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Highlights

- We develop a model to analyze distress spillover from the OTC interest rate swaps market into the interbank market.
- We analyze the impact of margin procyclicality on the propensity for liquidity hoarding.
- We show that margin procyclicality can lead to the onset of systemic liquidity shortages.
- We show that central clearing may increase systemic liquidity risk.

Interest Rate Swaps Clearing and Systemic Risk

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Abstract

We develop a model to analyze distress spillover from the OTC interest rate swaps (IRS) market into the interbank market due to central clearing and margin requirements. We show that margin procyclicality in the OTC IRS market derived by interest rate volatility can lead to the onset of systemic liquidity shortage in the interbank market. We also show that central clearing may increase systemic liquidity risk due to tight margin requirements.

Keywords: Margin Procyclicality; Funding Liquidity Risk; Systemic Risk; Contagion; Networks.
JEL Classification: G01; G15; G21; G28.

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1. Introduction

In the aftermath of the financial crisis of 2008, central clearing of all standardised derivatives contracts has been enacted to reduce interconnectedness and contain systemic risk in over-the-counter (OTC) derivatives markets. As a result, market participants are now required to make margin payments at least daily in response to changes in the market value of their derivatives positions. These new regulations introduce many improvements to the functioning of the OTC derivatives market such as providing transparency of trade positions which eliminates counterparty risk externality (Acharya and Bisin, 2014), improving post-trade transparency and trading activity (Loon and Zhong, 2014), and reducing collateral demand (Duffie and Zhu, 2011). However, margin requirements may result in some adverse consequences. While margin requirements focus on reducing counterparty credit risk through the mandate of daily mark-to-market and tight credit support annexes (CSA), there is significant funding liquidity risk from tight CSAs given that the amounts of variation margin calls can be large (ISDA, 2017). Indeed, there have been episodes of market turbulence in which daily margin requirements were unexpectedly high. For instance, on June 24, 2016, following the U.K. Brexit referendum, financial markets around the world went into turmoil due to the unexpected result of the vote. Yield curves moved by tens of basis points leading the volatility of interest rate swaps (IRS) market to soar due to its high sensitivity to changes in interest rates. On that day, the LCH SwapClear—which is the world's largest clearing house of OTC swaps—issued variation margin calls that reached billions of dollars and some of which were required to be paid within few hours. Overall, this day saw the largest daily aggregate variation margin in the recent history.

In this paper, we develop a model to analyze the impact of margin requirements on funding liquidity risk of the OTC derivatives market participants. In particular, we consider the impact of *margin procyclicality* during times of high market volatility—as a side effect of tight margin requirements—on the *propensity for liquidity hoarding* in the interbank market. Our work builds on the insights of Brunnermeier and Pedersen (2009) who study the interaction between market liquidity and funding liquidity. In their model, the financing of a bank's trading activity such as trading in OTC derivatives is largely based on collateralized borrowing where banks can finance long positions using collateralized borrowing from other banks in the interbank market. The model shows that, under certain conditions, interbank haircuts are destabilizing and market liquidity and funding liquidity are mutually reinforcing, leading to liquidity spirals.[1]

[1]In practice, the relationship between OTC derivatives market and interbank market can be captured through the links between banks. These links can be divided into two categories: exposures (which include, among others, off-balance sheet derivatives exposures) and funding (which include, among others, secured interbank lending). For

Our model considers the interaction between market volatility in OTC markets and funding liquidity in interbank markets. In particular, market volatility derives margin procyclicality which impacts funding liquidity risk. The ability of banks to meet margin requirements depends on available funding and if they do not have sufficient liquid assets to meet a margin call, they become distressed. Our work is related to the body of reserch that models interconnectedness in the banking system as in Krause and Giansante (2012) who show that the cascades of bank failures in the interbank market depends on the characteristics of the network of interbank loans, while Nier et al. (2007) show that liquidity effects can interact with the banking system structure to increase the chance of systemic breakdown. Similarly, Upper and Worms (2004) find that the failure of a single bank could result in a considerable scope for contagion that could affect a large proportion of the banking system.

2. The Model

We consider a model with N banks whose assets are divided between high-quality liquid assets, A_i^H, low-quality liquid assets A_i^L, interbank assets A_i^B, and other assets A_i^O, where $i = 1, ..., N$. These banks interact with each other in two different markets: the OTC derivatives market and the interbank market. Each market can be represented as a network of financial interactions between pairs of banks. In the interbank network, banks borrow and lend money to each other where the group of bank i's borrowers (lenders) is denoted as k_i^{in} (k_i^{out}), whereas in the OTC derivatives market, banks trade derivatives contracts and a central counterparty (CCP) performs the central clearing process. At the end of each trading day, the CCP issues variation margin calls to banks whose positions encountered losses during the day, which a bank can pay only using its A_i^H. Variation margin can be significant in times of high market volatility leading some banks to become *distressed* if:

$$v_i \quad > \quad A_i^H \tag{1}$$

where v_i is the variation margin required from bank i.

A distressed bank with insufficient holdings of A_i^H has two options to secure funding to cover its variation margin calls. The first is to withdraw its lending extended to other banks in the interbank market. In this case, the bank pays exit fees for prematurely calling the loan. Let γ_i be the exit fees that bank i has to pay. Thus, the maximum amount of A_i^H that i can obtain by

example, Langfield et al. (2014) map the UK banking system at the end of 2011 and show that while derivatives are the largest type of exposures, accounting for 44%, secured lending represents the largest type of funding, accounting for 66%.

withdrawing its lending from the interbank market is given by:

$$A_i^H = (1 - \gamma_i) A_i^B \tag{2}$$

The second option available for a distressed bank to secure additional funding is to use A_i^L as collateral to obtain A_i^H from the interbank market. In this case, the bank is subject to two types of haircut that apply to A_i^L. The first is a system-wide haircut $\alpha \in [0, 1]$ which reflects the perceived system wide liquidity risk of A_i^L compared to A_i^H. The second is a bank-specific haircut $\alpha_i \in [0, 1]$ to reflect the idiosyncratic risk associated with a given bank. Therefore, the maximum amount of A_i^H that bank i can obtain using its holdings of A_i^L as collateral is given by:

$$A_i^H = (1 - \alpha - \alpha_i)\ A_i^L \tag{3}$$

where $\alpha + \alpha_i < 1$ to put a non-negative lower bound on the amount of A_i^H obtained using A_i^L. A bank's decision to follow a specific funding option of the above depends on the option's cost to the bank. Thus, it follows from Eqs. 2 and 3 that liquidity hoarding will continue as long as it is less costly compared to using less liquid assets as collateral. In other word, when:

$$\gamma_i < (\alpha + \alpha_i) \tag{4}$$

Furthermore, we consider herding behaviour in the interbank market as a driver of contagion. Our approach is similar to the model of Acharya and Yorulmazer (2008) in which banks engage in herding behaviour to minimise the effect of bad information about other banks on their own borrowing costs. In our model, banks engage in herding behaviour when raising liquidity while they have to decide between withdrawing their lending to other banks in the interbank market and using their less-liquid assets as collateral to obtain funding. To illustrate the dynamics of this liquidity hoarding contagion, assume that, for a bank i, both Eqs. 1 and 4 are satisfied. Further, assume that the bank withdraws an additional amount of interbank lending as a precautionary action for subsequent margin calls. Let A_i^d be the amount hoarded which can be estimated as:

$$A_i^d = \frac{(1 + \lambda)v_i - A_i^H}{(1 - \gamma_i)} \tag{5}$$

where λ is a liquidity hoarding multiplier which can be estimated as a fraction of v_i. The term $(1 + \lambda)v_i$ represents the total amount that the bank needs to honour its obligations in the OTC derivatives market. This amount is then reduced by what is already avaialable for the bank A_i^H to reach at the net amount of cash needed. Then, the net amount is scaled up by the cost of liquidity hoarding to find the gross amount of assets hoarded from the interbank market A_i^d.

Conversely, if $\gamma_i > (\alpha+\alpha_i)$, the bank sells an amount of its less liquid assets to cover its liquidity shortage. Let A_i^s be the amount sold which can be estimated as:

$$A_i^s = \frac{(1+\lambda)v_i - A_i^H}{(1-\alpha-\alpha_i)} \tag{6}$$

Similar to above, to reach at the gross amount of assets that should be sold A_i^s, the net amount of liquid assets that the bank needs $((1+\lambda)v_i - A_i^H)$ is scaled up by the total haircut applied to the bank sales $(1-\alpha-\alpha_i)$.

We can also identify the tipping point for liquidity distress contagion in the interbank market as in Gai et al. (2011). Given that each bank i is connected to a group of k_i^{in} borrowers through the interbank lending transactions and assuming that its interbank withdrawals are proportionally distributed among its borrowers, for contagion to spread beyond i, there should be at least one bank $j \in k_i^{in}$ for which the following condition holds:

$$v_j \quad > \quad A_j^H - \left(\sum_i^{k_j^{out}} A_{ij}^B \cdot \frac{A_i^d}{A_i^B} \right) \tag{7}$$

where k_j^{out} is the group of bank j lenders and the term $\left(\sum_i^{k_j^{out}} A_{ij}^B \cdot \frac{A_i^d}{A_i^B} \right)$ represents the total amount of interbank assets that is withdrawn by the distressed lenders of bank j. Thus, a bank becomes distressed if the total amount of its available A_j^H is not sufficient to cover its variation margin, after accounting for the loss of interbank funding that it might experience due to liquidity hoarding by its lenders. Distressed banks, in turn, withdraw interbank lending leading to a vicious circle of liquidity hoarding.

Finally, we estimate the overall impact of distress spillover from the OTC derivatives market into the interbank market as:

$$\Phi = \frac{\sum_{i=1}^N \gamma_i A_i^d \quad + \quad \sum_{i=1}^N (\alpha+\alpha_i) A_i^s}{\sum_{i=1}^N A_i^B} \tag{8}$$

where Φ is an approximation to the systemic loss that the system encounters due to liquidity hoarding and salling less liquid assets. The term $\sum_{i=1}^N \gamma_i A_i^d$ represents the cost of liquidity hoarding in the interbank market and the term $\sum_{i=1}^N (\alpha+\alpha_i) A_i^s$ represents the cost of selling less liquid assets. We then estimate the systemic loss as the ratio of total cost to the initial amount of interbank assets $\sum_{i=1}^N A_i^B$.

3. Analysis

We build a stress scenario that resembles the OTC IRS market conditions on June 24, 2016, following the U.K. Brexit vote. We then use this scenario to estimate variation margin calls in the OTC IRS market on that day. Finally, we use these estimates to evaluate the distress spillover from the OTC IRS market to the interbank market as shown by Eq. 1. We consider the interbank market given its critical role as a large short-term funding source for financial institutions activities. It has also played a pivotal role in the financial crisis of 2008 which can be seen as a run on the repo market. In addition, we consider the OTC interest rate swaps market because it is the largest segment of the OTC derivatives market and due to the sensitivity of interest rate swaps to market volatility which makes them an optimal example to highlight margin procyclicality.

3.1. The Brexit Scenario

The Brexit stress scenario is shown in Table 1 which provides the basis point change in market interest rate for each currency-tenor combination. In addition, the last column shows average values of β for each tenor category which measures the sensitivity of a swap value to change in market interest rate. We estimate β as the average modified duration per dollar per basis point change in interest rate for each tenor category. We then estimate the change in value for each currency-tenor combination as follows:

$$\Delta V_{c,t} = \beta_t \cdot \Delta R_{c,t} \cdot S_{c,t} \tag{9}$$

where subindices c and t refer to currency and tenor, respectively, $\Delta V_{c,t}$ is the change in market value for this $c-t$ combination, β_t is the sensitivity of swap value to change in market interest rate, $\Delta R_{c,t}$ is the basis point change in market interest rates, $S_{c,t}$ is notional amount of swaps outstanding in this $c-t$ combination. We then use these changes in market value as an estimate of the variation margin amounts required by LCH SwapClear for outstanding IRS on that day. Finally, we estimate the variation margin for each clearing member of LCH SwapClear, v_i, based on its exposures on that day.

Our analysis is based on data on the U.S. banking system. Data is extracted from the Reports of Condition and Income (Call Reports), the quarterly derivatives report from the Office of the Comptroller of the Currency, and the OTC IRS exposures at LCH SwapClear. Given that we are interested in banks that are active in both the OTC derivatives market and the interbank market, we limit our focus to the group of insured commercial banks with total assets greater than \$3 billion which makes the number of banks in our analysis 250. We construct the network of both

		Currency				Sensitivity
		USD	EUR	GBP	Other	β
Tenor	0 - 2	20	20	25	15	0.0003
	2 - 5	30	25	35	20	0.0005
	5 - 10	40	30	45	20	0.0010
	10+	30	25	35	15	0.0025

Table 1: The Brexit stress scenario that is used to value IRSs and estimate variation margins.

markets as a core-periphery structure following the (Craig and von Peter, 2014). In our setting, the core of the OTC derivatives layer consists of the banks that act as clearing members of LCH SwapClear which are 15 banks. In the interbank layer, the number of core banks is determined based on the relative size of each bank's assets. To estimate this, we first rank banks and calculate the difference in the log of assets of each bank and its succeeding bank. Banks with a difference higher than 0.10 are taken to be the core banks. Based on this, the number of core banks in the interbank layer is set equal to 12. The probabilities of connection between banks are independent between the two layers. In line with Anand et al. (2017), we set the core-core probability of connection equal to 0.65, and the core-periphery probability of connection equal to 0.15. The percentage of centrally cleared contracts is set equal to 75% as reported by the International Swaps and Derivatives Association in its OTC Derivatives Market Analysis on interest rate derivatives. In addition, we use a system wide haircut percentage of 10% as recommended by the Bank for International Settlements. The base value of the liquidity hoarding multiplier is 0. The values of liquidity hoarding cost and bank-specific haircuts are driven from uniform distributions. The parameters used to estimate the model are shown in Table 2.

Parameters	Description	Baseline Values
N	Number of banks	250
N^{CoreB}	Number of core banks in the interbank layer	15
N^{CoreD}	Number of core banks in the OTC derivatives layer	12
ρ^{CC}	Probability of core-to-core connection	0.65
ρ^{CP}	Probability of core-to-periphery connection	0.15
ρ^{PP}	Probability of periphery-to-periphery connection	0.00
ω	Central clearing percentage	75%
λ	Liquidity hoarding multiplier	0
γ	Liquidity hoarding cost	$\approx U(0\%, 5\%)$
α	System-wide haircut	10%
α_i	Bank-specific haircut	$\approx U(0\%, 5\%)$

Table 2: Description and values of the parameters used to estimate the model.

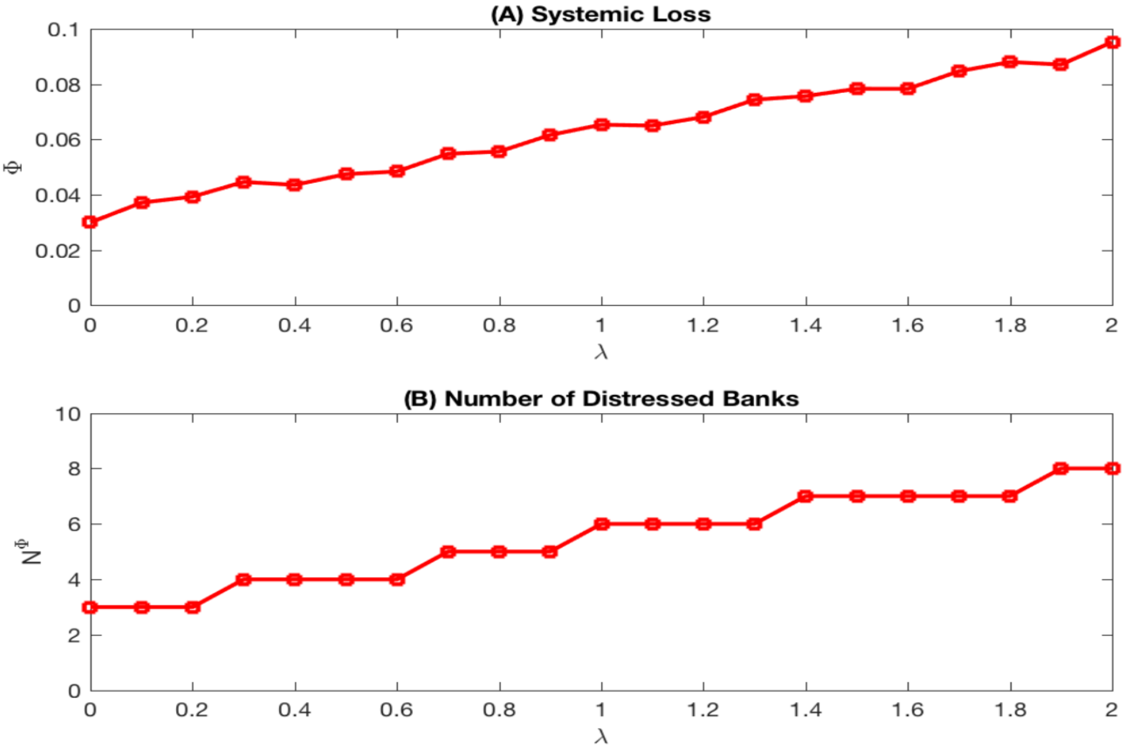

Fig. 1: Distress spillover from the OTC derivatives market to the interbank market. Φ is the systemic loss due to liquidity hoarding, N^{Φ} is the number of distressed banks, and λ refers to liquidity hoarding multiplier. Estimates are based on the parameters reported in Table 2.

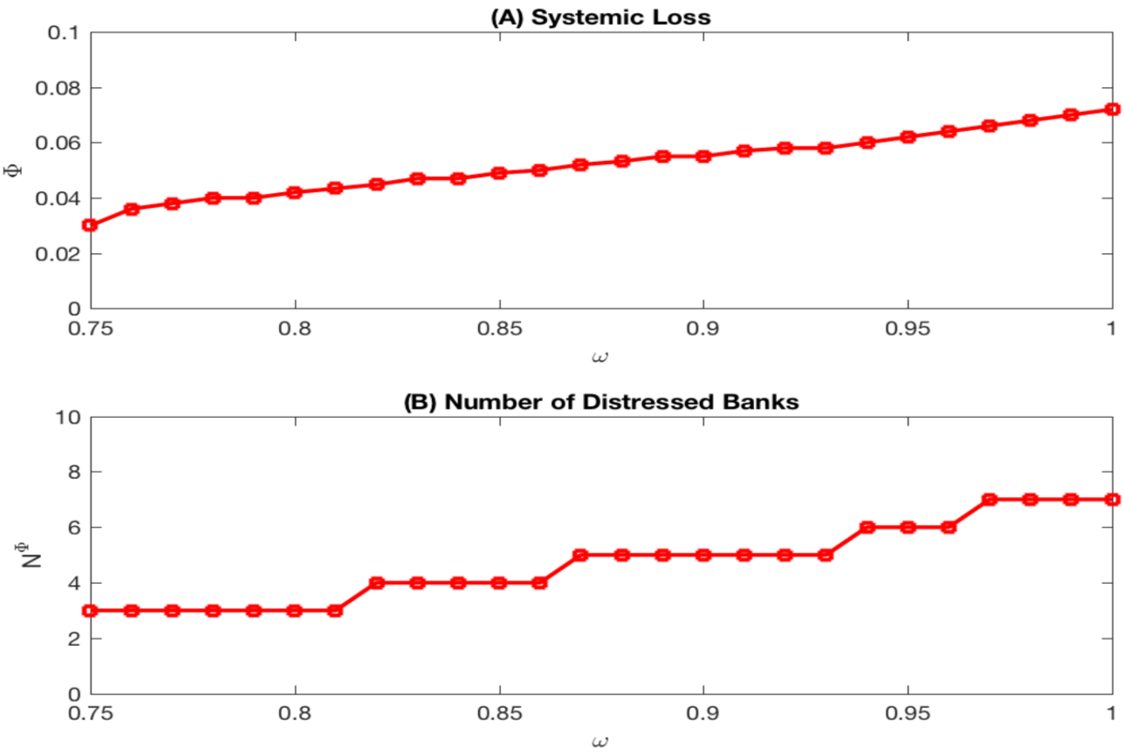

Fig. 2: Impact of central clearing on distress spillover from the OTC derivatives market to the interbank market. Φ is the systemic loss due to liquidity hoarding, N^{Φ} is the number of distressed banks, and ω refers to the percentage of centrally cleared IRS. Estimates are based on the parameters reported in Table 2.

3.2. Results

We provide here the main results on the dynamics of distress spillover from the OTC derivatives market to the interbank market as estimated by our model. The main factors of interest are margin procyclicality as captured by the Brexit stress scenario shown in Table 1, and the liquidity hoarding as captured by the multiplier λ which is used to proxy the average level of panic in the interbank market. The results of this exercise are provided in Figure 1 which shows the systemic loss and the number of distressed banks for each level of λ. As a benchmark, we assume that $\lambda = 0$, meaning that banks hoard liquidity only to the extent that covers their liquidity needs in the OTC derivatives market. At this level, although the propensity for liquidity hoarding is low, the significant variation margins can still lead some banks to become distressed causing a modest level of systemic loss. Furthermore, given that the interbank market has witnessed times of lending freeze and high levels of liquidity hoarding during the financial crisis of 2008, it is reasonable to assume higher levels for λ. We, thus, use a range of $\lambda \in [0, 2]$ to explore the dynamics of distress spillover. As shown by Figure 1, both systemic loss and the number of distressed banks increase with increases in λ. This result confirms the notion that, when uncertainty increases in the interbank market, banks hoard larger amounts of liquidity which leads to more panic and increases the number of banks that become distressed. Thus, our findings show that the interbank market can be vulnerable to systemic liquidity shortages due to knock-on effects through interbank linkages, which is consistent with previous evidence on herding in the interbank market during the financial crisis of 2008.

Furthermore, we assess the impact of central clearing compared to bilateral clearing on the distress spillover from the OTC derivatives market into the interbank market. In our benchmark model, we assume that the percentage of centrally cleared swaps is 75%. Also, we estimate variation margin for this part of swaps only and ignore non-centrally cleared swaps given that variation margin was not mandatory for them in June 2016. We extend this analysis to evaluate systemic risk under assumptions of higher percentages of central clearing. The results of this exercise reveal a striking finding as can be seen from Figure 2. The increase in the proportion of centrally cleared swaps positively affects systemic liquidity hoarding leading to higher systemic loss. One reason that explains this finding is that when more swaps become centrally cleared, variation margin increases in times of stress and as a consequence more banks become distressed. Our finding that central clearing may increase systemic liquidity risk provides a first step towards understanding the impact of margin requirements on funding liquidity risk that arises due to margin procyclicality at times of market stress.

4. Conclusion

In this paper, we analyze the distress spillover from the OTC derivatives market into the interbank market due to central clearing and margin requirements. We focus on the impact of margin procyclicality due to the day-to-day margining practices in the OTC derivatives market on the onset of systemic liquidity risk in the interbank market. Our model demonstrates that margin procyclicality derived by interest rate volatility can lead to the onset of a systemic liquidity shortage within the interbank market. It also shows that central clearing may increase systemic liquidity risk due to tight margin requirements. Our findings complement previous studies that focus only on the impact on counterparty risk (e.g. Acharya and Bisin, 2014; Loon and Zhong, 2014) and collateral demand (e.g. Duffie and Zhu, 2011). The findings from this paper have far-reaching implications. This paper sheds light on one of the overlooked adverse effects of margin requirement regulations that were enacted in the aftermath of the global financial crisis. It hints to regulators the importance of striking the balance between limiting counterparty credit risk through central clearing and tight margin requirements, and the side effect of increasing the possibility and magnitude of systemic liquidity shortages. In addition, regulators should adequately account for the impact of margin procyclicality when setting liquidity coverage ratios of banks as required by the new Basel III standards.

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