CCP resilience and clearing membership[☆,☆☆]

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Abstract

Central clearing counterparties (CCPs) have become a major concern regarding systemic risk and financial stability. Thus, assessing CCP resilience is a key challenge in the new financial landscape. We consider pre-funded waterfall resources, recovery tools and the assessment powers of major European and US CCPs. We also investigate loss allocation rules at the end of the waterfall and the impact of emerging resolution regimes on contingent liquidity obligations. As the resilience of a CCP depends on the soundness of the member base and its ability to provide funds, we question the payment capacity of a member base under normal and stressed scenarios. We show that under a cover 2 stressed scenario, member base quality erodes, jeopardising the ability of clearing members to fulfil possible contingent liquidity obligations. Conflicts of interest depending on the average quality and heterogeneity of member bases are shown to be a further matter of concern regarding CCP resilience.

Keywords: CCPs, financial stability, risk mutualisation, contingent liquidity, recovery, resolution

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1. Introduction

The ongoing regulatory reforms and the shift towards central clearing of derivative products add to the importance that central clearing counterparties (CCPs) play in the financial markets. To avoid risks to financial stability arising from CCP failure, maintaining and strengthening the resilience of CCPs entails the need for well-designed and prudent CCP risk management mechanisms. Given the reliance of CCP risk-sharing mechanisms on the soundness of its member base, assessing the credit quality of clearing members (CMs) is essential for financial stability.

In cases where a CCP's resilience is threatened due to CM defaults that have depleted the pre-funded resources up to the CCP's skin-in-the-game, the CCP is dependent on recovery tools, in the form of liquidity injections from surviving CMs as prescribed by the CCP rulebook, or regulatory bail-ins after entry into resolution. Here, the waterfall prescribes how losses are re-allocated across surviving CMs via risk-sharing mechanisms (Elliott, 2013; Pirrong, 2011). First, the pre-funded default fund contributions of the survivors will be used to cover the losses. Second, the CCP has to deploy recovery tools, such as the replenishment of the default fund, by demanding liquidity from survivors, which can pose problems due to payment delays from members (Duffie, 2014).

Assuming that all CMs have the same probability of default, Murphy and Nahai-Williamson (2014) investigate how the distribution of risk exposure among members impacts a CCP's resilience. They find that the cover 2 charge[1] may not be prudent for uniform exposure distributions. Under these circumstances, CCP resilience depends on the CMs capacity to jointly carry losses beyond the default fund. Especially in a distressed market, a CM's lower

[1]The regulatory default fund standard (cover 2) requires the covering of the default of the two CMs to which a CCP would have the largest unmargined exposure under extreme market conditions in a stressed scenario (European Union, 2012).

payment capability and (possibly) higher default probability may impact his ability to raise (external) funding. Also, if CMs have higher default probabilities, the CCP might possibly undergo more default shocks and will rely more on member mutuality to cover losses (see Tarullo (2015)).

Given the reliance of a CCP on the financial ability of its members, restricted access to clearing structures (Moser, 1998) and continuous monitoring of member quality (Bernanke, 2011; Gorton, 2013) have traditionally been key aspects of CCP risk management. With the introduction of mandatory clearing and the changes in CCP risk management due to regulators mandating open access to central clearing[2], CCPs face a 'membership dilemma' as described by Braithwaite (2015): on the one hand, the selectiveness of CCPs, when it comes to admitting members, serves to ensure that the CCP functions safely by effectively mutualising losses for a selected set of participants. On the other hand, the regulatory clearing mandate requires that all non-exempt market participants[3] have access to central clearing. As pointed out by Slive et al. (2011), CM eligibility criteria should aim to include institutions that can aid in managing defaults, but should exclude those that are more prone to default risk. Consequently, the analysis of CCP member bases, both in terms of average financial soundness and heterogeneity of default fund contributors, appears to be an important aspect of CCP monitoring and supervision.

This article investigates the exposures of CMs via risk-sharing mechanisms embedded in the

[2] An example for the impact that regulatory open access criteria can have is the decrease in the minimum requirement on capital requirements that OTC CCPs set as an entry requirement for CMs. In 2012, LCH.Clearnet LTD lowered its capital requirements from previously $5 billion in capital to $50 million and split its existing single default fund into three separate default funds. This was to ensure that the different clearing services would have enough financial resources to compensate for the reduction in the amount of capital LCH.Clearnet LTD could set as an entry criterion (Jaidey, 2012).

[3] 'Smaller' market participants with limited trading volumes of uncleared derivatives face difficulties assessing central clearing via client clearing (European Securities and Markets Authority, 2016a). Consequently, the European Securities and Markets Authority (ESMA) proposed a delay of the clearing obligation for these market participants.

CCP waterfall. In Section 2, we describe risk-sharing rules under the CCP scheme. We consider pre-funded resources, recovery tools and assessment powers across EU and US CCPs. We also discuss the impact of scheduled recovery and resolution regimes on contingent liabilities. As the efficiency of the waterfall, especially the default fund and its replenishment via assessment powers, depends on the soundness of a CCP's surviving member base, we investigate member base quality under normal and stressed scenarios in Section 3. In addition, we provide a typology of member bases and examine possible conflicts of interest, which may jeopardise the stability of the financial system. Section 4 concludes.

2. CCPs, clearing members, and risk-sharing rules

The financial resilience of a CCP can be considered from different points of view including clustering of defaults and contagion, wrong way risks, crowded trade effects, design of initial margin (IM), default fund models, and interdependencies between CMs' trading positions (Pirrong, 2014; Cruz Lopez et al., 2014; Ghamami, 2015; Menkveld, 2015; Murphy and Nahai-Williamson, 2014; Lin and Surti, 2015; Knott and Mills, 2002; Glasserman et al., 2015; Cruz Lopez et al., 2011). In this Section, we investigate risk-sharing mechanisms embedded in the CCP waterfall structure. We consider pre-funded waterfall resources, recovery tools, and the assessment powers of major European and US CCPs for IRS and CDS products. We also discuss risks related to recovery and resolution regimes, as these may bypass CCP rulebooks, resulting in unquantifiable exposures (Wendt, 2015). As CMs are interconnected via the default fund and other loss mutualisation mechanisms, the composition of a member base is an important factor when addressing CCP resilience.[4]

[4]The evolution of clearing networks, their default and contagion characteristics are often studied using network simulation approaches, see for example (Borovkova and El Mouttalibi, 2013). However, these approaches are outside the scope of this paper, as we would need exposure data to include different degrees of interconnections into our approach.

2.1. *Design of loss sharing rules*

CCP rulebooks regulate how losses incurred by the default of a member are allocated through the default waterfall (for a detailed overview see for example Pirrong (2011) or Cont (2015)). Table 1 summarises the default waterfall resources for the CCP CME Clearing US.

Table 1: Default waterfall resources for CME Clearing US for all asset classes

Initial Margin (in mn)	Skin-in-the-game amount (in mn)	Default fund contributions (in mn)	Assessment powers (in mn)
139000 $	300 $	6779 $	11068 $

Source: The financial data as at 30^{th} June 2016 for CME Clearing US. The data was retrieved from the CCP's website.

In case of a CM default, the CCP will use the defaulter's Initial Margin and default fund contribution to cover the incurred losses. The IM amount provided to CME Clearing US for all asset classes illustrates the fact that IM is the main protection against member default (defaulter pays approach). Nahai-Williamson et al. (2013) argue that IM requirements should reflect the credit quality of CMs. Under the 'Principles for financial market infrastructures' (PFMI) a CCP is obligated '*to effectively measure, monitor, and manage its credit risk from participants*' (see Committee on Payment and Settlement Systems - International Organization of Securities Commissions (2012), p.36). Thus, many CCPs monitor the counterparty risk of their clearing members using (internal) scoring methodologies[5]. These monitoring sys-

[5] The use of credit ratings as an explicit eligibility criterion for clearing membership has been dropped by major CCPs. For example, in April 2012, LCH.Clearnet LTD's rulebook contained a minimum rating requirement of at least an 'A' rating for prospective SwapClear participants. In contrast, the minimum rating for RepoClear participants was set at 'BBB' (the relevant section of the rulebook dated April 2012 is available at `http://www.google.fr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCoQFjAB&url=http%3A%2F%2Fsecure-area.lchclearnet.com%2FImages%2FSection1_Cir%252026-03-2012_tcm6-61371.pdf&ei=C8uSVZS-LIGwUs_NiqgI&usg=AFQjCNHoxmuxe-62izHthrrhx-L7aQNMdQ&sig2=Q3fO19_C9d7pVgXOeJDUwQ&bvm=bv.96783405,d.d24`). Furthermore, for CMs of both services that no longer adhered to the credit rating requirement, the CCP could apply a multiplier to the initial margin requirement. For example, for RepoClear the multiplier was set at 110% for a downgrade to 'BBB-' and at 200% for a downgrade to 'BB+'. A downgrade below 'BB+' resulted in the expulsion of the CM. Even before the new PFMI (Committee on Payment and Settlement Systems - International Organization of Securities Commissions, 2012) came into force, CCPs began implementing open, risk-based access requirements in 2012 (Fontaine et al., 2012). In the course of these changes, LCH.Clearnet LTD dropped the explicit minimum rating requirements for SwapClear and RepoClear.

tems may also take into account external credit rating data[6] (see for example LCH.Clearnet (2014) or Autoriteit Financiële Markten (2014)). To mitigate an increase in a member's counterparty risk, CCP rulebooks provide CCPs with mechanisms to call for additional margin (see for example ICE Clear Europe (2014)). IM models that are not procyclical create increased reliance on CM mutuality.

In case of member defaults with losses exceeding the defaulter's IM and default fund contribution, the financial resilience of a CCP depends on a designated tranche of CCP capital, referred to as the skin-in-the-game (SIG) amount. After using the CCP's SIG, losses are usually re-allocated across survivors via risk-sharing mechanisms, which are embedded in the default waterfall structure, and as part of a possible recovery or a resolution regime.

The higher a CM's default probability, the higher the risks to other CMs as they may pay for his default losses via the default fund. In this way, the CMs are interconnected via the default fund and exposed to counterparty credit risk. As default probabilities are not considered when sizing the default fund via stress tests, the exposure of CMs may increase significantly under a stressed scenario. The use of default fund contributions means that CMs subsidise each other as there is a transfer of losses from lower quality to higher quality CMs (Gregory, 2014).

Optimising the design of pre-funded resources has several aspects, including the choice of calculation methodology for IM[7] and default fund contributions, and the exact balance be-

[6] A recent exploratory study addressing the use of credit ratings in the Netherlands (Autoriteit Financiële Markten, 2014) found that CCPs use ratings in their credit assessment of a potential clearing participant, but on a relatively small scale and only as one of the input factors for their internal scoring model.

[7] IM calculation issues have been extensively researched: procyclicality of margin requirements (Murphy et al., 2015, 2014; Heller and Vause, 2011), possible negative feedback between haircuts and collateral value via the margin spiral (Brunnermeier, 2009; Brunnermeier and Pedersen, 2009), negative effects of high margin requirements on welfare, default risk and trading volumes (Gibson and Murawski, 2013; Hardouvelis and Kim, 1995; Hartzmark, 1986), and possible negative effects of conservatively high margin requirements, such as reducing the benefit of heterogeneous loss allocation methods and diluting the incentives of clearing members (Gregory, 2015).

tween IM and default fund. Aside from regulatory requirements regarding minimum IM and default fund levels (Committee on Payment and Settlement Systems - International Organization of Securities Commissions, 2012; Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2014; European Union, 2012, 2013a), CCP operators can design risk management systems tailored to their specific needs. Here, the choice of IM and default fund levels requires careful consideration of possible trade-offs. Higher IM requirements imply that the defaulter's estate pays more, which reduces potential costs for the other CMs and helps prevent contagion effects, but increases the amount of frozen collateral. Higher default fund requirements may lead to situations where survivors subsidise defaulting CMs (for a detailed discussion on these issues see Budding and Murphy (2014)).

The trade-off between IM (defaulter pays approach) and default fund (loss mutualisation) also depends on the degree of interconnection and the default probabilities of the clearing participants. Allen and Gale (2000) consider the effects of the degrees of interconnection. Their findings show that a complete network structure is optimal, when banks are exposed to small and diversified shocks. In this case, the interconnections constitute an insurance scheme. A complete network, in contrast, is prone to contagion, when banks are exposed to large shocks. Here, contagion spreads to all banks in the network, resulting in a sequence of bankruptcies. According to Haldane (2009) and Gourieroux et al. (2012), interconnection increases loss-absorption, whereas the probabilities of joint default are slightly increased. Moreover, Hauton and Héam (2016) find that in an interconnected network, the capacity of the banking system to carry risks increases as the default probabilities are smaller than in a network without connections. Furthermore, they find that in an interconnected network, systemic risk increases due to contagion and the probabilities of joint defaults are higher. Slive et al. (2011) put forward that a CCP with a broad and diversified member base may have less problems managing a systemic shock than a CCP with only G-SIFI members.

The replenishment of the default fund requires CMs to raise liquidity within a short period of time. If the level of unfunded default fund resources is high, the CCP would be very risky, as it would rely on liquidity in times when it is significantly more difficult for CMs to raise it (Cont, 2015; De Socio, 2013; Gorton and Metrick, 2012). As a rough indicator, consider the default fund contributions and the assessment powers for CME Clearing US for all asset classes as displayed in Table 1: the assessment powers are higher than the amount of the pre-funded default fund contributions. A CM's ability to raise funds by selling its assets may decline as a result of fire sales caused by capital erosion due, in turn, to falling asset prices coupled with the simultaneous tightening of lending standards and margin (Brunnermeier, 2009; Brunnermeier and Pedersen, 2009). The funding ability of a CM may also depend on the potential lenders' perception of his credit quality reflected by indicators such as credit ratings and default probabilities. Karam et al. (2014) find that rating downgrades of banks from an investment to a speculative rating grade are associated with a persistent decline of access to uninsured and wholesale funding sources. Clearing participants attempting to insure themselves against credit rationing, may resort to hoarding liquidity (Gale and Yorulmazer, 2013), which may in turn have negative effects on the interbank markets, such as increases in interbank lending rates for both secured and unsecured lending (Allen and Carletti, 2008; Acharya and Merrouche, 2013).

International guidelines require CCPs[8] to monitor their members' ability to provide liquidity[9] and also their credit quality[10]. Following the stress test exercise, European Securities and

[8]CCPs consider that they would '*be adversely impacted by the financial distress or failure of one or more of our clearing firms*' (CME GROUP INC. (2014), p.19); they consider the credit quality of market participants as a risk factor related to their business (Intercontinental Exchange, Inc., 2015).

[9]The PFMI state that an '*FMI should have a robust framework to manage its liquidity risks from the full range of participants and other entities.*' (Committee on Payment and Settlement Systems - International Organization of Securities Commissions (2012), p.59).

[10]The PFMI state that a CCP '*should effectively measure, monitor, and manage its credit exposures to participants*' (Committee on Payment and Settlement Systems - International Organization of Securities Commissions (2012), p.57).

Markets Authority (2016b) recommended that a CCP also considers the losses that participants, who clear at multiple CCPs, face from their participation in other CCPs[11]. Given that CCP bail-ins are privileged by regulators, the payment capacity of clearing members and the potential for moral hazard effects associated with dispersion in the credit quality of clearing members should not be ignored.

Moreover, regulators are currently considering further sources of liquidity and tools of loss allocation to enable the recovery of a CCP that has suffered losses beyond the pre-funded resources, such as cash calls and margin gain haircutting (Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2014). Since the international standard 'Recovery of financial market infrastructures' requires that a CCP '*take into account the extent to which participants, owners and third parties would have sufficient resources to meet their potential obligations when considering the reliability of a tool or set of tools*' (Committee on Payments and Market Infrastructures - International Organization of Securities Commissions (2014), p.13), monitoring the ability of CMs to sustain a CCP by providing liquidity is also essential to ensure the effectiveness of CCP recovery tools.

2.2. Pre-funded waterfall resources

The default fund can be designed in two basic ways: either a single default fund that covers all asset classes, or, several ring-fenced default funds, one per asset class. In contrast to default funds that have a strictly ring-fenced structure, separated according to asset classes, Eurex established a combined default fund for listed and OTC products (see Appendix A), with the exception of Eurex Credit Clearing for which a separate default fund[12] was put into

[11] Constancio (2015) mentions '*the interconnectedness via common exposures to clearing members as well as possible knock-on effects on the banking sector that could arise in case the guarantee fund of a CCP is wiped out and clearing members are required to cover the CCP losses*'.

[12] This integrated default fund is divided into different segments that are each associated with a certain group of products (liquidation groups). Losses arising from member default in a certain liquidation group can only be covered using the associated segment of the default fund. In this way, losses are, at first, mutualised amongst the active CMs in that specific liquidation group. If there is a surplus in another segmented default fund, this can be used to cover remaining losses (Eurex Clearing, 2014a). Eurex corroborates that their

place. When using a single default fund, contributions are lower as diversification benefits across products can be taken into account. On the other hand, a single default fund may lead to subsidising riskier asset classes. CMs would face exposure to losses arising in a risky asset class, which would be mutualised across all clearing members, possibly leading to moral hazard issues (Gregory, 2014).

Table 2: Pre-funded CDS waterfall resources

CCP	Initial Margin (in mn)	Skin-in-the-game amount (in mn)	Default fund contributions (in mn)
CME Clearing US	137549 $	50 $	650 $
ICE Clear Credit	19545 $	25 $	1560 $
ICE Clear Europe	6504 $	28.5 $	1126 $
LCH.Clearnet SA	21838 €	20 €	598 €

Source: The financial data as at 31^{st} March 2016 for each CCP. The data was retrieved from the CCP data provided under the 'Public quantitative disclosure standards for central counterparties' (PQD) (Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2015) by each CCP. See Armakolla and Bianchi (2017) for an exploration of this data set and its possible applications.

In Table 2, the pre-funded CDS resources for ICE Clear Credit, CME Clearing US, ICE Clear Europe, and LCH.Clearnet SA are displayed. For CME Clearing US and LCH.Clearnet SA the IM does not refer to the margin provided for CDS trades, but to the overall margin amount held by each CCP.

integrated default fund reduces the risk and size of the default fund by 30% as this structure benefits from portfolio effects between different products and asset classes (Eurex Clearing, 2014b).

Table 3: Pre-funded IRS waterfall resources

CCP	Initial Margin (in mn)	Skin-in-the-game amount (in mn)	Default fund contributions (in mn)
CME Clearing EU	0.1 $	44 $	96.4 $
CME Clearing US	137549 $	150 $	2810 $
Eurex	54191 €	1.7 €	125 €
LCH.Clearnet LLC	0,02 $	2 $	260 $
LCH.Clearnet LTD	101766 €	44 £	3219 £

Source: The financial data as at 31^{st} March 2016 for each CCP, except CME Clearing EU. The data file provided for the first quarter of 2016 does not report IM for IRS. Consequently, PQD data of the previous quarter was used. The data was retrieved from the CCP's website.

Besides pre-funded member contributions, the default waterfall comprises a pre-funded amount of CCP capital, the skin-in-the-game amount. The PFMI do not address SIG requirements at an international level. Currently, the provision of SIG is mandatory in the EU, but not in the US: under the European Market Infrastructure Regulation (EMIR), a CCP is required to contribute a SIG amount equal to 25% of its minimum capital requirement, which is to be used before using the surviving CMs default fund contributions. The capital contribution of the CCP to the default waterfall is to align the incentives of CMs and CCP operators and shareholders. Determining the optimal proportion of the SIG amount represents a trade-off and keeping the balance between the incentives of the CMs and those of the CCP (Murphy, 2017). CCPs may not want to set the SIG too high, as it may dis-incentivise CMs from bidding in auctions. On the other hand, the capital contribution to the pre-funded resources serves as an incentive for CCPs to maintain prudent and rigorous risk management practices (Carter and Garner, 2015). A properly sized SIG contribution will provide CCPs with a strong incentive to monitor changes in the risk profile of their member base.

All CCPs reviewed chose the cover 2 standard for the default fund size and place the SIG amount before the default fund in the waterfall. Anecdotal evidence shows that this is not always the case, as in the recent default of HanMag Securities, a futures broker at the South Korean exchange KRX (Vaghela, 2014). As HanMag's pre-funded resources were insufficient to cover its losses, KRX, in accordance with its rulebook, used the non-defaulters' default fund contributions to pay for the losses. According to KRX's rulebook, the exchange's SIG amount was placed behind the default fund in the waterfall structure. Apparently, clearing members were not aware of the KRX waterfall order and incurred $45 mn in losses via their default fund contributions. This example illustrates that clearing members are exposed to various risks when facing a CCP.

2.3. Unfunded waterfall resources

The exhaustion of the pre-funded resources forces CCPs to revert to recovery measures and to call for further liquidity from its members. The standard industry recovery measure is the replenishment of the default fund. In addition, variation margin gain haircutting (VMGH) is already part of many CCPs' rulebooks, especially in the UK.

Table 4: Assessment powers and VMGH application for cleared CDS

CCP	**Assessment power**		**VMGH**	
	Cap for single default	Cap for multiple default	Applied	Cap
ICE Clear Credit	100% of default fund contribution	3x100% of default fund contribution	No	No
CME Clearing US	Pro rata share of a size that covers 3rd and 4th largest losses	Pro rata share of a size that covers 3rd and 4th largest losses	No	No
ICE Clear Europe	100% of default fund contribution	3x100% of default fund contribution	No	No
LCH.Clearnet SA	100% of default fund contribution	3x100% of default fund contribution	Yes	The higher of 100€ mn or 100% of default fund contribution

Source: The assessment powers and VMGH information can be found in the rulebook of each CCP.

Table 5: Assessment powers and VMGH application for cleared IRS

CCP	Assessment power		VMGH	
	Cap for single default	Cap for multiple default	Applied	Cap
CME Clearing US	Pro rata share of a size that covers 3rd and 4th largest losses	Pro rata share of a size that covers 3rd and 4th largest losses	No	No
LCH.Clearnet LLC	100% of default fund contribution	3x100% of default fund contribution	Yes	The higher of 100€ mn or 100% of default fund
LCH.Clearnet LTD	100% of default fund contribution	3x100% of default fund contribution	Yes	The higher of 100€ mn or 100% of default fund

Source: The assessment powers and VMGH information can be found in the rulebook of each CCP.

Table 4 and Table 5 summarise the assessment powers and possible application of VMGH for CDS and IRS for the CCPs reviewed. CME Clearing US' assessment powers are capped at a size estimated to provide sufficient resources in the event of the default of the four clearing members to which the CCP has the most exposure as determined via internal stress tests. To give a rough idea of the size, CME Clearing US' default fund amounts and the estimated liquidity, which CME Clearing US could demand from its members via assessment powers, are displayed in Table 6. To evaluate the possible exposure of a CM, it must be taken into account that the displayed amounts are likely to be higher in times of stressed markets.

Table 6: Default fund size and assessment powers for CME Clearing US

Asset Class	CM Default fund contributions	Assessment powers of CME Clearing US
CDS	$650,000,000	$148,000,000
IRS	$2,853,000,000	$1,911,000,000

Source: The financial data as at 30^{th} June 2016 for CME Clearing US. The data was retrieved from the CCP's website.

For IRS assessment powers, CME Clearing US can call for additional liquidity amounting to more than half of the default fund contributions. It is probable that during a financial crisis more than one CCP will be in an extreme situation. For CMs, who clear at more than one CCP, which is the case for international dealer banks, a simultaneous demand for additional liquidity from multiple CCPs can lead to the amplification of the negative effects under stressed market conditions (Wendt, 2015). Based on a sample of 13 EU CCPs, Armakolla and Bianchi (2017) report that on average a clearing member of an EU CCP clears at 3 different EU CCPs. They point out that G-SIBs have a much higher degree of interconnectedness.

There remains thus uncertainty, that all surviving CMs will be able to provide the necessary unfunded liquidity when market conditions are unstable. Consequently, as the losses spread with each further default, the surviving clearing members might be exposed to contagion risk. This jeopardises regulators' wishes to mitigate interconnection risks and to promote transparency. For this reason, CCP users are promoting the idea of pre-funding all loss absorbency resources to eliminate this uncertainty (JPMorgan Chase & CO., 2014; PIMCO, 2014). CME Group (2015) promotes the idea that SIFI CMs with a huge client clearing business should provide additional funding to the default waterfall. In this way, solvent CMs are not exposed to risk arising from such a member's default and negative impacts for the defaulter's clients may also be avoided.

2.4. Impact of resolution versus recovery

Currently, international regulation covers neither recovery nor resolution regimes for CCPs. Only in the UK have regulators closed this gap by amending the Financial Services Act to address such issues.[13] In the past three years, regulators have drafted consultative documents (Financial Stability Board, 2011, 2014; European Commission, 2012; Committee on Payment and Settlement Systems - International Organization of Securities Commissions, 2013; Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2014) to advance the creation of such regimes, but certain reservations remain. As noted by Duffie (2014), a CCP's failure cannot be safely and effectively concluded neither under the currently available forms of bankruptcy[14], nor under the Dodd-

[13]A proposal covering CCP recovery and resolution by the European Commission was presented in late 2016, see European Commission (2016).

[14]See Duffie and Skeel (2012) for a discussion of the costs and benefits of automatic stays for OTC-derivatives and repurchase agreements in the case of CCP bankruptcy.

Frank Act's Title II administrative failure resolution. Though some authors have called for nationalising failed CCPs (Lubben, 2014), understandably regulators and central bankers are reluctant to agree to any kind of bail-out (Cœuré, 2015). When facing liquidity risk caused by delays in payments, access to central bank liquidity facilities may be an important factor: a CCP facing entry into resolution due to its inability to make counterparty payments, but with access to central bank liquidity, can continue to satisfy its contractual obligations while completing its recovery (Kress, 2011). Granting access to liquidity facilities or an emergency 'discount window', is subject to the decision of each individual national central bank under §85 of EMIR (European Union, 2012). Consequently, the access to central bank liquidity frameworks is fragmented across the different jurisdictions in the EU: in the UK, the Bank of England has granted all CCPs operating in the UK access to its sterling monetary framework (Bank of England, 2015). Other countries, for example Germany and France, allowed CCPs with a banking license to access their liquidity frameworks. In contrast, US regulators have been rather reluctant to make a formal commitment to CCPs using the emergency discount window.

However, apart from the possibility of emergency lines of credit, all losses would then be supported by market participants. Here, it should be considered that CCPs, often operating as for-profit entities, may be exposed to profit-making incentives possibly contorting their function as a tool for mitigating systemic risk (Tucker, 2014). In a recent discussion note, Financial Stability Board (2016) emphasises that imposing losses on existing CCP owners to avoid resolution, would help create appropriate incentives for the latter to ensure that the CCP has robust risk management arrangements in place.

As CCP capital involvement is quite limited, potential losses due to closing out market exposures of a defaulted market participant would then be mutualised (LCH.Clearnet, 2014), despite industry arguments that end-investors and surviving members should not pay the bill (Blackrock, 2014). As recently pointed out by the European Systemic Risk Board, current legislation does not clarify the timing and procedures to be applied when re-plenishing the default fund. Thus, clearing participants may have difficulties estimating the necessary financial resources, which must be considered from a procyclicality perspective (European Systemic Risk Board, 2015).

It is also likely that the resolution authorities would bypass the CCP waterfall. For instance initial margin haircutting is not formally banned in the latest document issued by the Financial Stability Board (Financial Stability Board, 2014), even though variation margin haircutting[15] is the privileged route chosen by the most prominent CCPs. Such an option, left to the discretion of the relevant national supervisor, would significantly magnify the exposures of market participants since initial margin amounts are by far higher than default fund contributions. Similarly, resolution authorities could constrain the replenishment of the default fund beyond the CCP's rights to assessment. In practice, this would mean that extra contributions would be called from clearing members and clients, following the financial architects tendencies to favour recovery over resolution (Financial Stability Board, 2014; Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2014).

3. Member bases across EU and US CCPs

We investigate the financial soundness and thus the ability of the member base to keep up their financial commitments to the CCP. As the creditworthiness of a financial entity is related to its credit rating, we will further use available credit rating information to assess the credit quality of a CCP's member base.

[15] VMGH may not be suitable for asset classes, where a daily exchange of VM does not take place or transactions are physically settled. In the latter case, adjusting settlement prices may pose several practical issues (Elliott, 2013).

3.1. Clearing member bases across EU and US CCPs

The dataset is comprised of 8 European and 5 US CCPs (see Table 7). For each CCP, the list of CMs is available on the CCP's website. Only CMs that can directly interact with the CCP are included in the sample. All other CM types are excluded.

Table 7: CCP overview

Group	CCP	Domicile	Company structure	Ownership structure
CME Group	CME Clearing US CME Clearing EU	US EU	For-profit entity	Exchange:100%
Deutsche Börse AG Group	Eurex	EU	For-profit entity	Exchange:100%
Intercontinental Exchange Inc.	ICE Clear Credit ICE Clear Europe ICE Clear US The Clearing Corporation	US EU US US	For-profit entity	Exchange:100%
LCH.Clearnet Group	LCH.Clearnet LLC LCH.Clearnet LTD LCH.Clearnet SA	US EU EU	For-profit entity	Exchange:60%, Other:40%
London Stock Exchange Group	CC&G	EU	For-profit entity	Exchange:100%
	EuroCCP	EU	For-profit entity	User:50%, Exchange:50%,
	ECC	EU	For-profit entity	Exchange:100%

Note: ECC is a wholly owned subsidiary of the European Energy Exchange AG (EEX), whose majority shareholder in turn is Deutsche Börse AG. The London Stock Exchange Group is, with 57% of shares, the majority shareholder of the LCH.Clearnet Group.

Differences in member bases between US and EU CCPs may also be explained by CCP business models, for example the importance of client clearing in the US (Norman, 2012). To illustrate the differences between US and EU CCPs regarding client clearing[16], the respective composition of the total IM in terms of member IM and client IM is shown in Tables 8 and 9, for US and EU CCPs, respectively.

[16]The evolution of client clearing will also depend on other aspects, for example the final implementation of the Leverage Ratio. There may be unwanted effects such as clearing members refusing clients as client clearing becomes less economic, possibly putting end-users at a disadvantage.

Table 8: Proportions of total IM provided by CMs and clients of US CCPs for all asset classes

CCP	Currency	IM provided by members (in %)	IM provided by clients (in %)
ICE Clear Credit	$	25.86 %	74.14 %
ICE Clear US	$	49.20 %	50.80 %
CME Clearing US	$	17.30 %	82.70 %

Source: The calculated IM compositions are based on the PQD data of the respective CCP at 31^{st} March 2016. The data was retrieved from each CCP's website.

Note: As at 30^{th} September 2015 there is no open interest at The Clearing Corporation and the IM reported for LCH.Clearnet LLC is negative.

For US CCPs, clients provide more than 50% of the margin. In contrast, for European CCPs, client margin does not represent more than 30%. Only for CME Clearing EU and ICE Clear Europe, who are both European composites of large US groups, does the client IM represent a non-negligible portion of the total IM. This may in part be attributed to the differences in clearing models[17], which define the legal relationship between the CCP, the CM, and the clients. In the US, the prevailing model is the 'agency model', where the client is in direct contact with the CCP in matters relating to contractual and operational requirements, such as the posting of margin (Gregory, 2014). As mentioned by Braithwaite (2015), there is a distinction between Futures Commission Merchants (FCMs) and clearing members. A FCM, who must be registered as such with the Commodity Futures Trading Commission (CFTC), can clear proprietary trades and trades on behalf of US and non-US domiciled clients. Clearing members on the other hand, can only clear trades on behalf of clients whose domicile is not in the US. In Europe, clients usually have no relationship with the CCP (principal-to-principal model), in which all contractual obligations are to the CM (Gregory, 2014).

[17]A certain percentage may also be attributed to differences in reporting of the PQD field between US and EU CCPs.

Table 9: Proportions of total IM provided by CMs and clients of EU CCPs for all asset classes

CCP	Currency	IM provided by members (in %)	IM provided by clients (in %)
CME Clearing EU	$	0.26 %	99.74 %
CC&G	€	83.16 %	16.84 %
Eurex	€	77.07 %	22.93 %
EuroCCP	€	77.98 %	22.02 %
ICE Clear Europe	$	34.74 %	65.26 %
LCH.Clearnet LTD	€	97.39 %	2.61 %
LCH.Clearnet SA	€	71.98 %	28.02 %

Source: The financial data as at 31^{st} May 2015 for ECC, as disclosure data is not available for this CCP. The financial data as at 31^{st} December 2015 for CME Clearing EU, as well as the data file provided for the first quarter of 2016 do not provide a number of the data fields considered here. For the remainder of the CCPs, the financial disclosure data as at 31^{st} March 2016 is used. The data was retrieved from each CCP's website.

A final consideration concerns the differences among member bases in terms of activity of the CMs. Using Bloomberg data and other publicly available information, individual clearing members were divided into four categories: banks, financial investment firms, financial-other, and other (government, information not available, energy, etc.). In Figures 1 and 2, the composition of the member bases for the US and EU CCPs in our sample is displayed. The majority of members of the US CCPs are financial investment firms. This is consistent with the fact that in the US client clearing seems to be more important than for European CCPs. Leaving aside CME Clearing EU and ICE Clear Europe, the member bases of European CCPs consist in majority of banks and to a lesser proportion in financial investment firms.

The introduction of mandatory clearing and the wide scope of cleared repos in Europe are also likely to negatively impact the composition and size of CCP member bases (Lane et al., 2013). As a result of regulatory changes, CCPs are required to have objective, risk-based and publicly disclosed criteria for member admission (Committee on Payment and Settlement Systems - International Organization of Securities Commissions, 2012).

Figure 1: Composition in terms of business activities of US member bases

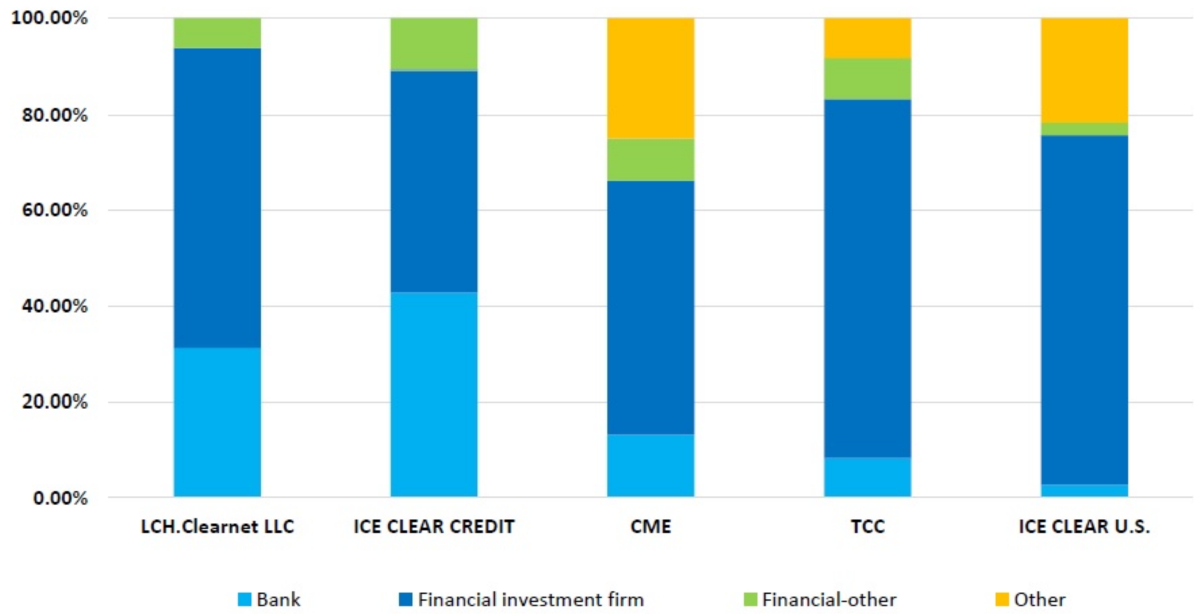
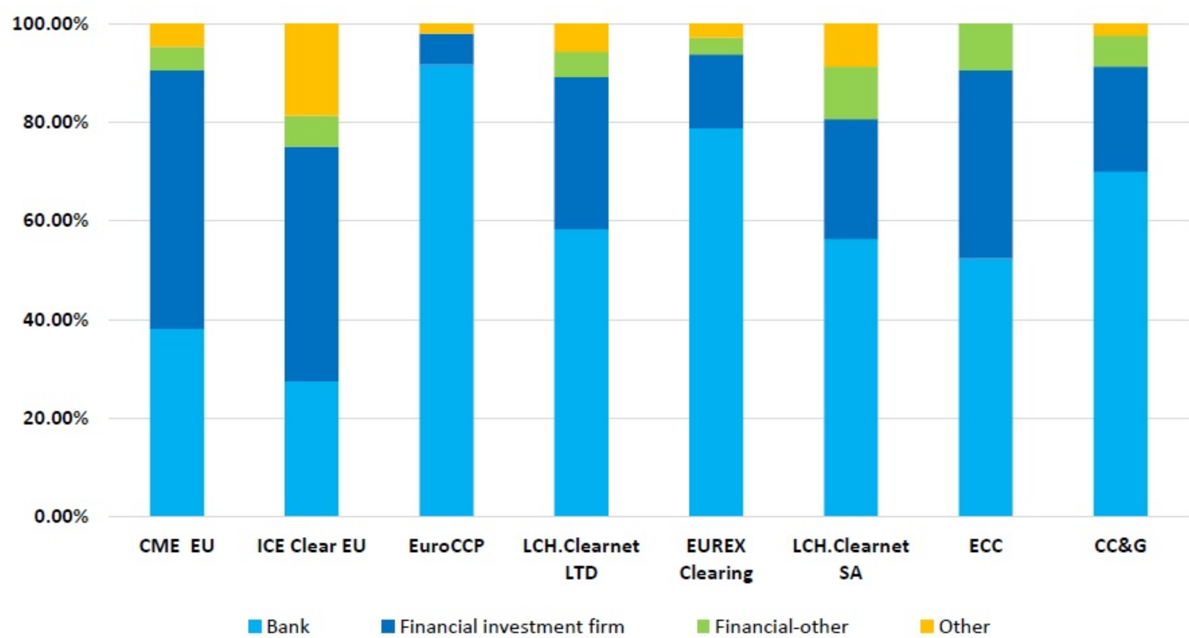


Figure 2: Composition in terms of business activities of EU member bases



3.2. Assessment of CCP resilience under normal market conditions

In this Section, we present a methodological approach for assessing the payment capacity of a CCP's member base under normal market conditions. Using the Basel III framework, we assess the distribution of default probabilities under normal market conditions for EU and US CCPs.

3.2.1. Methodology for assessing member bases under normal market conditions

For each CM considered, credit rating data from Bloomberg is extracted for Moody's Investor Service, Fitch Ratings, and Standard & Poor's. To best capture the ability of the CMs to honor their financial commitment to the CCP, the following rating categories are used: 'Long-Term Rating' and 'Senior Unsecured Debt' from Moodys, 'Long-Term Issuer Default Rating' and 'Senior Unsecured Debt' from Fitch Ratings, and 'Long-Term Foreign Issuer Credit' from Standard and Poor's. If a member is not rated in either category and a rating in one of the above categories is available for the parent company, the ratings of the parent company are used.

Descriptive statistics on the availability of CM credit rating data are displayed in Table 10. The CCPs with the highest percentage of not-rated CMs are ICE Clear US with 35.14% and CME Clearing US with 35.29%. The reason for such a high percentage of not-rated CMs is due to the fact that in many cases these are privately held companies that handle orders on behalf of their clients. Amongst the European CCPs, CC&G has the highest percentage of not-rated CMs (31.25%). This is partly due to the fact that in the aftermath of the financial crisis, rating agencies withdrew from rating several Italian banks (see for example Moody's Investors Service (2013a)) or the banks were placed under the administration of their national supervisor, the Bank of Italy (see for example Moody's Investors Service (2013b)).

Table 10: Availability of credit ratings

CCP	CMs Total	Not-rated CMs	Rated CMS	Percentage of not-rated CMs
CME Clearing US	68	24	44	35.29 %
CME Clearing EU	21	2	19	9.52 %
Eurex	174	34	140	19.54 %
ICE Clear Credit	28	0	28	0.00 %
ICE Clear Europe	80	19	61	23.75 %
ICE Clear US	37	13	24	35.14 %
The Clearing Corporation	12	1	11	8.33 %
LCH.Clearnet LLC	16	0	16	0.00 %
LCH.Clearnet LTD	156	11	145	7.05 %
LCH.Clearnet SA	103	18	85	17.48 %
CC&G	80	25	55	31.25 %
EuroCCP	48	11	37	22.92 %
ECC	21	2	19	9.52 %

Note: All European CCPs listed in Table 10, except for ICE Clear Europe, have been authorised by the ESMA to offer clearing services in the EU. Except for The Clearing Corporation and LCH.Clearnet LLC, all US CCPs in our sample have been authorised by the ESMA as third country CCPs under EMIR. Furthermore, CME Clearing US and ICE Clear Credit have been designated as systemically important Financial Market Infrastructures (FMU) under Title VIII of the Dodd-Frank Act.

For further quantitative studies, we assign default probabilities to not-rated CMs as follows: the Basel III regulatory framework (see Basel Committee on Banking Supervision (2015b), §146) assigns a 'BB' credit rating to not-rated counterparties (see Table 11). We checked for indicators of financial strength to validate this standard mapping. Unfortunately, in many cases standard indicators of financial strength are not available.

Table 11: Regulatory assignment of default risk weights to credit rating category

Credit rating category	AAA	AA	A	BBB	BB	B	CCC	Unrated
Default risk weight	0.5%	2 %	3 %	6 %	15 %	30 %	50 %	15 %

Source: Basel Committee on Banking Supervision (2015b), §146.

To conduct the analysis of the credit risk distribution of a CCP's member base, methods for estimating probabilities of default (PD) with credit ratings[18] can be used, see Tasche (2013), Gordy and Lütkebohmert (2013), Schuermann and Hanson (2004) and Lando and Skødeberg (2002). Ranges for estimated borrower default probabilities associated with Standard & Poor's whole letter rating grades, as provided by Tasche (2013) and Gordy and Lütkebohmert (2013), are displayed in Table 12.

Table 12: Credit rating grades and associated one year probabilities of default

S&P rating grade	Probability of default (in %) as in Tasche (2013)	Probability of default (in %) as in Gordy and Lütkebohmert (2013)
AAA	≤ 0.003	≤ 0.02
AA	$0.006 - 0.025$	$0.02 - 0.06$
A	$0.047 - 0.173$	$0.06 - 0.18$
BBB	$0.299 - 0.797$	$0.18 - 1.06$
BB	$1.138 - 2.280$	$1.06 - 4.94$
B	$3.943 - 19.557$	$4.94 - 19.14$
CCC	48.355	> 19.14

Such a mapping can also be obtained by following the guidelines provided by the Basel III document 'Revisions to the securitisation framework' (Basel Committee on Banking Supervision, 2014). Given the regulatory default risk weights, we can calculate the associated default probabilities[19] according to the regulatory formula[20][21] (see Basel Committee on Banking Supervision (2006), p.64):

[18]Raw historical default frequencies provided by rating agencies (see Moody's Investors Service (2014) and Standard & Poor's (2012)) have some drawbacks, such as being equal to zero for corporations considered to be of high quality.

[19]In the existing literature on CCP resilience, it is often assumed that the probability of default is equal for each clearing participant (see for example Barone Adesi et al. (2015)). Our analysis of member bases, on the contrary, shows that this assumption may not hold for all CCPs, see Appendix C.

[20]The formula provides the loss quantile as derived from the one factor model of Gordy (2003) and Vasicek (2002). See Basel Committee on Banking Supervision (2005) for a detailed explanation of the economic foundations as well as the underlying mathematical model and its input parameters.

[21]The maturity adjustment has been set equal to one (see §155 of the July 2015 version of the 'Fundamental review of the trading book' (Basel Committee on Banking Supervision, 2015b) and the expected loss has been included in the computation as prescribed in §49 of the 'Revisions to the securitisation framework' (Basel Committee on Banking Supervision, 2014). As the regulatory prescribed risk weight for defaulted exposure is equal to 100 %, we also need to set LGD equal to 100 % (Basel Committee on Banking Supervision, 2014).

$$DRW = N\left(\frac{1}{\sqrt{1-R}} \times G(PD) + \sqrt{\frac{R}{1-R}} \times G(0.999)\right), \quad (1)$$

$N(.)$ denotes the cumulative distribution function for a standard normal random variable, $G(.)$ denotes the corresponding inverse cumulative distribution function, PD is the default probability over a one year horizon, and R the coefficient of correlation, defined as:

$$R = 0.12 \times \frac{1-\exp^{-50\times PD}}{1-\exp^{-50}} + 0.24 \times \left(1 - \frac{1-\exp^{-50\times PD}}{1-\exp^{-50}}\right). \quad (2)$$

In Table 13, resulting associated probabilities of default are displayed according to credit rating[22]. Results are well in line with Tasche (2013) and Gordy and Lütkebohmert (2013). We will hereafter use the default probabilities derived from the regulatory formula for our empirical analyses.

Table 13: S&P rating grades and associated one year default probabilities

S&P rating grade	AAA	AA	A	BBB	BB	B	CCC	Unrated
Associated PD	0.01 %	0.05 %	0.09 %	0.23 %	1.16 %	5.44 %	14.21 %	1.16 %

For illustrative purposes, we use the traffic lights approach displayed in Figure 3. We choose to set the PD ranges as displayed in Figure 3 as they reflect the upper and lower bounds of the default probabilities associated with the respective regulatory default risk weights as displayed in Table 3.

[22]In contrast to our approach, the current regulatory mapping of default probabilities to credit quality steps by the European Union is more conservative (European Union, 2013b). The resulting correspondence between Standard and Poor's rating grades and default probabilities (see Joint Committee of the European Supervisory Authorities (2015), p.55, and Joint Committee of the European Supervisory Authorities (2014)) is as follows: the rating grades 'AAA' and 'A' are associated with a default probability of 0.01%, 'A' with 0.25%, 'BBB' with 1% and 'BB' with 7.5%. We do not apply this approach for the following reasons: firstly, default probabilities associated with 'B' and 'CCC' rating grades are not provided. Secondly, the default probabilities are much higher than those provided by Tasche (2013) and Gordy and Lütkebohmert (2013). Furthermore, the Basel Committee on Banking Supervision provides the following mapping of Standard and Poor's rating grades to default probabilities Basel Committee on Banking Supervision (2015a): the rating grade 'AAA' is associated with a default probability of 0.006%, for the category 'AA' the assigned probability of default ranges from 0.010% to 0.025%, for 'A' from 0.041% to 0.105%, for 'BBB' from 0.169% to 0.437%, for 'BB' from 0.703% to 1.818%, for 'B' from 2.923% to 7.561%, and finally for 'CCC' the associated default probability is 27.000% .

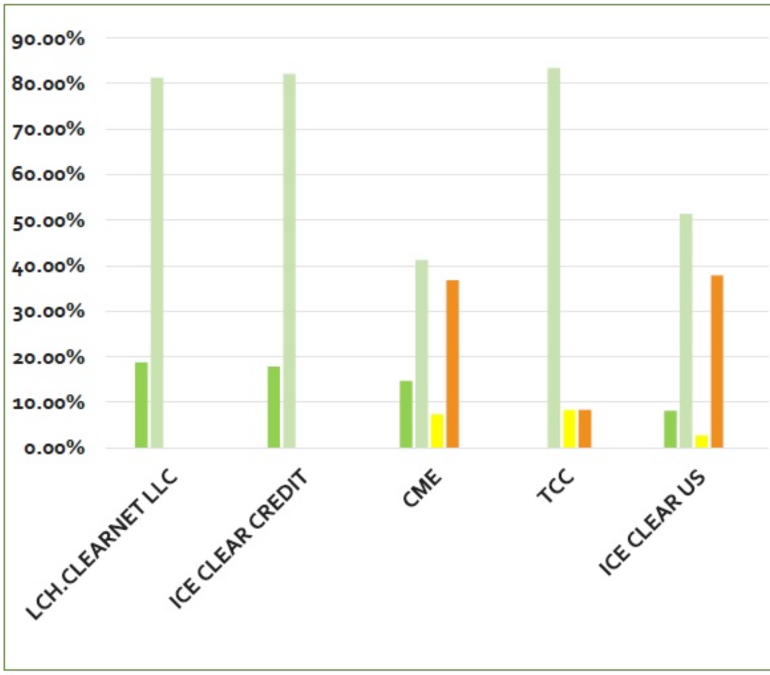
Figure 3: S&P rating grades and associated PD range

S&P Rating Category	PD ranges (in %)
AAA	[0 - 0.05)
AA	[0.05 - 0.09)
A	[0.09 - 0.23)
BBB	[0.23 - 1.16)
BB	[1.16 - 5.44)
B	[5.44-14.21)
CCC	≥14.21

3.2.2. CM risk distribution under normal market conditions

The default probability distribution of CMs is displayed in Figures 4 and 5 for the member bases of US and EU CCPs. The default probability distributions for each CCP are detailed in Appendix C.

Figure 4: Default probability distribution of US member bases under normal market conditions

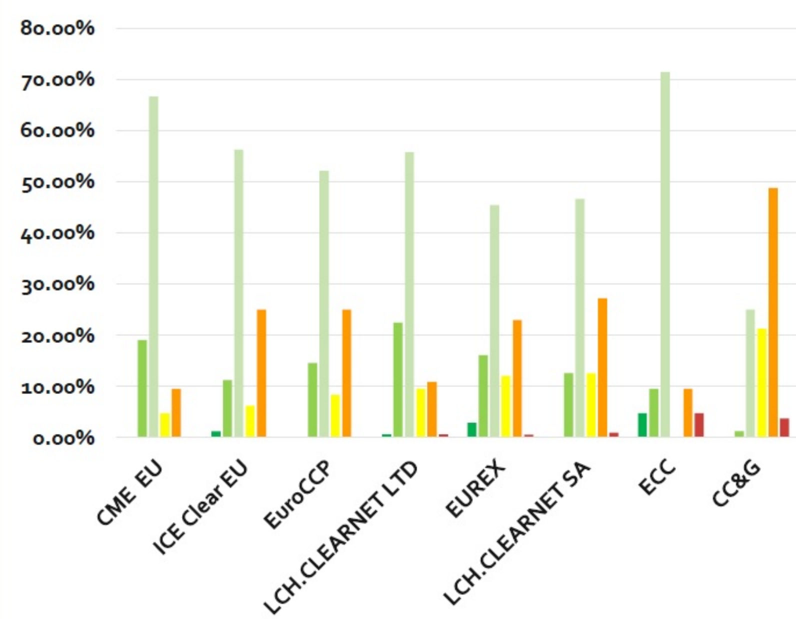


S&P Rating Category	DRW (in %)	PD (in %)
AAA	0.05	0.01
AA	2	0.05
A	3	0.09
BBB	6	0.23
BB	15	1.16

A qualitative inspection of Figure 4 shows that LCH.Clearnet LLC and ICE Clear Credit have the stronger member bases. CME Clearing US, The Clearing Corporation and ICE Clear US lag behind. Their member bases exhibit a lower quality and a higher degree of heterogeneity. This suggests that it might be difficult to align various interests, ex-ante in day-to-day risk management processes and ex-post when closing-out a defaulted member's open trades.

The default probability distributions of the clearing members of the EU CCPs are displayed in Figure 4. The member bases seem overall weaker compared to those of the US CCPs. CME Clearing EU followed by ICE Clear Europe and EuroCCP have the strongest member bases. A second group consists of LCH.Clearnet LTD and Eurex: the CMs' credit quality is lower on average and shows a much greater degree of heterogeneity. Furthermore, we can observe that five out of the eight European CCPs have members with a default probability of 5.44 %, which corresponds to a 'B' rating grade. Especially, ECC and CC&G each have about 5% of members in this category.

Figure 5: Default probability distribution of EU member bases under normal market conditions



S&P Rating Category	DRW (in %)	PD (in %)
AAA	0.05	0.01
AA	2	0.05
A	3	0.09
BBB	6	0.23
BB	15	1.16
B	30	5.44

3.3. Assessment of CCP resilience under stressed market conditions

In this Section, we present a methodological approach for assessing the financial soundness of a CCP's member base under stressed market conditions. We then we assess the distribution of default probabilities under stressed market conditions for EU and US CCPs.

Given the previous analysis of the possible impact of cash-calls and contingent liquidity, we need to assess the financial strength of clearing members under a stressed scenario. The regulatory cover 2 standard refers to the two CMs to which the CCP has the largest unmargined exposures in a stressed scenario[23]. As such data is not available, it is impossible to identify two CMs in accordance with the regulatory definition.

As exposure data at the CM level is not available, and changes in exposures over time cannot be accounted for, we use two average CMs in terms of default probability. If the member base of a CCP is rather homogeneous in terms of default probability, choosing two average CMs is rather unlikely to impact the results. However, for CCPs with rather heterogeneous member bases, the results may differ based on the choice of the two defaulting CMs in the stressed scenario.

Current regulatory stress test exercises, such as the first EU-wide stress testing exercise conducted by the ESMA, based on 2014 data, focused solely on counterparty credit risk[24] that EU CCPs would face as a result of market price shocks (European Securities and Markets Authority, 2016b). The stress test exercise did not consider how specific CM defaults would impact the credit quality of the non-defaulted CMs. Since contagion risk was not accounted for, the resulting credit spreads are lower than those under our methodological approach.

[23] The regulatory requirement is a LGD standard, which is based on CM exposure data.

[24] The 2017 ESMA stress test exercise framework will also cover liquidity risk (European Securities and Markets Authority, 2017).

3.3.1. Methodology for assessing member bases under stressed market conditions

Based on the scenario under normal market conditions, we identify two average CMs in terms of default probability for each CCP. Under the assumption that they have defaulted, we then calculate the conditional one year default probabilities of non-defaulted CMs[25]. We will hereafter denote by $F_i(.)$ the marginal cumulative distribution function associated with the default of CM i. In the remainder of this sub-Section, we provide an overview of the calculation of the one year conditional default probabilities. This is achieved using the Basel framework, i.e. a one factor default model as previously described. For more details on these models, we refer to Vasicek (2002), Pykhtin and Dev (2002) and Gordy (2003).

Let τ_i denote the default date of CM i for a CCP with n CMs for a given time period of one year. We denote the latent variable X_i for $i \in \{1, ..., n\}$, as $X_i = -\sqrt{R_i} \times Y + \sqrt{1 - R_i} \times Z_i$, where $Y, Z_1, ..., Z_n$ are independent standard normally distributed random variables and R_i is the correlation coefficient of CM i as defined in (2). Thus, we obtain $\tau_i = F_i^{-1}(N(X_i))$ and the conditional default probability of CM i given Y as

$$P(\tau_i < t|Y) = N\left(\frac{G(F_i(t)) + \sqrt{R_i} \times Y}{\sqrt{1 - R_i}}\right). \tag{3}$$

Under the definition of the cover 2 standard, we must calculate the one year conditional default probabilities given that two (average) clearing members have defaulted. Denoting by τ_{j_l}, for $j \in \{1, ..., n\}$ with $j_l \neq i$ and $l \in \{1, 2\}$, the default time of an average CM, we can write the conditional default probability of CM i $P(\tau_i < 1|\tau_{j_1} < 1, \tau_{j_2} < 1)$ under this scenario as follows. Given that τ_i, τ_{j_1} and τ_{j_2} are independent, conditionally on Y, the conditional default probability of joint defaults is the product of the single conditional default

[25] Hansen (2013) identifies two sources of systemic risk. Exposures to common shocks and networks of interconnected exposures. Our approach focuses on the resilience of CCPs to macro shocks. Interconnections would result in increased financial fragility, but would be difficult to assess in our context due to lack of data.

probabilities, we obtain

$$P\left(\tau_i < 1 | \tau_{j_1} < 1, \tau_{j_2} < 1\right) = \frac{\int P\left(\tau_i < 1 | y\right) \times P\left(\tau_{j_1} < 1 | y\right) \times P\left(\tau_{j_2} < 1 | y\right) \phi\left(y\right) dy}{\int P\left(\tau_{j_1} < 1 | y\right) \times P\left(\tau_{j_2} < 1 | y\right) \phi\left(y\right) dy},$$

where $\phi(.)$ represents the Gaussian distribution function. The denominator and numerator can be computed using various numerical approaches (Monte Carlo simulation, Gauss-Hermite quadrature, Trapezoidal integration). Results for the conditional probabilities are displayed in Table 14.

Table 14: Conditional default probabilities under cover 2 scenario

	PD of defaulted CMs						
CM PD	*0.01 %*	*0.05 %*	*0.09 %*	*0.23 %*	*1.16 %*	*5.44 %*	*14.21 %*
0.01 %	1.10 %	0.95 %	**0.45 %**	0.42 %	**0.21 %**	0.08 %	0.05 %
0.05 %	2.86 %	1.86 %	**1.83 %**	1.51 %	**0.75 %**	0.33 %	0.21 %
0.09 %	4.70 %	3.45 %	**2.97 %**	2.23 %	**1.19 %**	0.54 %	0.36 %
0.23 %	6.22 %	5.92 %	**5.84 %**	4.23 %	**2.42 %**	1.18 %	0.81 %
1.16 %	16.91 %	13.99 %	**12.28 %**	11.00 %	**7.12 %**	4.13 %	3.09 %
5.44 %	26.34 %	27.29 %	**25.94 %**	22.87 %	**17.79 %**	12.48 %	10.39 %
14.21 %	47.56 %	46.44 %	**43.78 %**	41.35 %	**34.30 %**	26.60 %	23.19 %

As expected, the lower the default probability of the two defaulted clearing members, the higher the negative impact on default probabilities. Since such a scenario is likely to be a systemic event, the stressed default probabilities are much higher than the unconditional default probabilities. For instance, if the two defaulted clearing members were associated with a default probability of 1.16 % (corresponding to a 'BB' rating grade), the resulting conditional default probability of a not-defaulted member with the same initial default probability would jump to 7.12 %, corresponding to a 'B' rating.

Although, the increase in default probabilities under the cover 2 scenario is striking, computations have been done under mild dependency assumptions. Firstly, we remain within the Gaussian copula framework associated with smooth tail dependencies. We refer to Burtschell et al. (2009) for a comparison of dependency structures. Then, we use low Basel II correlations[26]: typically pairwise correlations around 20%, being much lower than the 30% used by Murphy and Nahai-Williamson (2014), which as stated by the authors tends to underestimate joint losses. A stressed environment is usually associated with a sharp increase in default dependencies, as clearly experienced in 2008.

According to our approach, member defaults in the case of a CCP with high quality average clearing members is a more severe (and unlikely) scenario (see for comparison columns 4 and 6 of Table 14). CMs with a higher degree of interconnectedness such as G-SIB banks might also be associated with magnified effects on the credit quality of surviving CMs.

However, for CCPs with rather heterogeneous member bases, the results may differ based on the choice of the two defaulting CMs in the stressed scenario. Figures that are provided based on our modelling approach are to be seen as indicators rather than prescriptions as we deal with extreme and unknown scenarios.

3.3.2. CM risk distribution under stressed market conditions

In Table 14, the default probabilities for CMs according to their initial default probability and the initial default probabilities of the two average defaulted members are displayed[27]. Except for CC&G, all CCPs in the sample have average CMs with a default probability that corresponds to an 'A' rating grade. Thus, the probabilities reported in column 4 would be the default probabilities for CMs under the cover 2 scenario. For CC&G, the two average

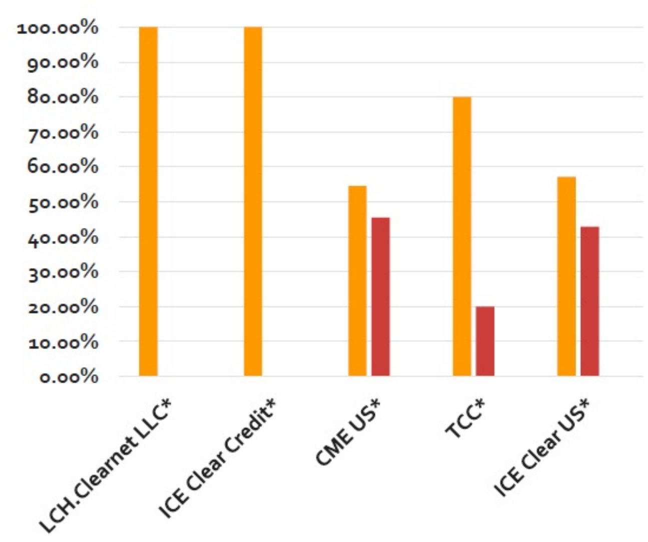
[26]Basel II correlations range from 12% to 24% (see equation (2)). Furthermore, the Basel Committee's findings indicate that the asset value correlations for financial corporations are at least 25% higher than for non-financial corporations (Basel Committee on Banking Supervision, 2009). To reflect this higher degree of correlation, current legislation (European Union, 2013b) sets out that for all exposures to large financial sector entities and to unregulated financial entities, the coefficient of correlation is multiplied by 1,25. Thus, the Basel III correlations range from 15% to 30%.

[27]To ensure that our results are robust and not biased by the inclusion of CMs without credit rating, we ran the following robustness test: we excluded CMs without credit ratings and performed the stress scenarios again to assess whether the default probabilities for the two average CMs are lower. The results only improve for CC&G.

CMs have an initial default probability that corresponds to a ‘BB’ rating grade, i.e. below investment grade. The probabilities reported in column 6 refer to the default probabilities for CMs under the cover 2 scenario for CC&G. The default probability distribution of CMs is displayed in Figures 6 and 7 for US and EU CCPs.

Under the stressed scenario for US CCPs, the resulting default probabilities would correspond to credit ratings that are all below investment grade. Murphy and Nahai-Williamson (2014) investigate the prudence of the cover 2 charge for CCPs. In their approach, all CMs are assigned the same default probability of 5%, which is within the ranges of conditional default probabilities of our stressed scenario. Interestingly, the authors consider 5% to be a very high value for the default probability of a member. Our results show, on the contrary, that the stressed default probabilities may be much higher.

Figure 6: Default probability distribution for US member bases under stressed market conditions



DP under cover 2 approach

CM PD conditional on the default of two average CMs (in %)		
PD of average CMs / CM PD	0.09%	S&P Rating Category
0.05 %	1.83	BB
0.09 %	2.97	
0.23 %	5.84	B
1.16 %	12.28	

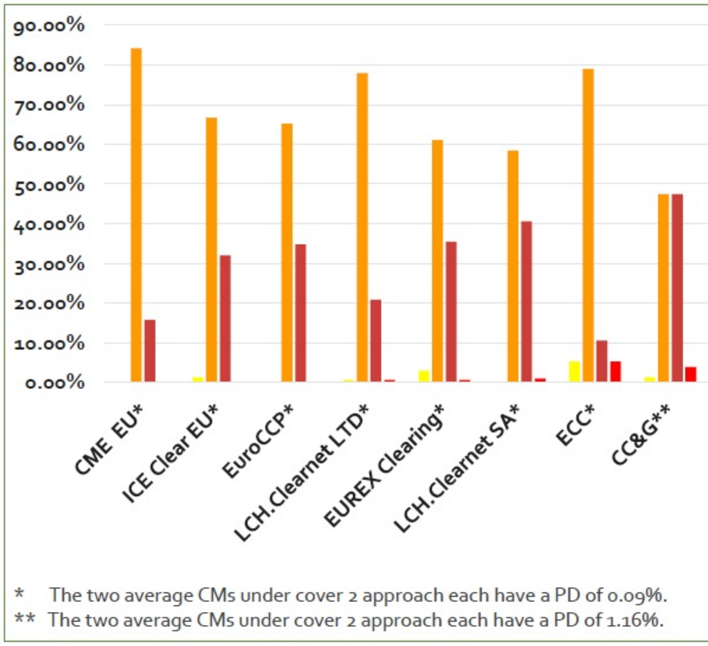
* The two average CMs under cover 2 approach each have a PD of 0.09%.

In the cover 2 stress scenario, ICE Clear US and CME Clearing US would each have a high percentage of members that have a default probability greater than 5.44%, which corresponds to a credit rating of ‘B’: ICE Clear US would have 46% of members in this category and CME

Clearing US approximately 43%. If the CCP demands liquidity via cash-calls, these CMs might face major problems raising liquidity in a short period of time due to the sensitivity of funding sources to credit rating downgrades (Karam et al., 2014). For ICE Clear US and CME Clearing US the risks would be concentrated in two large subsets of CMs corresponding to CMs without rating assignment. As already mentioned, not-rated CMs account for more than one third of these two major CCPs. Consequently, our results strongly depend upon the assignment of a pre-stressed default probability corresponding to a 'BB' rating for such members (as in Basel Committee on Banking Supervision (2013)). This quantification might obviously be disputable. Nevertheless, it does not undermine the broad concerns regarding the weakening of member bases in stressed scenarios.

Similar to US CCPs, the credit quality of European CCPs member bases would be severely impacted under a stressed scenario. Credit ratings of typical clearing members would be in the 'BB' or 'B' rating category, thus below investment grade. As mentioned previously, this would jeopardise the ability of CCPs to make cash calls on surviving clearing participants to replenish depleted default funds. Moreover, Raykov (2016) finds that the risk of CMs not meeting cash calls rises endogenously when cash calls become more likely, constraining the total amount of liquidity that can be raised. This means that CCPs without public support would remain in a weak position for a certain period of time, possibly threatening financial stability.

Figure 7: Default probability distribution for EU member bases under stressed market conditions



DP under cover 2 approach

CM PD conditional on the default of two average CMs (in %)		
PD of average CMs / CM PD	0.09%	S&P Rating Category
0.01 %	0.45	BBB
0.05 %	1.83	BB
0.09 %	2.97	
0.23 %	5.84	B
1.16 %	12.28	
5.44 %	25.94	CCC

CM PD conditional on the default of two average CMs (in %)		
PD of average CMs / CM PD	1.16%	S&P Rating Category
0.05 %	0.75	BBB
0.09 %	1.19	BB
0.23 %	2.42	
1.16 %	7.12	B
5.44 %	17.79	CCC

As the member bases of European CCPs are not homogeneous, we may face run problems. Nahai-Williamson et al. (2013) suggest that runs that may be mitigated with credit sensitive IM requirements and default fund contributions.

The small proportion of high quality, resilient clearing members would be exposed to the risk of having to subsidise the CCP. If only the members in such a subset are capable of managing defaulted positions, other participants may choose to free ride on the services paid for by the small proportion of high quality members (Pirrong, 2011). Finally, considering the number of clearing members with 'CCC' ratings for CC&G and ECC, it is likely that the cover 2 scenarios presented are not conservative enough.

Considering that the regulatory cover 2 charge and stress test scenarios for determining default fund size do not take into account the possibly significant proportion of members with critical payment capacities, risk-sharing mechanisms may prove inefficient when market conditions deteriorate and the quality of a member base further erodes. The higher the default probability of a CM, the higher the possibility that the CCP may have to revert to the default fund. Thus, the member base quality should be taken into account when designing stress scenarios for sizing the default fund.

3.4. Member bases and member eligibility criteria

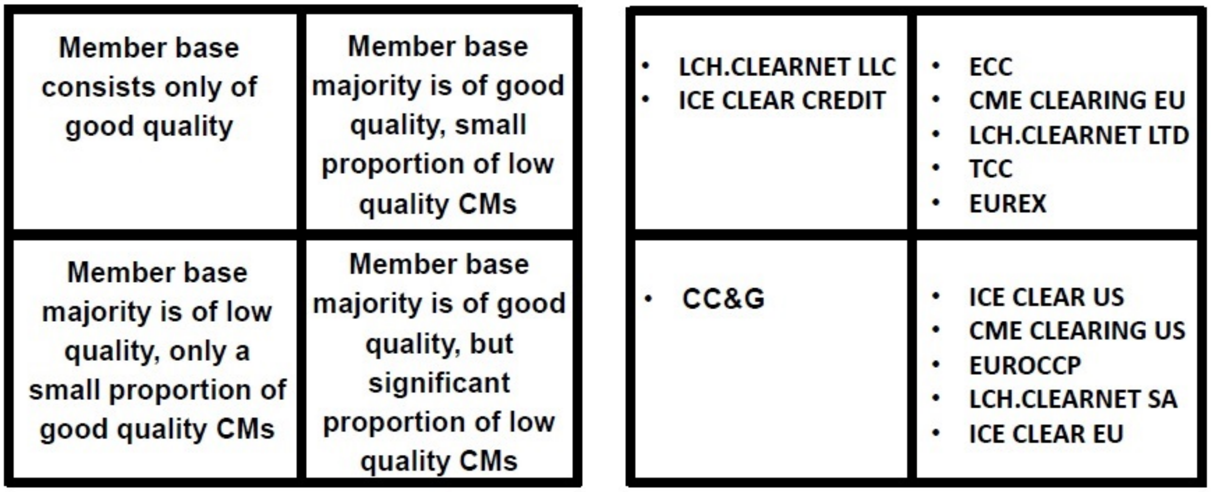
Based on the findings of the previous Sections, we propose a typology of CCP member bases that allows for the visualisation of the various issues associated with evolving stages of good and low quality members. We conclude with some considerations on member eligibility criteria.

3.4.1. Member base typology

When a CCP determines the required level of resources to be maintained, it should consider the number of simultaneous participant defaults that are extreme but plausible given the composition of its particular participant base (Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2016). As member bases differ with regards to the members' quality, each CCP should carefully consider the issues it may face based on the type of its respective member base.

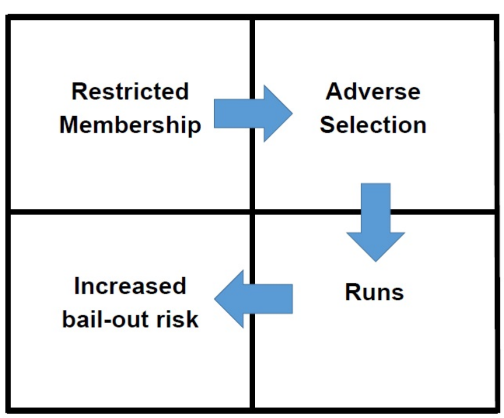
To facilitate the understanding of possible issues specific to a certain type of member base composition, we represent the results using a two dimensional mesh. We introduce a matrix consisting of four cells, where each corresponds to a member base with varying proportions of good and lower quality members, see Figure 8. Based on the CM risk distribution of each CCP, we assign each CCP to the corresponding cell.

Figure 8: Member base typology



As we have seen in Section 3.3, member base quality may erode over time, especially in times of crisis. The four different types of member base composition, as identified in Figure 8, allow the illustration of such a process. The composition of a member base deteriorates throughout four different stages, where each stage is associated with varying levels of good and low quality members. Starting from the upper left cell and going clockwise, the member base quality decreases with each further stage, resulting in a member base of low quality with only few good quality clearing members. In Figure 9, we present possible issues associated with each of the four stages.

Figure 9: Financial stability dilemma



Each type of member base may pose different kinds of issues:

- A CCP with only good quality CMs may restrict membership. Given CCP proliferation[28] and possible ‘races to the bottom’, CCPs of this category may not be sustainable in the long term, unless CCP regulation and supervision is stringent.

- For a member base with a majority of good quality CMs and only a small proportion of low quality CMs, adverse selection problems may arise. The overall stronger payment capacity may result in lower pre-funded contributions. Such a constellation is most probably going to attract low quality CMs.

- A member base consisting primarily of good quality CMs, but with a significant proportion of low quality members, is prone to runs. If confronted with a costly bail-in in case of failure, the good quality CMs may choose to run from the CCP.

- For a member base with a majority of low quality and only a small proportion of good quality CMs, market instability may cause further erosion of the CMs’ credit quality and lead to increases in default probabilities. If such a CCP is not systemically important, it will be most probably resolved. In contrast, a CCP of systemic importance may face a costly bail-out.

3.4.2. Discussion of CM eligibility criteria

As outlined by Pirrong (2011), member eligibility criteria impact the ability of a CCP to muster the financial resources necessary to be sufficiently capitalised to absorb default losses. This is also reflected in the historical evolution of member eligibility criteria: when clearing houses evolved in the 19^{th} century, they had ’club’-like structures, only admitting high quality members of good reputation. This distinct evolution of ’club’-structures, governed by the rules of clearing associations and not by regulation, was based on the idea of ’collective responsibility’ (Cox and Steigerwald, 2016). A member’s reputation and his financial integrity were a key factor in remaining in the ’club’, as failure to demonstrate evidence of

[28] CCP proliferation needs to be monitored, as it may negatively impact counterparty exposure, netting and collateral demand (Duffie and Zhu, 2011; Singh, 2011; Cont and Kokholm, 2014; Duffie et al., 2015).

one's financial ability could result in suspension or expulsion (Moser, 1998).

To ensure that each member was able to fulfil his commitments, early clearing houses developed monitoring mechanisms similar to bank examinations[29] so that each member was aware of the actual abilities of the other members (Gorton, 2013). The monitoring examinations were facilitated by the fact that members had to submit very detailed records of their business operations and financial abilities.

Another factor with likely impacts on the composition of member bases is the de-mutualisation of user-owned CCPs. The ownership structure may have a direct impact on the entry requirements, as user-owners may prefer to let only high quality members that are similar in terms of size and capital resources 'join the club' (Committee on Payment and Settlement Systems, 2010). However, the crisis most likely entailed moving from rather homogeneous to more diversified member bases in terms of clearing members capital and size.

The introduction of mandatory clearing led to fundamental changes in these rather restrictive entry criteria, following the regulators mandating fair and open access to central clearing, as documented by Fontaine et al. (2012) for LCH.Clearnet LTD's SwapClear. The prior entry criteria restricted access via a minimum capital amount of \$ 5 billion, a minimum size (minimum trading book of \$ 1 trillion), a minimum credit rating of 'A', and proof that the members were capable of performing during default management processes. As the CFTC voted to lower capital requirements, SwapClear criteria regarding capital were decreased to \$ 50 million (scaled to the amount of risk assumed). While the performance criterion remains and CMs can now outsource their performance obligation to a CCP approved third party, the minimum requirement for the trading book size was dropped. Finally, LCH.Clearnet

[29] As Gorton (2013) also points out, the results of these monitoring exams were not made available to the public to avoid runs. He also mentions, that during a crisis, a clearing house could perform as a lender-of-last resort to its clearing members by issuing loans to avoid a run on the member in question.

LTD now assesses CMs based on its own scoring system (Fontaine et al., 2012). As historical records of member bases are not available for all CCPs, the actual changes in member bases in terms of size, quality, and homogeneity, following the changes in entry criteria, remains to be assessed.

The member base and its ability to provide contingent liquidity is a crucial factor to sustain a CCP, once it relies on loss mutualisation mechanisms, especially the provision of un-funded liquidity. Given the results of our previous analysis on the capacity of member bases to provide contingent liquidity, the question remains of how to set member eligibility criteria and which factors to consider. In this spirit, we believe that there is no unique set of criteria that is suitable for each CCP. On the contrary, given that each CCP is rather unique, involved stakeholders may want to consider the following aspects, when setting entry criteria adapted to the characteristics of a CCP:

- **Diversification vs. 'club-structure'** As Duffie (2010) emphasises, the inclusion of smaller, high quality institutions, who are capable of providing valuable contributions to risk and default management, increases the total unwind capacity of a member base. A member base consisting only of G-SIFI institutions may be less capable of managing major systemic shocks, as pointed out by Slive et al. (2011). A 'club'-like structure also results in a smaller network and a reduced liquidity pool for trading. Following the argument of Singh (2014) that losses should be shared to the highest extent possible, a broad and diversified member base may also prove more capable of sharing losses.

- **Size** A minimum trading book size requirement may not be consistent with the mandatory clearing requirement. The demise of Lehman Brothers exemplified that dealer banks do fail, thus this criterion cannot guarantee that institutions large in terms of their trading book size will be less likely to fail than a smaller dealer bank (Slive et al., 2011).

- **Interconnectedness** Major dealer banks, broker firms and other types of financial investment firms are in most cases members of multiple CCPs (Armakolla and Bianchi, 2017; European Securities and Markets Authority, 2016b). If they are moreover interconnected, this may jeopardise the ability of a CCP to assess the financial soundness of its members.

The monitoring of member base quality should also be considered from a micro- and macro-prudential perspective. From a micro-prudential point of view, it makes sense to monitor member base quality and adapt margining policies accordingly via add-ons. On the other hand, extra margin requirements for weak members could lead to funding liquidity issues or forced deleveraging. Also, pushing weaker participants out of centrally cleared derivative markets could drive them to less transparent bilateral uncleared markets, where counterparty risk might concentrate; or could lead to the exclusion of weaker participants from the hedging benefits of derivatives.

4. Conclusion

As the clearing landscape is changing rapidly and regulations are continuously being introduced, and due to the prominent role of central clearing, researchers must address a number of adverse effects and sources of financial fragility that could materialise within the new architecture. The ability of a CCP to withstand member defaults can be improved in various ways, such as better control of membership eligibility, sizing-up IM requirements, especially for clients that do not contribute to the default fund, increased default fund requirements and limited allowance of unfunded contributions for lower quality clearing members. Each of the above ideas should be considered with moderation, as each has some clear drawbacks in terms of transaction fees for client clearing, limited access to central clearing, freezing of liquid assets and potentially pro-cyclical requirements. Quality at the heart of the financial system comes at a price and resources should thus be devoted in a rational way. CCPs enhance interconnection. Uncontrolled exposures via default funds of core clearing members may create the same kind of opaqueness that led to the disparagement of OTC derivatives during the financial crisis. Regulators should be cautious regarding incentives provided to market participants that could result in races to the bottom or runs in the context of increased CCP competition, subsidising of low quality CMs that might overload a CCP at the expense of others, thus jeopardising the efficiency of risk-sharing mechanisms. For this purpose, a closer look at default fund exposures and failure mechanisms is of major importance. Furthermore, the default fund should be sensitive with regards to risk and differences between different default fund structures.

A number of CCPs have a significant proportion of members with critical payment capacities. An even greater proportion have quite heterogeneous member bases. Consequently, analysing CCP membership bases, both in terms of average financial soundness and heterogeneity among default fund contributors, is an important aspect of CCP resilience. A decrease in a CM's credit quality leads to an increase in the common exposure via the default fund. Thus CCPs may consider integrating default fund add-ons for members with decreasing credit quality into existing risk management frameworks.

Under a stressed scenario member base quality erodes and many CCPs may face severe liquidity problems, if CMs cannot provide contingent funding to sustain the CCP's resilience.

As member base composition has just become a topic of interest for researchers, regulators and other CCP interested parties, they will need tools that allow the monitoring of member base quality and also the dispersion of risk amongst members. The approaches presented here may be a first step in this direction.

AppendixA. Waterfall resources

As mandated by the PQD (Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2015), CCPs are to report quantitative data at the level of clearing service with segregated default funds and aggregated per currency, if the clearing service comprises multiple clearing currencies. The data aggregation differs across the different CCPs and in some cases the data files may contain errors, data fields may not be filled as required, or data fields may even be empty.

The PQDS data is provided under Principle 23 of the PFMI and published quarterly since 30^{th} September 2015. The publication of this data is not mandatory, thus some CCPs in our sample have not published the data. The data files provided by the CCPs are structured according to a prescribed matrix and grouped together according to the respective principle of the PFMI. For example, IM values are to be found under Principle 6, Margin. For a more detailed overview of the different data fields, we refer the reader to (Committee on Payments and Market Infrastructures - International Organization of Securities Commissions, 2015). A discussion of the issues related to the usage of PQD data provided by EU CCPs can be found in Armakolla and Bianchi (2017). The article also provides an overview of the EU CCP ecosystem using PQD data and other publicly available data sources.

The following data was extracted for each CCP in our sample (when available)

- The IM values refer to the data fields provided under 6.1.1.
- The SIG amount refers to data field 4.1.1.
- The default fund contributions refer to data field 4.1.4.

Table A.15: Pre-funded default waterfall resources for EU CCPs

CCP	Clearing Service or Currency	Initial Margin (in mn)	SIG (in mn)	Default Fund (in mn)
CME Clearing EU	Futures and Options	49 $	20 $	10.8 $
	IRS	NA	47 $	91.1 $
CC&G	Equity Derivatives and Shares	2854 €	3.9 €	1103 €
	Bonds	9397 €	12.8 €	3602 €
	Energy Derivatives	4.1 €	0.02 €	6.6 €
	Agricultural Commodity Derivatives	0.5 €	0.002 €	0.7 €
ECC	Commodities	1105 €	5.5 €	130 €
Eurex	Equity Derivatives	54191 €	€ 29 €	2152 €
	Fixed Income Derivatives		6 €	445 €
	OTC IRS		1.7 €	125 €
	Property Futures		0.05 €	4.1 €
	Commodities		0.02 €	1.5 €
	Precious Metals		0.009 €	0.7 €
	FX		0.006 €	0.5 €
	Remaining Products		13 €	977 €
EuroCCP	CHF	169 CHF	5.5 €	243 €
	DKK	468 DKK		
	€	749 €		
	NOK	68 NOK		
	SEK	552 SEK		
ICE Clear Europe	Futures and Options	42941 $	100 $	1850 $
	CDS	6504 $	28.5 $	1126 $
LCH.Clearnet LTD	ForexClear	101766 €	3.7 $	272 $
	SwapClear		44 £	3219 £
	Commodities		0.2 $	16 $
	Listed Interest Rates		0.4 £	28 £
	Equities		2.9 £	216 £
	Fixed Income		13 €	919 €
LCH.Clearnet SA	CDSClear	21838 €	20 €	598 €
	Cash&Derivatives		9.3 €	766 €
	Fixed Income		11.2 €	924 €
	€GCPlus		1.7 €	139 €

Source: The financial data as at 31^{st} May 2015 for ECC, as disclosure data is not available for this CCP. The PQD file of CME Clearing EU does not provide a number of data fields here considered, such as IM for IRS. For the remainder of the CCPs, the financial disclosure data as at 31^{st} March 2016. The data was retrieved from each CCP's website.

Table A.16: Pre-funded default waterfall resources for US CCPs

CCP	Asset Class	Initial Margin (in mn)	SIG (in mn)	Default Fund (in mn)
ICE Clear US	Futures	12851 $	50 $	404 $
ICE Clear Credit	CDS	19545 $	25 $	1560 $
LCH.Clearnet LLC	IRS	0,02 $	2 $	260 $
CME Clearing US	Base Financial	137549 $	100 $	3276 $
	IRS		150 $	2810 $
	CDS		50 $	650 $

Source: The financial data as at 31^{st} March 2016. The data was retrieved from each CCP's website.

Note: As at 30^{th} September 2015 there is no open interest at The Clearing Corporation. Consequently, the CCP's current initial margin on deposit is 0$. The default fund amount as at 30^{th} September 2015 is equal to 1.2$ mn. The information was retrieved from the CCP's website.

AppendixB. Credit rating and default risk weight assignment

Table B.17: Credit rating and default risk weight assignment

Interpretation	Moodys	Fitch Rating	Standard & Poor's	DRW
Extremely strong payment capacity	Aaa	AAA	AAA	0,5%
Very strong payment payment capacity	Aa	AA	AA	2 %
Strong payment capacity	A	A	A	3 %
Adequate payment capacity	Baa	BBB	BBB	6 %
Likely to fulfil payment obligations, high credit risk	Ba	BB	BB	15 %
Highly Speculative, very high credit risk	B	B	B	30%
Extremely speculative, extremely high credit risk	Caa	CCC	CCC	50%
Not rated				15 %

AppendixC. PD distributions

Table C.18: PD distribution among CMs per EU CCP

	PD						
CCP	0.01 %	0.05 %	0.09 %	0.23 %	1.16 %	5.44 %	14.21 %
CME Clearing EU	0.00%	19.05%	66.67%	4.76%	9.52%	0.00%	0.00%
ICE Clear Europe	1.25%	11.25%	56.25%	6.25%	25.00%	0.00%	0.00%
LCH.Clearnet LTD	0.64%	22.44%	55.77%	9.62%	10.90%	0.64%	0.00%
ECC	4.76%	9.52%	71.43%	0.00%	9.52%	4.76%	0.00%
Eurex	2.87%	16.09%	45.40%	12.07%	22.99%	0.57%	0.00%
EuroCCP	0.00%	14.58%	52.08%	8.33%	25.00%	0.00%	0.00%
LCH.Clearnet SA	0.00%	12.62%	46.60%	12.62%	27.18%	0.97%	0.00%
CC&G	0.00%	1.25%	25.00%	21.25%	48.75%	3.75%	0.00%

Table C.19: PD distribution among CMs per US CCP

	PD						
CCP	0.01 %	0.05 %	0.09 %	0.23 %	1.16 %	5.44 %	14.21 %
LCH.Clearnet LLC	0.00%	18.75%	81.25%	0.00%	0.00%	0.00%	0.00%
ICE Clear Credit	0.00%	17.86%	82.14%	0.00%	0.00%	0.00%	0.00%
CME Clearing US	0.00%	14.71%	41.18%	7.35%	36.76%	0.00%	0.00%
The Clearing Corporation	0.00%	0.00%	83.33%	8.33%	8.33%	0.00%	0.00%
ICE Clear US	0.00%	8.11%	51.35%	2.70%	37.84%	0.00%	0.00%

Table C.20: Conditional PD distribution among CMs per EU CCP

	Conditional PD range			
CCP	[0.23 – 1.16)	[1.16 – 5.44)	[5.44 – 14.21)	$\geq$ 14.21
CME Clearing EU	0.00 %	84.21 %	15.79 %	0.00 %
ICE Clear Europe	1.28 %	66.67 %	32.05 %	0.00 %
LCH.Clearnet LTD	0.65 %	77.92 %	20.78 %	0.65 %
ECC	5.26 %	78.95 %	10.53 %	5.26 %
Eurex	2.91 %	61.05 %	35.47 %	0.58 %
EuroCCP	0.00 %	65.22 %	34.78 %	0.00 %
LCH.Clearnet SA	0.00 %	58.42 %	40.59 %	0.99 %
CC&G	1.28 %	47.44 %	47.44 %	3.85 %

Table C.21: Conditional PD distribution among CMs per US CCP

	Conditional PD range		
CCP	[1.16 – 5.44)	[5.44 – 14.21)	$\geq$ 14.21
LCH.Clearnet LLC	100.00 %	0.00 %	0.00 %
ICE Clear Credit	100.00 %	0.00 %	0.00 %
CME Clearing US	54.55 %	45.45 %	0.00 %
The Clearing Corporation	80.00 %	20.00 %	0.00 %
ICE Clear US	57.14 %	42.86 %	0.00 %

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