Central Clearing of OTC Derivatives: bilateral vs multilateral netting *

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Abstract

We study the impact of central clearing of over-the-counter (OTC) transactions on counterparty exposures in a market with OTC transactions across several asset classes with heterogeneous characteristics. The impact of introducing a central counterparty (CCP) on expected interdealer exposure is determined by the tradeoff between multilateral netting across dealers on one hand and bilateral netting across asset classes on the other hand. We find this tradeoff to be sensitive to assumptions on heterogeneity of asset classes in terms of ‘riskyness’ of the asset class as well as correlation of exposures across asset classes. In particular, while an analysis assuming independent, homogeneous exposures suggests that central clearing is efficient only if one has an unrealistically high number of participants, the opposite conclusion is reached if differences in riskyness and correlation across asset classes are realistically taken into account. We argue that empirically plausible specifications of model parameters lead to the conclusion that central clearing does reduce interdealer exposures: the gain from multilateral netting in a CCP overweighs the loss of netting across asset classes in bilateral netting agreements. When a CCP exists for interest rate derivatives, adding a CCP for credit derivatives is shown to decrease overall exposures. These findings are shown to be robust to the statistical assumptions of the model as well as the choice of risk measure used to quantify exposures.

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1 Central clearing of OTC derivatives

Over-The-Counter (OTC) derivatives represent a sizable fraction of financial transactions worldwide, encompassing a wide variety of contracts and asset classes. Figure 1 depicts the development in the OTC derivatives markets for different asset classes since 1998. Although the increase in notionals has stopped since the peak of the financial crisis the overall growth is impressive. The contraction in some OTC derivatives asset classes since the beginning of the crisis is clearly seen from Table 1 which shows gross notional values in different asset classes as of June 2007 and June 2010.

Table 1: Gross notional values in OTC derivatives markets in billions as of June 2007 and June 2010. Source: BIS

| Asset Class          | 2007   | 2010   |
|----------------------|--------|--------|
| Commodity            | 8,255  | 3,273  |
| Equity Linked        | 9,518  | 6,868  |
| Foreign Exchange     | 57,604 | 62,933 |
| Interest Rate        | 381,357| 478,093|
| Credit Derivatives   | 51,095 | 31,416 |
| Other                | 78     | 72     |
| **Total**            | 507,907| 582,655|

Most bilateral OTC contracts involve exchange of collateral between counterparties, to mitigate counterparty risk. However, there is evidence
that collateral requirements in bilateral Credit Support Annexes (CSAs) lead to non-negligible residual counterparty exposures. This is particularly the case in credit derivatives contracts where jump-to-default risk is typically not covered by bilateral collateral requirements (Cont, 2010). In fact, the collapse of AIG in September 2008 was triggered by CDS collateral requirements it could not meet. Brigo et al. (2011) and Fujii and Takahashi (2011) both show that even in the extreme case of continuously collateralized CDS contracts, counterparty risk is present, e.g. jump-to-default risk. Arora et al. (2012) find evidence of counterparty risk in the interdealer CDS markets. Singh (2010) finds that most large banks active in the OTC derivatives market are under-collateralized.

One of the solutions proposed for mitigating counterparty risk is the central clearing of OTC derivatives. The Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 has mandated central clearing for standardized Over-The-Counter (OTC) derivatives. Many classes of OTC derivatives are already being partially cleared through Central Counterparties (CCPs), e.g. LCH Clearnet for Interest Rate Swaps (IRSs), ICE Clear and CME for Credit Default Swaps (CDS), Fixed Income Clearing Corp (FICC) for fixed-income OTC derivatives and many others. The volume of OTC derivatives cleared through central counterparties will most likely increase with the implementation of the Dodd-Frank Act and increased capital requirements in Basel 3 for non-cleared OTC transactions.

With a CCP, a bilateral OTC derivative trade between two counterparties is replaced by two symmetric trades between the CCP and each counterparty. Trading OTC derivatives through a CCP has some desirable effects: in a bilateral market default of one entity can spread throughout the system leading to a chain of contagious defaults (Cont et al., 2010; Iyer and Peydro, 2011). A CCP can break this chain of contagion. It has been argued that clearing trades through a CCP leads to a gain in multilateral netting among market participants in the asset class being cleared, higher transparency, risk sharing among members of the clearinghouse, no duplicative monitoring, mitigation of counterparty risk as counterparties are insulated from each other’s default, a reduction in commitment frictions (Nosal, 2011). Moreover, by centralizing information, supervision and transparency for regulators are facilitated while retaining trade anonymity, and from a moral hazard perspective it is less problematic to bail out a CCP compared to bailing out individual banks. While a CCP leads to higher multilateral netting it comes at the cost of reduced bilateral netting: if only a subset of OTC contracts is cleared, netting across asset classes due to hedging is not accounted for, e.g. if a fixed income position is hedged with an OTC interest rate derivative, separate clearing of the derivative leads to larger collateral requirements.

Tables 2 and 3 show the OTC derivatives notionals in four different asset classes of the 10 largest US derivatives dealers. Inspection of the tables re-
Table 2: Notional OTC derivative exposures for the 10 largest US derivatives dealers, March 31, 2009 (billions USD). Source: Office of the Comptroller of the Currency.

| Dealer          | Forwards | Options | Swaps  | Credit |
|-----------------|----------|---------|--------|--------|
| JP Morgan Chase | 8,422    | 10,633  | 51,221 | 7,495  |
| Bank of America | 9,132    | 6,908   | 50,702 | 5,649  |
| Goldman Sachs   | 1,631    | 6,754   | 30,958 | 6,601  |
| Morgan Stanley  | 1,127    | 3,530   | 26,112 | 6,307  |
| Citigroup       | 4,743    | 5,868   | 15,199 | 2,950  |
| Wells Fargo     | 1,217    | 543     | 2,748  | 286    |
| HSBC            | 595      | 185     | 1,565  | 913    |
| Taunus          | 667      | 20      | 162    | 144    |
| Bank of New York| 371      | 304     | 404    | 1      |
| State Street    | 571      | 45      | 24     | 0      |
| Total           | 28,476   | 34,792  | 179,094| 30,348 |

Table 3: Notional amounts of OTC derivatives contracts of the 10 biggest US derivatives dealers as of December 31, 2010 in billions. Source: Office of the Comptroller of the Currency.

| Dealer          | Forwards | Options | Swaps  | Credit |
|-----------------|----------|---------|--------|--------|
| JP Morgan Chase | 11,807   | 8,899   | 49,332 | 5,472  |
| Bank of America | 10,287   | 5,848   | 43,482 | 4,367  |
| Citigroup       | 6,895    | 7,071   | 28,639 | 2,546  |
| Goldman Sachs   | 3,805    | 8,568   | 27,392 | 4,233  |
| Morgan Stanley  | 5,459    | 3,855   | 27,162 | 4,648  |
| Wells Fargo     | 1,081    | 463     | 1,806  | 93     |
| HSBC            | 758      | 127     | 1,901  | 700    |
| Bank of New York| 420      | 367     | 555    | 1      |
| Taunus          | 848      | 21      | 199    | 33     |
| State Street    | 599      | 76      | 79     | 0      |
| Total           | 41,959   | 35,295  | 180,547| 22,093 |
reveals a decrease in the notional of the credit derivatives class between 2009 and 2010. This is primarily a consequence of increased trade compression and the increased use of central clearing in the CDS market (Vause [2010]): the first CDS clearing facility, operated by ICE Clear, started its operations in 2009 and currently clears a sizable fraction of interdealer trades in index and single name corporate CDSs. Comparing Table 3 with Table 2 suggests that the central clearing of CDSs initiated in 2009 and the resulting compression of bilateral trades led to an overall decrease of the magnitude of dealer exposures.

To understand why central clearing of OTC trades can lead to such a decrease in the sum of bilateral exposures, consider a stylized market of four participants with bilateral exposures like shown in the left part of Figure 2. In this market the sum of bilateral exposures amounts to 350, taking into account bilateral netting. Introducing a CCP enables multilateral netting of the exposures (Figure 2, right) which reduces the total net exposure to 180.

Figure 2: Left: A stylized bilateral market. Right: A centrally cleared market.

The above example highlights the benefits of multilateral netting through a CCP. But there are also situations where central clearing of a single asset class may actually increase overall net exposures. If only a subset of OTC contracts is cleared, netting across asset classes due to hedging is not accounted for. For instance, if a fixed income position is hedged with an OTC interest rate derivative, separate clearing of the derivative leads to larger exposure, which in turn leads to larger collateral requirements. A relevant question is thus to compare the impact of these two competing effects:

- the reduction of net exposures due to multilateral netting across counterparties through central clearing, and

- the increase in net bilateral exposures through the loss of netting across asset classes.

In an influential paper widely disseminated to regulators, Duffie and Zhu (2011) argue that if only a subset of OTC contracts is cleared in a clearing-
house, then there may be a loss of netting across asset classes which exceeds the gain in multilateral netting across market participants. This conclusion has been interpreted by some to mean that ‘CCPs increase net exposure’.

**Contribution** In the present work, we reconsider the impact of central clearing of over-the-counter (OTC) transactions on counterparty exposures in a market with OTC transactions across several asset classes with heterogeneous characteristics. We find that the impact, on total expected inter-dealer exposure, of introducing a central counterparty for a single class of OTC derivatives is highly sensitive to assumptions on heterogeneity of asset classes in terms of ‘riskyness’ of the asset class as well as correlation of exposures across asset classes. In particular, while a model with independent, homogeneous exposures suggests that central clearing is efficient only if one has an unrealistically high number of participants, these conclusions are not robust to departures from the assumptions of independent and homogeneity. In fact, we find that the opposite conclusion is reached if differences in riskyness across asset classes are realistically taken into account. Empirically plausible specifications of these parameters lead to the conclusion that the gain from multilateral netting in a CCP overweighs the loss of netting across asset classes in bilateral netting agreements. When a CCP exists for interest rate derivatives, adding a CCP for credit derivatives is shown to decrease overall exposures. This result distinguishes our study from Duffie and Zhu (2011) where the marginal effect of clearing credit derivatives is very limited when interest rate swaps are already being cleared. These findings are shown to be robust to the choice of distribution for OTC credit derivatives exposures.

**Outline** The remainder of the paper is structured as follows.

Section 2 introduced a stylized model of an OTC market with $K$ different asset classes and examines how the separate or joint clearing of one or more asset classes in a CCP affects bilateral exposures. Section 3 emphasizes the key role played by assumptions on heterogeneity of various parameters—heterogeneity of riskyness across asset classes, heterogeneity of exposure sizes across dealers—and proposed a flexible parameterization to account for this heterogeneity.

Section 4 uses this framework to study how the introduction of CCPs affects OTC derivatives exposures, using three different risk measures. Finally, Section 5 concludes.
2 A stylized model of OTC clearing

To compare the impact on exposures of multilateral netting across counterparties, as opposed to cross-asset netting in OTC markets with bilateral transactions, we consider a market where $N$ participants trade over-the-counter derivatives in $K$ different asset classes, labeled $k = 1...K$. Collateral requirements, whether bilateral or in CCPs, are typically based on an estimation of exposures over a horizon which we denote by $X_{ij}^k$; the net value of the total positions at some future time point that $i$ owns of derivatives belonging to asset class $k$ with $j$ as the counterparty. The exposure of $i$ to $j$ in asset class $k$ is then defined as

$$\max \left\{ X_{ij}^k, 0 \right\}.$$

(1)

We want to compare total exposures across three configurations:

1. The total exposure $e_i^0$ of company $i$ under bilateral netting (no central clearing):

$$e_i^0 = \sum_{j \neq i} \max \left\{ \sum_{k=1}^K X_{ij}^k, 0 \right\}.$$

(2)

2. The exposure $e_i^1$ assuming asset class $K$ is cleared through a central counterparty

$$e_i^1 = \sum_{j \neq i} \max \left\{ \sum_{k=1}^K (1 - w_k) X_{ij}^k, 0 \right\} + \max \left\{ \sum_{j \neq i} w_K X_{ij}^K, 0 \right\},$$

(3)

where $w_k$ denotes the fraction of asset class $k$ that is being cleared. Hence in this case we have that, $w_k = 0$ for $k = 1, ..., K - 1$.

3. The exposure $e_i^2$ when two asset classes $K - 1$ and $K$ are separately cleared through a central counterparty

$$e_i^2 = \sum_{j \neq i} \max \left\{ \sum_{k=1}^K (1 - w_k) X_{ij}^k, 0 \right\} + \max \left\{ \sum_{j \neq i} w_{K-1} X_{ij}^{K-1}, 0 \right\}$$

$$+ \max \left\{ \sum_{j \neq i} w_K X_{ij}^K, 0 \right\},$$

(4)

where $w_k = 0$ for $k = 1, ..., K - 2$. 

6
In equation (2), all netting is done bilaterally across all \( K \) asset classes and the total net exposure of dealer \( i \) is the sum of the net exposure with each counterparty \( j \). When a CCP is introduced in the market, as in equations (3) and (4), the total net exposure is the sum of the bilateral net exposures to all counterparties and the exposures to the CCPs. Hence, the introduction of clearinghouses transfers exposure reductions from bilateral netting to multilateral netting. Whether the introduction of a clearinghouse increases or decreases net exposures depends on the particular market, e.g. the notional sizes of the asset classes, riskyness of the asset classes, correlation between the asset classes, the number of asset classes, the number of banks etc. In terms of dealer risk management our analysis underestimates the risk reduction from central clearing since we put the same risk weights on bilateral dealer exposures and exposures to a CCP. In most cases the riskyness of a CCP will be lower than that of a dealer - and hence have a smaller risk weight. The reader is referred to Arnsdorf (2012) for a model to quantify the CCP risk a dealer faces when participating in a CCP.

In the sequel we consider different distributional choices for the exposures, and we compare expected net exposures, Value at Risk (VaR), expected shortfall and the mean of the maximum of realized exposures across dealers across various clearing scenarios.

3 Accounting for heterogeneity

3.1 The importance of correlation and heterogeneity in exposures

The stylized model above requires assumptions on the joint distribution of exposures.

Let us first consider the baseline case where \( X_{ij}^k \sim N(0, \sigma_k) \) are normally distributed for all \( i \neq j \) and allowed to be correlated across asset classes. As in Duffie and Zhu (2011), we assume that the standard deviation of \( X_{ij}^k \) is proportional to the credit exposure

\[
\sigma_k = \alpha_k C E_k.
\]

Table 4 shows the gross credit exposures \( C E_k \) in six different asset classes as of June 2010. OTC interest rate derivatives clearly account for the major portion of this value.

Consider first a market where only one single asset class is being cleared. In Duffie and Zhu (2011) it is shown that if \( \alpha_k = \alpha \) for all \( k = 1, ..., K \) and if the exposures are uncorrelated, the number of entities required to participate in the central clearinghouse has to be equal to or greater than 461 in order to see a reduction in expected exposures: this is an unrealistically high number, so it would imply in practice that existing clearing schemes do not
Table 4: Gross market values in OTC derivatives markets in billions as of June 2010. Source: BIS

| Asset Class     | Exposure |
|-----------------|----------|
| Commodity       | 457      |
| Equity Linked   | 706      |
| Foreign Exchange| 2,524    |
| Interest Rate   | 17,533   |
| CDS             | 1,666    |
| Other           | 1,788    |
| **Total**       | **24,673** |

result in reduction of exposures. But, altering the assumption on risk per dollar notional to e.g. $\alpha_K = 3\alpha$ in the same model, the picture is changed dramatically and the threshold number drops to 54. If furthermore we assume the correlation between the asset class exposures is, e.g., 10%, then the number of clearing members needed to achieve compression of exposures is down to... 17! Table 5 reports the required number of participants for different scenarios. Figure 3 depicts the minimal number of members required to participate in the clearinghouse in order to see expected exposure reductions as a function of correlation and riskyness of the cleared asset class. The Figure clearly reveals that the base case considered in Duffie and Zhu (2011), $\rho = 0$ and $\alpha_K = 1$, is a singularity: a slight deviation from these parameters alters the conclusions of the model dramatically.

Table 5: Minimal number of clearing members required in order for a CCP to reduce expected exposure. $X_{ij}^k \sim N(0, \alpha_k^2 C E_k^2)$ are jointly Gaussian.

| Assumptions                                      | N   |
|--------------------------------------------------|-----|
| Duffie & Zhu’s example:                          |     |
| $\rho = 0, \alpha_i = \alpha$                   | 461 |
| $\rho = 0, \alpha_K = 3\alpha$                  |     |
| $\alpha_i = \alpha, i < K$                      | 54  |
| $\rho = 0.1, \alpha_K = 3\alpha$                |     |
| $\alpha_i = \alpha, i < K$                      | 17  |
| $\rho = 0.2, \alpha_K = 2\alpha$                |     |
| $\alpha_i = \alpha, i < K$                      | 11  |

These observations illustrate that, even in a simple setting with (Gaussian) identically distributed exposures, the tradeoff between netting across asset classes versus multilateral netting across market participants is highly
sensitive to assumptions on the correlation of exposures and the heterogeneity of riskyness across asset classes. Conclusions based on a model with homogeneous risk across asset classes are not robust to departures from this homogeneity assumption.

We now introduce a model which allows to parametrize this heterogeneity of exposure sizes across dealers and asset classes and differentiates various asset classes in terms of their risk characteristics, as measured by the ‘risk’ (or collateral requirement) per dollar notional.

### 3.2 Accounting for heterogeneity across dealers

Instead of credit exposures we now use notional values to determine the distribution of the $X_{ij}^k$s and assume that they are proportional to the notional values via

$$X_{ij}^k = \beta_k Z_i^k \frac{Z_j^k}{\sum_{h \neq i} Z_h^k} Y_{ij}^k,$$  

where $Y_{ij}^k$ is a random variable with zero mean and unit variance, and $Z_i^k$ is the total notional size of dealer $i$ in asset class $k$. In this way the exposure of $i$ to $j$ in class $k$ is a weighted fraction of company $i$’s total notional in derivatives class $k$, where the weight equals $j$’s notional size in asset class $k$. 

Figure 3: Minimal number of members $N$ required to participate in the CCP in order to see a reduction in the expected exposures as a function of riskyness of the asset class being cleared $\alpha_k$ and the correlation between asset classes $\rho$. 


relative to the total notional size of the dealers in asset class $k$.

### 3.2.1 Normally distributed exposures

We first study the case where $Y_{ij}^k$ is a standard normally distributed variable. In the Gaussian case we can get closed formulas for the expected net exposures

\[
E[e_0^i] = \frac{1}{\sqrt{2\pi}} \sum_{j \neq i} K \sum_{k=1}^{K} \sum_{m=1}^{K} \rho_{km} \beta_k Z_k^i \beta_m Z_m^j \sum_{h \neq i} Z_h^m \sum_{h \neq i} Z_h^m 
\]

\[
E[e_1^i] = \frac{1}{\sqrt{2\pi}} \sum_{j \neq i} K \sum_{k=1}^{K} \sum_{m=1}^{K} (1 - w_k) (1 - w_m) \rho_{km} \beta_k Z_k^i Z_k^j \sum_{h \neq i} Z_h^m Z_h^m 
+ \frac{1}{\sqrt{2\pi}} \beta_{K} w_K Z_K^i \sqrt{\frac{\sum_{j \neq i} (Z_j^K)^2}{\sum_{h \neq i} Z_h^K}} 
\]

\[
E[e_2^i] = \frac{1}{\sqrt{2\pi}} \sum_{j \neq i} K \sum_{k=1}^{K} \sum_{m=1}^{K} (1 - w_k) (1 - w_m) \rho_{km} \beta_k Z_k^i Z_k^j \sum_{h \neq i} Z_h^m Z_h^m 
+ \frac{1}{\sqrt{2\pi}} \beta_{K-1} w_{K-1} Z_{K-1}^i \sqrt{\frac{\sum_{j \neq i} (Z_{j}^{K-1})^2}{\sum_{h \neq i} Z_{h}^{K-1}}} 
+ \frac{1}{\sqrt{2\pi}} \beta_{K} w_K Z_K^i \sqrt{\frac{\sum_{j \neq i} (Z_j^K)^2}{\sum_{h \neq i} Z_h^K}} 
\]

where $\rho_{km} = 1$ for $k = m$.

We compute the Value at Risk and expected shortfalls at the 99% level by simulation as these quantities are not available in closed form.

### 3.2.2 $t$-distributed CDS exposures

We also assume that the value of the CDS positions are given by

\[
X_{ij}^K = \beta_K Z_i^K Z_j^K \sum_{h \neq i} Z_h^K t_{3,ij}^K, 
\]

where $t_{3,ij}^K$ is a normalized $t$-distribution with unit variance and 3 degrees of freedom (Cont and Kan, 2011). The other asset classes are kept normally distributed as in equation (6). Correlation between the classes with different distributional assumptions is introduced via a normal Copula with correlation parameter $\rho$. In the case of the $t$-distribution the risk measures
are not known in analytical closed form so we will use simulation in order to compute them.

3.3 Heterogeneity of risk across asset classes

Another important feature which affects the analysis is the difference of asset classes in terms of riskyness. For example, an interest rate swap and a CDS with same notional and maturity typically will not lead to the the same collateral requirements, since their risk is not considered to be identical. A simple metric for this is the exposure per dollar notional for a given asset class.

To obtain an estimate of this parameter for various asset classes, a simple approach is to examine the standard deviation of the historical daily profit/loss, in terms of percentage of contract notional. For the CDS asset class, we estimate $\beta_K$ as the mean of the standard deviation of the daily profit-loss of 5-year credit default swaps on the names constituting the CDX NA IG HVOL series 12 in the period July 1st, 2007 to July 1st, 2009. In the estimation the notionals of the CDSs are assumed equal to 1 and the recovery rate equal to 0.4.

For the same period, we compute the $\beta_k$ for the interest rate class as the standard deviation of the historical daily profit-loss from holding a 5-year interest rate swap with notional of 1 and we use this estimate for all asset classes other than the CDS class.

The estimated values are

$$\beta_k = 0.0039 \text{ for interest rate swaps}$$

(11)

$$\beta_K = 0.0098, \text{ for CDS}$$

(12)

i.e. the risk per dollar notional is around three times higher for the CDS asset class.

4 Does central clearing reduce inter-dealer exposures?

Using the setting described in the previous section, we now compare the magnitude of inter-dealer exposures under different market clearing scenarios:

0. No central clearinghouse.

1. One central clearinghouse for IRSs.

2. One central clearinghouse for CDSs.

3. Two central clearinghouses: one for IRSs and one for CDSs.
4. One central clearinghouse for both IRSs and CDSs.

Given that, in each of these scenarios, the total interdealer exposure is a random variable, we need a criterion for evaluating the magnitude of exposures. Duffie and Zhu (2011) focus on the expected exposures; to check for robustness of results with respect to this choice we have computed various risk measures for the total interdealer exposure in each scenario:

- expected exposure
- 99% quantile of the total exposure
- 99% tail conditional expectation

These risk measures are reported below in terms of the ratio to their value under the base scenario where no clearinghouse exists.

Currently some markets for OTC derivatives are already being cleared. Following a meeting on January 27th, 2010 at The Federal Reserve New York, 14 major dealers say in a letter of March 1st, 2010 that they will aim to centrally clear \( w_K = 85\% \) of new and historical credit derivatives trades. In interest rate derivatives, dealers are working to clear \( w_{K-1} = 90\% \) of new eligible trades.\(^1\) We will use these clearing fractions in equations (2)-(4) when evaluating the above scenarios. In the case where one single CCP clears both IRSs and CDSs the classes can be considered to belong to the same class and we use equation (3).

We use the notional values reported in Table 2 and assume that there exist 10 identical European dealers, hence the total number of participants is 20. This is not a high number, at the time of writing the number of participants in SwapClear at LCH Clearnet is 38.

For the case of the Gaussian CDS exposures we use the analytical formulas to compute the expected exposures and \( 10^6 \) simulated scenarios to compute the other two risk measures. When \( t \)-distributed exposures are involved we approximate the three measures using \( 10^6 \) simulations and correlate the exposures across asset classes via a Gaussian Copula.

Tables 6 and 7 report the results for the cases where the exposures are decorrelated and correlated with \( \rho = 0.1 \), respectively. From Table 6, comparing the case of no central clearing in the market to the case where the OTC interest rate swaps are cleared (columns 1, 5 and 9), we see that the overall exposures are reduced significantly for almost all dealers and in all risk measures. The notional positions of the dealers who have no reduction are very small compared to the total notionals of the 10 biggest dealers. The rows with totals report the total expected exposure of all 20 dealers relative to the total expected exposures in the scenario 0 with no CCP. We

\(^1\)The letter is available for download at http://www.newyorkfed.org/markets/otc_derivatives_supervisors_group.html.
Table 6: Reduction of interdealer exposures in various clearing scenarios, relative to the base scenario without central clearing, based on OCC data for gross notional sizes (Q1 2009), assuming independence of exposures across asset classes. Top: normally distributed CDS exposures. Bottom: $t$-distributed CDS exposures.

| Scenario         | Expected Exposure | Value at Risk | Expected Shortfall |
|------------------|-------------------|---------------|--------------------|
|                  | IRS CDS Two Joint | IRS CDS Two Joint | IRS CDS Two Joint |
|                  | CCP CCP CCPs CCP | CCP CCP CCPs CCP | CCP CCP CCPs CCP |
| Gaussian CDS exposures |
| JP Morgan Chase  | 0.72 1.03 0.65 0.57 | 0.95 1.01 0.92 0.90 | 0.97 1.01 0.94 0.92 |
| Bank of America  | 0.66 1.04 0.61 0.55 | 0.93 1.01 0.91 0.90 | 0.95 1.01 0.93 0.92 |
| Goldman Sachs    | 0.78 1.01 0.62 0.52 | 0.97 1.00 0.90 0.89 | 0.98 1.00 0.92 0.91 |
| Morgan Stanley   | 0.80 0.99 0.58 0.47 | 0.97 1.00 0.88 0.87 | 0.98 1.00 0.91 0.90 |
| Citigroup        | 0.84 1.02 0.78 0.70 | 0.98 1.01 0.95 0.94 | 0.99 1.00 0.97 0.95 |
| Wells Fargo      | 0.76 1.03 0.75 0.70 | 0.96 1.01 0.95 0.93 | 0.97 1.01 0.96 0.95 |
| HSBC             | 1.00 0.82 0.64 0.53 | 1.00 0.96 0.89 0.88 | 1.00 0.97 0.91 0.91 |
| Taunus           | 1.04 0.96 0.99 0.94 | 1.01 0.98 0.99 0.98 | 1.01 0.99 0.99 0.98 |
| Bank of New York | 0.95 1.00 0.95 0.95 | 0.99 1.00 0.99 0.99 | 0.99 1.00 0.99 0.99 |
| State Street     | 1.01 1.00 1.01 1.01 | 1.00 1.00 1.00 1.00 | 1.00 1.00 1.00 1.00 |
| Total            | 0.74 1.02 0.64 0.56 |                   |                    |

| Scenario         | Expected Exposure | Value at Risk | Expected Shortfall |
|------------------|-------------------|---------------|--------------------|
|                  | IRS CDS Two Joint | IRS CDS Two Joint | IRS CDS Two Joint |
|                  | CCP CCP CCPs CCP | CCP CCP CCPs CCP | CCP CCP CCPs CCP |
| $t$-distributed CDS exposures |
| JP Morgan Chase  | 0.68 1.03 0.64 0.57 | 0.94 1.01 0.92 0.90 | 0.95 1.01 0.94 0.92 |
| Bank of America  | 0.63 1.03 0.61 0.55 | 0.93 1.01 0.91 0.90 | 0.94 1.01 0.93 0.92 |
| Goldman Sachs    | 0.72 1.02 0.62 0.53 | 0.95 1.00 0.90 0.89 | 0.96 1.00 0.92 0.91 |
| Morgan Stanley   | 0.73 1.01 0.58 0.48 | 0.95 1.00 0.88 0.87 | 0.96 1.00 0.90 0.89 |
| Citigroup        | 0.81 1.03 0.78 0.71 | 0.97 1.01 0.95 0.94 | 0.98 1.00 0.96 0.95 |
| Wells Fargo      | 0.75 1.03 0.75 0.70 | 0.95 1.01 0.95 0.93 | 0.96 1.01 0.96 0.95 |
| HSBC             | 0.95 0.89 0.68 0.57 | 0.99 0.96 0.89 0.88 | 0.99 0.96 0.91 0.89 |
| Taunus           | 1.03 0.99 1.01 0.97 | 1.01 0.99 1.00 0.98 | 1.01 0.99 1.00 0.98 |
| Bank of New York | 0.95 1.00 0.95 0.95 | 0.99 1.00 0.99 0.99 | 0.99 1.00 0.99 0.99 |
| State Street     | 1.01 1.00 1.01 1.01 | 1.00 1.00 1.00 1.00 | 1.00 1.00 1.00 1.00 |
| Total            | 0.70 1.03 0.64 0.56 |                   |                    |
Table 7: Reduction of interdealer exposures in various clearing scenarios, relative to the base scenario without central clearing, based on OCC data for gross notional sizes (Q1 2009), assuming correlated exposures across asset classes with $\rho = 0.1$. Top: normally distributed CDS exposures. Bottom: $t$-distributed CDS exposures.

| Scenario          | Expected Exposure | Value at Risk | Expected Shortfall |
|-------------------|-------------------|---------------|--------------------|
|                   | IRS CDS Two Joint | IRS CDS Two Joint |
|                   | CCP CCP CCPs CCP | CCP CCP CCPs CCP |
| Gaussian CDS exposures |
| JP Morgan Chase   | 0.71 1.00 0.63 0.56 | 0.94 1.00 0.91 0.90 | 0.96 1.00 0.93 0.92 |
| Bank of America   | 0.66 1.01 0.60 0.54 | 0.93 1.00 0.90 0.89 | 0.94 1.00 0.92 0.91 |
| Goldman Sachs     | 0.76 0.98 0.60 0.52 | 0.95 0.99 0.89 0.88 | 0.97 0.99 0.91 0.91 |
| Morgan Stanley    | 0.77 0.96 0.56 0.47 | 0.96 0.98 0.88 0.87 | 0.97 0.99 0.90 0.90 |
| Citigroup         | 0.82 0.99 0.74 0.67 | 0.96 0.99 0.93 0.92 | 0.97 0.99 0.95 0.94 |
| Wells Fargo       | 0.75 1.01 0.72 0.68 | 0.94 1.00 0.93 0.92 | 0.96 1.00 0.95 0.94 |
| HSBC              | 0.96 0.80 0.62 0.53 | 0.99 0.95 0.88 0.88 | 0.99 0.96 0.91 0.90 |
| Taunus            | 1.02 0.94 0.95 0.91 | 1.00 0.97 0.97 0.96 | 1.00 0.98 0.98 0.97 |
| Bank of New York  | 0.91 1.00 0.91 0.91 | 0.97 1.00 0.97 0.97 | 0.98 1.00 0.98 0.98 |
| State Street      | 1.01 1.00 1.01 1.01 | 1.00 1.00 1.00 1.00 | 1.00 1.00 1.00 1.00 |
| Total             | 0.73 0.99 0.62 0.55 |                |                    |

| Scenario          | Expected Exposure | Value at Risk | Expected Shortfall |
|-------------------|-------------------|---------------|--------------------|
|                   | IRS CDS Two Joint | IRS CDS Two Joint |
|                   | CCP CCP CCPs CCP | CCP CCP CCPs CCP |
| $t$-distributed CDS exposures |
| JP Morgan Chase   | 0.68 1.01 0.63 0.57 | 0.93 1.00 0.91 0.90 | 0.94 1.00 0.92 0.92 |
| Bank of America   | 0.63 1.01 0.60 0.55 | 0.92 1.00 0.90 0.89 | 0.93 1.00 0.92 0.91 |
| Goldman Sachs     | 0.71 0.99 0.61 0.53 | 0.93 0.99 0.89 0.88 | 0.95 0.99 0.91 0.90 |
| Morgan Stanley    | 0.71 0.98 0.56 0.48 | 0.94 0.99 0.88 0.87 | 0.95 0.99 0.90 0.89 |
| Citigroup         | 0.79 1.00 0.75 0.68 | 0.95 0.99 0.93 0.92 | 0.96 0.99 0.94 0.94 |
| Wells Fargo       | 0.74 1.01 0.72 0.68 | 0.94 1.00 0.93 0.92 | 0.95 1.00 0.95 0.94 |
| HSBC              | 0.91 0.86 0.65 0.56 | 0.97 0.95 0.88 0.87 | 0.98 0.95 0.90 0.89 |
| Taunus            | 1.01 0.96 0.97 0.93 | 1.00 0.98 0.98 0.97 | 1.00 0.98 0.98 0.97 |
| Bank of New York  | 0.91 1.00 0.91 0.91 | 0.97 1.00 0.97 0.97 | 0.98 1.00 0.98 0.98 |
| State Street      | 1.01 1.00 1.01 1.01 | 1.00 1.00 1.00 1.00 | 1.00 1.00 1.00 1.00 |
| Total             | 0.70 1.00 0.62 0.56 |                |                    |
only compute the “total” for the expected exposures as the other two risk measures are not additive.

While it is debatable whether the introduction of a clearinghouse for CDSs will reduce exposures when there is no existing clearinghouse in the market (columns 2, 6 and 10), the results are more definitive when the interest rate class is already being cleared (columns 3, 7 and 11). For both distributional choices of the CDS class, adding a CCP for the CDS class decreases the three different risk measures. Depending on the assumptions made, the total expected exposures are decreased with additional 6-11% compared to the case when only interest rate swaps are cleared. In absolute values this corresponds to reductions in the order of USD 41-76 billions in total expected net exposure.

In the case where a single CCP clears both IRSs and CDSs the net exposure reductions are higher since multilateral netting is possible across both types of derivatives classes. We also note that the difference in exposure reductions between scenarios 1) and 3) are bigger than the difference between scenarios 3) and 4), and especially for the risk measures VaR and expected shortfall. Hence, the decision to clear the CDS asset class is the most important, whether it is done by the same CCP that clears IRSs or not.

As expected, the results reported in Table 7 confirm that in the presence of positive asset class correlation, introduction of central clearinghouses increases the benefit from clearing compared to the zero correlation case. All the fractions are slightly smaller with a correlation parameter of $\rho = 0.1$. When the asset classes are positively correlated the exposure reductions due to bilateral netting across classes are reduced.

Interestingly, we note that using $t$-distributed CDS exposures instead of Gaussian exposures does not change the conclusions.

For the different scenarios, Table 8 reports the average of the maximum realized net exposure across dealers, which can be interpreted as a worst case measure of dealer exposure. Yet again we observe that scenarios 1), 3), and 4) result in significant exposure reductions.

Table 8: Average of the maximum exposure across counterparties in the five scenarios and for the four different exposure specifications. All the numbers are in millions.

| Scenario               | Bilateral | IRS | CDS       | Two CCPs | Joint CCP |
|------------------------|-----------|-----|-----------|----------|-----------|
| Gaussian CDS, $\rho = 0$ | 136,460 | 114,340 | 138,830 | 108,110 | 103,190 |
| Gaussian CDS, $\rho = 0.1$ | 145,040 | 120,440 | 144,850 | 113,130 | 109,160 |
| $t$-distributed CDS, $\rho = 0$ | 136,020 | 111,630 | 138,480 | 107,770 | 103,070 |
| $t$-distributed CDS, $\rho = 0.1$ | 144,140 | 117,500 | 144,370 | 112,650 | 108,820 |
For the different clearinghouse scenarios, Figure 4 depicts the histograms of the reduction in exposures across counterparties

$$e_i^n = e_i^0 - e_i^n,$$

(13)

where $n = 1, \ldots, 4$ corresponds to the clearing scenario, in a market with 20 participants and independent Gaussian exposures. Positive values correspond to cases where central clearing reduces the exposure. Hence, scenarios 1), 3), and 4) are generally giving rise to positive reductions in exposures. In particular it is observed how the CDS clearing scenarios 3) and 4) significantly reduce the tail of the distribution of differences compared to scenario 1) where only IRS are cleared.

Figure 4: Histograms of the simulated differences (13) in the Gaussian CDS exposure zero correlation specification. Here all the exposure differences of the CCP participants are bundled together in a single vector.
5 Conclusion

Using a stylized model of OTC exposures with multiple asset classes, we have compared the effects of bilateral netting across classes with those of multilateral netting across counterparties as allowed in a CCP. We find that the impact, on total expected exposure, of introducing a central clearing facility for a given class of OTC derivatives is highly sensitive to assumptions of heterogeneity across asset classes in terms of ’riskyness’, as measured by the exposure per dollar notional, as well as correlation of exposures across asset classes. The base example (IID, homogeneous Gaussian exposures) previously considered by [Duffie and Zhu (2011)] suggested that CCPs are inefficient in reducing exposures unless one has an unrealistically high number of participants, but the opposite conclusion is reached if plausible model parameters are used to take into account differences in riskyness across asset classes. A second finding is that, when a CCP already exists for interest rate swaps, clearing of credit derivatives decreases exposures whether it is done by a new CCP or by the same CCP clearing IRSs. This result distinguishes our study from [Duffie and Zhu (2011)] where the marginal effect of clearing credit derivatives is very limited when interest rate swaps are already cleared. The findings are robust to distributional assumptions on (CDS) exposures.

We find, as in [Duffie and Zhu (2011)], that the exposure reduction is highest if one CCP clears all asset classes. However, this scenario would lead to a high concentration of systemic risk in the clearinghouse and also expose it to a high level of operational risk, since simultaneous clearing of different asset classes requires a more sophisticated risk management technique. A serious examination of the benefits and drawbacks of having multiple CCPs cannot be done solely based on expected exposures and requires a model where systemic risk can be quantified as part of the tradeoff.
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