-9.06*	-9.87*	1.23***	1.17***
	(3.80)	(4.82)	(-1.75)	(-1.82)	(4.93)	(5.22)
F × BB	3.58***	2.88***	53.53***	42.89***	4.39***	3.97***
	(5.96)	(5.14)	(3.71)	(3.17)	(4.70)	(4.14)
BB	-3.40	-3.03	-4.04	-151.23***	-5.43***	5.78***
	(-1.46)	(-1.36)	(-0.08)	(-2.82)	(-3.18)	(2.99)
LOS	-0.93***	-0.29*	-6.88	-8.58	-0.07	0.82*
	(-4.89)	(-1.78)	(-1.21)	(-1.53)	(-0.21)	(1.89)
S	0.03***	0.03***	0.06**	0.04	0.04***	0.04***
	(24.33)	(22.26)	(2.35)	(1.47)	(28.13)	(29.05)
Log(stock volume)	-0.28***	0.01	-5.42***	-2.16	1.20***	1.27***
	(-3.03)	(0.09)	(-3.10)	(-1.25)	(10.09)	(10.90)
Log(bond volume)	0.00	-0.04**	-0.45	-1.16**	0.17***	0.16***
	(0.13)	(-2.07)	(-0.88)	(-2.44)	(6.94)	(7.48)
Log(bond Amihud)	0.01	-0.01	1.33***	0.83**	0.01	0.02
	(0.65)	(-0.70)	(3.43)	(2.26)	(0.39)	(1.18)
Stock bid-ask spread	0.01***	0.00**	0.10***	0.11***	0.02***	0.01**
	(3.53)	(2.18)	(2.75)	(3.15)	(5.90)	(2.46)
VIX	0.13***	0.05***	4.79***	0.99***	0.06***	0.13***
	(11.23)	(5.89)	(13.08)	(7.53)	(3.83)	(8.59)
Observations	163,875	163,875	97,500	97,500	163,875	163,875
R-squared	0.585	0.623	0.459	0.527	0.394	0.432
Number of firms	309	309	271	271	309	309
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Table 5. The effect of the upfront payment cost in Markit sample

This table reports the effects of the funding cost of the upfront payment *FC* on the *Bid-ask spread*, the *ABS(Basis)* and the *CDS volatility*, where *FC=Fee×Libor-OIS spread*. The regressions are based on the Markit sample (April 1, 2010 to May 31, 2014). Numbers in parentheses are *t*-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	*Bid-ask spread*	*Bid-ask spread*	*ABS(Basis)*	*ABS(Basis)*	*CDS volatility*	*CDS volatility*
FC	0.82***	0.71***	4.55**	4.92**	0.93***	0.86***
	(8.25)	(7.20)	(2.04)	(2.17)	(7.60)	(6.85)
S	0.04***	0.04***	0.14***	0.13***	0.03***	0.04***
	(36.34)	(34.40)	(4.91)	(4.51)	(28.51)	(27.98)
Log(stock volume)	-0.06	0.05	0.27	0.26	0.89***	0.89***
	(-1.07)	(0.97)	(0.36)	(0.34)	(10.99)	(11.08)
Log(bond volume)	-0.02*	-0.03***	-0.95***	-0.90***	0.14***	0.13***
	(-1.85)	(-2.76)	(-4.97)	(-4.78)	(9.09)	(8.96)
Log(bond Amihud)	-0.01	0.01	0.17	0.12	0.02**	0.02*
	(-0.51)	(0.89)	(0.86)	(0.62)	(2.10)	(1.83)
Stock bid-ask spread	-0.05***	-0.04*	0.21	0.09	-0.06**	-0.05**
	(-3.00)	(-1.76)	(0.67)	(0.28)	(-2.52)	(-2.19)
VIX	0.02***	0.08***	-0.04	-0.16**	0.16***	0.18***
	(3.11)	(15.21)	(-0.30)	(-2.21)	(16.48)	(17.98)
LOS	3.65***	1.93***	13.29	5.56	-3.26***	-2.53***
	(8.31)	(4.05)	(1.55)	(0.69)	(-7.32)	(-3.63)
Observations	285,249	285,249	221,860	221,860	285,311	285,311
R-squared	0.581	0.618	0.118	0.126	0.351	0.367
Number of firms	414	414	364	364	414	414
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Table 6. The effects of the upfront payment cost excluding centrally cleared contracts

This table reports the effects of the funding cost of the upfront payment *F* on the bid-ask spread, CDS-bond basis and CDS volatility using a subsample of non-centrally-cleared observations in the CMA sample. 9950 observations are centrally cleared and excluded from the CMA sample. Interaction terms between BB and control variables are not reported in the table. Numbers in parentheses are t-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Bid-ask spread	Bid-ask spread	ABS(Basis)	ABS(Basis)	CDS Volatility	CDS Volatility
F	0.58***	0.69***	-7.63**	-7.12*	1.34***	1.24***
	(5.57)	(6.49)	(-2.13)	(-1.92)	(7.68)	(7.35)
F × BB	2.78***	2.38***	43.80***	39.78***	3.59***	3.34***
	(6.67)	(5.93)	(4.34)	(4.13)	(4.82)	(4.52)
BB	-0.69	-0.75	73.98**	-15.49	-2.74**	8.17***
	(-0.54)	(-0.56)	(2.30)	(-0.49)	(-2.11)	(5.54)
LOS	-0.43***	0.16	1.60	-0.70	0.68***	1.85***
	(-3.34)	(1.16)	(0.47)	(-0.22)	(3.09)	(6.31)
S	0.03***	0.03***	0.09***	0.07***	0.04***	0.05***
	(32.59)	(29.84)	(4.69)	(2.98)	(37.84)	(38.62)
Log(stock volume)	-0.08	0.14**	-3.24**	-0.10	1.33***	1.33***
	(-1.34)	(2.48)	(-2.35)	(-0.07)	(11.26)	(11.51)
Log(bond volume)	0.01	-0.03**	-0.58	-1.20***	0.13***	0.12***
	(0.39)	(-2.13)	(-1.55)	(-3.23)	(6.95)	(7.04)
Log(bond Amihud)	0.02**	0.01	1.39***	1.01***	-0.01	0.01
	(2.08)	(0.70)	(4.43)	(3.28)	(-0.62)	(1.05)
Stock bid-ask spread	0.01***	0.00**	0.14***	0.15***	0.02***	0.01***
	(2.73)	(2.05)	(2.78)	(3.20)	(7.97)	(4.22)
VIX	0.10***	0.04***	3.24***	0.77***	0.02*	0.11***
	(12.68)	(7.43)	(13.95)	(9.41)	(1.75)	(11.22)
Observations	348,095	348,095	228,932	228,932	348,095	348,095
R-squared	0.654	0.678	0.427	0.468	0.475	0.502
Number of firms	461	461	406	406	461	461
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Table 7. Cleared vs. Non-cleared

This table reports the effects of the funding cost of the upfront payment F on the bid-ask spread, CDS-bond basis and CDS volatility. The regressions are based on a subsample of the Markit sample from April 1, 2010 to October 30, 2014. The subsample consists of firms that were initially centrally cleared during April 1, 2010 to October 30, 2014. Thus the non-cleared observations and the cleared observations are from the same set of firms. *Cleared* is a dummy variable that is equal to 1 if a firm is centrally cleared at date t, otherwise 0. Numbers in parentheses are t-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Bid-ask spread	Bid-ask spread	ABS(basis)	ABS(basis)	CDS volatility	CDS volatility
FC	5.05***	4.57***	23.32	28.09*	4.22***	3.36**
	(6.19)	(5.64)	(1.46)	(1.74)	(2.81)	(2.36)
FC × Cleared	-3.20***	-3.00***	-3.24	-8.08	-2.43*	-1.98
	(-3.29)	(-3.03)	(-0.17)	(-0.45)	(-1.72)	(-1.41)
Cleared	0.76***	0.38**	-5.57	-2.92	0.54***	0.36*
	(5.55)	(2.54)	(-1.37)	(-0.83)	(3.01)	(1.71)
S	0.04***	0.04***	0.21***	0.20***	0.04***	0.04***
	(17.89)	(17.16)	(4.12)	(3.81)	(17.20)	(17.29)
Log(stock volume)	-0.11*	-0.02	0.28	0.32	0.62***	0.65***
	(-1.71)	(-0.29)	(0.22)	(0.24)	(4.89)	(5.12)
Log(bond volume)	-0.01	-0.02	-1.37***	-1.31***	0.14***	0.12***
	(-0.81)	(-1.12)	(-3.22)	(-3.32)	(5.41)	(5.26)
Log(bond Amihud)	0.02*	0.03***	-0.33	-0.36	0.01	0.01
	(1.70)	(2.65)	(-1.04)	(-1.12)	(0.86)	(0.44)
Stock bid-ask spread	-0.00	-0.00	0.23	0.15	-0.03	-0.02
	(-0.02)	(-0.33)	(0.55)	(0.35)	(-0.89)	(-0.65)
LOS	3.18***	2.28***	15.56	-2.25	-2.13***	-1.73
	(5.34)	(3.49)	(1.49)	(-0.26)	(-3.22)	(-1.63)
VIX	0.06***	0.07***	-0.05	-0.09	0.14***	0.17***
	(5.53)	(9.82)	(-0.25)	(-0.72)	(8.69)	(10.28)
Observations	88,365	88,365	72,906	72,906	88,365	88,365
R-squared	0.695	0.724	0.244	0.254	0.430	0.447
Number of firms	93	93	90	90	93	93
Firm FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES	NO	YES

Table 8. CDS Small Bang

This table reports the effects of the funding cost of the upfront payment *F* on the bid-ask spread, CDS-bond basis and CDS volatility using a sample of European firms from April 1, 2004 to October 30, 2014. *SB* is a time dummy variable which is equal to 1 if date is later than Jun 20, 2009, otherwise 0. *VSTOXX* is EURO STOXX 50 volatility index. Euro Libor-OIS spread is the spread between 3 month Euro Libor rate and 3 month Euro OIS rate. Interaction terms between *SB* and control variables are not reported in the table. Numbers in parentheses are t-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
Dependent variable	*Bid-ask spread*	*Bid-ask spread*	*CDS volatility*	*CDS volatility*
F	1.50***	1.50***	1.81***	2.02***
	(5.16)	(5.00)	(6.64)	(7.01)
F × *SB*	3.23***	3.37***	1.38	1.30
	(2.77)	(2.94)	(1.55)	(1.44)
SB	-1.58***	-4.41***	-5.39***	-4.72***
	(-4.54)	(-7.85)	(-18.02)	(-7.38)
S	0.05***	0.04***	0.04***	0.04***
	(25.12)	(23.47)	(30.81)	(28.24)
VSTOXX	0.13***	0.02***	0.06***	0.14***
	(14.93)	(4.39)	(8.36)	(17.08)
Euro Libor-OIS spread	-0.39**	0.95***	1.80***	0.95***
	(-2.29)	(5.77)	(11.59)	(2.65)
Observations	420,775	420,775	420,775	420,775
R-squared	0.654	0.678	0.497	0.522
Number of firms	401	401	401	401
Firm FE	YES	YES	YES	YES
Year-Quarter FE	NO	YES	NO	YES

Table 9. North American and European names

This table reports the differential effects of the funding cost of the upfront payment *F* on the bid-ask spread, CDS-bond basis and CDS volatility using a combined sample of North American and European firms from January 25, 2009 to June 20, 2009. *NA* is a dummy variable which is equal to 1 if an observation is for a North American firm, otherwise 0. Interaction terms between *BB* and control variables are not reported in the table. Numbers in parentheses are t-statistics based on standard errors that are clustered by firm and are corrected for heteroscedasticity. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Bid-ask spread	Bid-ask spread	CDS volatility	CDS volatility
F	1.10***	1.11***	1.11*	1.13*
	(4.24)	(4.26)	(1.86)	(1.88)
F × BB	-0.86*	-0.82	-0.84	-0.59
	(-1.67)	(-1.60)	(-0.81)	(-0.57)
F × BB × NA	2.09***	2.04***	2.14**	1.86*
	(3.81)	(3.72)	(2.19)	(1.91)
BB	-1.42	-3.65**	20.80***	-18.10***
	(-1.05)	(-2.47)	(5.18)	(-3.68)
S	0.02***	0.02***	0.01***	0.02***
	(14.32)	(14.42)	(4.09)	(4.70)
VSTOXX	0.06***	0.00	-0.08**	0.07***
	(3.59)	(0.28)	(-2.24)	(3.57)
VIX	-0.05***	-0.01	-0.09***	-0.23***
	(-3.74)	(-0.96)	(-3.05)	(-7.55)
Euro Libor-OIS spread	5.52***	2.05***	13.38***	7.31***
	(7.20)	(3.31)	(6.75)	(3.31)
LOS	-7.27***	-2.72**	9.57**	-7.30*
	(-5.14)	(-2.20)	(2.49)	(-1.69)
Observations	58,043	58,043	58,043	58,043
R-squared	0.245	0.251	0.083	0.105
Number of firms	731	731	731	731
Firm FE	YES	YES	YES	YES
Year-Month FE	NO	YES	NO	YES

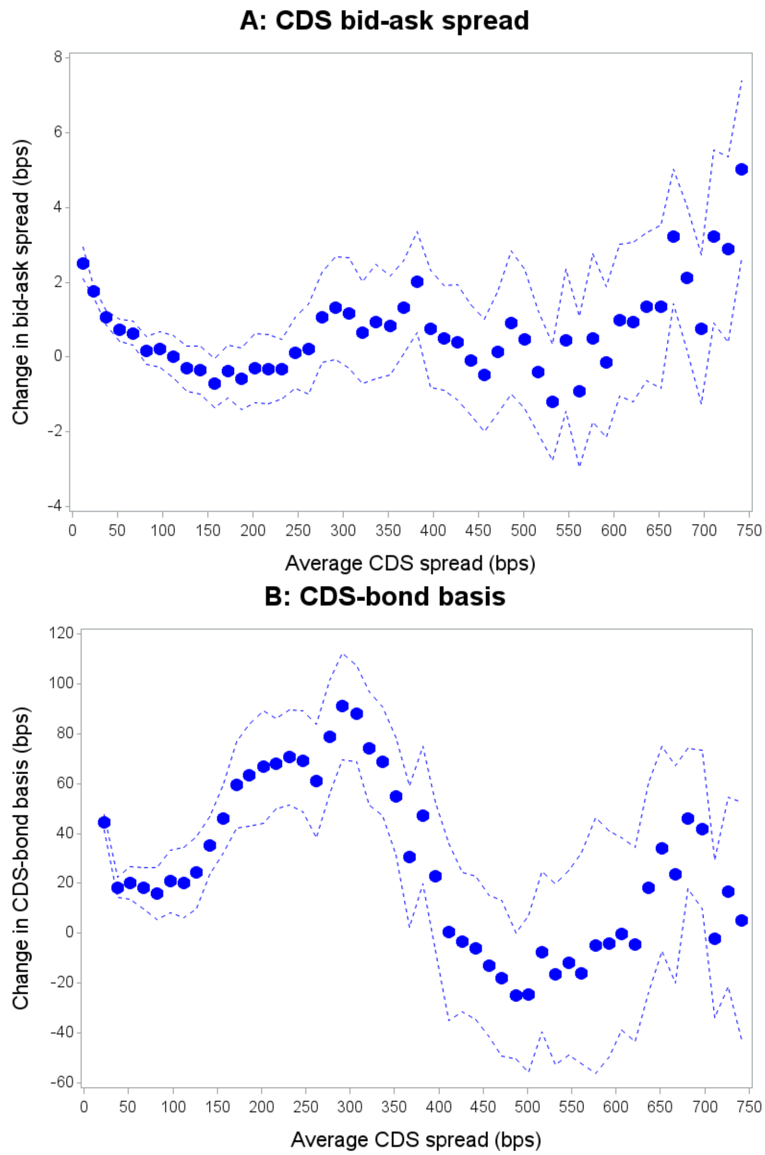

Figure 1: Change in bid-ask spread and CDS-bond basis around the CDS Big Bang

We divide the CMA sample (January 1, 2004 to September 30, 2010) into pre- and post-Big Bang periods. Observations are divided into 50 groups by CDS spreads. For each group, we average the bid-ask spread and the CDS-bond basis for the pre- and post-Big Bang subsamples. Panel A plots the change in the average bid-ask spread between the two subsamples against the average CDS spread. Panel B plots the change in the absolute value of the average CDS-bond basis between the two subsamples against the average CDS spread. The dotted lines are the 95% confidence interval.