Central Counterparty Exposure in Stressed Markets

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Outline

Background & Motivation

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- What are central counterparties (CCPs)?

- CCPs have become systemic nodes of financial markets
- Regulators are worried about CCPs risk management in *fast-paced electronic markets*

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- What is the nature of CCP exposure change?
  - What drives CCP exposure changes? Normal vs. stress times?
  - How is CCP exposure distributed among members/securities? Normal vs. stress times?
- We propose an approach to decomposing CCP exposure in near real-time and implement the approach on a sample of high-frequency equity CCP data and find
  - Contribution of member's portfolio returns correlation (i.e., crowding) $\uparrow$ as exposure increases $\rightarrow$ extreme
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Outline

ExpCCP(Duffie and Zhu, 2011; Menkveld, 2017)

- A single CCP, J clearing members and I securities
- Aggregate loss:

$$A_t = \sum_j L_{j,t} = \sum_j -\min\left(0, X_{j,t}\right) = \sum_j -\min\left(0, N'_{j,t} R_t\right) \tag{1}$$

where $R_t \sim \mathbf{N}(0, \Omega_t)$

- CCP exposure:

$$ExpCCP_t \equiv \text{VaR}(A_t) = \mathrm{E}(A_t) + \alpha \mathrm{var}(A_t)^{\frac{1}{2}} \tag{2}$$

- Lots of algebra skipped...

$$ExpCCP_t = f\left(\Sigma_t\right) \tag{3}$$

where $\Sigma_t = N'_t \Omega_t N_t$ is the portfolio covariance matrix and $N_t = (N_{1,t}, N_{2,t}, \ldots, N_{J,t})$

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Decomposition $\Delta ExpCCP$

- To arrive at a meaningful decomposition, *ExpCCP* is rewritten as:

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\begin{aligned}
ExpCCP_t &= f(\Sigma_t) \\
&= f(D_{\Sigma_t} R_{\Sigma_t} D_{\Sigma_t}) \\
&= f\left(D_{\Sigma_t}\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_t\right), R_{\Sigma_t}\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_t\right)\right)
\end{aligned} \tag{4}
$$

- One-factor-at-a-time (OFAT), i.e., sequentially update the deep parameters All components

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\begin{aligned}
\Delta ExpCCP_t =& f\left(D_{\Sigma}\left(\overset{1}{D}_{\Omega_t}, \overset{2}{R}_{\Omega_t}, \overset{3}{P}_t, \overset{4}{\tilde{N}_t}\right), R_{\Sigma}\left(\overset{1}{D}_{\Omega_t}, \overset{2}{R}_{\Omega_t}, \overset{3}{P}_t, \overset{5}{\tilde{N}_t}\right)\right) \\
&- f\left(D_{\Sigma}\left(D_{\Omega_{t-1}}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right), R_{\Sigma}\left(D_{\Omega_{t-1}}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right)\right)
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- Exposure changes are decomposed into five components:

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\Delta ExpCCP_t = \underbrace{RetVola_t + RetCorr_t + PrLevel_t}_{\text{Price components}} + \underbrace{TrPosition_t + TrCrowding_t}_{\text{Trade components}}
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Decomposition *ExpCCP*

$$ExpCCP = \sum_j \sigma_j \left(\frac{\partial}{\partial \sigma_j} ExpCCP \right) \tag{6}$$

$$ExpCCP = \sum_i \omega_i \left(\frac{\partial}{\partial \omega_i} ExpCCP \right) \tag{7}$$

Outline

Data

- A European Multilateral Clearing Facility (EMCF) sample of trade reports filed by its (anonymous) members.
- It contains all trades in stocks listed in Denmark, Finland and Sweden.
- The period is Oct 19, 2009 though Sep 10, 2010.
- 228 trading days, 242 stocks, 226 trading accounts (87 house and 139 client accounts)

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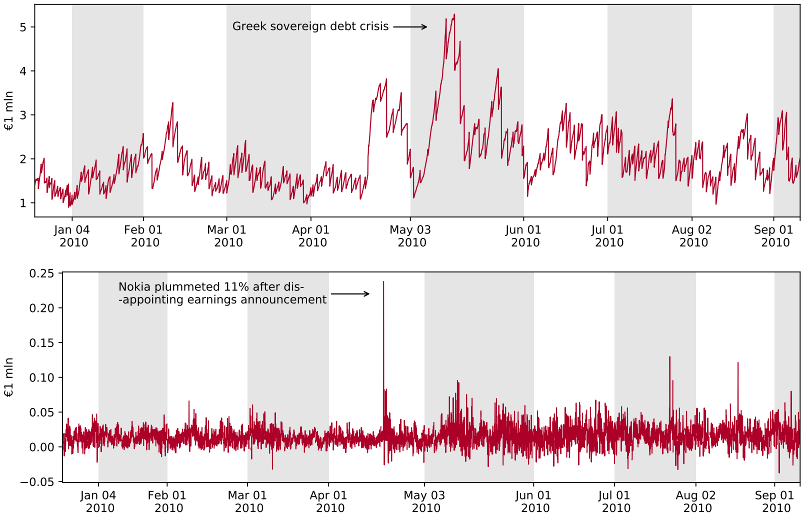
ExpCCP and Δ*ExpCCP*



What drives Δ*ExpCCP* the most?

	Full sample	Top 100 Δ*ExpCCP*	Top 10 Δ*ExpCCP*
	Panel A : CCP exposure change decomposition in euro		
RetVola	272	10,949	69,311
RetCorr	113	3,555	-89
PrLevel	-133	3,195	-5,324
TrPosition	14,255	38,002	39,445
TrCrowding	443	8,186	15,571
Δ*ExpCCP*	14,949	63,887	118,914
	Panel B: CCP exposure change decomposition in percentage		
RetVola	1.8%	17.1%	58.3%
RetCorr	0.8%	5.6%	-0.1%
PrLevel	-0.9%	5.0%	-4.5%
TrPosition	95.4%	59.5%	33.2%
TrCrowding	3.0%	12.8%	13.1%
Δ*ExpCCP*	100.0%	100.0%	100.0%

Who contributes to *ExpCCP* the most?

	Full sample	Top 10% *ExpCCP*	Top 1% *ExpCCP*
Panel A: Decomposition of CCP exposure across traders			
Top 1 member	9.3%	14.4%	25.5%
Top 5 members	27.8%	34.9%	46.8%
Top 10 members	41.7%	48.2%	57.3%
Herfindahl-Hirschman Index (HHI)	0.030	0.046	0.085
Panel B: Decomposition of CCP exposure across stocks			
Top 1 stock	18.7%	28.0%	16.1%
Top 5 stocks	43.3%	48.9%	41.1%
Top 10 stocks	59.3%	62.6%	57.3%
Herfindahl-Hirschman Index (HHI)	0.080	0.176	0.053

Principal component analysis of member portfolio returns

	Full sample	Top 10% *ExpCCP*	Top 1% *ExpCCP*
PC1	7.8%	20.8%	37.6%
PC2	5.2%	8.9%	10.8%
PC3	2.7%	6.4%	6.2%
PC1+PC2+PC3	15.7%	36.0%	54.7%

- The correlation of PC1 with the local market index: 0.43 for the full sample, 0.86 for the top 10% subsample, and 0.98 for the top 1% subsample.

Decomposition of *ExpCCP* across house/client accounts

	Full sample	Top 10% *ExpCCP*	Top 1% *ExpCCP*
Panel A: Contribution to CCP exposure by account type			
Contribution by house accounts (%)	66.8%	66.0%	69.7%
Contribution by client accounts (%)	33.2%	34.0%	30.3%
Panel B: HHI within account type			
HHI within house accounts	0.051	0.083	0.160
HHI within client accounts	0.068	0.071	0.081

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Conclusion

- We study the nature of CCP's exposure towards its clearing members.
- We develop an approach to decomposing CCP exposure to identify the relative contribution of various factors, members and securities.
- The empirical results confirm that there is more crowding/concentration in the extreme CCP exposure levels/changes.

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Implementation issues

- Volume clock $\approx$ 15-minute frequency on wall clock volume-clock versus wall-clock
- Exponentially weighted moving average (EWMA) covariance matrix

$$\Omega_t = (1 - \lambda) R_{t-1} R'_{t-1} + \lambda \Omega_{t-1}. \quad (8)$$

- $\alpha = 2.5$ to make *ExpCCP* a 99% VaR

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Literature

- **Empirical literature on central clearing**
  - **Daily CCP exposure versus margin:** Lopez et al. (2017) and Menkveld (2017)
  - **Netting efficiency of central clearing:** Duffie, Scheicher, and Vuillemey (2015)
  - **The effect of central clearing on trading**: **benos16**; Loon and Zhong (2014), Loon and Zhong (2016), and Menkveld, Pagnotta, and Zoican (2016).
- **Literature on central clearing and systemic risk**
  - **Endogenous build-up of asset concentration due to central clearing:** Capponi, Cheng, and Rajan (2019)
  - **Adverse effects of partial multilateral netting:** Amini, Filipović, and Minca (2015)
  - **Margin requirements with multiple CCPs:** Glasserman, Moallemi, and Yuan (2015)
  - **Fire sale risk with a CCP:** Menkveld (2016)

Statistics on member portfolio returns: wall/volume-clock

	Skewness		Kurtosis		Jarque-Bera	
Member	Wall-clock	Volume-clock	Wall-clock	Volume-clock	Wall-clock	Volume-clock
1st largest	-0.47	-0.05	15.51	1.97	10.06	0.16
2nd largest	1.96	0.19	46.60	3.15	91.12	0.42
3rd largest	1.50	0.01	30.66	3.16	39.54	0.42
4th largest	1.96	0.27	109.55	3.96	500.69	0.66
5th largest	-0.29	-0.24	8.69	3.42	3.16	0.50
Largest 5 pooled	1.01	0.03	46.79	3.20	91.38	0.43
All pooled	-0.62	-0.19	205.47	18.46	1759.19	14.20

All components of $\Delta ExpCCP$

- The three price components are:

$$\begin{aligned} RetVola_t = & f\left(D\left(\mathbf{D}_{\Omega_t}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right), R\left(\mathbf{D}_{\Omega_t}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right)\right) \\ & - f\left(D\left(D_{\Omega_{t-1}}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right), R\left(D_{\Omega_{t-1}}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right)\right), \end{aligned} \quad (9)$$

$$\begin{aligned} RetCorr_t = & f\left(D\left(D_{\Omega_t}, \mathbf{R}_{\Omega_t}, P_{t-1}, \tilde{N}_{t-1}\right), R\left(D_{\Omega_t}, \mathbf{R}_{\Omega_t}, P_{t-1}, \tilde{N}_{t-1}\right)\right) \\ & - f\left(D\left(D_{\Omega_t}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right), R\left(D_{\Omega_t}, R_{\Omega_{t-1}}, P_{t-1}, \tilde{N}_{t-1}\right)\right), \text{ and} \end{aligned} \quad (10)$$

$$\begin{aligned} PrLevel_t = & f\left(D\left(D_{\Omega_t}, R_{\Omega_t}, \mathbf{P}_t, \tilde{N}_{t-1}\right), R\left(D_{\Omega_t}, R_{\Omega_t}, \mathbf{P}_t, \tilde{N}_{t-1}\right)\right) \\ & - f\left(D\left(D_{\Omega_t}, R_{\Omega_t}, P_{t-1}, \tilde{N}_{t-1}\right), R\left(D_{\Omega_t}, R_{\Omega_t}, P_{t-1}, \tilde{N}_{t-1}\right)\right). \end{aligned} \quad (11)$$

- The two trade components are:

$$\begin{aligned} TrPosition_t = & f\left(D\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \mathbf{N}_t\right), R\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_{t-1}\right)\right) \\ & - f\left(D\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_{t-1}\right), R\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_{t-1}\right)\right) \text{ and} \end{aligned} \quad (12)$$

$$\begin{aligned} TrCrowding_t = & f\left(D\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_t\right), R\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \mathbf{N}_t\right)\right) \\ & - f\left(D\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_t\right), R\left(D_{\Omega_t}, R_{\Omega_t}, P_t, \tilde{N}_{t-1}\right)\right). \end{aligned} \quad (13)$$

Back

Decomposition of *ExpCCP* across securities

- *ExpCCP* being homogeneous of degree one in $\omega_k, k = 1, 2, \ldots, I$ yields:

$$ExpCCP = \sum_i \omega_k \left(\frac{\partial}{\partial \omega_k} ExpCCP \right). \tag{14}$$

- The contribution of security k therefore is:

$$ExpCCP_k = \sum_{i,j} \omega_k \left(\frac{\partial}{\partial \omega_k} ExpCCP \right) = \sum_j \sqrt{\frac{1}{2\pi}} \frac{B_{jj}}{2\sigma_j} + \\ + \frac{\alpha}{2\mathrm{std}A} \sum_{i,j} \left(\frac{\pi - 1}{2\pi} \right) \left(M'\left(\rho_{ij}\right) B_{ij} + \frac{\sqrt{1-\rho_{ij}^2} - 1}{\pi - 1} \left(\frac{\sigma_j}{2\sigma_i} B_{ii} + \frac{\sigma_i}{2\sigma_j} B_{jj} \right) \right) \tag{15}$$

where

$$B_{ij} = n_i' \frac{\partial \Omega}{\partial \omega_k} n_j. \tag{16}$$

Back

Alternative sequencing in $\Delta ExpCCP$ decomposition

	Full sample	Top 100 $\Delta ExpCCP$	Top 10 $\Delta ExpCCP$
	Panel A : CCP exposure change decomposition in euro		
RetVola	275	11,003	69,022
	(263, 288)	(1,0581, 1,1427)	(65,622, 72,392)
RetCorr	115	3,612	215
	(112, 118)	(3,555, 3,669)	(-93, 534)
PrLevel	-132	3,363	-3,619
	(-136, -128)	(3,171, 3,555)	(-5,390, -1,881)
TrPosition	14,598	38,656	39,875
	(14,245, 14,951)	(37,609, 39,723)	(37,246, 42,661)
TrCrowding	93	7,253	13,421
	(-253, 439)	(6,347, 8,180)	(11,435, 15,565)
$\Delta ExpCCP$	14,949	63,887	118,914
	Panel B: CCP exposure change decomposition in percentage		
RetVola	1.8%	17.2%	58.0%
	(1.8%, 1.9%)	(16.6%, 17.9%)	(55.2%, 60.9%)
RetCorr	0.8%	5.7%	0.2%
	(0.8%, 0.8%)	(5.6%, 5.7%)	(-0.1%, 0.4%)
PrLevel	-0.9%	5.3%	-3.0%
	(-0.9%, -0.9%)	(5%, 5.6%)	(-4.5%, -1.6%)
TrPosition	97.7%	60.5%	33.5%
	(95.3%, 100%)	(58.9%, 62.2%)	(31.3%, 35.9%)
TrCrowding	0.6%	11.4%	11.3%
	(-1.7%, 2.9%)	(9.9%, 12.8%)	(9.6%, 13.1%)
$\Delta ExpCCP$	100.0%	100.0%	100.0%

Alternative covariance in $\Delta ExpCCP$ decomposition

	EWMA estimate of Cov(*R*)			Rolling-window estimate of Cov(*R*)		
	Full sample	Top 100	Top 10	Full sample	Top 100	Top 10
Panel A : CCP exposure change decomposition in euro						
RetVola	272	10,949	69,311	-414	5,156	24,953
RetCorr	113	3,555	-89	-22	553	-1,225
PrLevel	-133	3,195	-5,324	-168	4,964	-525
TrPosition	14,255	38,002	39,445	18,956	59,148	80,765
TrCrowding	443	8,186	15,571	624	11,388	20,255
$\Delta ExpCCP$	14,949	63,887	118,914	18,976	81,208	124,223
Panel B: CCP exposure change decomposition in percentage						
RetVola	1.8%	17.1%	58.3%	-2.2%	6.3%	20.1%
RetCorr	0.8%	5.6%	-0.1%	-0.1%	0.7%	-1.0%
PrLevel	-0.9%	5.0%	-4.5%	-0.9%	6.1%	-0.4%
TrPosition	95.4%	59.5%	33.2%	99.9%	72.8%	65.0%
TrCrowding	3.0%	12.8%	13.1%	3.3%	14.0%	16.3%
$\Delta ExpCCP$	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Alternative frequencies in $\Delta ExpCCP$ decomposition

	Baseline: 34 bins per day (15-minute intervals)		17 bins per day (30-minute intervals)		8 days per day (1-hour intervals)	
	Full sample	Top 10	Full sample	Top 10	Full sample	Top 10
Panel A : CCP exposure change decomposition in euro						
RetVola	272	69,311	984	89,104	3,881	276,342
RetCorr	113	-89	316	14,133	683	26,155
PrLevel	-133	-5,324	-351	-20,163	-1,603	-24,318
TrPosition	14,255	39,445	38,730	101,854	123,654	327,711
TrCrowding	443	15,571	1,279	22,431	5,052	77,654
$\Delta ExpCCP$	14,949	118,914	40,959	207,359	131,667	683,545
Panel B: CCP exposure change decomposition in percentage						
RetVola	1.8%	58.3%	2.4%	43.0%	2.9%	40.4%
RetCorr	0.8%	-0.1%	0.8%	6.8%	0.5%	3.8%
PrLevel	-0.9%	-4.5%	-0.9%	-9.7%	-1.2%	-3.6%
TrPosition	95.4%	33.2%	94.6%	49.1%	93.9%	47.9%
TrCrowding	3.0%	13.1%	3.1%	10.8%	3.8%	11.4%
$\Delta ExpCCP$	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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