Liquidity Management in Central Clearing:

How the Default Waterfall Can Be Improved

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ABSTRACT

Central counterparties' (CCPs) mitigation of counterparty credit risk gives rise to liquidity risk, which can exacerbate financial shocks if not managed properly. CCPs shift this risk onto clearing members and end-users by having them unduly act as the effective sole contributors to the default waterfall. Because CCPs are generally prudent in handling this capital by allocating nearly all cash to central bank deposits where available, such access should be more widely offered. Initial margin model lookback periods should be increased to prevent procyclicality arising from prolonged low volatility, and additional consideration should be given to the practice of posting outsized portions of securities rather than cash during these periods, which can amplify market stress. Capital requirements for clearing members need to incorporate smaller clearing members' contribution to CCP risk as well as the outsized systemic risk attributable to clearing members belonging to many CCPs; the current Cover 2 standard does not address these issues.

Keywords: central counterparties (CCPs,) clearing members, default waterfall, initial margin, default fund, skin in the game (SITG,) liquidity risk, SRISK

I. INTRODUCTION

Central counterparties (CCPs) are systemically important intermediaries that connect many financial institutions. CCPs help to mitigate counterparty credit risk but have the undesirable side effect of increasing liquidity risk, which, if not managed correctly by all market participants, can lead to financial destabilization in the form of increased defaults. Procyclicality[1] of margin calls, whereby increases in market stress and margin calls are intertwined in a positive feedback loop, is one adverse consequence of such mismanagement. Unexpected spikes in volatility can lead to liquidity problems for participants trading with a CCP as changes in initial margin are highly correlated with changes in volatility for many products that CCPs clear, particularly exchange-traded derivatives and equities as shown in Figure 1.

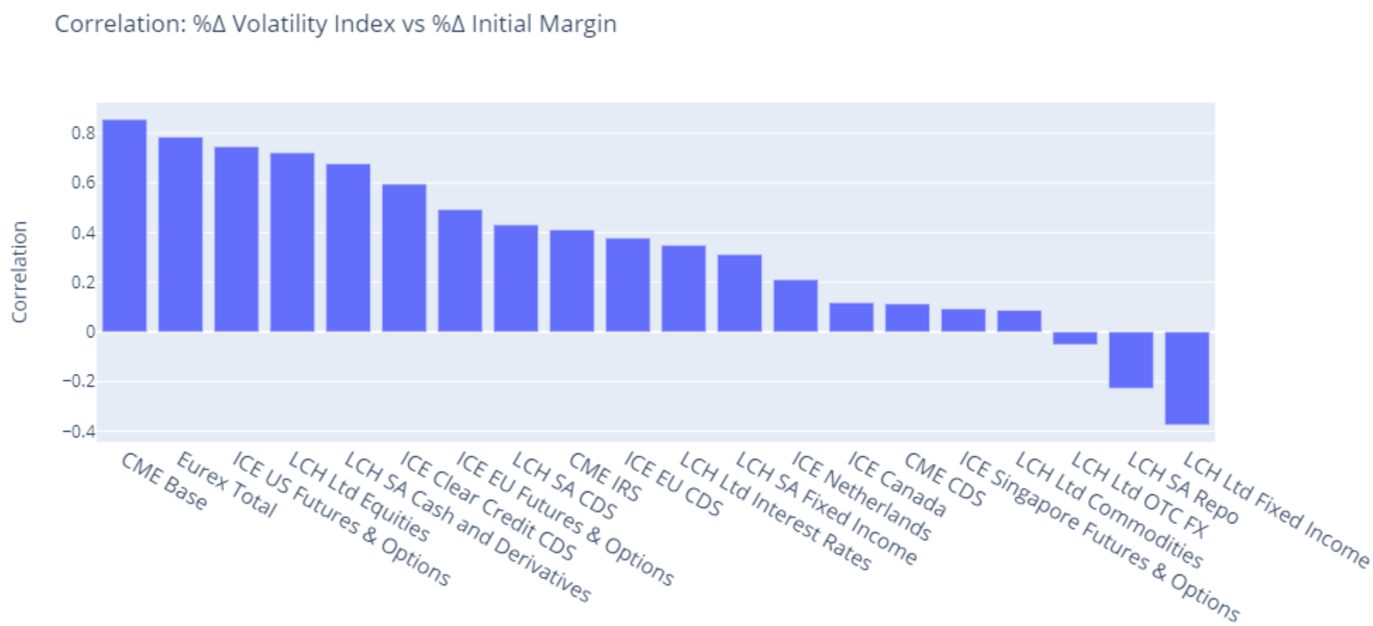

Figure 1: Correlation: Quarterly Percent Change in Initial Margin and Volatility, Q4 2015 to Q1 2021. Products with too few data points are omitted. Descriptions of products and volatility indexes are available in the appendix in Figure A2 and A3, respectively. The three product categories with the highest correlations are exchange-traded derivatives. (Source: PQD Reports from CCPs listed in Figure A1 in the appendix)

[1] The Bank of International Settlements (BIS) and International Organization of Securities Commissions (IOSCO) define procyclicality as "changes in risk-management practices that are positively correlated with market, business, or credit cycle fluctuations and that may cause or exacerbate financial instability" (BIS; IOSCO, 2012).

We detail in this paper how liquidity is broadly managed by CCPs, how they manage liquidity under stress, and most importantly, deficiencies in current practices. We show that the general liquidity management procedures of CCPs include shifting most of the liquidity risk onto clearing members and derivative end-users by contributing negligible amounts of capital to prefunded resources used to cover defaults. Although CCPs tend to be prudent in their cash investing activities (shown by their preference to fully utilize any access to central bank deposits, which should be extended to systemically important CCPs at a minimum,) the models used in practice to derive the liquidity burden taken on by clearing members and end-users do not adequately capture market-wide and CCP-specific risk profiles. We find that the procyclicality in margin calls mentioned earlier may result from short lookback periods[2] in margin models; current practices also allow for end-users to adopt a form of leverage by posting unusual amounts of securities rather than cash to satisfy initial margin calls, causing a dash-for-cash when volatility spikes. For clearing members, the Cover 2 standard (described in section III.2) that determines required capital contributions to a CCP does not reflect the contribution of risk for all clearing members, and more subtly, ignores outsized systemic risk imposed by clearing members who are typically global systemically important banks that belong to multiple CCPs.

Understanding the liquidity management practices of CCPs is critical as clearing practices, particularly in derivatives markets, can induce substantial stress in the broader economy if not managed properly. The immense size of these global markets indicates that the well-being of the financial system relies on proper risk management. As indicators of this immense size, notional amounts outstanding in the over-the-counter derivatives market at the end

[2] Lookback periods refer to the window of historical data that is used to determine market volatility, i.e., longer lookback periods incorporate more historical market data. Models with longer lookback periods are less likely to fall victim to the assumption that more recent market dynamics are wholly representative of future volatility.

of June 2021 totaled $102 trillion foreign exchange products, $488 trillion interest rate products, $8 trillion equity products, $2 trillion commodity products, and $9 trillion credit default swaps[3] along with $34 trillion futures and $46 trillion options notional values outstanding in the exchange-traded derivatives markets[4] as of December 2021. Particularly after the 2008 financial crisis, regulators worldwide have pushed for more products to be centrally cleared. Many over-the-counter products that were once part of the bilateral market are now centrally cleared (although they still bear the name "over-the-counter,") which further emphasizes the importance assessing CCP liquidity management practices. The capital resources that CCPs can draw on to cover clearing member defaults, which have the potential to create liquidity stress, are collectively known as the "default waterfall." The default waterfall includes the CCP's own equity (referred to as "skin in the game" or SITG,) contributions from clearing members in the form of a "default fund" (which largely serves as the cost of membership) and "initial margin," an amount of excess capital derivative end-users must post while a trade is live.

Several possible solutions to limit procyclicality in margin calls have been suggested by the Futures Industry Association (FIA). These solutions generally revolve around better calibration of margin models. As highlighted in section V.1, these suggestions largely call for the calculation of market volatility itself to more accurately reflect appropriate margin levels derived from it. We find that exchange-traded derivatives and equities markets may benefit the most from these recommendations, and that additional consideration should be given to asset composition and frequency of margin calls. Beyond initial margin, calculation of clearing member contributions needs to be updated to reflect individual clearing members' default probabilities. The Cover 2 methodology assumes 100 percent default of the largest two

[3] https://www.bis.org/statistics/derstats.htm
[4] https://www.bis.org/statistics/extderiv.htm

members, and zero percent for all remaining members. We show that clearing members that belong to more CCPs exhibit higher systemic risk (as measured by SRISK). This additional risk should result in measurably higher contributions to default resources for these clearing members.

I.1 Related Literature

This paper contributes to the body of literature surrounding CCP liquidity management. King et al. (2020) documents central clearing infrastructure, highlighting the interconnectedness among CCPs and clearing members, as well as the liquidity risks that arise from the mitigation of counterparty credit risk. Saguato (2017) outlines how the unusually low values of SITG may not properly align risk management incentives. Huang and Takáts (2020) further find that higher levels of SITG are associated with lower model risk. We reinforce the idea that much of the liquidity risk generated from central clearing is shifted onto clearing members and add that CCPs deposit nearly all the cash portion of these resulting funds in central bank deposits when they have been granted access.

The dash-for-cash scenario during the onset of the COVID pandemic led many to revisit the idea of margin procyclicality; FIA (2020) highlight that anti-procyclical standards that are currently in place are not robust enough and that margin models should be calibrated such that they do not become vulnerable to prolonged low volatility. We add that that liquidity shocks are not only driven by margin models with insufficient lookback periods, but also from the fact that end-users use leverage in the form of posting securities rather than cash when markets are calm. For the liquidity burden imposed on clearing members, Berner and Graulich (2021) as well as Murphy and Nahai-Williamson (2014) suggest a further assessment of the adequacy of the Cover 2 standard as it does not properly capture the default risk distribution, which also may vary by

CCP. We reemphasize the pitfalls of Cover 2 and add that it does not capture the contribution to systemic risk from clearing members belonging to many CCPs.

I.2 Outline of the Paper

This paper continues in Section 2 by describing the data we use. Section 3 describes the market participants involved in central clearing. Section 4 describes the components of the default waterfall. Section 5 addresses the question of how liquidity is broadly managed by CCPs, while Section 6 discusses CCP liquidity management in stressed markets. Section 7 outlines additional data needs and areas for future discussion. Section 8 finishes with concluding remarks.

II. DATA

The findings in this report are largely derived from the "Public Quantitative Disclosure" reports (PQDs) that select CCPs release on a quarterly basis. These reports contain a wide range of risk management data points, many of which relate to the default waterfall components. The granularity varies by CCP, and the publication generally starts in Q4 2015 (we use reports up to and including those from Q1 2021.) The report focuses on five CCPs: Chicago Mercantile Exchange (CME,) London Clearing House Ltd (LCH Ltd,) London Clearing House SA (LCH SA,) Intercontinental Exchange (ICE,) and Eurex. For volatility indexes (VIX, CVIX, MOVE, and Goldman Sachs Commodity Volatility Index,) quotes are sourced from Bloomberg. For SRISK calculations, data from Yahoo Finance was scraped to calculate figures in accordance with NYU's SRISK documentation[5]

[5] More information on SRISK can be found on the NYU V-Lab website: https://vlab.stern.nyu.edu/docs/srisk

III. MARKET PARTICIPANTS

II.1 Central Counterparties (CCPs)

Because the derivatives market is a zero-sum game, any party who wants to buy a contract needs to find a counterparty willing to sell the same contract. When the two parties are paired off against each other, they have a bilateral agreement to fulfill their obligation to each other—if a trade moves in party A's favor, party B is obligated to pay. Although party A may have effectively hedged its risk to moves in the underlying asset (assuming the trade is acting as a hedge,) party A now has a new risk that party B will default and not be able to fulfill its obligation should the market swing in party A's favor; this is known as counterparty credit risk.

CCPs act as intermediaries for derivatives transactions and ensure the performance of the contract to both parties. Although counterparty credit risk technically still exists (now with the CCP,) CCPs have an extensive capital infrastructure in place, as well as the ability to net many other trades against each other, which largely negates any remaining counterparty credit risk. However, the drastic mitigation of counterparty credit risk gives rise to liquidity risk, whereby end-users and clearing members can experience large and unexpected increases in capital requirements needed to remain as participants in the market. Such capital comes in the form of margin and default fund contributions.

The myriad of CCPs across the globe vary in both size and range of products cleared. Of all these institutions, the 13 listed in Figure 2 are designated as "systemically important" CCPs by the Financial Stability Board (FSB, 2021).

CCP	Home Jurisdiction
BME Clearing	Spain (EU)
Cassa di Compensazione e Garanzia (CC&G)	Italy (EU)
CME Inc.	US
Eurex Clearing	Germany (EU)
EuroCCP	Netherlands (EU)
HKFE Clearing Corporation	Hong Kong SAR
ICE Clear Credit	US
ICE Clear Europe	UK
LCH Ltd	UK
LCH SA	France (EU)
Nasdaq Clearing	Sweden (EU)
Options Clearing Corporation (OCC)	US
SIX x-clear	Switzerland

Figure 2: FSB Systemically Important CCPs
(Source: FSB)

We focus our research on CME, LCH Ltd, LCH SA, Eurex, and ICE, as these five CCPs are generally regarded as some of the most prominent globally and are all listed in Figure 2.

II.2 Clearing Members

Only designated parties, known as "clearing members," are allowed to trade directly with a CCP. Those who want to participate in the derivatives market must trade with a clearing member who will then execute trades with the CCP on behalf of the end user. To become a clearing member, a party must pay flat fees, fees per trade, and income generated on margins held. There are generally two tiers of membership to a CCP:

1. General clearing member (GCM) – can clear trades and trades on behalf of third parties
2. Individual/Direct clearing member (ICM) – can clear only clear own (proprietary) trades

In general, there is considerable overlap of clearing members across CCPs. Except for ABN AMRO, institutions that are clearing members of all five CCPs we analyzed, listed below in Figure 3, are all designated by the Financial Stability Board as G-SIBs[6] (FSB, 2021).

Institution	G-SIB
J.P. Morgan	Yes, Bucket[7] 4
BNP Paribas	Yes, Bucket 3
HSBC	Yes, Bucket 3
Bank of America	Yes, Bucket 2
Barclays	Yes, Bucket 2
Deutsche Bank	Yes, Bucket 2
Goldman Sachs	Yes, Bucket 2
Credit Suisse	Yes, Bucket 1
Santander	Yes, Bucket 1
UBS	Yes, Bucket 1
Morgan Stanley	Yes, Bucket 1
ABN AMRO	No

Figure 3: Clearing Member of all five CCPs analyzed and G-SIB Status (Source: FSB)

Clearing member overlap across CCPs is not ideal because it can lead to the instability of one clearing member to develop into a financial contagion that spreads to multiple CCPs. The general mechanism CCPs use to prevent major adverse effects of a clearing member default is the "default waterfall," which is comprised of several layers of capital that may be drawn upon in the event of a clearing member default.

[6] G-SIB refers to "Globally Systemically Important Bank," as designated by the Financial Stability Board; there are 30 banks with this designation as of November 2021.
[7] Banks with higher bucket numbers are required to have higher capital buffers in accordance with their systemic importance; the highest bucket number is 5.

IV. THE DEFAULT WATERFALL

CCPs have several mechanisms in place to prevent against counterparty credit risk, namely, payment and close-out netting[8], trade compression[9], and most importantly, the default waterfall. The default waterfall (shown in Figure 4 below,) is a hierarchy of funds to be utilized in the event of default of a clearing member or derivative end user.

Line of Defense	Source
1	Initial margin of defaulting member
2	Default fund contribution of defaulting member
3	"Skin in the Game" (SITG) – portion of CCP's own equity
4	Default fund contributions of non-defaulting members

Figure 4: CCP Default Waterfall Components
Note that in the PQD reports, 2 and 4 are reported as one combined number

In addition to the listed components, which are considered "funded," there are several resources that may be utilized should the waterfall be exhausted. Lines of credit, one alternative resource, are generally not significant (or non-existent) in size compared to the funded default waterfall components, as shown below in Figure 5 (apart from ICE Singapore, which has a small default waterfall to begin with.) A second resource, "variation margin gains haircuts," or "VGMH," in which CCPs pay less-than-fair variation margin (or possibly no variation margin at all) when margin is owed to clearing members by a CCP, is typically not a comparatively significant source of protection as shown in Figure 6, which shows sources of capital drawn upon in a hypothetical stress scenario across CCPs.

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[8] Definition and additional information for close-out netting can be found at risk.net/definition/close-out-netting
[9] Definition and additional information on trade compression can be found at lch.com/services/swapclear/enhancements/compression

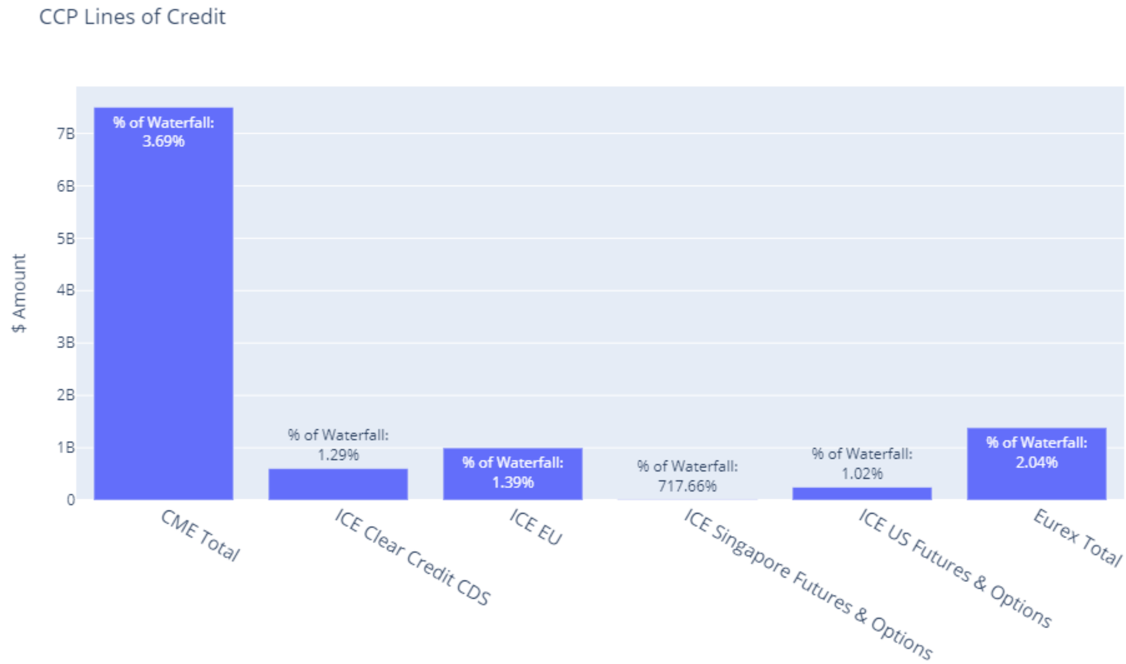

Figure 5: Lines of Credit and Comparison to Total Waterfall Size for Various CCPs as of Q2 2021
All lines of credit shown are secured, except for that of Eurex, which is unsecured.
Any CCP or product category not shown did not report a line of credit.
(Source: PQD Reports)

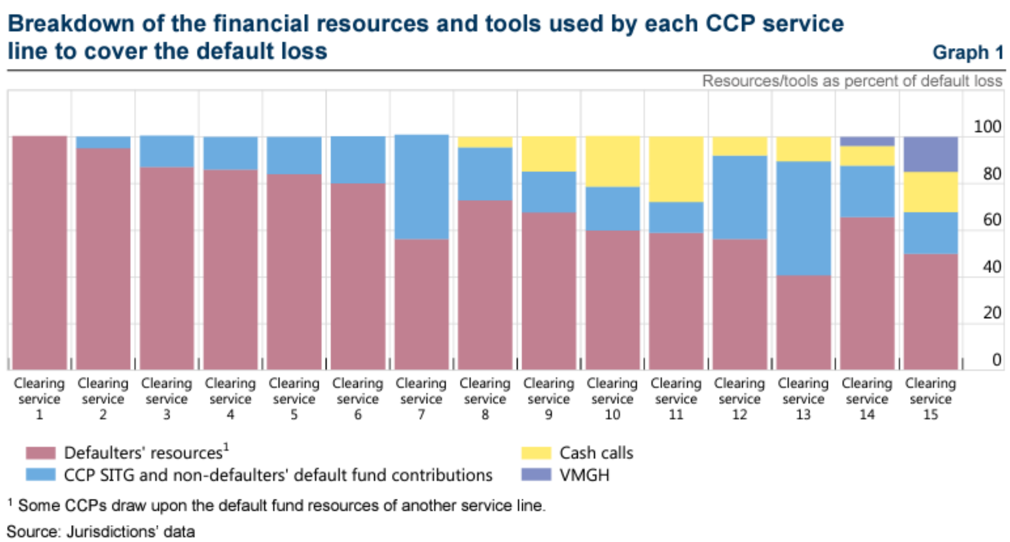

Figure 6: Sources of Capital Drawn Upon for 15 Undisclosed CCPs in a Hypothetical Stress Scenario
(Source: Central Counterparty Financial Resources for Recovery and Resolution, FSB, 2022)

III.1 Initial Margin

During the life of a trade, end-users make both variation margin and initial margin payments. Variation margin covers the current exposure of a trade should one party default; however, transactions cannot be closed out the moment one party defaults and will remain active for a period of time until legal work can be sorted out and transaction settlement can occur. This period of unhedged counterparty credit risk known as the "Margin Period of Risk" (MPOR.) MPOR is protected by an additional collateral beyond variation margin in the form of initial margin (sometimes referred to as "independent amount," albeit with a slightly different meaning.[10]) CCPs typically use a 5-day MPOR for initial margin calculations, in comparison to the bilateral market in which counterparties use 10-days (Mark Paddrik, 2020). Initial margin is intended to cover fluctuations in the value of a trade *within a certain confidence interval* by using methodologies like VaR. In fact, over 60 percent of CCPs globally use some form of VaR directly, including historical, parametric, and Monte Carlo versions; about a fifth use the SPAN[11] methodology, while the remainder of models are mostly unclassified (BIS; IOSCO, 2021). Capital that is acceptable to be posted as initial margin is typically cash or high-quality securities such as government bonds.[12]

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[10] Independent amount and initial margin serve the same purpose; independent amount is used in the bilateral market and is a static amount paid when derivatives trades are entered into; initial margin is a modern form of independent amount that fluctuates throughout the life of a trade based on measures of forward-looking risk. Initial margin takes on a slightly different meaning in the repo market: it is equal to the market value of securities divided by the repo price, which is an alternative way of expressing the haircut.

[11] More information on the SPAN (Standard Portfolio Analysis of Risk) methodology, which was developed by the CME and is based on VaR, can be found at:
cmegroup.com/clearing/risk-management/span-overview.html

[12] Eligible collateral and haircut schedules can be found on CCP websites:
cmegroup.com/clearing/financial-and-collateral-management/acceptable-collateral-for-cash.html
lch.com/collateral-management/ltd-collateral-management/ltd-acceptable-collateral/ltd-acceptable-securities
lch.com/collateral-management/sa-collateral-management/sa-acceptable-collateral/sa-acceptable-securities
eurex.com/ex-en/data/clearing-files/Haircut-and-adjusted-exchange-rate

Compared to variation margin, initial margin is a significant liquidity constraint[13] as required amounts dwarf average daily variation margin payments, as seen in Figure 7 below for LCH Ltd.'s interest rates product category (other CCP products appear similar.) Aside from margin call frequency (discussed in section V.1,) there are limited options to dampen procyclicality resulting from variation margin calls, as such calls are the amount that is indisputably owed between participants. Initial margin, however, is a modelled amount representing future risk and therefore subject to model assumptions. This gives rise to the need to balance acceptable levels of counterparty credit risk and liquidity risk.

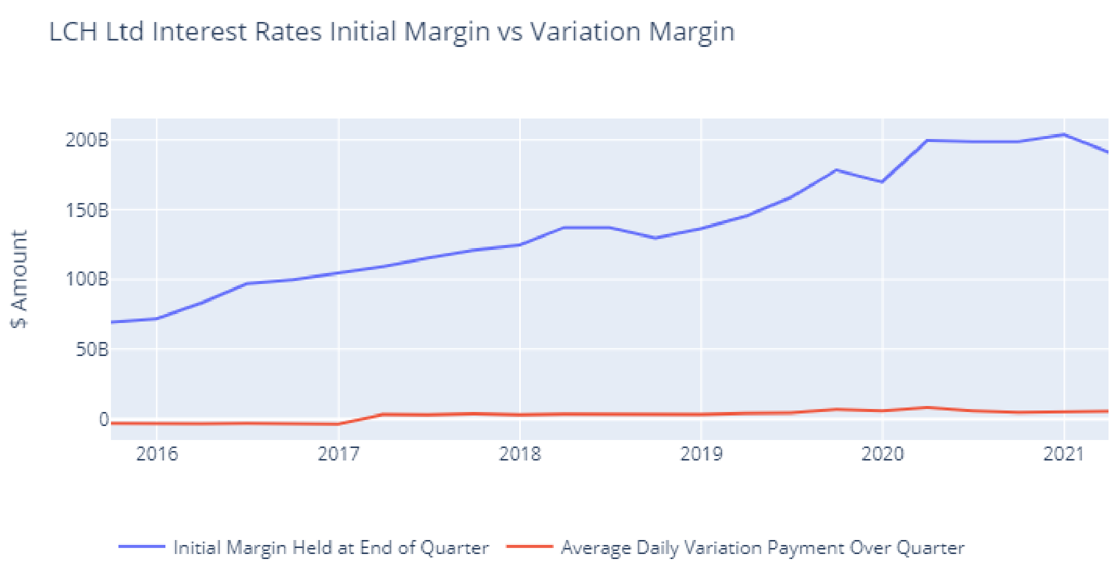

Figure 7: Initial Margin Held vs Average Daily Variation Margin Payment for LCH Ltd Interest Rates (Source: LCH Ltd PQD Reports)

[13] Because it is a significant amount, initial margin may result in MVA (Margin Valuation Adjustment,) an adjustment to the value of a trade that reflects the cost of funding initial margin.

III.2 The Default Fund

The second line of defense if initial margin of the defaulting clearing member is the default fund; more specifically, the default fund contribution of the defaulting clearing member as noted in Figure 4. CCPs typically calculate their default fund in accordance with the "Cover 2" standard outlined in BIS and IOSCO's Principals for Financial Market Infrastructure.[14] A CCP must then decide how much each clearing member must contribute to the default fund to satisfy Cover 2[15]. When looking at CCPs individually, the Bank of England notes that "CCPs meeting the Cover 2 standard are not highly risky provided that tail risks are not distributed too uniformly amongst CCP members" (David Murphy, 2014). This means that an amount of capital equal to the size of the losses of the two largest clearing members is largely sufficient to cover losses in stress evens, provided that smaller firms to not have outsized contributions to the overall risk of the CCP. This does not mean the Cover 2 amount is a coherent methodology to derive the required capital for clearing members, only that it is sufficient given the assumptions of regulatory stress scenarios. However, these assumptions may not be fully realistic:

1. The simultaneous default of the largest two clearing members would likely only occur under extreme market stress, in which case many smaller clearing members would likely also be facing default.
2. Cover 2 inherently allows the default fund to remain unchanged if a CCP registers more clearing members, provided they are smaller than the largest two.

[14] The cover 2 standard stipulates that a CCP must hold enough capital to cover the default losses of the largest two clearing members in a hypothetical stress environment.

[15] Eurex determines individual clearing members' contributions proportional to their individual expected stress loss above initial margin, even though the default fund is only determined by the expected stress loss above initial margin for the largest two members (i.e., Cover 2,) an obvious dislocation of the model eurex.com/ec-en/find/circulars/clearing-circular-2432854

3. The Cover 2 calculation uses an MPOR of 5 days, but the time required to liquidate or hedge positions in an extreme stress event would likely be larger than it would be under normal market conditions. For such calculations, CFTC has proposed using "stress period of risk" (SPOR[16]) as this proposed measure "could in some instances be longer than the MPOR[17], reflecting the stress-related increase in volatility and reduction in market liquidity." (Berner & Graulich, 2021)

III.3 Skin in the Game

Skin in the Game (SITG) is an amount of equity contributed to the default waterfall by the CCP itself. The monetary value of SITG is a highly debated topic that has its roots in classical finance: parties who enjoy returns on capital should also bear the associated risks, however, SITG values are remarkably low (described in the following section.) The Market Risk Advisory Committee of the CFTC published the report titled "DCO Capital and Skin in the Game Areas for Discussion," which states that SITG's purpose is to "incentivize management of market and other risks, rather than serve as a significant resource to absorb losses arising from a clearing member's default" (Betsill & Crighton, 2021). The same report highlights that CCPs are prohibited from using mutualized resources (i.e., the default fund) to cover non-defaulting losses (losses arising from operations, asset custody, etc. that are controllable only by the CCP itself.) This suggests that SITG is primarily intended to cover non-defaulting losses, with the minor secondary function of being part of the default waterfall (albeit a miniscule contribution.)

[16] Along with the Cover 2 standard, initial margin models are subject to the same shortcomings of a static MPOR; SPOR may also be a beneficial feature to add to these models.
[17] In an extreme case, Nasdaq Clearing's Nordic commodities exchange took nine months from the time of default to fully offload Einar Aas's power derivatives positions (Mourselas, 2021).

The report also reveals that market participants disagree on what should be considered adequate in terms of the monetary value of SITG[18].

V. HOW IS LIQUIDITY GENERALLY MANAGED BY CCPS?

IV.1 Waterfall Levels

Almost all waterfalls across CCPs appear similar in terms of these relative component levels. Initial margin is typically several orders of magnitude larger than the default fund, and SITG (the CCP's own contribution) is virtually zero. This can be seen in Figure A4 in the appendix, a time series of CME's default waterfall for its interest rate swaps product class. Initial margin is not only the largest component but is also the most variable; even during stress scenarios such as COVID, the default fund and SITG components remain relatively unchanged. For the five CCPs analyzed, Figure 8 shows the average default waterfall component levels over the time series; Figure 9 shows the same data broken down by products cleared[19] as reported in the PQD disclosures.

Waterfall Component	Portion of Waterfall
Initial Margin	75%
Default Fund	22%
SITG	3%

Figure 8: Average CCP Default Waterfall Component Relative Levels (Source: PQD Reports from CCPs listed in Figure A1 in the appendix)

[18] Eurex and CME (CCPs) generally favored the current regulation around SITG, while Vanguard, JPMorgan, and Blackrock (clearing members and end-users) favored increases in SITG

[19] Descriptions of each product can be found in the appendix in Figure A2.

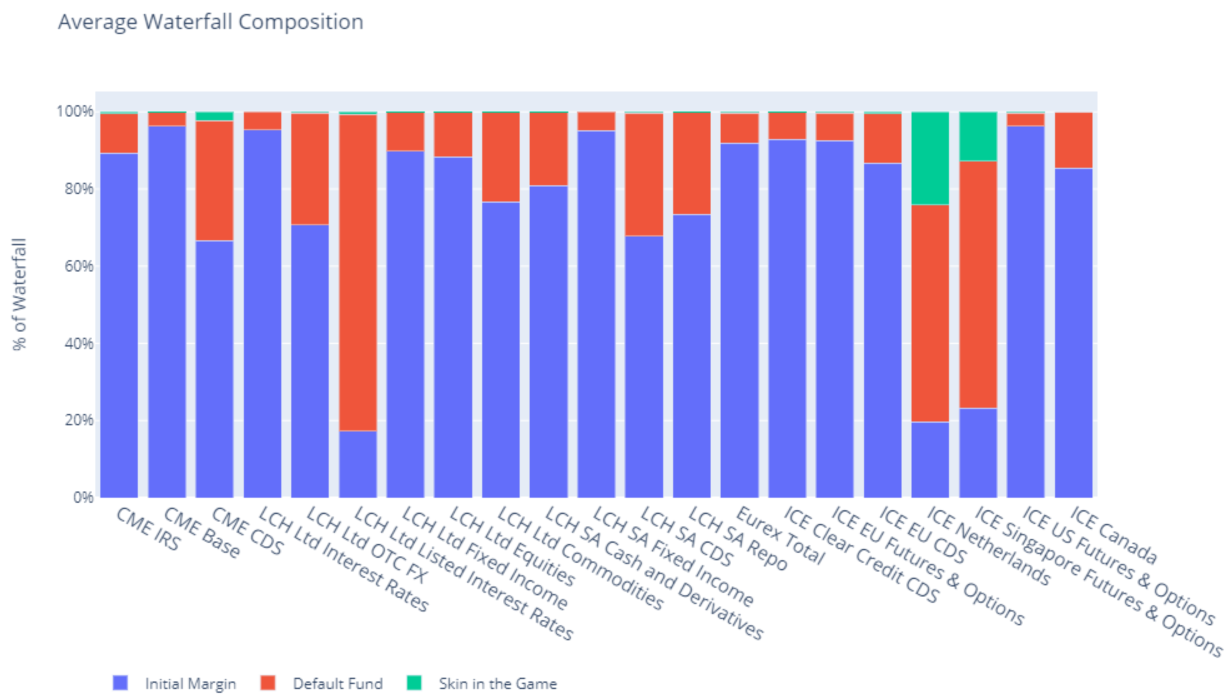

Figure 9: Waterfall Component Levels by Product for Each CCP Analyzed
(Source: PQD Reports from CCPs listed in Figure A1 in the appendix)

The low values of SITG create a potential misalignment in risk management incentives, highlighted by Paolo Saguato (2017) in "The Ownership of Clearinghouses: When "Skin in the Game" Is Not Enough, the Remutualization of Clearinghouses:"

> Not only do shareholders have limited incentives to invest time and resources in monitoring the firm, but shareholders are also more likely to take on riskier and more profitable projects because they assume that the guaranty fund (and the other resources available in the "default waterfall" mechanism) will absorb the eventual losses (Saguato, 2017).

Although it may be prudent for regulators to require higher levels of SITG capital for risk management purposes, the tradeoff is that excessively high required SITG values could incentivize CCPs to charge higher fees for clearing, countering clearing members' and end-users' reduced liquidity risk. LCH (the parent company of LCH Ltd and LCH SA) directly addressed this tradeoff in a 2015 report: "It is ironic that when financial market participants are arguing for a CCP to increase the SITG, they are in effect advocating for an increase in clearing fees" (LCH, 2015). With this in mind, and in the context of Figure 8 and Figure 9, we derive our first finding:

> ***Finding 1a:*** *End-users and clearing members appear to be the bearers of nearly all the liquidity risk: end-users are responsible for about three quarters of the of the risk (through initial margin) and clearing members are responsible for nearly all the rest (through the default fund.) The SITG contribution has negligible loss-absorption capacity; requiring increases should be considered but would likely necessitate regulation of a CCP elsewhere so as costs would not be raised for end-users.*

IV.2 Cash Investment Decision

CCPs must return identical securities, which cannot be rehypothecated, when returning margin to end-users. When cash is posted as margin, CCPs must determine where to invest this cash to earn interest, mainly because the entity that posts initial margin is entitled to interest on the amount posted. For the five CCPs analyzed, the average portion of initial margin that was posted as cash over the time series was significant – roughly 60 percent (derived from the PQD reports.) The investment decision of where to invest cash can therefore have a significant effect on interest earned, *possibly* encouraging a degree of "active management" on the part of the CCP. In his 2017 speech "Central Clearing and Liquidity," Jerome Powell addressed the challenges CCPs face when taking large amounts of cash in the form of margins:

> CCPs can deposit some of these [cash margin] funds with commercial banks. But regulatory changes have made it more expensive for banks to take large deposits from other financial firms, and in some cases banks may be unwilling to accept more cash from a CCP. And many of the largest banks are also clearing members, which introduces a certain amount of wrong-way risk (Powell, 2017) [20].

Powell also notes that in addition to the difficulty of finding banks that are willing to accept the needed deposits, it "may be too late in the day to rely on the repo market" (Powell, 2017). The repo market also may be subject to procyclicality as haircuts on collateral tend to rise during stress; minimum haircuts have been proposed to dampen this effect (Comotto, 2012).

LCH SA and Eurex, the only two CCPs analyzed that have ECB banking licenses that give them access to the European Central Bank services, show a remarkable difference in their cash allocation structures in comparison to all the other CCPs analyzed: close to 100 percent of their cash is allocated to central bank deposits (Figure A5 and A6 in the appendix.) In a similar fashion, CME was classified as a "Designated Financial Market Utility" (DFMU) under Title VIII of the Dodd-Frank Act, giving them the ability to make deposits at the Federal Reserve starting in 2016. Since Q4 2016, CME has made a significant shift toward central bank deposits, which at the end of the time series accounts for about 90 percent of its waterfall cash (Figure A7 in the appendix.) Conversely, LCH Ltd and ICE, the remaining CCPs analyzed, have a significantly higher portion of cash invested in other assets, namely secured commercial bank deposits (which include repo transactions) and government bonds:

[20] "Wrong-way risk" as defined by risk.net is "A form of counterparty credit risk, wrong-way risk arises when the exposure to a counterparty increases together with the risk of the counterparty's default" (Risk.net, n.d.). A CCP depositing cash received from a clearing member in an account at that same clearing member is problematic from a counterparty credit risk perspective.

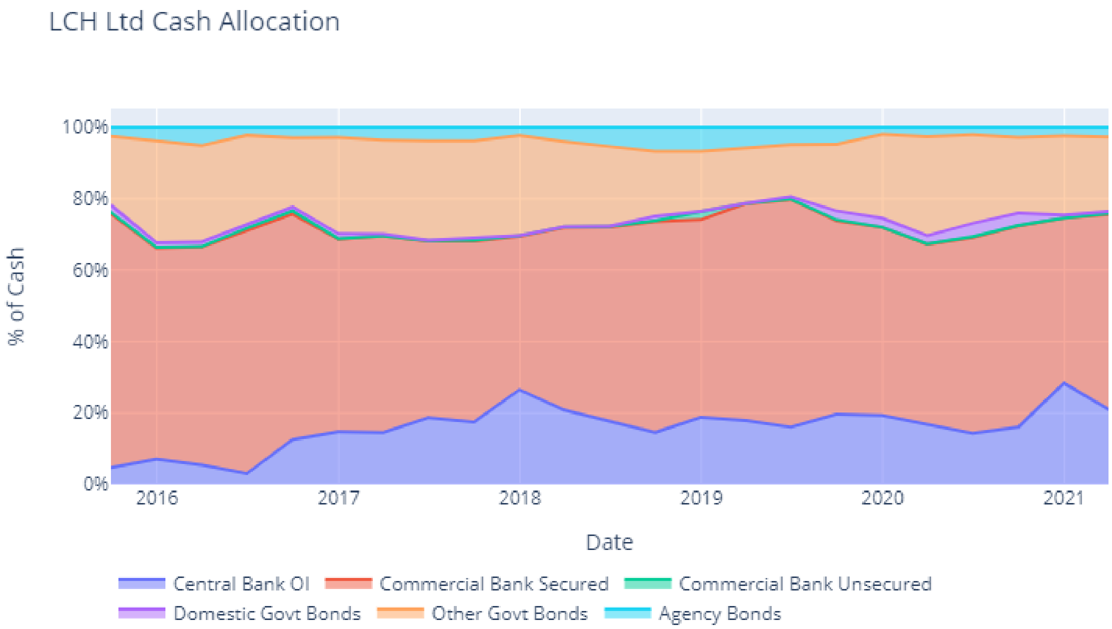

Figure 10: LCH Ltd Default Waterfall Component Relative Levels
Note that "Central Bank OI" refers to Central Bank of Issue i.e., central banks that issue the currency being deposited
(Source: LCH Ltd PQD Reports)

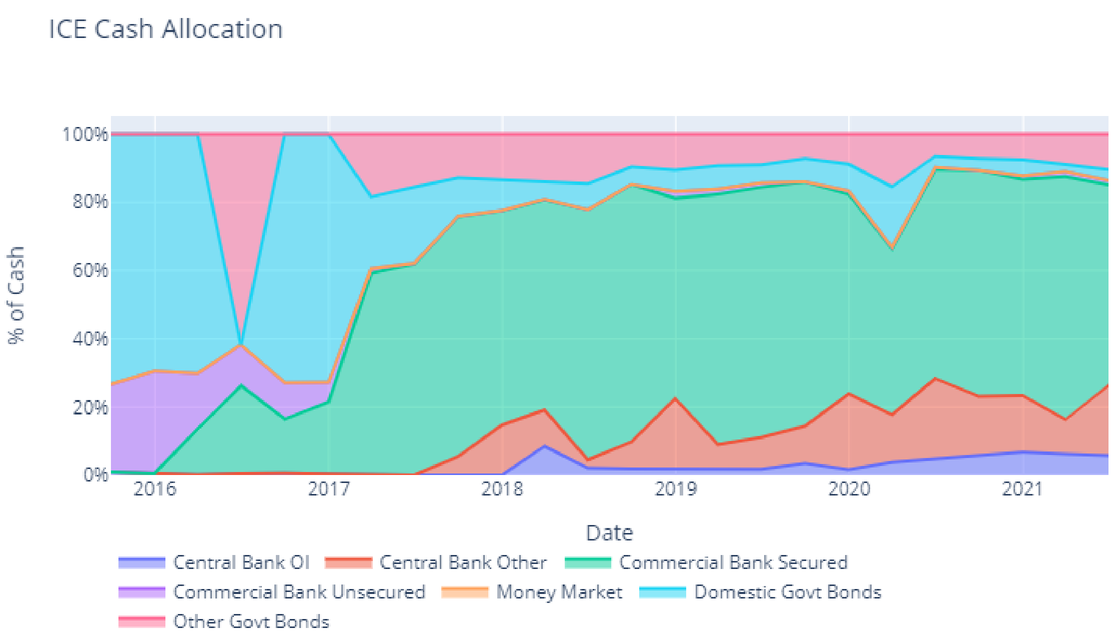

Figure 11: ICE Default Waterfall Component Relative Levels
(Source: ICE PQD Reports)

These differences give rise to our second finding:

> ***Finding 1b:*** *Access to central bank facilities is a major driver of cash allocation. CCPs with access to central bank deposit services utilize them for nearly all cash in their default waterfalls. The repo market may not be sufficient to absorb liquidity shocks, and commercial bank deposits may either not be available or introduce wrong-way risk*[21]*. It may be prudent for regulators to grant central bank access to systemically important CCPs listed in Figure 2*[22]*, as well as other prominent but CCPs that narrowly fall shy of the FSB systemic importance designation.*

VI. HOW DO CCPS MANAGE LIQUIDITY UNDER STRESS?

V.1 Initial Margin: Model Calibration

As margin models are largely driven off the volatility of the underlying market they represent, periods of prolonged low volatility are generally accepted as a major cause of unusually low margin levels, which may trigger liquidity shocks. Since the global financial crisis of 2008 and before COVID, volatility across many major asset classes sunk to and remained close to historical lows before spiking dramatically during COVID:

- VIX (Equity) hit a low of 9.14 on 11/30/2017 and spiked to 82.69 on 3/16/2020
- CVIX (FX) hit a low of 4.87 on 2/12/2020 and spiked to 16.36 on 3/19/2020
- MOVE (Rates) hit a low of 42.53 on 3/20/2019 and spiked to 163.7 on 3/9/2020

[21] In The Federal Reserve Board's paper "Central Clearing and Systemic Liquidity Risk" it is noted that "In practice, most of the institutions that are in a position to commit to providing significant liquidity [to CCPs] are large banks that also participate directly in CCPs" (King, Nesmith, Paulson, & Prono, 2020)

[22] All US-domiciled CCPs in Figure 2 are classified as DFMUs, thereby granting them access to central bank deposits. As mentioned, only Eurex and LCH SA have ECB banking licenses, leaving other systemically important European CCPs without access to such facilities.

From Q4 2019 to Q1 2020, when the COVID pandemic shocked markets, initial margin calls, as well as the amount posted as cash correspondingly increased markedly across products at various CCPs:

Figure 12: Percent Change in Initial Margin Across Various CCP Products During COVID (Source: PQD Reports from CCPs listed in Figure A1 in the appendix)

Pre-COVID levels of initial margin may were abnormally low, leading to the sudden increase in requirements during March of 2020. Although the initial margin history goes only as far back as 2015 in the PQD reports, we can use the time series of initial margin requirements for exchange traded products as a proxy[23] for margin levels pre-2015. Figure 13, showing margin requirements per contract for Eurodollar futures, shows that margin levels were at historic lows pre-pandemic, suggesting that the amount that CME (and likely other CCPs) was collecting in initial margin was unusually low. When volatility spiked in Q1 2020, margin requirements followed suit. This is undesirable from a liquidity perspective as many derivative end-users were

[23] Historical CME margin requirements for exchange traded products are available via https://www.cmegroup.com/clearing/risk-management/historical-margins.html

met with large, but more importantly *unexpected*, margin calls during an already economically stressful period.

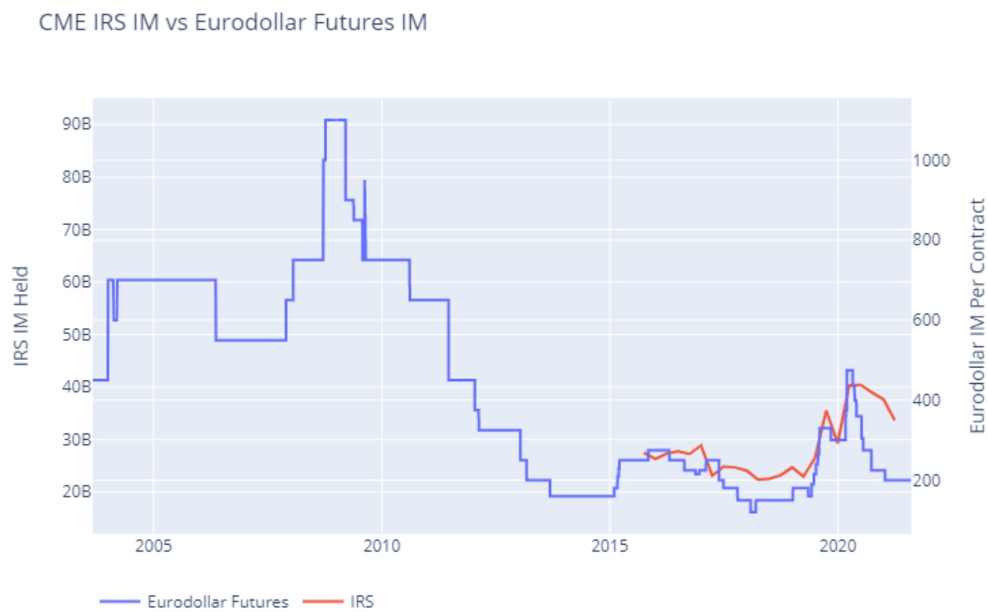

Figure 13: Eurodollar Initial Margin Requirements vs CME IRS Initial Margin Held
Initial margin held for CME's interest rate swap product category is overlayed to highlight the effectiveness of Eurodollar initial margin requirements as a proxy
(Source: CME)

Jon Gregory highlights this effect more generally: "[procyclicality] encourages high leverage in bullish market environments, leading to sudden and extreme crises" (Gregory, 2014). This "leverage effect" not only reveals itself in the *level* of margin, but also in the *composition* of margin via the ratio of cash to securities that makes up the total amount posted as initial margin. For example, the ratio of initial margin posted as cash to total initial margin for CME's "Base" product category (exchange traded derivatives,) was roughly 25 percent right before COVID and rose sharply during the initial onset of market stress, as seen in Figure 14. Figure 12 also shows that for many products, cash initial margin increased more on a percentage basis than did overall initial margin, further revealing the leverage employed by end-users in the form of margin composition.

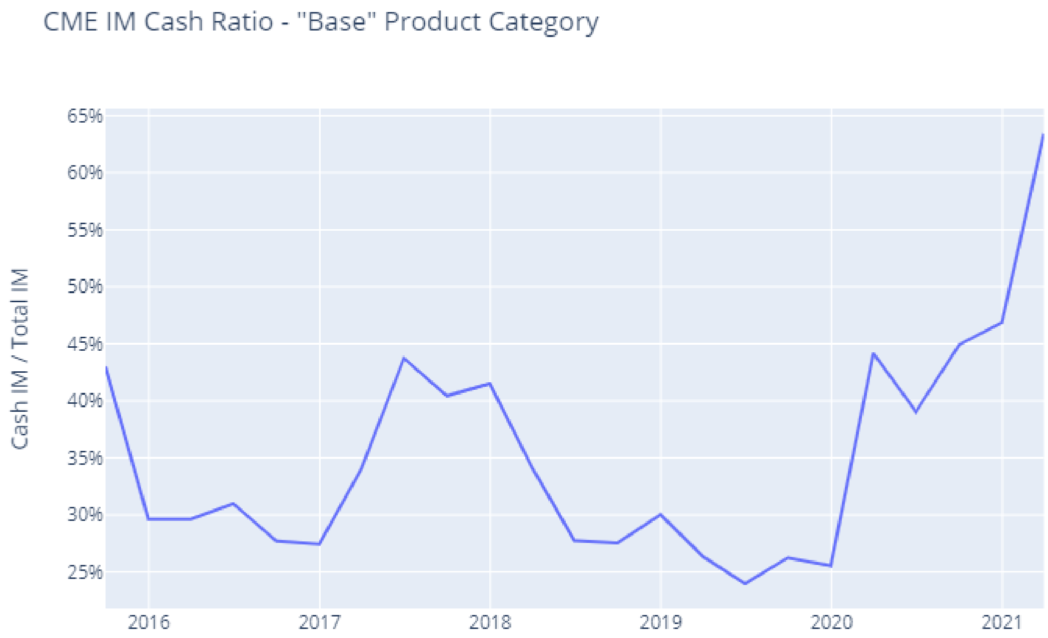

Figure 14: Ratio of Cash Initial Margin to Total Initial Margin for CME's "Base" Product Category (exchange traded derivatives)
(Source: CME PQD Reports)

ISDA's "COVID-19 and CCP Risk Management Frameworks" report similarly notes that during the onset of the COVID pandemic, the changes in collateral composition mostly involved changes in cash:

> The majority of CCPs reported no changes in the credit quality of collateral. If there were changes in collateral composition, these mostly involved increased levels of cash. That is because it was easier for clearing participants to pay increased margin in cash, and this has partially and slowly been substituted with securities collateral. (ISDA, 2021)

Cash was likely easier to post because the cost of funding non-cash eligible collateral (generally government debt) increased as repo rates plummeted during covid. In the US market, the cost of borrowing government securities hit record highs, notably the 10-year US treasury, of which the repo rate plummeted to a low of negative 4.25 percent, meaning that entities borrowing this security to meet margin calls would have to pay an annualized rate of 4.25 percent (Chavez-Dreyfuss, 2021).

In a response to BCBS-CPMI-IOSCO's paper "Consultative Report on Review of Margining Practices," BlackRock noted that "CCP IM models, particularly in futures, were shown to be highly sensitive to market moves, resulting in large, sudden, and unpredictable spikes in IM calls across CCPs" (BlackRock, 2022). This relationship among futures held true in the PQD report data, as seen in Figure 1, where exchange-traded derivatives products have the highest correlations with volatility. Basel Committee on Banking Supervision's (BCBS) "Review of margining practices" paper reveals that the equities and exchange-traded derivatives (ETD) categories have some of the shortest margin model lookback periods in comparison to other asset classes, as shown below in Figure 15 (BCBS, 2021).

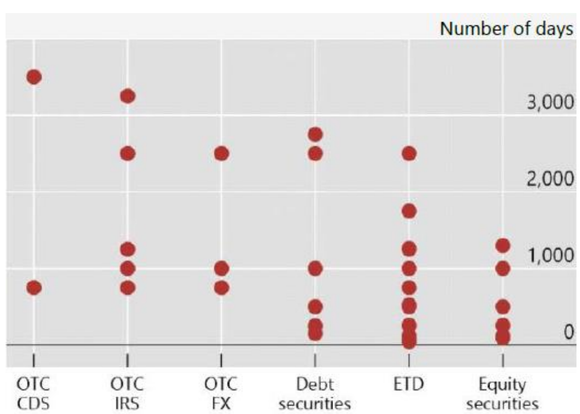

Figure 15: CCP Initial Margin Model Lookback Periods Across Product Types (Source: BCBS)

The paper further comments that no CCPs have enacted anti-procyclicality tools targeting stress periods for equities, and only a handful have for exchange-traded derivatives; this may have been a partial stress driver in these markets. Figure 16 below shows that changes in initial margin are generally highly correlated across products, revealing that this issue may be systemic in nature.

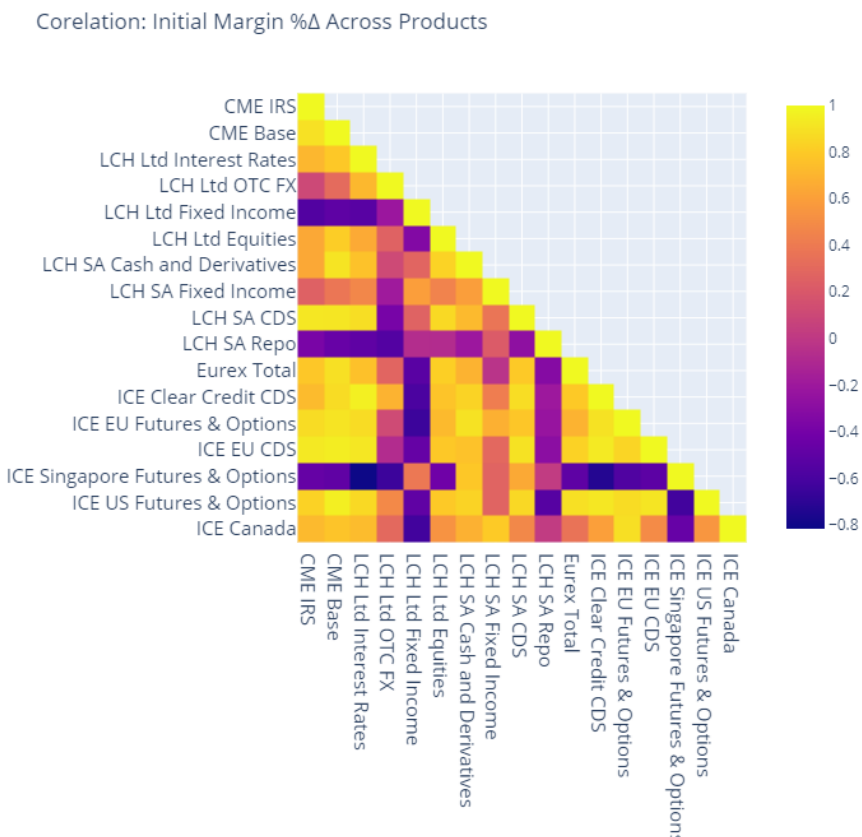

Figure 16: Correlation of Changes in Initial Margin Across CCP Products (Source: PQD Reports from CCPs listed in Figure A1 in the appendix)

In 2018, the European Market Infrastructure Regulation (EMIR) put forth "Anti Procyclicality Controls," which requires European CCPs to include at least one of the following techniques in their margin calculation methodologies, described in the European Securities and Markets Authority (ESMA) anti-procyclicality guidelines paper (ESMA, 2018):

1. Apply a margin buffer at least equal to 25% of the calculated margins which it allows to be temporarily exhausted in periods where calculated margin requirements are rising significantly
2. Assign at least 25% weight to stressed observations in the lookback period calculated in accordance with Article 26 of the RTS
3. Ensure that its margin requirements are not lower than those that would be calculated using volatility estimated over a 10-year historical lookback period

The FIA noted that such standards are somewhat ambiguous and can be interpreted in ways that prevent them from being effective; in response, the FIA made three suggestions that may be more robust (FIA, 2020):

1. Stress lookback periods – making sure margin calculations include a long enough lookback period such that they include stress scenarios
2. Minimum volatility floors – putting a simple (calibrated) threshold on initial margin, whereby negative breaches are not permitted
3. Absolute and percentage returns – FIA describes this as "set floors that are adequate in both low and high price regimes," thereby accounting for the level of asset rather than just percentage changes.

Judging from Figure 15, FIA's first proposition of ensuring stress lookback periods in equities and exchange-traded derivatives is a critical area for improvement of anti-procyclical measures. Many CCPs in the report Figure 15 was sourced from did indicate they employ some form of margin floor, which may address FIA's second and third propositions.

In addition to specifications of initial margin models themselves, the frequency of margin calls likely contributes to the degree of procyclicality in each market. As an example, in early

March 2020, Tsingshan Holding Group Co, a nickel producer, was facing massive margin calls on its short nickel futures position (acting as a hedge to its production) at the London Metals Exchange. The company could not quickly come up with the necessary funds to meet its margin calls but was eventually able to secure lines of credit from banks including JPMorgan (Cang & Chan, 2022). Had Tsingshan not had adequate time to arrange the lines of credit, it would have been considered in default, adding more stress to the market, even though its overall economic position was likely closer to break-even when considering its nickel production assets. This scenario highlights that increasing the frequency of margin calls can dramatically increase liquidity risk while providing miniscule decreases in counterparty credit risk. A solution is to decrease the frequency of margin calls—while increasing the associated models' MPOR to compensate. From this analysis we conclude our next finding:

> ***Finding 2a:*** *Procyclicality and margin shocks appear to be the most significant in the exchange traded derivatives and equities markets. This is likely due to short lookback periods for margin models, as well as from end-users employing leverage in low volatility environments by posting securities rather than cash as initial margin. Increasing lookback periods and enforcing limits on margin amounts posted as securities is critical in further reducing procyclicality of margin calls; decreasing the frequency of margin calls (within reason) should also be considered as this may also dampen liquidity risk.*

V.2 Default Fund: Sizing

During the COVID pandemic, there were at least three documented cases of member defaults, although CCPs generally remained resilient. CME's clearing member Ronin Capital was unable to meet increased capital requirements, resulting in CME being forced to auction off

Ronin's portfolios held at CME on March 20, 2020 (CME, 2020). Ronin capital was an individual clearing member (ICM,) therefore trades associated with this default were only those that belonged to Ronin itself. The two other documented cases of member defaults were at smaller European CCPs: one at IRGiT (Poland) and another at Keller (Hungary.) In the cases of default at IRGiT and Keller, waterfall resources in addition to initial margin were drawn upon, whereas at the CME, no other resources were needed outside of initial margin (ISDA, 2021). It appears that in all three cases, no additional capital was needed outside of the prefunded default waterfall. During this market shock, liquidity resources appeared to be adequate, but potentially for the wrong reasons (mentioned in section III.2.) A more comprehensive scheme to determine the size of the default fund should follow the following formula:

$$default\ fund = \sum_{i=1}^{\#\ CMs} SLOIM_i \mathbb{P}(default_i | stress\ event) \quad (1)$$

Where:

- $stress\ event$ is the predetermined stress scenario
- $SLOIM_i$ is the stress loss over initial margin for clearing member i

This formula is essentially how Cover 2 default fund sizing is currently being used, with the odd caveat that the probability of default is 100 percent for each of the largest two clearing members and zero percent for all other clearing members. To reflect the overall risk profile of a CCP more accurately, default probabilities for individual clearing members can be inferred from CDS market data (risk-neutral probabilities) or from credit ratings ("actual" probabilities.) The data sources used to derive default probabilities should themselves be included in the stress event design.

In addition to the shortcomings described in section III.2, Cover 2 neglects additional systemic risk imposed by clearing members that are belong to multiple CCPs. To show this risk, we aggregate SRISK for all clearing members that strictly belong to n CCPs (where each $bucket_n$ represents clearing members that belong to 1, 2, 3, 4, or 5 of the CCPs used in this report:)

$$SRISK\%_n = \sum_{CM_i \in bucket_n} \frac{SRISK\ CM_i}{\sum_j SRISK\ CM_j} \quad (2)$$

$SRISK\ CM_i$ is defined by $k(debt_i) - (1-k)(1 - LRMES_i)equity_i$. $LRMES_i$ is the "Long-Run Marginal Expected Shortfall," defined by $1 - \exp(\ln(1-d)\,\beta)$. Consistent with the SRISK documentation, the value of d is set at 40 percent, the value of k is set at eight percent (slightly more conservative than suggested as this value is meant for US firms; some clearing members analyzed are not US domiciled,) and β is the regression coefficient from the CAPM, capturing non-idiosyncratic risk of a given institution. The results (in Figure 17 below) show that clearing members that belong to all five CCPs in our analysis contribute 44 percent of the systemic risk, even though they represent only about 15 percent of the clearing members analyzed[24]. Additionally, in Figure 18, we see that the equity volatilities of clearing members belonging to all five CCPs spiked more on average during the onset of the COVID pandemic than did those of other clearing members, further revealing the risk of these institutions from being highly integrated in the clearing ecosystem.

[24] Because SRISK requires the book value of debt, the market capitalization, and a beta coefficient for each institution analyzed, only clearing members with publicly available data are included in the calculations.

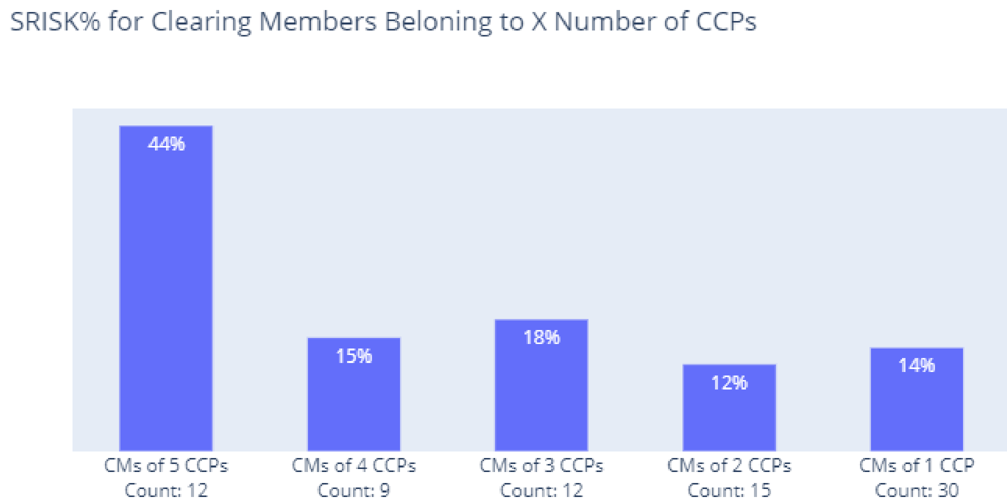

Figure 17: SRISK% and Market Capitalization for All Clearing Members
(Market Data for Calculations retrieved on 3/18/2022 from Yahoo Finance)

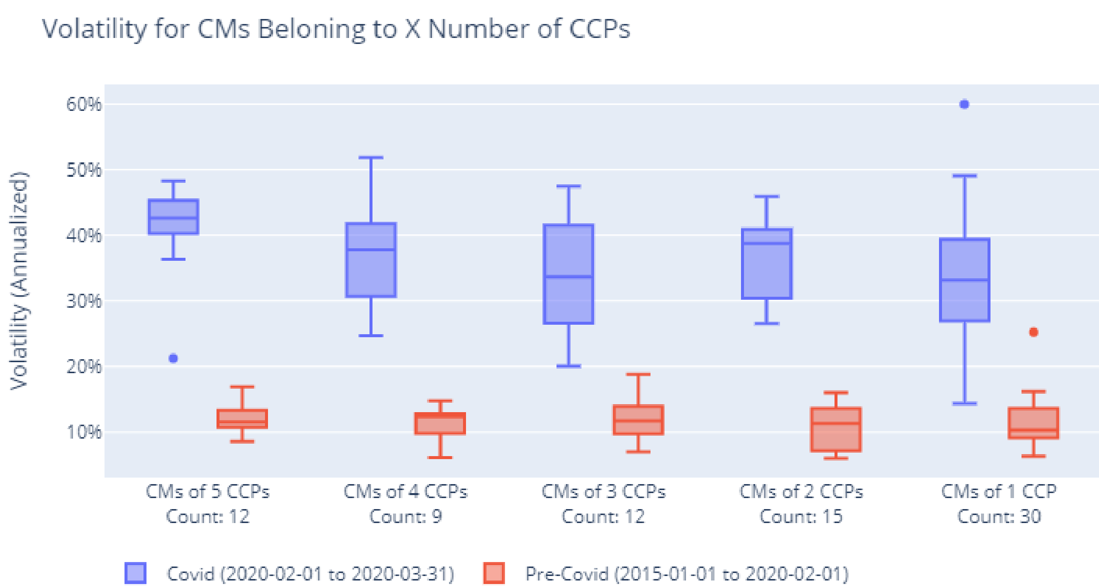

Figure 18: Equity Volatility for All Clearing Members
(Market Data for Calculations Sourced from Yahoo Finance)

These two charts suggest that clearing members that are more interconnected in the financial system contribute more to systemic risk, especially during stress events. This leads us to our last finding:

Finding 2b: *Sizing the default fund via the Cover 2 standard introduces a mismatch between the overall risk of a CCP and how much each clearing member contributes to the default fund. The size of the default fund should equal the sum of the risks contributed by each clearing member. Clearing members that belong to many CCPs contribute more to systemic risk, which needs to be reflected in their default fund contributions. This is particularly important because nearly all these clearing members are designated as G-SIBs.*

VII. ADITIONAL DATA NEEDS AND AREAS FOR FUTURE DISCUSSION

To analyze risk inherent in all CCPs, in 2015, CPMI-IOSCO published the "Public quantitative disclosure standards for central counterparties" (PQDs,) whereby CCPs would voluntarily publish various quantitative risk measurements quarterly basis. It was not until 2017 that CCP12[25] designed a standardized template for the PQD reports. Even after the standardized template was published, there are still five main issues with the PQD data that complicate analysis:

1. Data only goes as far back as 2015
2. Data is only reported on a quarterly basis
3. Data is published with a lag of one quarter
4. Formats frequently change (even after the standard template was released) across CCPs and across time within each CCP
5. Many quantities, such as gross notional per cleared product, are often not reported

[25] In 2001, 12 CCPs around the globe formed a working group, "CCP12," to share information that would enhance standards and policies regarding sustainable CCP infrastructure.

Access to a longer time series of more temporally granular data would be the largest benefactor to this analysis. An autoregression analysis of initial margin amounts would then be possible and would provide a statistically rigorous quantification of procyclicality in margin calls. Default and capital adequacy modeling is difficult when there are few periods of systemic market stress. The longer time series (or a robust proxy) would prove beneficial should it incorporate more market shocks as the only substantial crisis period in the current PQD reports is the COVID pandemic. The availability and standardization of the PQD reports still leaves a lot to be desired; a central repository for the reports, or access to an API would streamline analysis and allow research to be done quickly across many CCPs simultaneously. A more standardized data source would also prevent submissions that currently have hyperlinks in fields that are supposed to contain numerical values.

In addition to analysis on a more complete dataset, more research needs to be done on developing a more comprehensive approach for default fund sizing. Deriving methodologies to determine weights (that ultimately represent default probabilities) in Formula 1 should be a key focus; ancillary factors including the determination of an appropriate SPOR methodology also need to be considered. An adequate methodology should not be subject to excessive model risk such that CCPs would not be able to effectively implement it in practice. One approach could be based on credit rating and number of CCPs a clearing member belongs to. An advantage of the Cover 2 standard is that is unambiguous aside from the determination of the stress scenario used; an update to Cover 2 should be approached with caution as to not completely remove this element but should simultaneously better reflect the risk profile of a CCP's clearing members.

VIII. CONCLUSION

CCPs have become an integral part of the stability of the financial system. They nearly eliminate counterparty credit risk, but in doing so introduce substantial liquidity risk. Enforcing proper management of this resulting risk is critical because liquidity shocks can have destabilizing effects that leak outside of the financial sector and into the broader economy. The reluctance of CCPs to absorb a meaningful portion of the liquidity risk generated from their activities should be addressed (with caution) as to better balance liquidity risk with trading costs. It is promising, however, to see that CCPs tend to be conservative with their cash investments and allocate nearly all possible cash to central bank deposits where possible. More CCPs (particularly those designated as systemically important in Figure 2) should be granted access to these facilities to promote financial stability.

The first line of defense against default, initial margin, generally uses coherent modelling practices, but assumptions in these models need to be adjusted to better reflect economic realities, as well as better balance the counterparty default risk/liquidity risk tradeoff. An obvious benefit to the exchange-traded derivatives, equities, and potentially other markets is to increase the model lookback periods—the pre-COVID period revealed that many models fell victim to prolonged low volatility. This period also revealed that a further assessment needs to be carried out to determine what should be deemed acceptable in terms of the ratio of cash to securities posted as margin, as a ratio that is too low can amplify margin shocks during a market regime shift toward stress. Additionally, the high frequency of margin calls may push participants into default even though they may be able to secure necessary capital for margin calls via their less-liquid resources.

The second line of defense, the default fund, may be well capitalized, but for the wrong reasons. The Cover 2 standard used to determine the size of the default fund assumes the simultaneous default of the two largest clearing members—if the two largest clearing members are facing default, it is highly likely that not only will many other smaller clearing members face default, but also that the largest clearing members at other CCPs will face default, as the largest clearing members are generally the same across CCPs. In essence, a scenario in which Cover 2 would be applicable to would be a total market collapse in which CCPs each only have enough capital to cover two clearing members. This implied scenario underscores the importance of addressing systemic risk, which should be reflected in the default fund contributions of highly interconnected clearing members. In general, the default fund should use a framework in the spirit of Formula 1, which accounts for the shortfall of *all* clearing members, rather than just two.

CCPs appear to be generally well insulated from market shocks as seen during COVID, but by no means does that imply there is not more work to be done to better protect the financial system. In a yet-to-be-experienced scenario, current practices may induce stress outside of a CCP itself in the form of procyclicality or improper capitalization, particularly as clearing members and end-users effectively absorb all the resulting liquidity risk. Further research needs to be undertaken to better understand the market-wide tradeoff between counterparty credit risk and liquidity risk and new regulatory frameworks that would provide a more stable balance between the two.

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APPENDIX

Reference	Legal Name
CME	Chicago Mercantile Exchange Inc
LCH Ltd	London Clearing House Ltd (London)
LCH SA	London Clearing House SA (Paris)
Eurex	Eurex Clearing AG (and all subsidiaries)
ICE	Intercontinental Exchange Inc

Figure A1: Legal names of CCPs included in this study

CCP	Product	Description
CME	Base	Exchange-Traded Futures & Options for Various Asset Classes
CME	IRS	Over-the-Counter Interest Rate Swaps
CME	CDS	Over-the-Counter Credit Default Swaps
LCH Ltd	Interest_Rates	Over-the-Counter Interest Rate Derivatives
LCH Ltd	OTC_FX	Over-the-Counter Foreign Exchange Derivatives
LCH Ltd	Listed_interest_Rates	Exchange-Traded Interest Rate Futures & Options
LCH Ltd	Fixed_Income	Fixed Income Products
LCH Ltd	Equities	Equities
LCH Ltd	Commodities	Commodities
LCH SA	Cash_and_Derivatives	Exchange-Traded Futures & Options for Various Asset Classes
LCH SA	Fixed_Income	Fixed Income Products
LCH SA	OTC_CDS	Over-the-Counter Credit Default Swaps
LCH SA	€GC_Plus	Repo Agreements
Eurex	Total	*Only aggregate figures reported, consisting of mainly exchange-traded derivatives
ICE	ICC_CDS	ICE Credit Clear Credit Default Swaps
ICE	ICEU_F&O	ICE EU Exchange-Traded Futures & Options for Various Asset Classes
ICE	ICEU_CDS	ICE EU Credit Default Swaps
ICE	ICNL	ICE Netherlands
ICE	ICSG_F&O	ICE Netherlands Exchange-Traded Futures & Options for Various Asset Classes
ICE	ICUS_F&O	ICE US Exchange-Traded Futures & Options for Various Asset Classes
ICE	ICE_NGX	ICE Canada Exchange-Traded Futures & Options for Various Asset Classes

Figure A2: Product Descriptions as Reported in PQD Reports

Volatility Index	Used for
VIX	Equities and products classified as general exchange-traded derivatives
MOVE	Interest-rate-based products
CVIX	Foreign Exchange products
Goldman Sachs Commodity Volatility Index	Commodities products

Figure A3: Volatility Indexes
In Figure 1, each product is correlated with a volatility index appropriate for its asset class.

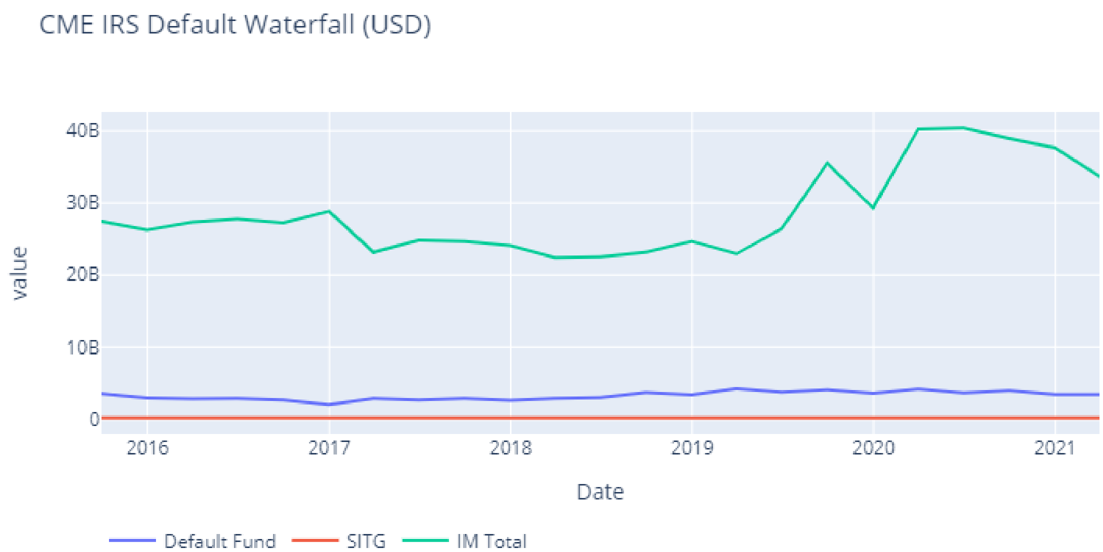

Figure A4: CME Interest rate swaps waterfall components
Charts for other CCPs analyzed are omitted for brevity but show a nearly identical structure
(Source: CME PQD Reports)

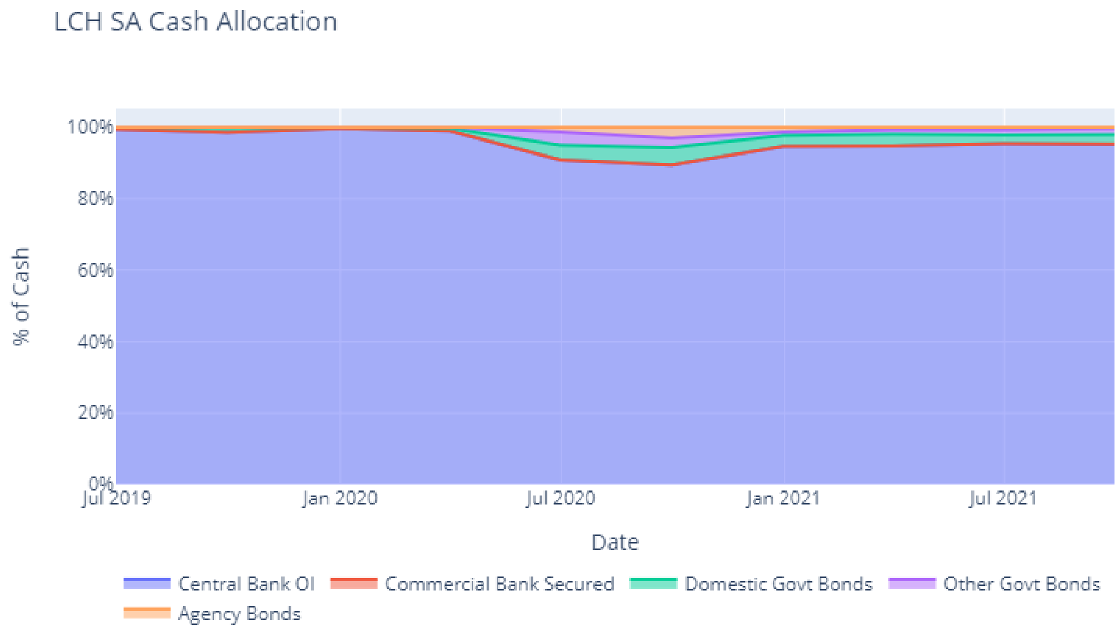

Figure A5: LCH SA Default Waterfall Relative Levels
(Source: LCH SA PQD Reports)

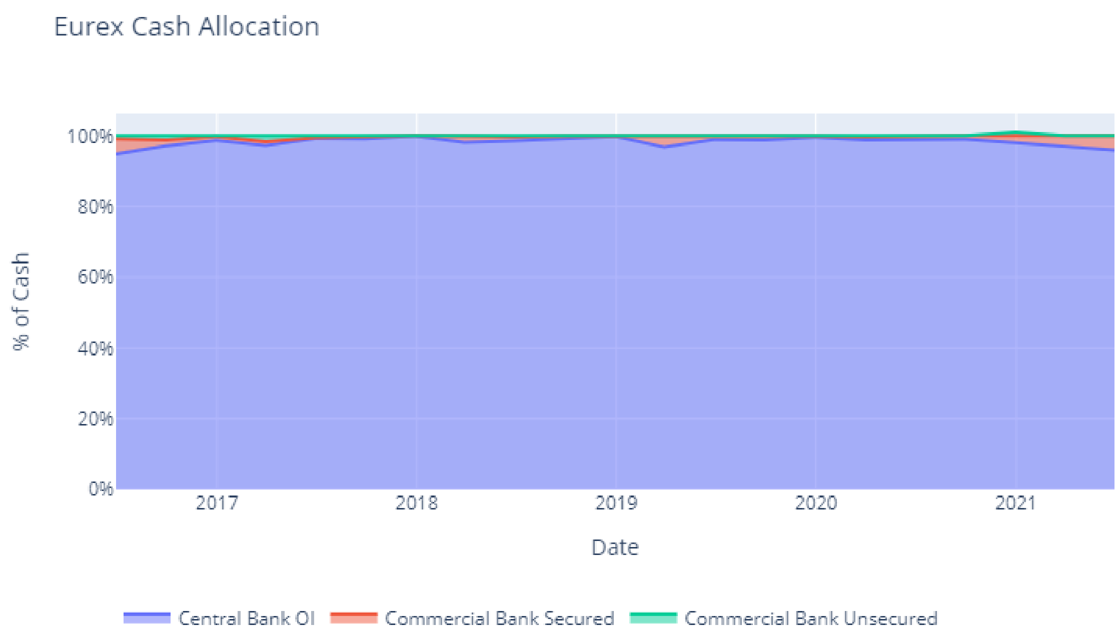

Figure A6: Eurex Default Waterfall Relative Levels
(Source: Eurex PQD Reports)

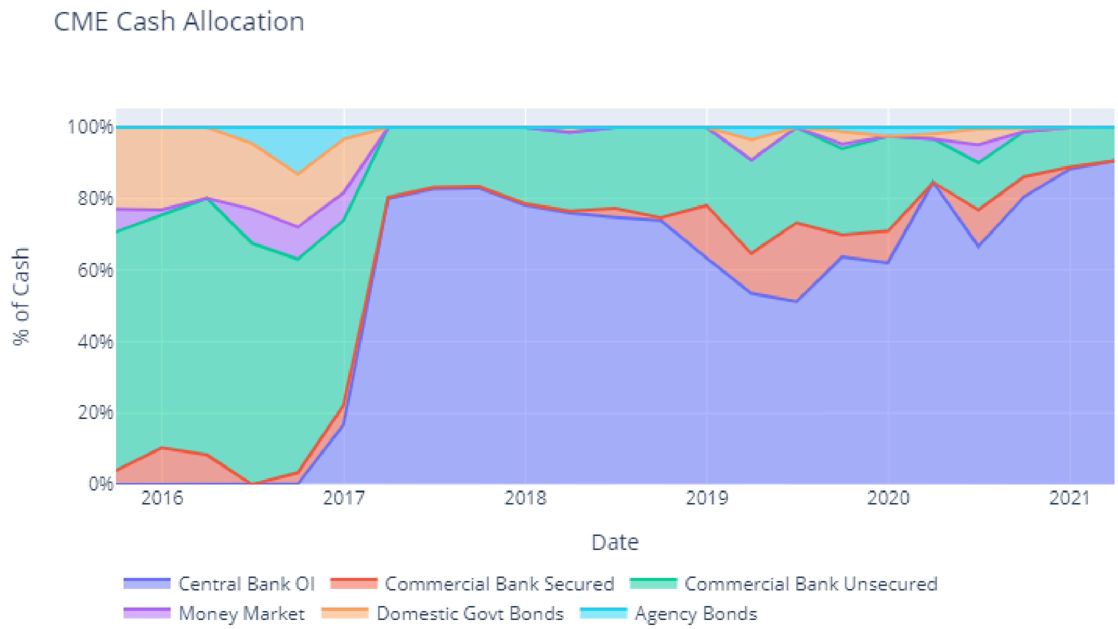

Figure A7: CME Default Waterfall Relative Levels
The temporary decline in central bank OI starting in 2018 is likely due to the acquisition of NEX
(Source: CME PQD Reports)