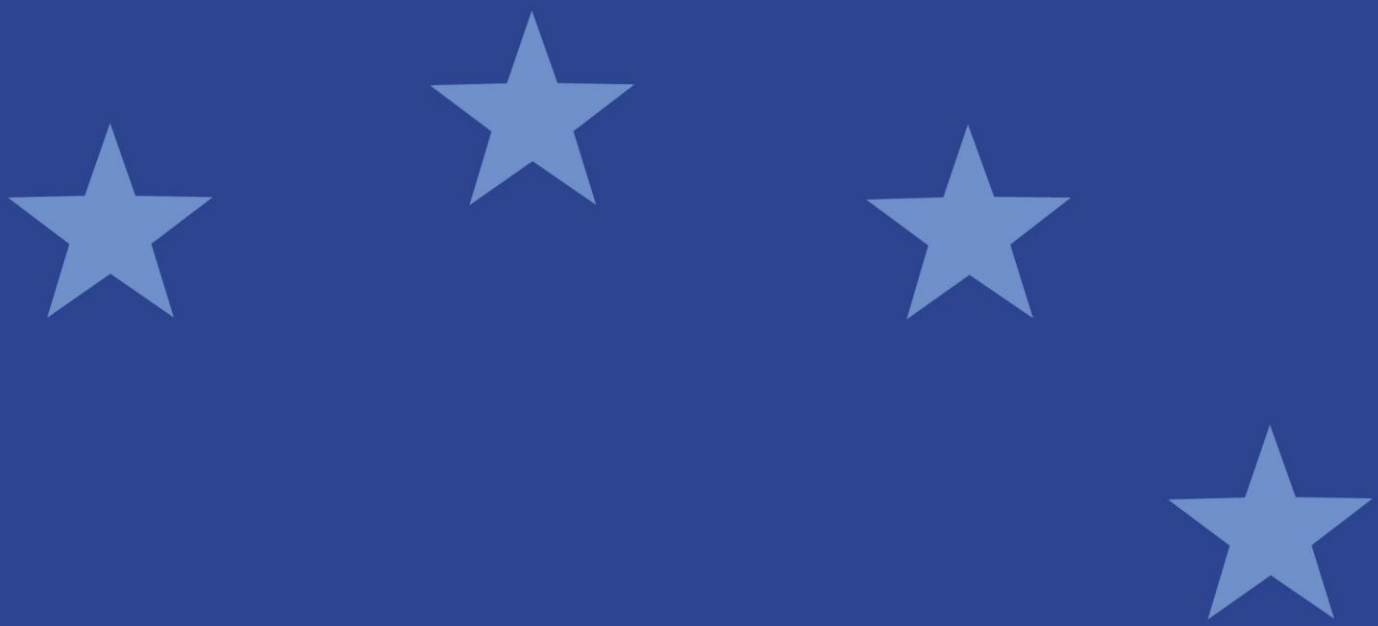
esma European Securities and Markets Authority

Report

EU-wide CCP Stress Test 2017



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Acronyms used

EMIR	European Market Infrastructures Regulation – Regulation (EU) 648/2012 of the European Parliament and Council on OTC derivatives, central counterparties and trade repositories
ESMA	European Securities and Markets Authority
ESRB	European Systemic Risk Board
ETD	Exchange Traded Derivatives
FX	Foreign Exchange
LEI	Legal Entity Identifier
NCA	National Competent Authority
OTC	Over-the-counter
RTS	Regulatory Technical Standards
RTS on CCP	Commission Delegated Regulation (EU) No 153/2013 on requirements for central counterparties (OJ L 52, 23.2.2013, p.41)
bps	Basis points
EU	European Union
P&L	Profit and Loss
pp	Percentage points
SITG/SIG	Dedicated CCP Resources (“Skin in the game”)
MD-A	Credit Member default scenario assuming that the top-2 clearing members per CCP will default simultaneously
MD-B	Credit Member default scenario assuming that the top-2 groups of clearing members EU-wide in terms of exposure will default simultaneously
MD-C	Credit Member default scenario assuming that the top-2 groups of clearing members EU-wide in terms of exposure weighted by their probability of default will default simultaneously
PD	Probability of default
LGD	Loss given default
PoA	Powers of Assessment, i.e. not-prefunded additional resources that can be called by CCPs from non-defaulting members
HHI	Herfindahl-Hirschmann index used for the assessment of concentration
DvP	Delivery versus Payment

1 Executive Summary

Introduction

This report presents the results of the second EU-wide stress test exercise for Central Counterparties (CCPs). In line with the methodology published in February 2017, compared to the first stress test exercise, ESMA has extended the scope to include liquidity risk and improved the framework for the definition of the scenarios and validation of the results.

As with all stress test exercises of this scale and type, there are some limitations. To a significant extent, the results rely on the data provided by CCPs and on a set of validation checks performed by the individual National Competent Authorities (NCAs). Especially when it comes to the liquidity stress scenarios, the exercise tests and assumptions were tested for the first time leading to some residual uncertainties. Therefore, the granularity of published results is limited for the liquidity stress test part. ESMA remains committed to further improve and evolve the methodology and scope of the CCP stress tests and address residual limitations in future exercises.

Concentration and Interconnectedness

The stress test results are presented in Section 4. The CCPs provided for the purpose of this exercise detailed data on their exposures and financial resources for one reference date. This data was not only used to run the credit and liquidity stress tests, but also to provide an overview of the size of the industry and identify common practices and divergences with potential risk implications.

The background analysis and discussion of the findings is followed by the concentration analysis. The level of concentration to individual clearing participants has been assessed using the Herfindahl - Hirschmann Index (HHI) methodology and thresholds. The results presented in 4.2.1 have not evidenced any systemically critical concentration to single clearing members or groups at EU-wide level. We also studied the interconnectedness between CCPs through common clearing members, custodians and liquidity providers and the results are set out in 4.2.2. As expected, the top clearing member groups have simultaneous exposures to multiple CCPs. Keeping in mind the limitations of the exercise, the interconnectedness analysis has indicated that these exposures would generally not hit simultaneously the default fund waterfall of all these CCPs under one of the common, internally consistent stress scenarios considered. Concerning the identification of top common custodians, the analysis has indicated that multiple CCPs may rely on a small number of cash and securities custodians, including mainly ICSDs and for one particular currency one commercial bank. Regarding top common liquidity providers, not many CCPs have reported committed repo lines from commercial entities. Moreover, there is no convincing evidence suggesting single financial groups committing to providing liquidity to many CCPs at the same time.

Credit Stress Test

The results of the credit stress test are presented in 4.3, for different combinations of member default scenarios and market stress scenarios. The scenario simulating the default of the EU-wide top-2 groups of clearing members (MD-B) combined with the common market stress scenarios indicate that, under the assumptions and limitations of the exercise, the losses could be absorbed by the available prefunded resources, leaving no uncovered losses.

As part of a separate scenario, and in order to assess the resilience of each individual CCP to the default of its most relevant clearing participants under harmonised price shocks, we also assumed the default of the top-2 groups of clearing members selected for each individual CCP. The defaulting members could be different for each CCP under this particular scenario, but still using the common market stress scenarios. The default fund amounts would also in this case be sufficient to cover the simulated losses, with the exception of one CCP where we would have a marginal shortfall with no systemic implications. In particular, for one CCP (BME Clearing), this scenario would result in a need to call for a very small amount (less than 1 million EUR) of additional non-prefunded resources, since the mutualised prefunded resources for one of the default funds would be depleted. The shortfall is only marginal and with no systemic impact, considering also that the CCP had access to surplus collateral of the defaulting members in other default funds and excess margin that could in this case be used to cover this very small shortfall. For another CCP (ICE Clear Europe), the prefunded resources would be enough, but these would only marginally cover the simulated losses (97% consumption of the default fund). The excess margin held on top of the minimum required, could also significantly reduce the consumption of prefunded resources.

The MD-A member default scenario, where we selected the default of the top-2 entities at each CCP and then considered these entities to be in default at all CCPs lead to a very large number of members defaulting, due to the cross-default condition. Also here, for the same two CCPs there would be a need to call for additional non-prefunded resources. Overall, although not possible to calculate exactly, the combined probability of such a large number of entities defaulting simultaneously is expected to be very low, implying that this scenario goes beyond what can be reasonably considered as plausible.

Finally, the knock-on analysis presented in 4.4 was employed to assess the impact of CCPs using the mutualised resources (default fund contributions and power of assessments) on non-defaulting clearing members. Under the considered scenarios, assumptions and limitations there was no evidence of systemic implications via the risk-sharing mechanism of CCPs.

The reverse stress analysis discussed in 4.5 is meant to capture the sensitivity of the credit stress results to small changes of the underlying assumptions. For that purpose, we increased the number of defaulting entities and the severity of the market shocks, beyond what was considered as plausible, for the purpose of this exercise. Overall, the analysis showed a high sensitivity at one CCP (ICE Clear Europe) to relatively small increases of

either the number of defaulting groups (to 3) or the shocks (to 120% of the baseline stress shocks), that could lead to material breaches of its prefunded resources.

Liquidity Stress Test

The results of the liquidity stress tests are presented in section 4.6. They demonstrate that under all market scenarios, EU CCPs could achieve sufficient capacity to meet their liquidity needs assuming the default of 2 relevant entities (Cover 2) or the default of 2 groups of entities EU-wide using a variety of tools. According to the rules of the exercise, one of the CCP requires undisrupted access to markets and the ability to settle immediately. Some large CCPs require access to the short-term FX markets to cover requirements in some major currencies. Some CCPs make use of their access to central bank repo lines.

Overall Results

This year's exercise confirms the results of last year, i.e. that EU CCPs are overall resilient to common shocks and multiple defaults. However, for the credit tests the use of harmonised shocks permitted to highlight differences in resilience between CCPs. This allowed the identification of either minor failures of no systemic relevance or higher sensitivity to marginal increases of price shocks or number of defaults that might have systemic relevance. Also for the liquidity stress tests, the exercise did not reveal any systemic risk. CCPs use different tools to cover their liquidity needs, some are highly reliable as central bank repos, others less, but no particular deficiency was found in the management of liquidity risks by EU CCPs.

Next Steps

In line with the EMIR mandate, where the assessments expose shortcomings in the resilience of one or more CCPs, ESMA will issue as a next step the necessary recommendations. ESMA is currently considering whether any recommendation is needed and what form it should take.

2 Introduction

2.1 Background

1. Central Counterparties (CCPs) can be systemically important and ensuring their resilience is critical to achieve the stability of the financial system. They were setup to reduce systemic risk stemming from bilateral relationships. They are still however, counterparties to all their clearing members, and thus any shortcomings leading to a failure to mitigate risks could potentially lead to spill-over effects and exacerbate systemic risk.

2. CCPs run daily stress tests based on stringent prudential requirements that focus on their own environment (participants, cleared products, activity). The individual stress tests run by CCPs are necessary but cannot always reveal implications from system-wide events because of their limited scope. As shown in the first EU-wide stress exercise conducted by ESMA, CCPs are interconnected through common participants. Therefore, the EU-wide picture is necessary to identify potential emerging systemic risks.

3. One of the objectives of Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories (EMIR) is to promote central clearing and ensure safe and resilient CCPs. Therefore, ESMA shall, in cooperation with the ESRB, initiate and coordinate Union-wide assessments of the resilience of CCPs to adverse market developments. Where the assessment exposes shortcomings in the resilience of one or more CCPs, ESMA shall issue the necessary recommendations.

4. The present report sets out the results of the 2017 EU-wide stress test exercise in Section 4, following a description of the employed methodology in Section 3. The objectives, scope and overview of the different tests performed are presented in the following paragraphs of this section.

2.2 Objectives

5. The objectives of the 2017 EU-wide stress test exercise result directly from the legal mandate given to ESMA under EMIR. The objectives are to:

   - assess the resilience of CCPs to adverse market developments,
   - identify any potential shortcomings in the CCPs' resilience, and
   - issue recommendations as appropriate.

6. The overall design of the stress test framework was also guided by a number of overarching principles. ESMA has assessed the resilience of all scoped CCPs, individually and as a system. This was done on the basis of, as much as possible, common methodologies and criteria. The market shocks and stress assumptions were combined with the simultaneous default of market participants, while the scenario

design considers the EMIR prudential requirements. The EU-wide CCP stress testing exercise is not aimed at assessing the compliance of the CCPs with regulatory requirements nor at identifying any potential deficiency of the stress testing methodology of individual CCPs. It may however expose such individual shortcomings, in which case ESMA will issue the necessary recommendations.

2.3 Scope of the Exercise

7. The stress test exercise covers all EU CCPs that were authorised on the date of the publication of the present report. This includes 16 CCPs[1] and a complete list is provided in 6.1. All services and products, for which CCPs operate clearing services, fall within the scope of the EU-wide CCP stress test. We considered all positions for all clearing members and accounts, including proprietary and client accounts.

8. Concerning the types of risk considered in the stress test exercise, the first exercise conducted by ESMA in 2016 was focused on the counterparty credit risk that EU CCPs would face as a result of potential clearing member defaults and simultaneous market price shocks. The scope of this year's exercise is extended to cover liquidity risk. The liquidity stress test is a separate component of the stress test framework and its design is discussed in detail in section 3.4.

9. Counterparty credit risk due to member defaults and liquidity risk are the core types of risks faced by CCPs. However, CCPs are also subject to other types of risks that are either not covered or are partially covered by this exercise and could in isolation or in combination with credit and liquidity risks challenge their resilience. In particular, risks stemming from price shocks to collateral that go beyond the applicable CCPs' haircuts were not assessed, in an effort to limit the data request and the required effort for all participants. Moreover, risks linked to the investment policy of CCPs, including wrong way risk[2], are only assessed in the context of potential liquidity implications in the liquidity component. Finally, operational, legal and any type of business risks are again left outside the scope of the exercise, because of their largely idiosyncratic nature and may be considered in future exercises.

10. As mentioned above, assessing the compliance of the CCPs with EMIR is not part of the exercise and it is actually assumed and taken as one of the starting points of this exercise, as it is expected to be ensured through the supervisory process involving the NCAs and the Colleges. The stress test does not review, and is not able to conclude whether individual CCPs meet the minimum regulatory requirements. Also potential shortcomings in policies and practices of individual CCPs, such as for example in the operationalisation of default handling procedures, can challenge their resilience but are beyond what will be considered in the course of this exercise.

[1] The stress test exercise covers 16 CCPs, instead of the initially planned 17, since one CCP has closed its operations since the launch of the exercise.
[2] for example the risk linked to a correlation between the default of a participant and the value of the collateral.

2.4 Overview of the Process

11. The methodology and the scope of the EU-wide CCP stress exercise have significantly evolved from the first exercise finalised in April 2016, with the objective to strengthen its robustness. The key improvements are the extension of the scope to include liquidity risk, the improvement of the stress scenario design and implementation (by employing common, internally consistent market stress scenarios) and the enhancement of the validation process. The key steps needed for the implementation of the exercise are summarised in the following figure and discussed in the following paragraphs.

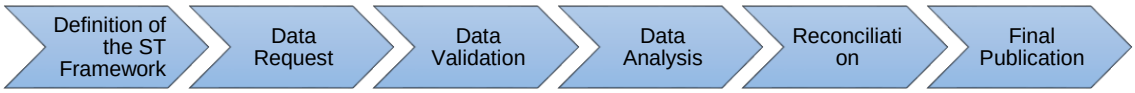


FIGURE 1: OVERVIEW OF THE PROCESS

12. ESMA published in February 2017, the framework for the 2017 CCP Stress Test Exercise[3], setting out the scope, an overview of the methodology and the expected deliverables. The ESRB provided the set of market stress scenarios that were specifically developed for the purpose of this exercise. ESMA defined the data request templates and provided the CCPs with detailed instructions on how they were expected to calculate and report the required data, especially concerning how they were expected to translate the market stress scenarios to P&L calculations for their own portfolios. In order to ensure close cooperation with all the relevant authorities in the design phase, a Stress Test Task Force[4] (STTF) was setup and involved in the development of the framework, including the scenarios, the data request and the assessment of the results. We also organised two workshops, where the CCPs were consulted on the design of the data request templates and the instructions.

13. The data request was launched immediately after the definition of the Stress Test Framework, and the CCPs were requested to deliver the completed data templates to the NCAs. This step was followed by the first data validation phase, where the NCAs validated the submitted data against the instructions and according to a common set of validation rules that detailed the checkpoints and set the allocation of work across the participating authorities (i.e. NCAs and ESMA). Each NCA appointed one officer that was the single point of communication. Where needed, the appointed officers were in contact with ESMA staff and fellow officers from other NCAs in order to facilitate the consistent implementation of the framework across all CCPs. Moreover, in order to facilitate the convergence of the validation practices across different authorities, ESMA staff compiled and shared with the authorities a list of frequently asked questions, together with the respective answers. The first validation phase was concluded with the delivery of the data templates to ESMA that acted as a second line of defence in terms of data quality assurance. Following the NCAs' validation, ESMA checked at least on a

[3] https://www.esma.europa.eu/file/21270/download?token=EmSs2Ank
[4] Participants of the Task Force included experts from National Competent Authorities (NCAs), representatives from other Competent Authorities in the Member States, one representative from ESRB and one representative from ECB. The ESRB participation facilitated the coordination of the input from the ESRB on the price shock definition, while the ECB involvement was particularly relevant for the design of the liquidity stress test.

sample basis, that the reported data are consistent, reasonable and conform to the requirements included in the instructions. It finally assessed the overall plausibility of results, including a comparison between CCP results, to detect any outliers.

14. Following the data validation process, ESMA calculated and analysed the results by applying the member/entity default scenarios. ESMA discussed the results with the Task Force, where the relevant risk experts from almost all the NCAs in the scope of the exercised were present. As a final step, ESMA reconciled part of the results with each individual CCP via the relevant NCA, in an effort to reconfirm their robustness. ESMA could not reconcile with NCAs / CCPs all results, as for example the EU-wide scenarios contain indications about specific clearing members' exposures in other CCPs. Therefore, the set of results that could be shared with each NCA/CCP for reconciliation are only the ones that are CCP-specific and refer to results produced using this specific CCP's exposures. The reconciliation process had to be done within a very short timeframe. The purpose of this process was to reconfirm the correctness of the interpretation of the sourced data and the absorption of losses through the CCP's resources.

15. Overall, although not directly comparable due to the different approach employed, the level of data quality assurance for the credit stress data is much higher than what was achieved during the first exercise. This allows for a higher degree of transparency when it comes to the publication of data. The introduction of an enhanced framework, the two-step validation process and a reconciliation phase has provided additional comfort concerning the quality of the sourced data and the results. One caveat, that has to be emphasised though, is that ESMA staff lacked the resources, detailed knowledge of specificities of products cleared, and direct access to the CCPs in order to redo all the validation checks that have been performed by the NCAs. This also applies regarding checking the details of the modelling procedures employed by each CCP for product-level valuations or conservative propagation of shocks in the forward curve. Therefore, to a significant extent, the quality of the data and results still rely on the primary checks performed by the NCAs.

16. Concerning the level of granularity of published results, the different approach for the liquidity results is justified by the fact that this was the first EU-wide CCP liquidity stress test. Thus, the liquidity stress instructions were lagging in detail, leading to some residual uncertainties concerning the interpretation of the underlying data. Moreover, the liquidity stress tests are generally more complex than the credit stress test, while the approaches used by the different CCPs in their own stress frameworks are also less harmonised and focus more on the individual liquidity needs and sources. Since a multi-CCP exercise cannot acknowledge fully the individual processes at each CCPs, several modelling assumptions needed to be made, which are sensitive to the interpretation of the underlying data and therefore susceptible to potential misleading interpretations.

17. Overall, we believe that the introduced methodological and procedural changes have greatly contributed to the robustness of the exercise. It should however be noted that the changes have at the same time significantly increased the complexity of the exercise and therefore the effort required for all participants involved. Moreover, as with all stress test exercises of this scale and type, not all limitations can and will be addressed in this

exercise. We are however committed to further improve and evolve the methodology in future stress tests.

3 Methodological overview

3.1 Key aspects and components

18. The stress test exercise has the following components:

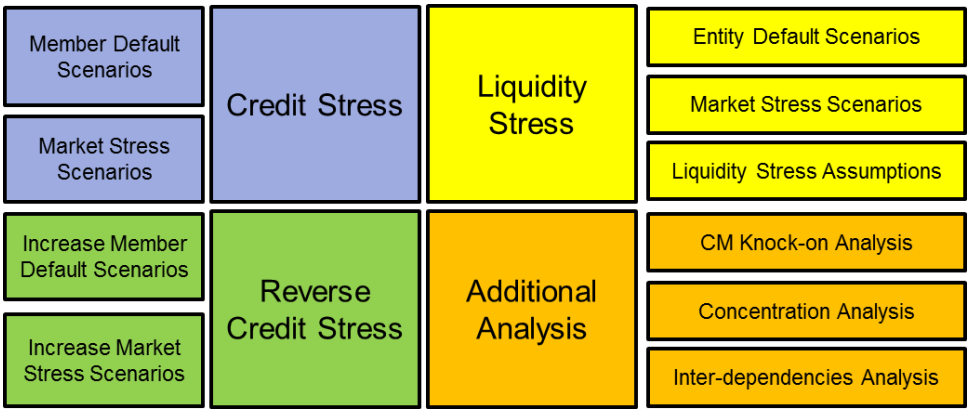


FIGURE 2: COMPONENTS OF THE STRESS TEST EXERCISE

- **Credit Stress**: Assess the sufficiency of CCPs' resources to absorb losses under a combination of market price shocks and member default scenarios.
- **Liquidity Stress**: Assess the sufficiency of CCPs' liquid resources under a combination of market price shocks, member/liquidity provider default scenarios and additional liquidity stress assumptions.
- **Reverse Credit Stress**: Increase the number of defaulting entities and level of shocks to identify at which point resources are exhausted.
- Additional Analysis
    - **Concentration analysis:** Assess the degree of concentration of CCPs exposures.
    - **Inter-connectedness**: Assess the degree of inter-connectedness of CCPs through common clearing members / service providers groups.
    - **CM knock on analysis:** Assess the impact of the loss sharing mechanism of CCPs (default fund contributions and powers of assessments) on the capital of non-defaulting clearing members.

3.2 Market Stress Scenarios

19. One of the key methodological changes of the new exercise has to do with the design and use of the market stress scenarios. In particular, the stress results are not based

on the CCPs' own scenarios subject to a list of minimum price shocks, or on modelled hypothetical scenarios[5]. The stress results in the new exercise are based on a set of pre-defined and internally consistent market stress scenarios that have been provided by the ESRB[6] and are common across all CCPs. The same market stress scenarios are used for credit and liquidity stress tests.

20. The financial shock scenarios stem from an assumed, abrupt (instantaneous) materialisation of one or multiple risks to the EU financial system (as identified by the ESRB).

Box 1: Narrative of the CCP stress test scenario provided by ESRB[6]

The scenarios for the CCP stress test take as a starting point the materialisation of any of the key risks to the EU financial system identified by the ESRB. This could happen in the event that new information or data is released that hints at a likely or actual materialisation of one or more of these risks. This, in turn, may result in a surge in risk premia, leading to major shifts in market prices across a broad range of asset classes. In such an event, market price movements would be coupled with increased volatility. The dependence between asset prices observed during normal times would likely change materially during a short period of time, with no clear direction of safe-haven flows across countries and markets. While such unprecedented asset price movements may be short-lived and global financial markets may stabilise swiftly, it is assumed that markets would undergo pronounced stress lasting for at least five days.

21. The ESRB has developed the methodology and calibrated the common adverse financial scenarios that were used for the current exercise. The ESMA Stress Test Task Force actively provided input and feedback during the design phase in order to ensure that the provided shocks would have the expected level of granularity and severity. The shocks were calibrated for a large number of high-level risk factors and the CCPs were asked to provide stress results for these specific market stress scenarios. This way the results across CCPs will be based on the same scenario and not on different scenarios meeting minimum risk factor shocks.

22. The scenarios are also internally consistent and were calibrated to take into account historical dependencies reflecting realistic assumptions of co-movements of risk factor prices, also in times of stress. In order to respect that condition, it was not possible to simply combine the maximum shocks for different asset classes. For that reason, in order to ensure that all CCPs clearing a wide range of financial products are subject to sufficient stress, it was needed to use multiple (three) scenarios. They differ from each other with respect to the market segment (Rates, CDS or FX) from which a shock is assumed to originate. Each shock scenario is consistent in that dependencies of all risk

[5] HypA / HypB scenarios used in the first exercise were calibrated by scaling up margin requirements.
[6] link to Stress Scenarios

factors vis-à-vis the shock origin are accounted for. For example, the first scenario ("CDS") reflects severe shocks for many asset classes, including Equities, Bonds and CDS. Since it could be misleading to associate the scenarios and severity of relevant results to individual asset classes, we used for the identification of the market stress scenarios the codes 1, 2 and 3 instead of the original names.

23. EMIR mandates that for each identified market the CCP shall specify extreme but plausible conditions based at least on a range of historical scenarios, including periods of extreme market movements observed over the past 30 years, or as long as reliable data have been available, that would have exposed the CCP to the greatest possible financial risk. The initially proposed methodology with a 2-day simulation period did not produce high enough stress levels to match the observed historical worst cases for most risk factors. This could be in part linked to some basket averaging effect coming from the choice of a set of driving risk factors and from the technical limits arising from the confidence level that can be chosen. In order to achieve a higher severity while keeping the same co-dependency between the returns, the CDS and Rates scenarios have been scaled by a common factor. The choice of the scaling according to the 5-day rule yields reasonable numbers across asset classes consistent with the observed historical worst cases.

Box 2: Simulation methodology employed by ESRB

The simulation methodology is based on a nonparametric conditional expected shortfall approach. In each of the scenarios, the shock originates in a market segment to which CCPs are exposed. The dependencies of all risk factors vis-à-vis the shock origin are captured in a nonparametric manner, i.e. without pre-imposing any parametric functional form on either the marginal distributions or the copula that, together, constitute a joint distribution of all factors. Many of the factors involved in the scenarios are characterised by highly non-normal features; therefore, a nonparametric approach is warranted in order to avoid parametric misspecification that might otherwise result in an underestimation of tail risk responses.

The scenarios are designed under the assumption of a predefined shock probability of 0.1%, along with a forward horizon of two or five business days[7]. First, a nonparametric conditional expected shortfall shock simulation is conducted using a rolling window of 60 business days over the whole sample period and the conditional responses of all risk factors are recorded. Then, in a second step, the 60-day window which, on average, implies the maximum conditional responses to the shock is selected to generate the shock responses.

[7] Under the plain bootstrap approach, used in these simulations, it was not possible to achieve higher severity over a two-day horizon, as reducing the probability to below 0.1% did not add to the severity for statistical reasons. Therefore, the shock response profiles were initially simulated at the two-day horizon with a 0.1% probability and then scaled up to a five-day horizon for CDS and RATES scenarios in order to achieve higher severity.

3.3 Credit Stress Test

24. The objective of the credit stress test is to assess the sufficiency of CCPs' resources to absorb losses under a combination of market price shocks and member default scenarios. The CCPs were asked to report for each clearing member and default fund the losses they would face in case of the member's default under specific market stress scenarios and the amount of resources that could be used to cover those losses. ESMA then identified, based on the different member default scenarios, the entities with the top exposures by comparing the reported losses to the resources that are available to cope with the default. The results are presented for different combinations of member default scenarios and market stress scenarios.

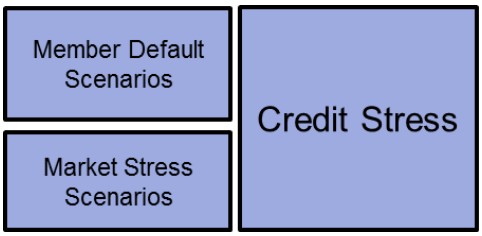


FIGURE 3: CREDIT STRESS TEST COMPONENTS

3.3.1 Calculation of Credit Exposures using Market Stress scenarios

25. Given that it was not feasible to define scenarios for each and every risk factor of all CCP-cleared contracts, the scenarios were defined for a set of (approximately 550) high level risk factors across six asset classes and the CCPs needed to translate the risk factor shocks into P&L for their cleared products and members' portfolios. Therefore, the CCPs were provided together with the data request and the market stress scenarios a set of instructions that explained how these were to be implemented. The instructions were drafted to provide clarity and address all material implementation challenges. Some of the key provisions in the instructions are discussed below in order to outline the assumptions underlying the exercise.

26. The test was run for a single reference date, for all CCPs, in order to limit the calculation / validation effort for all participants. The selected stress date was Saturday 17 September 2016. This specific date was selected in order to reflect in the results of the exercise the increased activity and exposures from quarterly expiries (3rd Friday). Moreover, we selected a date that preceded the data request in an effort to avoid having CCPs improving their positions in anticipation of the exercise.

27. The default scenario simulated a 'weekend' default, where the members are declared to be in default on Monday morning and do not cover obligations that are due on Monday. All payments due on the Friday prior to the default are assumed to be met in full. After the default, which occurs during the weekend, no payments are exchanged between the CCP and the defaulting member. Trading access is revoked during the weekend, so that no position changes are accepted after the last novation cycle of Friday. The positions therefore reflect the positions as of Friday end of day, including all transactions that were accepted for novation during Friday.

28. In the determination of losses, no hedging strategy is to be acknowledged or modelled. In other words, the CCP is assumed to not having performed any risk mitigating transactions in order to limit the risk of the defaulting member's positions, but liquidate all defaulting member's position at the stressed price. All price movements are supposed to be happening instantaneously at the time the defaults are announced and no further price action after Monday was modelled.

29. All positions are assumed to be closed, for each individual account, at the prices implied by the stress market shocks. The CCPs were asked to report the requested data, for each default fund, at clearing member (and not account) level in order to constraint the amount of data to be managed. The CCPs still needed to reflect all applicable segregation rules, e.g. that client's resources cannot be used to cover losses from house positions. It was assumed that no porting of clients would occur, hence all client's account are not assumed to be ported and are assumed to be liquidated at the same stressed prices.

30. The CCPs are asked to report both the minimum required collateral, i.e. not including any excess amounts, and separately the total available collateral. The minimum required margins were defined as the sum of the following amounts:

- the margins required on Friday morning,
- any payment issued and paid during Friday as a result of margin calls,
- any of the collateral previously held as excess but consumed by the member's activity or intra-day valuations during Friday and offset against the computation by the CCP of margin requirements during Friday, the absence of which would have led to a margin call according to the CCP's existing rules and procedures.

31. The minimum required collateral is meant to reflect a scenario where defaulting members would have withdrawn under stressed conditions any collateral exceeding the minimum required. In fact, any member experiencing financial difficulties would most probably post only the minimum required collateral. Nevertheless, the CCPs have been asked to report also the actually held (total available) collateral, including excess amounts. Therefore, although the base stress results will only consider the required collateral, for completeness reasons we will also present the stress test results using the excess collateral, where this would make a difference. In order to make the two sets of results (with / without excess) directly comparable, the same defaulting entities will be considered and in particular, the defaulting entities will always be selected using the minimum required collateral without the excess.

32. Beyond the margin collateral that cannot be used to cover losses stemming from other member(s)[8], the CCPs were also asked to report additional prefunded resources that correspond to the different layers of their default waterfall, i.e. the resources that can be used in case of a clearing member default. These included the default fund contributions of clearing members, the additional dedicated CCP resources ("skin-in-the-game" or

[8] Additional restrictions apply, such as for example, that client collateral can only be used to cover losses from the same account. The CCPs were asked to reflect these restrictions in the stress losses reported.

SITG) as required by EMIR and other additional resources that can be used in case of a default of a clearing member, where applicable.

33. A typical default waterfall is presented below, only for illustration purposes. The actual default waterfall of each individual CCP, as this was reflected in the data reported, has been considered to calculate the absorption of losses in the EU-wide CCP stress tests.

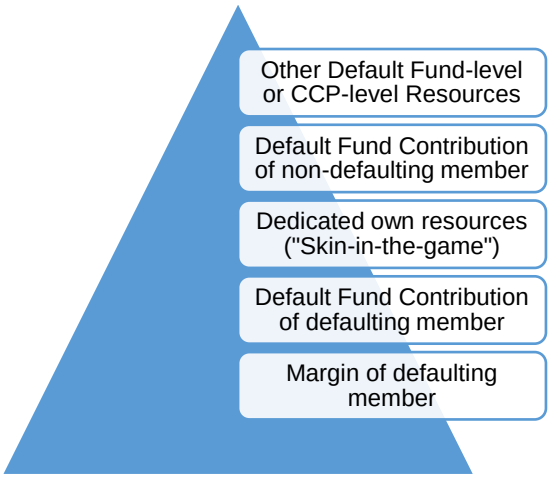


FIGURE 4: CCP DEFAULT WATERFALL

34. The default fund amounts considered in the stress exercise reflect the minimum default fund contributions actually paid on the Friday evening before the default. Pending default fund contributions that were not met until that time were not taken into account. Concerning the own dedicated resources, ("skin-in-the-game"), the CCPs were asked to report the full actual dedicated resources as of the reference date, even if higher than the minimum requirement[9].

35. CCPs were also asked to report additional committed and prefunded resources, where available to cover losses within the given default fund (other DF-level resources) or across Default Funds (other CCP-level resources). According to the instructions, these resources should be committed and prefunded, reflected in the rules of the CCP setting the applicable default waterfall and invested in accordance with the investment policy requirements of EMIR. This type of resources cannot include any type of (parental[10]) guarantees.

36. Beyond the prefunded resources, the CCPs were also asked to report separately the amount of Powers of Assessment[11] that can be called from each member and default fund. Since the amount that can be called may depend on the number of defaulting members, the CCPs were asked to report the maximum amount subject to different number of members defaulting, in line with the provisions of their own Rulebooks as of the reference date.

[9] As set in EMIR RTS Article 35.
[10] e.g. non-prefunded guarantees provided by affiliates.
[11] Powers of Assessment refer to additional not-prefunded resources that can be called from non-defaulting clearing members following a default.

37. The amounts were reported in one currency (EUR) also accounting for the provided FX shocks. In particular, the conversion of results from other currencies to EUR, was performed using the ECB exchange rate as of Friday before the default, and the shocks provided for the stress of FX markets. In other words, all currency conversions reflected the stressed exchange rates.

38. CCPs were also instructed on how to identify or adjust when needed the shocks to be applied to their own products using the defined risk factor shocks. Instructions were provided, where relevant, also per asset class. For example, this included the methodology used for calibrating shock multipliers for underlyings with high volatility or low liquidity, the treatment of products with no directly applicable shocks[12], and the methodology to be used for modelling shocks along the different point in the curves. As a general rule, CCPs needed to operate a full repricing on the basis of the provided risk factor shocks using the pricing models they normally use for the daily valuations of positions, as opposed to any approximate pricing model or sensitivity-based estimation of losses. Wherever available, CCPs were instructed to use actual market prices for the base price, i.e. the price to which the shocks are to be applied. Model-implied prices were only to be accepted where market prices are not available or not reliable.

39. Overall, the level of the granularity of the instructions was driven by the need to balance between very detailed instructions that would not cater for the different characteristics of products cleared at different CCPs and very high-level instructions that would leave large room to the CCPs for interpretation. The instructions were drafted with a view to provide clarity and address all material implementation challenges. Considering the very large number of products cleared at the different CCPs, it was not possible for ESMA to verify the prudent interpretation of the instructions across all CCPs, since it would require the knowledge of the characteristics of the different products. The NCAs, having direct access to the CCPs and better knowledge of the individual products cleared at each CCP, were in a better position to check during the validation process and verify the prudent implementation of the provided instructions.

3.3.2 Member Default Scenarios for Credit Stress Test

40. The credit stress test targets to assess the sufficiency of CCPs' resources subject to a number of clearing members defaulting under stressed market conditions. Therefore, the results are always presented for a combination of one of the three market stress scenarios with a member default scenario. The member default scenarios define the conditions that are used to select the entities that are considered to be in default. The following member default scenarios were tested.

41. **MD-A:** For each CCP, we identify the two (2) Clearing Members with the highest exposure under a particular market scenario. These members are considered to be in default across all CCPs. This means that a CCP can face multiple members (more than 2) defaulting at the same time. This member default scenario may lead to an extremely

[12] This is only the case for a few products with an assumed marginal impact on the end-results. The CCPs were instructed to use their own stress scenarios, making also sure that these are consistent with the provided narrative.

large number of clearing members defaulting, because of the cross-default condition. However, it has the merit of ensuring that members will default in all CCPs and thus all CCPs will be stressed at the same time.

42. **MD-B:** Across all CCPs (EU-wide), we identify the two (2) corporate groups with the highest aggregate exposure under a particular market scenario. All clearing members that belong to an identified corporate group are assumed to default across all CCPs. Also in this case, this may count for more than 2 members per CCP but the number of members defaulting at each CCP is expected to be smaller when compared to the MD-A scenarios. The reason for that is that the initial condition requires the default of 2 groups across all CCPs as opposed to 2 members per CCP.

43. **Cover-2 groups per CCP:** For this scenario, we select the defaulting clearing members as the members belonging to the top-2 groups of clearing members for each CCP. The defaulting clearing members will be different for each CCP and are not considered to be in default in other CCPs. This scenario includes the rather unrealistic assumption that an entity would default in only one CCP, but will help assess the resilience of individual CCPs and interpret the results. In particular, the MD-A scenario, where we select the top-2 clearing members per CCP and then consider these entities to be in default in all other CCPs, leads to an extremely large number of entities defaulting at EU-wide and at CCP level. The assessment of the resilience of individual CCPs cannot be solely based on a scenario involving this rather unrealistic number of defaults. Moreover, the MD-B scenarios, where we select the top-2 groups EU-wide, cannot be used to assess the resilience of individual CCPs, as the selection algorithm will always focus on the two most systemically important groups and may fail to highlight shortfalls for individual CCPs. Therefore, the inclusion of this member default scenario is important in order to allow the assessment of the resilience of individual CCPs.

44. We also explored the use of an additional member default scenario (MD-C), which is in practice only a variation of MD-B. Across all CCPs (EU-wide), we would identify the two (2) corporate groups with the highest aggregate exposure weighted by the probability of default under a particular market scenario. The weighting was based on the multiplication of exposures with default probabilities (which is not contemplated in MD-B), while the probabilities of default (PDs) were provided by ESRB[13]. The methodology used to calculate the market-implied PDs, is detailed in the scenarios provided by ESRB. One should note, that the PDs would be used to weight the exposures only when selecting the top groups, while the unweighted exposures would be used to assess the sufficiency of the resources of CCPs. MD-C could represent a more likely scenario to materialise, as it takes into account the probability of the default of an entity. It was identified that the results from this scenario would be very similar to the results of the MD-B scenario, leading to broadly the same defaulting members and therefore impact on CCPs. Therefore, it was decided not to present these results, as also by construction the MD-B scenario will always generate more losses than MD-C.

[13] The ESRB provided the CDS-implied PDs for a list of entity groups that was selected by ESMA as the most relevant in terms of exposure. If one group consisted of more than one entity, the average CDS price of the group was computed by averaging over the average CDS price of each entity. Where the PD was not available, a default value was used.

3.3.3 Residual Limitation of Credit Stress Test

45. As with all similar exercises, not all limitations can be addressed within a single and at the same time practicable design. The methodology has significantly evolved to address important limitations that were experienced in the first EU-wide stress test. The following limitations will not be addressed in the context of credit stress analysis in this year's exercise. As already stated, we are committed to further improve and evolve the methodology in future exercises.

46. Any risks stemming from CCPs policies/decisions to invest the available resources including the provided collateral will not be covered in the context of the credit stress test, as the CCPs were asked to report the cash equivalent amounts. For example, any potential losses linked to the selection of the custodian or counterparty of CCPs investments are not explored in the course of the credit stress exercise. Potential adverse implications on the liquidity risk profile are further explored in the context of the liquidity stress test. Similarly, any residual market risks in case of collateral prices falling more than what is reflected in the CCPs haircuts are not considered.

47. Wrong way risks linked to the default of the issuer of instruments that are cleared or used as collateral / investment can also not be considered, as the defaulting entities will be identified after the data delivery. For example, wrong way risk would materialise if part of the collateral posted to the CCP by one defaulting member was issued by another defaulting member. This limitation is due to the fact that the selection of which members are supposed to default needs to be performed ex-ante by selecting the largest exposures to a member or to its group.

48. Potential second round effects to prices following the default of entities will not be modelled. The price shocks are the ones provided by the ESRB and the number of defaults are the ones described above, but the two are taken exogenously. Also, the default of additional entities due to losses accumulated from non-cleared exposures are not considered because the scope of the exercise is limited to CCPs exposures. The potential of second round effects to non-defaulting members via the risk-sharing mechanism of CCPs (e.g. default fund and powers of assessment) will be assessed as part of the additional analysis (CM knock on analysis), but only the defaults implied by the member default scenarios will be considered when testing the sufficiency of the resources.

3.4 Liquidity Stress Test

49. For the purpose of the ESMA Union-wide stress test, liquidity risk can be defined as the risk that the CCP has insufficient liquid funds to meet its payment obligations in a timely manner when they become due over the relevant time horizon. It can arise due to unexpected generation of liquidity needs and/or absence of sufficient liquidity resources.

50. The liquidity stress test assesses the resilience of EU CCPs to market wide and idiosyncratic liquidity stress events. It captures the systemic dimension of liquidity risk

in addition to the analysis of resilience of individual CCPs and enables ESMA to identify potential shortcomings and issue recommendations to address those.

51. Under Article 51(2) of the RTS (Commission Delegated Regulation EU No 153/2013), CCPs are required to conduct stress tests considering inter alia their liquidity risk management frameworks. Under Article 54(3) of the RTS, scenarios used in the stress testing of liquid financial resources must consider the design and operation of the CCP, and include all entities that might pose material liquidity risk to it.

52. Article 32(4 and 5) of the RTS prescribe the framework to be designed and implemented by individual CCPs in order to accurately address the liquidity risk dimension of the CCP stress tests, taking into account any interdependencies across the entities and multiple relationships it might have to those entities in its liquidity risk management framework.

53. ESMA incorporated the above regulatory requirements in the design of this exercise.

3.4.1 Liquidity modelling overview

54. The objective of the liquidity stress test is to assess the adequacy of CCPs' liquid resources under a combination of market price shocks, member and/or liquidity provider default scenarios and additional liquidity stress assumptions.

55. A liquidity scenario involves the combination of market shocks with the simultaneous default of market participants. The shocks are the ones applied in the context of counterparty credit risk. The default of market participants is the actual or technical insolvency of Clearing Members and/or providers of liquidity and services with impact on the liquidity profile of an individual CCP.

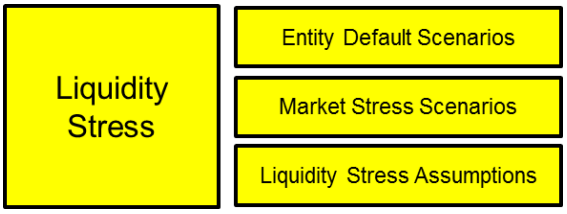


FIGURE 5: LIQUIDITY STRESS TEST COMPONENTS

56. Given the market shocks, cash inflows and outflows were calculated and reported by the CCPs for the whole duration of the liquidity horizon. The liquidity horizon is set at 7 days, as some CCPs use a 7 days MPOR on OTC products. A final bucket aggregates any cash flows that come strictly after the maximum horizon.

57. A liquidity mismatch analysis of individual CCPs is then run under the different scenarios; all projected cash in- and outflows, linked to clearing, facilitating settlements and payments and investment activities as well as other cash flows relevant to the operational activities of the CCPs for the predefined time horizon are aggregated per time bucket and the counterbalancing capacity is assessed.

58. Liquidity risk is generated by the following channels:

59. **Variation Margin due by the defaulted CMs**: CCPs need to post cash VM to non-defaulting CMs for positions held by defaulted CMs.

60. **Reduction of initial margin of non-defaulting CMs:** changes in initial margin requirements of non-defaulting CMs are accounted for.
61. **Settlement of obligations of defaulted CMs:** cash flows are linked to the fulfilment of the settlement of physical obligations of the defaulted CM. Cash outflows are generated when a CCP has to step in on behalf of the defaulted CMs to post cash to non-defaulting CMs or when a CCP needs to execute buy-in transactions for failed deliveries on behalf of the defaulting member.
62. **Non-performance of liquidity provider,** which would imply a reduction of the counterbalancing capacity (e.g. investment counterparties, credit line provider, investment agent for funds received temporarily into its accounts, repo counterparties).
63. **Non-performance of service provider:** the CCP cannot get access to the funds accumulated on its accounts with the payment / settlement / concentration bank due to its failure.
64. **Failure of custodian,** which would incur in delayed/impaired access to assets held with that custodian (including non-cash collateral and investments). We will assume no access at all for the liquidity horizon.
65. The implementation of the methodology to compute exposures and resources was implemented through an in-house program. Therefore, there is no discretion in how the method is applied across CCPs.
66. The methodology was run on data provided by the CCPs and validated by the NCAs. ESMA staff performed different levels of checks, ensuring for example a minimum level of consistency between credit and liquidity. However, given the nature of the exercise and its sensitivity to some of its inputs, the results could be affected by errors in the data provided or assumptions used by CCPs to extract these data. The two levels of validations (by NCAs and ESMA staff) aimed at limiting the risk of wrong computations by CCPs, but this risk cannot be completely eliminated with ex-post desk-based verifications.

3.4.2 Evaluating the liquidity position of a CCP

67. As required by the framework, ESMA staff assessed the liquidity position of each CCP in each of the currencies that it clears in, assuming that there is no access to the short-term FX markets. We will only report the results for the main currencies: EUR, USD and GBP.
68. In addition, the overall liquidity position of that CCP is assessed by relaxing the assumption of FX market closure at the CCP level.
69. Given a set of liquidity assumptions, the algorithm identifies: the liquid resources, liquidity requirements and other counterbalancing capacities.

70. The algorithm then computes the liquidity position, performing the aggregation according to the right of use of collateral rules[14].

3.4.2.1 Liquidity assumptions

71. Before assessing the liquidity position of a CCP, a selection of the defaulting entities and of the modelling assumptions is performed.
72. The entities considered to be in default under the different scenarios are selected from an initial list of all entities having one of the following capacities: clearing members, issuers, custodians, payments banks or repo counterparties.
73. CSDs, Central Banks or issuers of government fixed income securities are never defaulted in the exercise. The interoperability between CCPs is not taken into account.
74. The payment bank capacity is tested by assuming that any net positive inflow going through a defaulting payment bank will be lost if it occurs at T+0 (Monday). This is done for each clearing member in each relevant currency.
75. Based on the framework, various liquidity assumptions are made, covering both the market conditions and the tools available to the CCPs. In the presentation of the results, we varied some of the assumptions to assess their impact.
76. In particular, we analysed the impact of: a market access delay of one day when attempting to sell liquid resources, of a settlement lag of 2 days for sell-offs of liquid resources and securities, and of including excess collateral in the liquid resources.
77. Therefore, the exercise tests different tools used to fulfil liquidity needs, i.e.is based on a set of very conservative, but realistic end of day assumptions to compute the liquidity needs of the different CCPs. These assumptions are:
    a. No access to short-term FX markets.
    b. Market access delay of one day for liquid resources.
    c. A settlement lag of 2 days for asset sell-offs.
    d. No use of excess collateral.
    e. No use of uncommitted repo lines.
78. As explain in section 4.6, some of those assumptions are relaxed to identify the tools on which CCPs rely on to fulfil their liquidity needs.
79. In addition, when CCPs have access to central bank liquidity and although this liquidity resource is highly reliable, we have quantified the reliance on this tool by testing the liquidity need that would result in the implausible event of absence to central bank repo. This by no means puts into question the availability of this tool, but it is the only way to test the degree of reliance on it, which was one of the objectives of the exercise.

[14] For example: a security posted as collateral by a member may or may not be usable by the CCP for liquidity purposes for the management of a default

3.4.2.2 Identifying the liquid resources

80. Within the chosen default fund and the chosen currency, we selected all the liquid resources (defined in Article 47(1) of EMIR and Annex II of the RTS) that are not in the custody of or issued by the defaulting entities. Uncommitted credit lines are not taken into account.
81. Liquid resources must be of one of the following types: Cash - Central Bank, Cash - Commercial Bank Secured (Reverse Repo), Cash - Commercial Bank Unsecured (Deposit), Government Fixed Income Securities, Other Fixed Income Securities, Equities or Committed Line. Banks guarantees are not considered.
82. The liquid resources considered are the ones allocated to CCP own funds, committed lines, default fund contributions, required collateral / IM or SIG (skin in the game).

3.4.2.3 Identifying the liquidity requirements

83. In each relevant currency, the CCPs have reported the schedule of flows arising from Variation Margin, Premium Settlements, IM change, Settlement. ESMA staff checked the reporting convention for flows to achieve consistency between credit and liquidity.
84. The algorithm selects the relevant liquidity requirements given the defaulting entities and the assumptions, assuming that the CCP will have to make / receive payments to / from non-defaulting clearing members.
85. The close of business schedule will add cumulative relevant cash flows per clearing member.
86. Any flows from liquidity provisions are added at this stage.

3.4.2.4 Liquidity exposure profile

87. The schedule of liquid resources is modified to reflect the assumptions made on market access delay, on settlement lag and on the nature of the repo lines (committed/uncommitted).
88. It takes into account the list of repo counterparties and their respective capacities per currency. It is assumed that repos are entered up to the maximum capacity per currency given the available collateral for the maximum duration.
89. Likewise, the schedule of liquidity requirements is modified to reflect liquidity provisions and intraday assumptions.
90. The intraday modelling depends on the number of settlement cycles. The purchase of securities that should have been delivered by the defaulting clearing members need to be done before starting the settlement cycle. This extra liquidity need is added on the day of the purchase only. The number of securities to be bought is inversely proportional to the number of settlement cycles. The more settlement cycles the less significant the intraday impact will be.

91. Under the chosen working assumptions, the schedule of liquidity exposures is generated by aggregating the different resources and requirements.

92. Having looked at the resources available in each default fund, we then look at the resources available from the defaulting members that were not already taken into account. This could include resources not used in one default fund, and that could be used in another one.

93. The CCPs were able to define the largest usage possible for each resource (i.e. clearing member, default fund or CCP level). Some resources are restricted to clearing member or default fund level.

94. For each non-defaulting clearing member that has the usage of its collateral restricted to itself, we take out from the liquidity position both its restricted liquid resources and the liquidity requirements for “IM change” and “Premium Settlements”. The “Variation Margin” and “Settlement” flows are unaffected as they are passed through.

95. We assume that all resources of defaulting CMs can be used at CCP level. We make the simplifying and lenient assumption here that even client margin of a defaulting member can be used for liquidity purposes only at CCP level.

96. We then perform the aggregation and get the final position per currency. The worst position over the schedule is taken as the liquidity position.

97. Finally, to get the overall liquidity position, assuming access to the short term FX markets, we aggregate all the currencies, converting them to EUR using stressed FX Rates.

3.4.3 Entity selection procedure

98. For each market stress scenario, ESMA staff performed the selection of entities using the most conservative end of day liquidity assumptions. No selection was performed using any other set of assumptions.

99. When performing further analysis by varying the liquidity assumptions, we will assume that the entities defaulting are unchanged. This helps the analysis and reduces the computational requirements. This means however that the entities selected are not necessarily the worst ones in terms of liquidity outside of the most conservative assumptions.

100. The selection is based on the worst liquidity position aggregated over all currencies given the defaulting entities. In order not to select an entity based on a marginal gap in a marginal currency, any excess from one default fund is not restricted to that default fund. Therefore, the entities selected are not necessarily the worst ones in terms of liquidity for each currency.

101. As restricting the defaults to 2 entities or groups per CCP generates interesting results already, we are not reporting results assuming that all those entities default across CCPs, which would generate unrealistic liquidity requirements on the CCPs.

102. However, we are reporting the results from a scenario called LDB where we select the top-2 groups EU-wide.

4 Stress Test Results

4.1 Background Analysis

103. The 16 CCPs included in the scope of the exercise provided detailed data on their exposures and resources. This data was used to run the credit and liquidity stress tests presented in the following sections. The background analysis presented in this section is used to set the scene for the core stress test analysis, provide a useful overview of the size of the industry, the breakdown of activity by individual CCPs or participants and also to help identifying convergent or divergent practices.

104. It should be noted, that the resources required from CCPs may vary significantly from one day to another and the presented results correspond to one particular date, i.e. the reference date of the stress test. It cannot therefore provide any information on the height of the resources held at any other time, including the time of publication of this report. Although one can identify different practices and risk management techniques, the purpose of presenting this data is not to benchmark CCPs. Different CCPs clear different products with distinct characteristics. The size of resources or exposures alone cannot indicate the effectiveness or efficiency of the CCP's risk mitigation arrangements. The resilience of CCPs to adverse market developments is assessed using the credit and liquidity stress results presented in the following sections.

4.1.1 CCPs

105. The total amount of default fund contributions at each CCP is presented in the following chart. For CCPs that have more than one default funds, this corresponds to the sum across all default funds. The CCPs are ranked by the total amount of default fund contributions and it can be seen that the top-5 CCPs are significantly larger than the remaining CCPs. The total amount of default fund contributions across all CCPs corresponds to 21.7bn EUR, with the top-5 CCPs collecting 93% of these contributions.

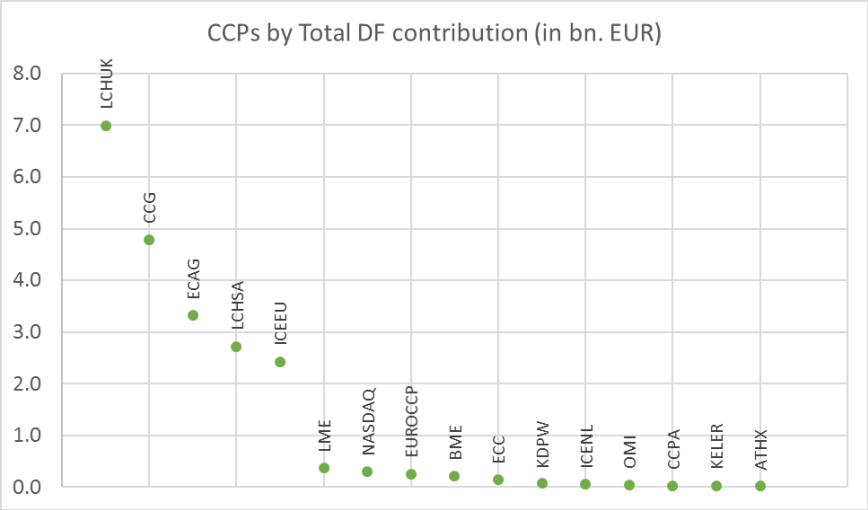


FIGURE 6: CCPS BY TOTAL SIZE OF DEFAULT FUNDS

106. The total amount of margin required by each one of the 16 CCPs across all their clearing services is presented in the following figure. The illustrated amounts include all required margin, such as initial margin and the different margin add-ons, but exclude any excess margin held on top of the minimum required. The conditions used to define the required versus the total (i.e. including excess) margin are set out in 3.3.1.

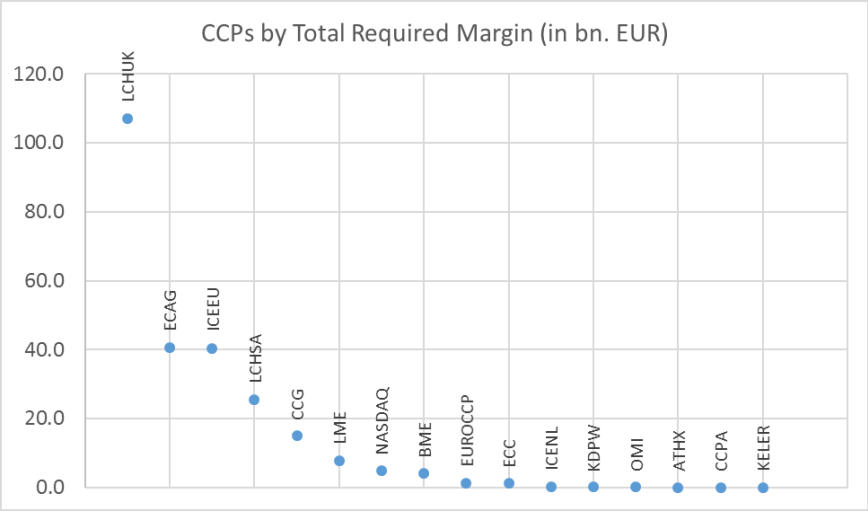


FIGURE 7: CCPS BY TOTAL REQUIRED MARGIN

107. The same CCPs are top-5 in terms of total required margin and total default fund contributions and, similar to what is observed in the default fund case, they account for approximately 92% of the total margin required from all CCPs. However, the margin requirement for one CCP is significantly higher than the margin requirement of all the remaining CCPs, while also the rank of the top 5 CCPs is not the same in the two charts. These indicate that the allocation of resources between margin and default fund contributions is not always proportional. This can also be observed in Figure 8, where for each CCP we plot, using a logarithmic scale, the required margin versus the default fund contributions.

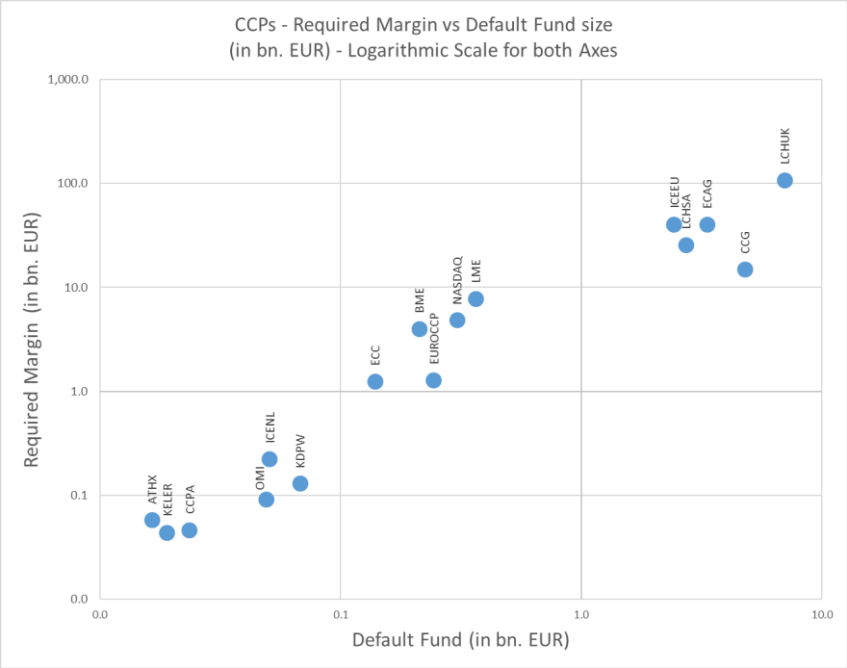


FIGURE 8: TOTAL REQUIRED MARGIN VS DEFAULT FUND CONTRIBUTIONS

108. The size of the default fund contributions compared to the margin requirements depends on several other factors, such as the number of clearing members, the concentration of the exposures to the top clearing members, the minimum default fund contributions and the ratio between adverse and stressed market conditions. Therefore, it should again be highlighted that this alone can in no way be used as an indication of the effectiveness or the efficiency of a CCP's risk management arrangements.

4.1.2 Clearing Members

109. Close to 900 individual entities being clearing members to one or more CCPs have been identified, while approximately 40 entities were members at 5 or more CCPs. The number of clearing members and cumulative share (percentage), in terms of their aggregate contribution to the Default Fund of all CCPs (Figure 9) and in terms of the aggregate margin required again from all CCPs (Figure 10) are presented below.

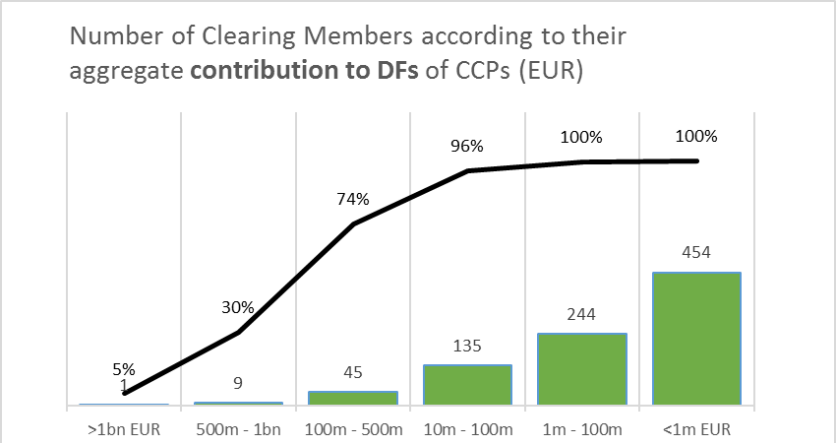


FIGURE 9: CLEARING MEMBERS ACCORDING TO THEIR AGGREGATE DF contributions

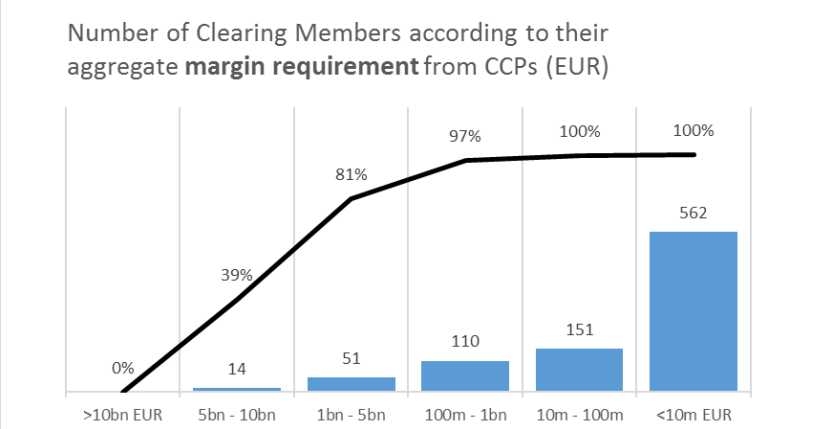


FIGURE 10: CLEARING MEMBERS ACCORDING TO THEIR AGGREGATE MARGIN REQUIREMENT

110. It can be seen that one single entity has an aggregate default fund contribution of more than 1bn EUR. In terms of margin requirement, the top 14 entities have each provided margins that were higher than 5bn EUR. In both cases, the top-10 entities account for approximately 30% of the resources provided and overall there is no strong evidence of significant concentration of resources.

111. As expected, when the same analysis is run at the corporate group level, after adding the resources provided by affiliates within a single group, the level of concentration increases (Figure 11 and Figure 12). In total, we have identified approximately 65 clearing member groups having more than one entity active as a clearing member at EU-CCPs. The top-10 groups account for approximately 50% of the provided resources, while there are 5 groups with a default fund contribution of more than 1bn EUR and 10 groups with a margin requirement of more than 10bn EUR.

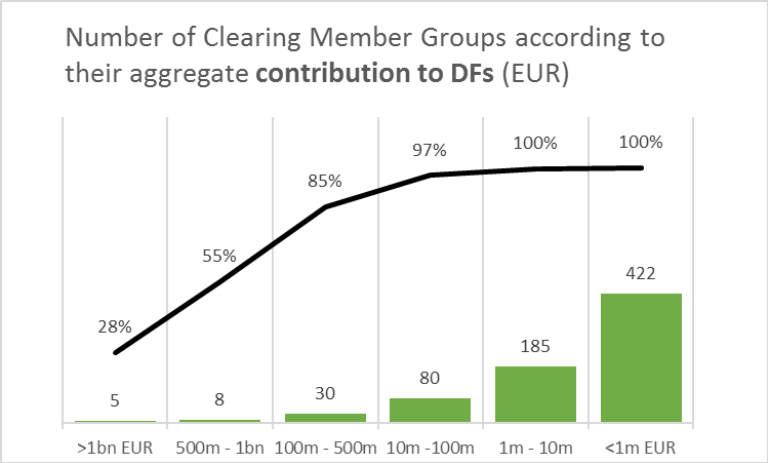


FIGURE 11: CLEARING MEMBER GROUPS ACCORDING TO THEIR AGGREGATE DF CONTRIBUTIONS

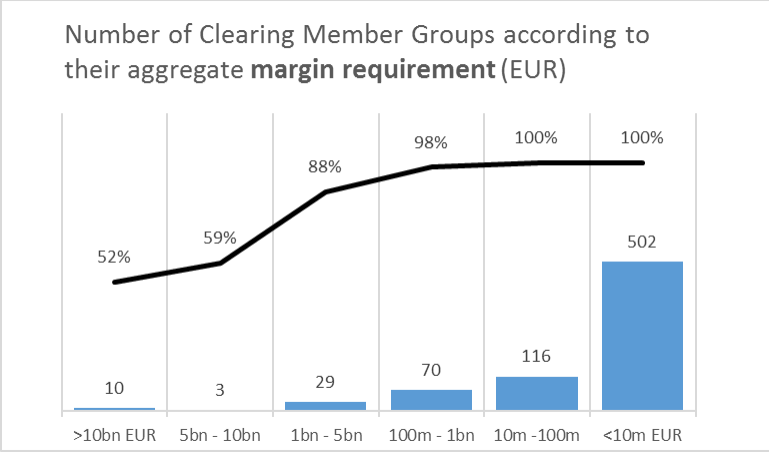


FIGURE 12: CLEARING MEMBER GROUPS ACCORDING TO THEIR AGGREGATE MARGIN REQUIREMENT

4.1.3 Prefunded Resources

112. The total amount (and % share) of resources allocated to each tranche of the default waterfall across all CCPs can be seen in the following picture. The aggregate margin requirement from all CCPs is approximately 250bn EUR with the total default fund contributions reaching 21.7bn EUR (8% of all resources). The dedicated own resources ("skin-in-the-game") account for a very small part of the default waterfall (0.2%), while this is also the case for other additional prefunded resources provided by the CCPs.

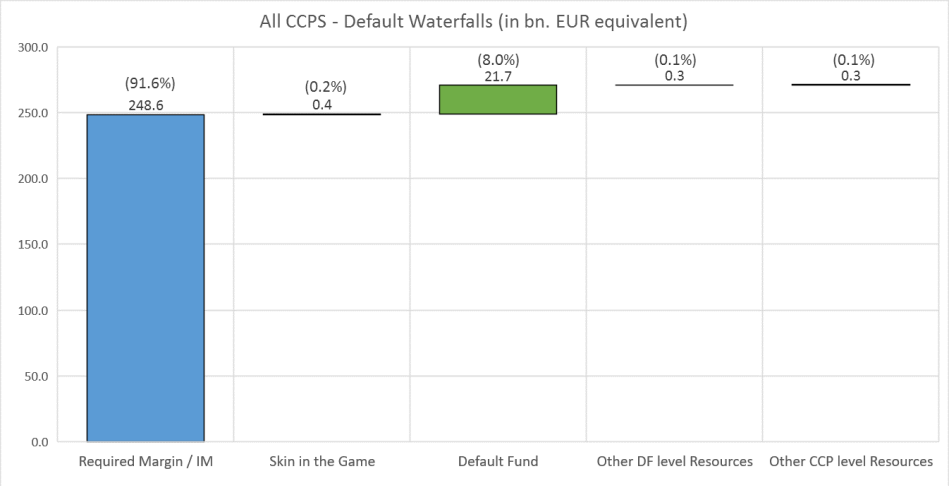


FIGURE 13: DEFAULT WATERFALL AMOUNTS – ALL CCPS

113. It should be noted that the resources presented in Figure 13, can only be used according to their priority in the default waterfall and subject to the limitations provided in EMIR and each individual CCP's rulebook. For example, the margin amounts allocated to clients' accounts can only be used to cover losses stemming from the same account, while margin cannot be used across clearing members. Therefore, not all amounts presented in the following chart will be liable to cover losses. This is duly considered when losses are allocated in the stress exercise.

114. If we zoom in on the allocation of resources at each individual CCP (Figure 14), it can be observed that only for smaller CCPs, the dedicated own resources ("skin-in-the-game") account for an observable share of the default waterfall. This is due to the methodology imposed for the calculation of the regulatory minimum amount of dedicated own resources. However, even in these cases the actual amounts are small. The default fund contributions across the different CCPs range between 4% and 33% of the total resources. As a general remark, it can be seen that the smaller CCPs also tend to have a larger default fund relative to the total available resources. Also on a theoretical basis, since all CCPs have to meet as a minimum and independently of their size, the cover-2 requirement, the risk-sharing part will generally be smaller for CCPs that have a larger number of clearing members and smoother allocation of exposures across their top participants.

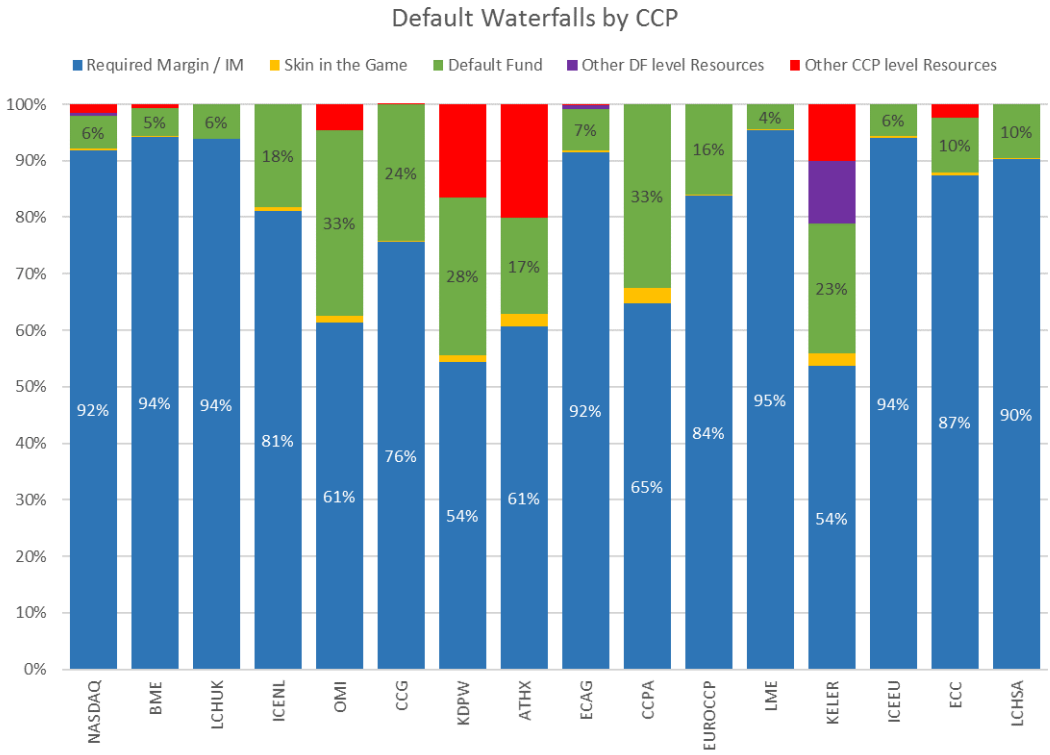


FIGURE 14: DEFAULT WATERFALL % PER CCP

4.1.4 Required / Excess Collateral

115. CCPs were asked to report both the required and the total available margin collateral. The assessment of the resilience of the CCPs will be primarily based on the minimum required collateral. Overall, the excess collateral accounted for approximately 40bn EUR and a relatively small percentage (13%) of the total provided margin collateral.

116. However, this is not the case for all CCPs. In particular, as it can be seen in Figure 16, for 5 CCPs the excess collateral is higher than the minimum required collateral. Although not always the case, one can observe that the share of the excess margin tends to be higher for smaller CCPs and in particular CCPs that clear cash securities. One of the key differences between cash- and derivative- clearing services is that for the derivative clearing services the exposure is mainly driven by the stock of the existing positions, while for the cash- clearing services the daily trading activity can account for a large share of the end-of-day exposure. Because of the short settlement cycle of securities, the exposure can change significantly from one day to another. Therefore, clearing members tend to generally over collateralise their end-of-day exposures in order to avoid potential intraday margin calls during the next trading session.

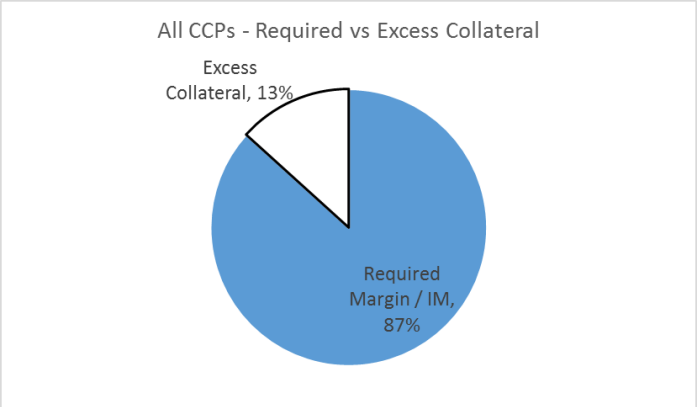


FIGURE 15: REQUIRED VS EXCESS COLLATERAL – ALL CCPS

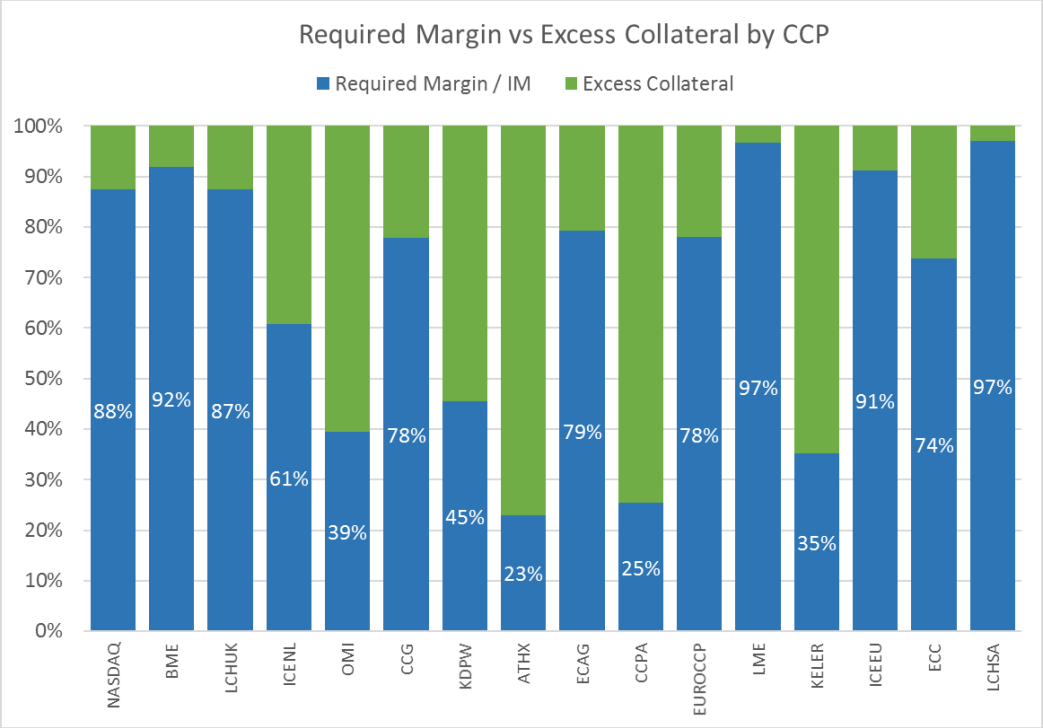


FIGURE 16: REQUIRED VS EXCESS COLLATERAL PER CCP

4.1.5 Prefunded vs non-prefunded resources

117. According to EMIR, the CCPs shall maintain sufficient prefunded financial resources to cover potential losses that exceed the losses to be covered by margin requirements and the default fund. These shall enable the CCP to withstand the default of at least the two clearing members to which it has the largest exposures under extreme but plausible market conditions.

118. The CCP may also require non-defaulting members to provide additional funds in the event of a default of another clearing member (Powers of Assessment). We have asked the CCPs to report the maximum powers of assessment that can be called from each clearing member and default fund in accordance with their own Rulebook. In many cases, the CCPs link the maximum amount to be called from a single clearing member

to the number of defaulting entities, also expressed as a multiplier of its default fund contribution at the time of the default. Therefore, the CCPs were asked to report the maximum powers of assessment for a different number of defaults. These are recognised and used consistently when running the stress test[15].

119. Overall, the total amount that can be called by all CCPs in case of default of 2 clearing members at each default fund of each CCP is 40bn EUR (Figure 17). As expected, this is approximately equal to two times (number of defaults assumed) the prefunded default fund contributions. Not all CCPs reported having provisions to call for powers of assessments. These are not to be confused with the additional funds that should be called by all CCPs to replenish a default fund after a default and in order to prepare for potential future defaults. The powers of assessments are generally meant to cover residual losses (over the prefunded resources) stemming from already experienced defaults.

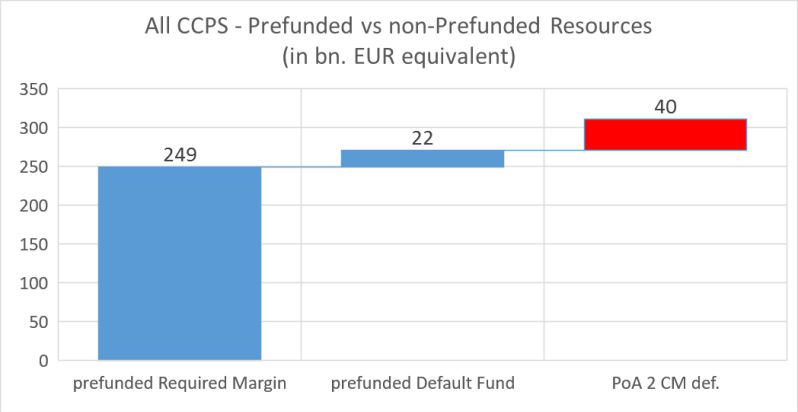


FIGURE 17: PREFUNDED VS NON-PREFUNDED RESOURCES

120. In Figure 18, one can observe how the total amount evolves as the number of defaults assumed at each default fund of each CCP increases. As expected, the increase is not proportional, as many CCPs have set a cap of the amounts that can be called at a certain number of clearing members defaulting[16]. This is meant to implement the EMIR requirement that the clearing members shall have limited exposures towards the CCP. However, this is not a common practice for all CCPs. It seems that this provision is in some cases interpreted as a requirement to have limited exposure per default of clearing member. Therefore, the total amount is not capped even after assuming the theoretical default of 10 clearing members. Nevertheless, the impact on non-defaulting clearing members through the risk-sharing mechanism of CCPs, including the potential additional non-prefunded calls, is assessed in the knock-on analysis.

121. Of course, one should note that each CCP uses different definitions, assumptions and conditions, when setting the maximum amounts. These may include for example specific cool-off periods, distinction between simultaneous and sequential defaults and

[15] For example, if under a particular scenario, three (3) clearing members are considered to be in default, only the maximum amounts (subject to 3 defaults) that can be called from the remaining non-defaulting clearing members are considered in the stress test as part of the non-prefunded resources.
[16] e.g. a CCP may call up to 3 times the original default fund contribution, even if more than 3 clearing members default.

different priorities amongst clearing members depending on the source of the default event. Therefore, any effort to use a harmonised modelling approach in order to analyse the impact across CCPs and clearing members can only serve as an approximation.

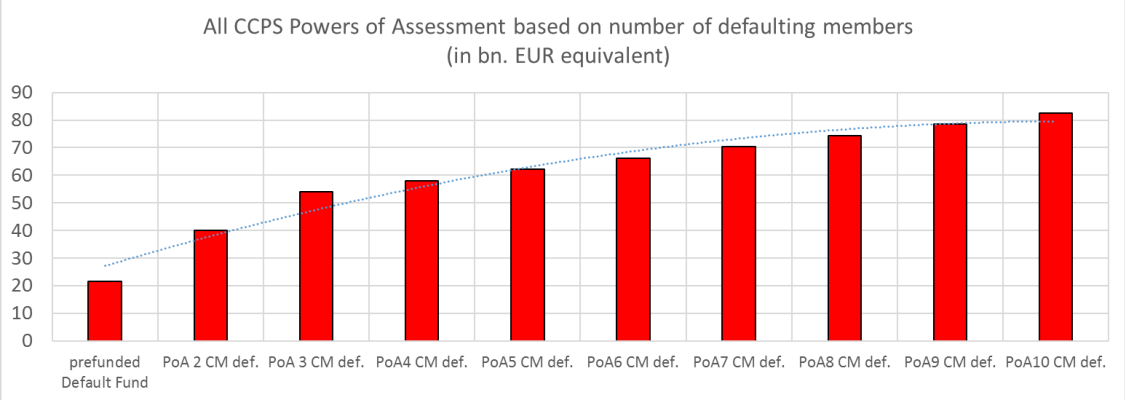


FIGURE 18: POWERS OF ASSESSMENT BASED ON THE NUMBER OF DEFAULTING MEMBERS

4.1.6 Resources per currency and Asset Type

122. The CCPs were asked to report all liquid resources, including the margin collateral and default fund contributions also broken down per currency and asset type. This data is used here also to provide an overview of the allocation of resources in an effort to identify outliers or increased concentration in particular currencies or asset types.

123. As the purpose of collecting this data was to run the liquidity stress test, the resources and their allocation correspond to the actually available resources, as of the reference date, considering the fact that the CCPs may re-invest the received collateral, subject to specific requirements, thus changing the original currency or asset type. Due to the re-investment of received collateral, there is not always a direct (one-to-one) link between specific available assets and the origin of the provided collateral (i.e. which member provided the resources, in what form and for what purpose). Therefore, where provided resources were reinvested, the CCPs were asked to allocate the available assets proportionally[17]. The same rule was also used to allocated assets between required and excess margin, subject also to concentration limits as these were applicable to different CCPs. The total available collateral (i.e. including required and excess) is used for the background analysis, while the impact from the non-availability of excess collateral is further assessed in the stress tests. It should be noted, that the data presented in this section correspond to a snapshot of the resources that were available on one single day in the past and do not provide any information on the resources held at any other time including the time of publishing the report.

124. In terms of currencies (Figure 19), approximately half of the margin collateral and default fund contributions are available in cash or assets denominated in EUR. The top

[17] for example, a clearing member that has contributed 10% of the reinvested cash could be allocated 10% of the amount invested in each asset type.

5 currencies (EUR, USD, GBP, CHF, JPY) account for 97% of these resources and overall (at EU-wide level) there is no concern on increased concentration on smaller currencies. Of course, individual CCPs that clear products in smaller currencies, do accept collateral denominated in the relevant currencies.

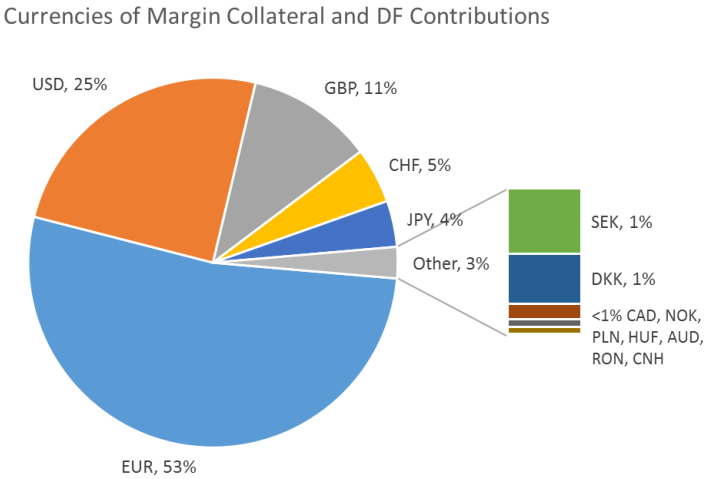


FIGURE 19: CURRENCIES OF MARGIN COLLATERAL AND DEFAULT FUND CONTRIBUTIONS

125. The aggregate breakdown of all CCPs' resources in terms of different asset types is presented in the following Figure. Overall, 59% of the resources correspond to Bonds and Equities, 39% to cash and only 1% are provided in the form of bank guarantees, including central bank and commercial bank guarantees. Category "Other", accounting in total for less than 1% has been used by CCPs to report other type of resources, including for example interoperable collateral, asset backed securities and gold.

126. The vast majority (92%) of Bonds & Equities are Government Fixed Income Securities, while 7% are Other Fixed Income Securities and only 1% Equities. For the purpose of this exercise, fixed income securities are classified as Government Fixed Income Securities when they are issued or explicitly guaranteed by a government, a central bank, a multilateral development bank, the European Financial Stability Facility or the European Stability Mechanism. They are classified as Other Fixed Income Securities otherwise. Concerning cash, 42% is kept at a central bank and 57% at a commercial bank under arrangements that secure the collateralisation of the cash[18], leaving only 1% kept in the form of deposits (unsecured) at commercial banks.

[18] Arrangements that ensure the collateralisation of the cash with highly liquid financial instruments, e.g. reverse repo.

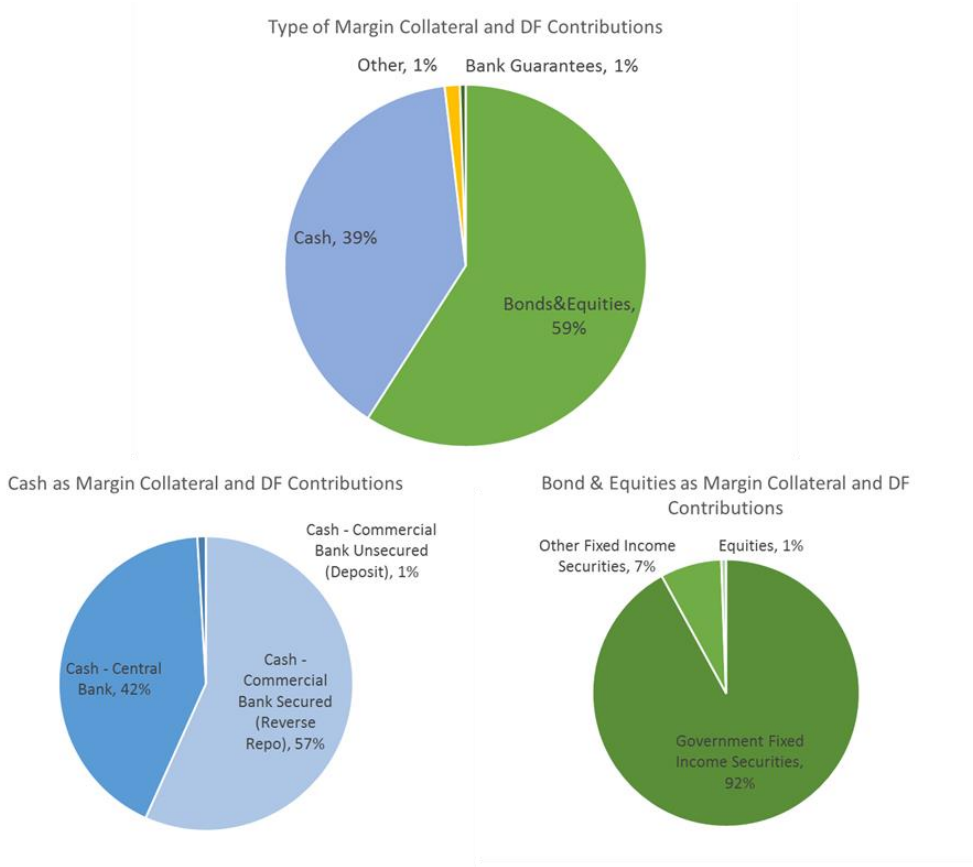


FIGURE 20: BREAKDOWN OF COLLATERAL AND DEFAULT FUND CONTRIBUTIONS BY TYPE – ALL CCPS

127. The overall, EU-wide picture looks rather reassuring and no specific concern needs to be raised concerning the different type of resources. In order to assess whether there could be cases of over-reliance on specific types of collateral at particular CCPs, a similar analysis is presented for each CCP in Figure 21.

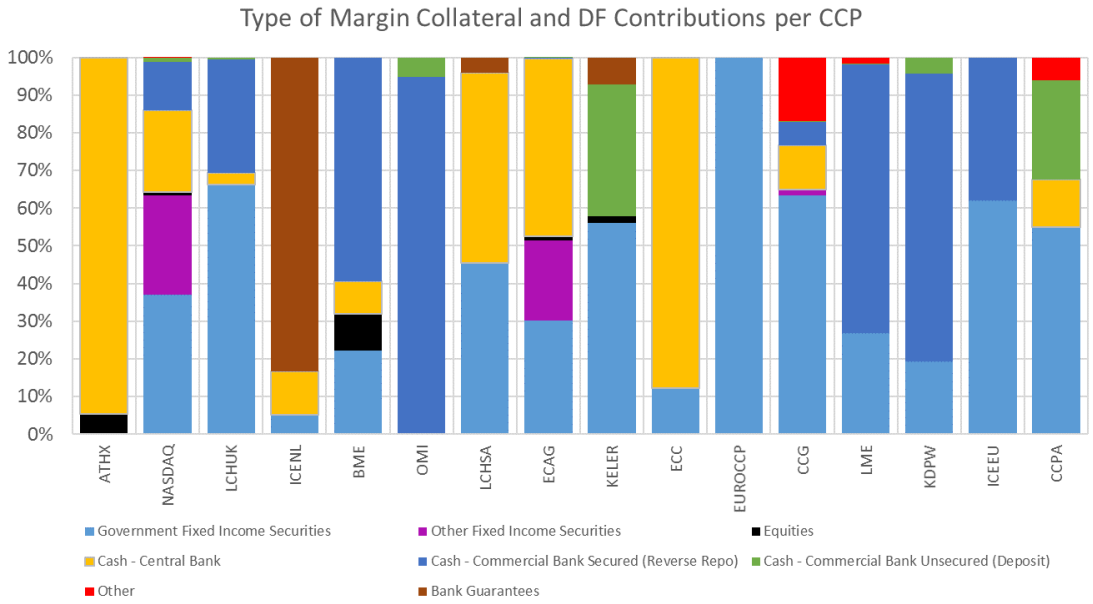


FIGURE 21: BREAKDOWN OF COLLATERAL AND DEFAULT FUND CONTRIBUTIONS BY TYPE PER CCP

128. Overall, it is difficult to identify across CCPs any prevailing convergent practices when it comes to setting the eligible collateral types or investing the available collateral in different asset types. The shares of the different asset types differ significantly between the different CCPs. This was expected, as each CCP has to consider its own environment and participants, subject also the strict regulatory requirements setting the eligible asset types and additional conditions, including for example the creditworthiness, marketability or wrong way risk of individual assets.

129. A number of high-level conclusions can still be drawn based on the presented data. Almost all CCPs have government fixed income securities with the exception of two (2), for which the majority of the resources are kept in the form of cash. Concerning access to central bank deposits, ten (10) CCPs keep at least a share of the margin collateral and default fund contributions at a central bank, but only for three (3) of them, this accounts for more than half of the available resources.

130. Equities have been accepted as collateral by six (6) CCPs, but only for two (2) of them this accounts for a material share of their resources, with the maximum share of equities at a single CCP being 10%. For 2 CCPs, a significant share of the aforementioned resources corresponds to fixed income securities, other than government bonds. These are mainly corporate and covered bonds.

131. For two (2) CCPs, the share of cash that is kept in the form of deposits at commercial institutions without ensuring its collateralisation through reverse repo arrangements is significant. In both CCPs, only one commercial institution is used, which is not the same for the two CCPs.

132. In terms of over-reliance to individual asset types, one (1) CCP reported investing all collateral received in government fixed income securities. Moreover, although only a

few CCPs reported having accepted bank guarantees, for one (1) of them this accounts for more than 90% of the margin collateral and default fund contributions. These are guarantees issued by a central bank. For the remaining CCPs that reported having accepted bank guarantees, only for one (1) CCP these included bank guaranties issued by commercial banks.

4.2 Interconnectedness and Concentration

4.2.1 Concentration

133. The degree of concentration of CCP resources aims to identify the concentration of default fund contributions (credit risk analysis) or liquidity provided (liquidity risk analysis) at CCP and at the EU-wide level. The analysis focuses on individual legal entity level and at group level, for clearing members (credit risk) or liquidity providers (liquidity risk) respectively.

134. The degree of concentration of the CCP resources is calculated using the Herfindahl-Hirschmann index (HHI), a measure developed and used in industrial economics to assess the extent of concentration/competition in a particular industry. HHI is defined as the sum of the squares of market share(s) of the i firms within an industry:

$$HHI = \sum_{i=1}^{N} s_i^2$$

135. The index ranges from 0 to 10,000 points. Increases (decreases) in the HHI indicate a decrease (increase) in competition. Competition and antitrust laws usually have the HHI as a reference concentration measure as the HHI has the property of assigning additional weight to firms with larger size (market shares are squared before being summed up).

136. In the present analysis, the HHI methodology is applied to investigate the degree of concentration of available resources within a CCP and across CCPs as part of the stress test exercise (default fund contributions for credit and amount of liquid resources provided for liquidity).

137. The rationale is that higher concentration could entail higher risk, as default fund contributions/liquidity are provided by a reduced number of clearing members/liquidity providers. The more concentrated available resources are, the higher is the probability that stress in one institution will impact one or more CCPs, potentially having systemic consequences. As an example, if there were only one clearing member/liquidity provider allocating resources in a CCP, the concentration would be 100% and the HHI would equal 10,000. If there were thousands of clearing members/liquidity providers in a CCP, the allocated resources would have nearly 0% concentration and the HHI would be close to zero.

138. Concentration thresholds refer to the European Commission Guidelines on the assessment of horizontal mergers under the Council Regulation on the control of concentrations between undertakings (Section III).[19] The following levels are identified:

0– 1000	no significant concentration
1000 – 2000	small concentration observed
> 2000	significant concentration

139. Within the CCP framework, we define the HHI at CCP level and EU-wide level for both the credit and liquidity analysis. Details of the analyses and results for credit and liquidity risks are reported below.

4.2.1.1 Concentration of Credit Exposures

140. HHI is defined as the sum of squares of the share of default fund contributions by default fund within a CCP. The share is calculated as the sum of default fund contributions allocated by each clearing member for a particular default fund over the total held by a CCP for the same default fund.

141. The CCP level concentration is calculated following two methods:

- As the weighted sum of the HHI calculated at default fund level per CCP (HHI Weighted Average across DFs). Weights are calculated from the default fund size ratio over the total for the CCP;
- Taking the maximum value of the default fund-level HHI, as this was calculated per default fund. This will correspond to the default fund-level HHI for those CCPs reporting only one default fund. In those cases in which a CCP has several default funds the highest HHI value across the different types is considered.

142. For this analysis, the default fund contributions are used as a proxy for the credit counterparty risk assumed by the CCP towards its clearing members, as according to EMIR,[20] the contributions shall be proportional to the exposures of each clearing member. Across the 16 CCP considered in the analysis there are only few for which (according to the HHI methodology and the thresholds used) the default fund contributions can be considered to be highly concentrated on a limited number of clearing members (Table 1).

143. When the weighted average is considered, there are only two CCPs showing high levels of concentration (red), one more than last year, with five being moderately concentrated, same number as last year, of which three with a level very close to the lower bound of the threshold as given in the European Commission Guidelines defined above. The rest of the CCPs results show no concentration (green). When the maximum value is considered, the level of concentration increases: six CCP show high

[19] Council Regulation (EC) No 139/2004 of 20 January 2004 on the control of concentrations between undertakings. Art 19 and art.20 of the EC Guidelines refer both to levels and changes in the HHI following a merger. In this analysis, we consider only levels as changes would not be applicable in the specific case.
[20] EMIR Article 42

concentration (3 more than last year), yet again in three cases values are close to the lower bound (2,000). Between the two CCPs showing high concentration, in the weighted average case, according to the data received, the CCP with the highest concentration (7,661) reports contributions from only three clearing members with the share of the top member being approximately 85%. Therefore, one single member gives a contribution for almost the total of the market. This is different from the results of the 2015 EU-wide stress test as the top member accounted for a share that was close to 50%. In the case of the other CCP showing levels beyond the threshold, fourteen clearing members are reported, with two of them having together more than 60% of the share in terms of default fund contributions.

144. Compared to last year exercise, data are more granular. This is related to the validation process and also to the type of data the CCP themselves submitted. Also, data composition is slightly different. Moreover to be noted is the difference in the positions held by the clearing members on the specific date when data where reported by the CCP, that has an impact on the computation of the index and therefore on the values compared to last year results. In terms of the difference between the HHI based on the weighted average of CCP default funds and the HHI based on the maximum value of the default fund-level HHI, this is linked to the fact that there are smaller default funds that are structurally more concentrated given the nature of the cleared market and clearing activity. It is worth noting, that resources cannot be moved across Default Funds.

145. Finally, overall concentration levels of credit exposures to clearing members at an EU-wide level are analysed with the EU-Wide HHI at single clearing member level and the EU-Wide HHI based on groups, (Table 2). The HHI by clearing member/group is defined as the sum of the squares of the default fund share by clearing member/group across the 16 CCPs considered in the analysis. Results show that, at the EU-level, concentration levels are low.

	HHI Weighted Average across DFs	HHI Maximum across DFs
KDPW	785	1,103
LCHSA	856	3,002
EUROCCP	642	642
CCG	1,005	6,429
LME	474	474
ECC	1,071	1,071
NASDAQ	1,069	1,279
OMI	2,583	2,583
ICEEU	563	795
ICENL	7,661	7,661
ATHX	1,118	1,355
LCHUK	243	924
ECAG	344	344
KELER	1,610	2,286
BME	978	2,373
CCPA	514	514

Note: HHI (WA) = weighted sum of HHI calculated as the sum of shares squared of default fund contributions by default fund per CCP. Weights = default fund size ratio over the total per CCP. HHI (Max) = Max of HHI per DF per CCP. Red indicates significant concentration levels (> 2,000); Yellow, small concentration levels (1,000 - 2,000); Green, no significant concentration (0 - 1,000). Computations at 16 September 2016.

TABLE 1: CONCENTRATION OF CREDIT EXPOSURES TO CLEARING MEMBERS PER CCP

EU-Wide HHI	152
EU-Wide HHI Group	286

TABLE 2: CONCENTRATION OF CREDIT EXPOSURES TO CLEARING MEMBERS EU-WIDE

4.2.1.2 Concentration of Liquidity Exposures

146. With respect to liquidity exposures, the HHI at CCP level is defined as the sum of squares of the share of liquid resources committed by liquidity providers within a CCP. The amount is expressed in EUR converted using the ECB exchange rates when needed. The share is calculated as the sum of liquid resources allocated by each liquidity provider within a CCP.

147. In the context of a stress scenario, we exclude resources provided as excess collateral. Moreover, we exclude also those resources that are allocated to clearing members only, i.e. resources that can only be used to cover liquidity needs stemming from the same clearing member.

148. Across the 16 CCPs considered, there is only one CCP for which, liquidity resources can be considered to be highly concentrated, while the rest are either moderately concentrated or not at all concentrated, at low values (Table 3). Therefore, no systemic risk is envisaged in terms of liquidity.

149. Finally, overall concentration levels of liquidity exposures at an EU-wide level are analysed with the EU-Wide HHI at single liquidity provider level and the EU-Wide HHI based on group liquid resources. Results show that, at the EU-level, concentration levels are low.

	HHI by CCP
KDPW	748
LCHSA	506
EUROCCP	815
CCG	563
LME	513
ECC	1,905
NASDAQ	456
OMI	1,431
ICEEU	458
ICENL	6,284
ATHEX	1,227
LCHUK	247
ECAG	510
KELER	1,166
BME	604
CCPA	1,413

EU-Wide HHI
180
EU-Wide HHI Group
360

Note: HHI = sum of shares squared, of liquidity provider by CCP. Share expressed in terms of total liquidity resources provided in EUR. Red indicates significant concentration levels (> 2,000); Yellow, small concentration levels (1,000 - 2,000); Green, no significant concentration (0 - 1,000). Computations at 16 September 2016.

TABLE 3: CONCENTRATION OF LIQUIDITY EXPOSURES

4.2.2 Interconnectedness

150. Interconnectedness, as defined by the network of different types of direct or indirect exposures between institutions can be a source of both credit and liquidity risk. In the CCP world, interconnectedness can materialise through various channels including common clearing members, custodians or service providers such as settlement banks, credit and liquidity providers, or investment counterparties. In this section, we will analyse interconnectedness between CCPs through common clearing members, custodians and liquidity providers. To ensure readability of the charts in this section, we will display the network of CCPs with the ten biggest groups, as counterparties were consolidated at the group level in a previous step.

4.2.2.1 Interconnectedness of CCPs through clearing member groups

151. For clearing membership, we first looked at interconnectedness in terms of collateral posted. More precisely, the size of the red bubbles[21] representing CCPs is proportional to the total default fund (DF) and the total margins posted at each CCP, while the size of the blue bubbles representing the clearing member's groups is proportional to the sum of all DF contributions and margins posted by the given clearing member's group. The width of the edge is then proportional to each clearing member's DF and margins posted to each individual CCPs. Only the top-10 groups of clearing members are considered, therefore the size of the CCPs does not correspond to the total default fund contributions and margins collected by each CCP, but the amounts collected from the EU-wide top-10 clearing member groups. Figure 22 shows that most European CCPs are very interconnected via common clearing membership of the ten biggest clearing member's groups.

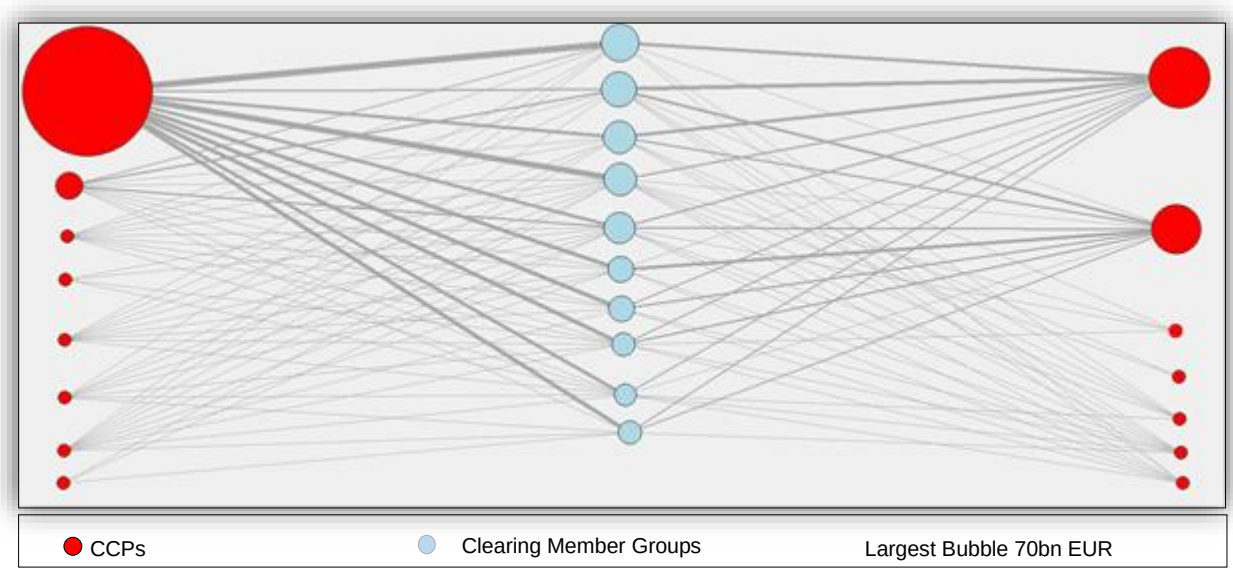


FIGURE 22: NETWORK OF TOP-10 CLEARING MEMBER GROUPS BY DF CONTRIBUTIONS AND MARGINS

152. When looking at exposures in times of market stress using the Stress Loss over own Resources (clearing members' own Default Fund contributions and required margins), CCPs are less interconnected. This indicates, that although the top groups have exposures to multiple CCPs (high interconnectedness when considering DF contributions and margins), these exposures would generally not arise simultaneously under one of the common, internally consistent scenarios considered in this exercise.

153. However, the degree of interconnectedness changes also depending on the scenario, showing small but a relatively higher dependency in the most severe scenario (scenario 1, shown in Figure 23) and basically no interconnectedness in the two others.

[21] A minimum size applies for the bubbles in all network charts for illustration purposes.

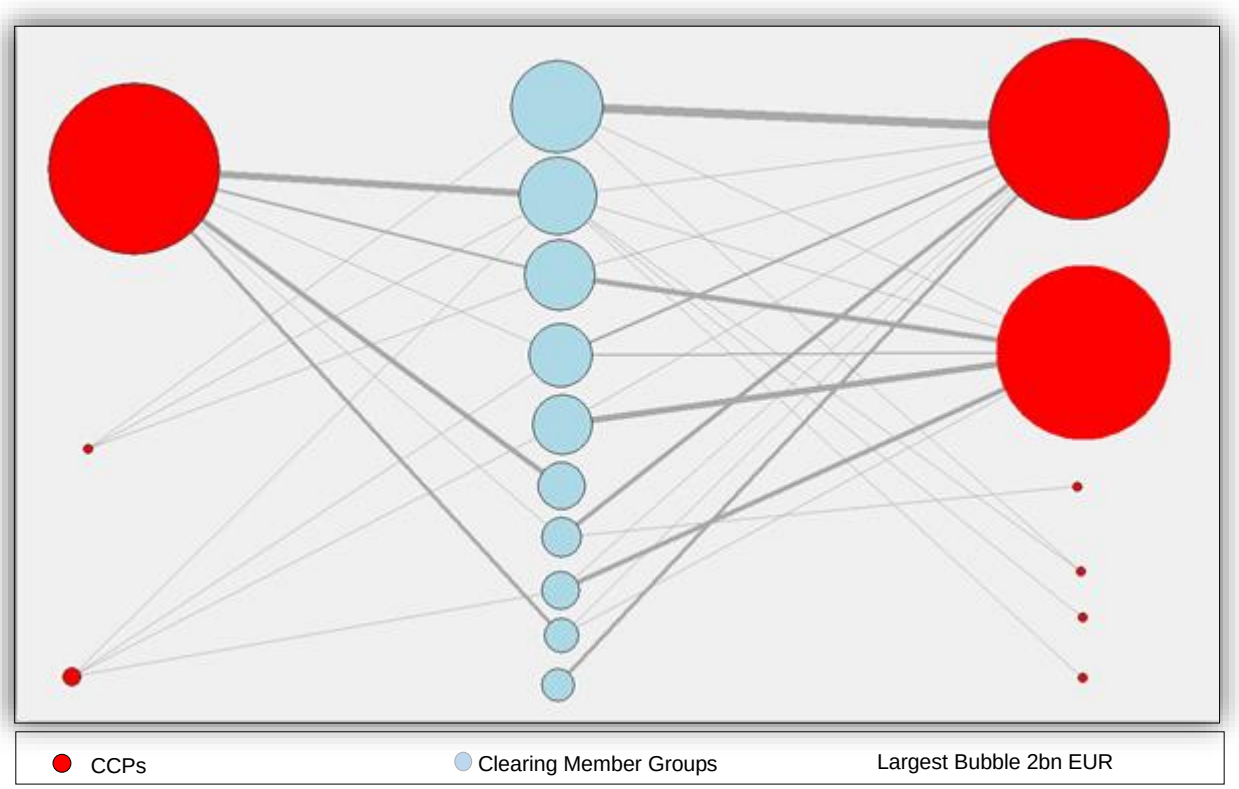


FIGURE 23: NETWORK OF TOP-10 CLEARING MEMBER GROUPS BY TOTAL LOSS OVER REQUIRED RESOURCES – STRESS SCENARIO 1

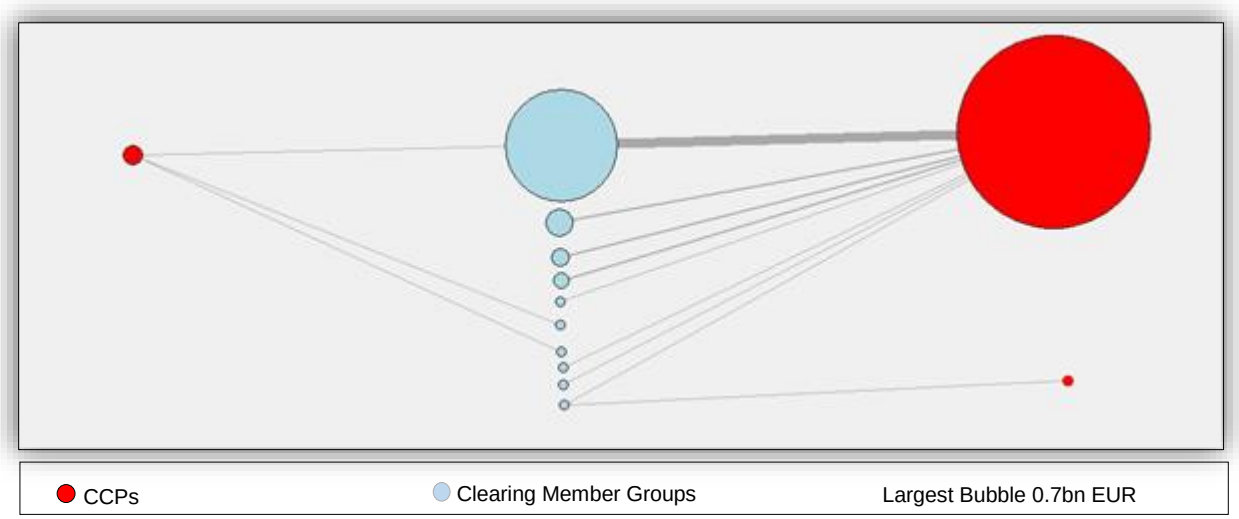


FIGURE 24: NETWORK OF TOP-10 CLEARING MEMBER GROUPS BY TOTAL LOSS OVER REQUIRED RESOURCES – STRESS SCENARIO 2

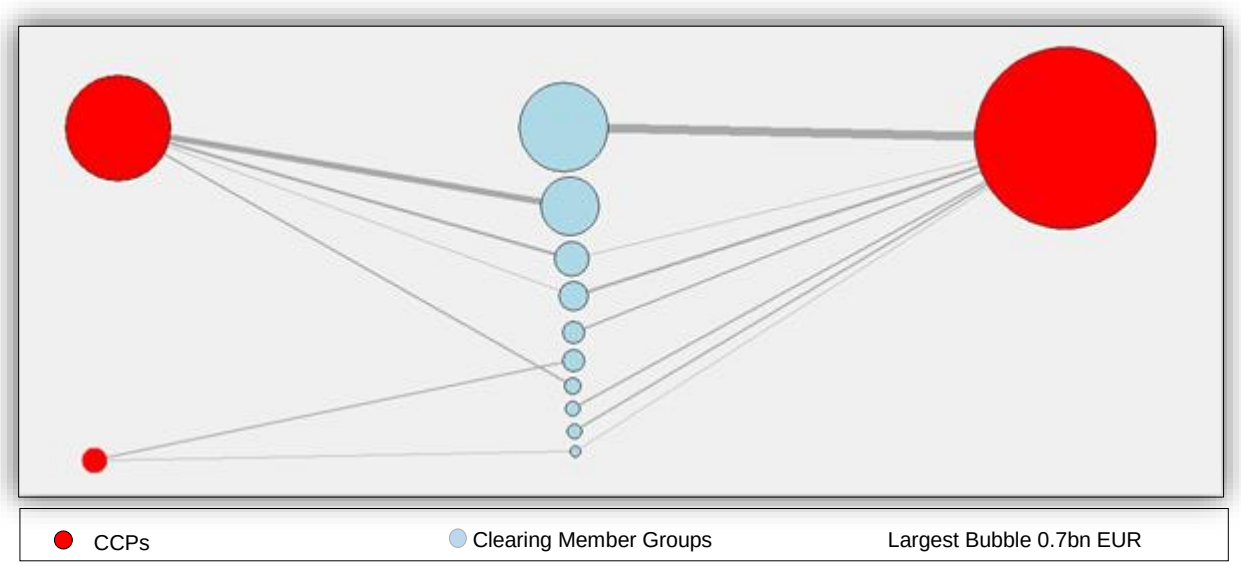


FIGURE 25: NETWORK OF TOP-10 CLEARING MEMBER GROUPS BY TOTAL LOSS OVER REQUIRED RESOURCES – STRESS SCENARIO 3

4.2.2.2 Interconnectedness of CCPs through custodians

154. In this part, we show the interlinkages between CCPs via their common custodians. We looked, in a first step, at the exposure of CCPs to custodians in terms of cash amounts under custody. Cash here consists of commercial bank cash, reverse repos and deposits[22]. We then looked at total amounts under custody including cash and securities, first for all currencies of denomination, and then looking at individual currency separately (EUR, USD, GBP). Figures 26 and 27 show the network for all currencies, with cash under custody (Figure 26) and then adding securities under custody (Figure 27). Here a few big CCPs, are linked via three institutions, including ICSDs but not only.

[22] Cash kept at Central banks is excluded from the scope of this analysis

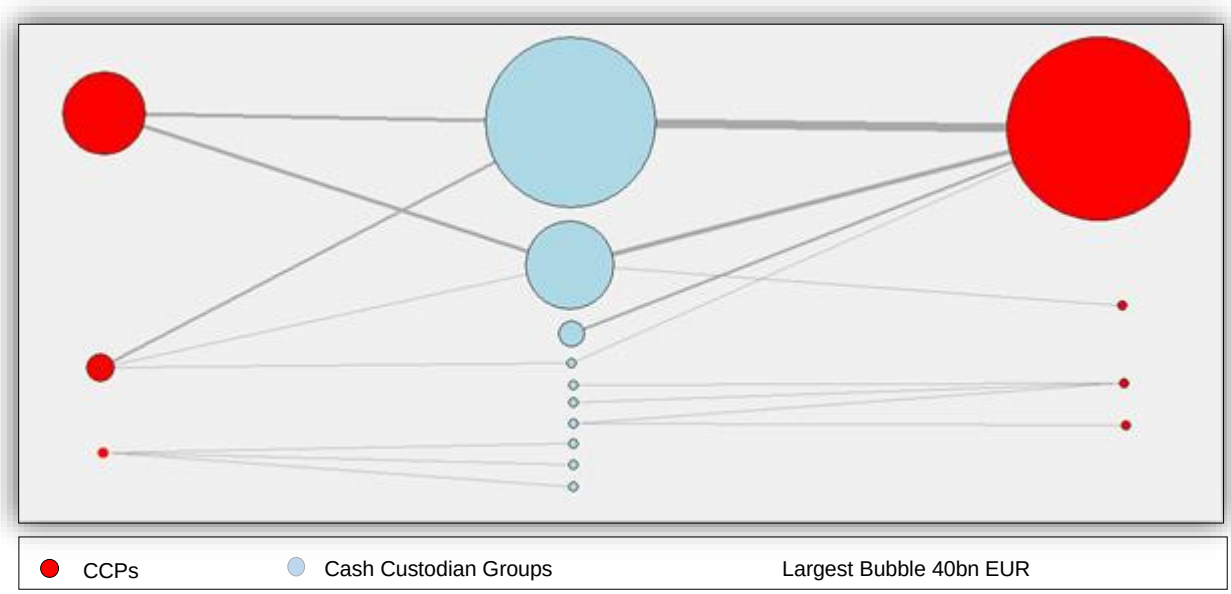


FIGURE 26: NETWORK OF TOP-10 CUSTODIANS – CASH ONLY – ALL CURRENCIES

155. Concerning cash custodians (Figure 26), it can be observed, that at EU-wide level and considering all currencies, the majority of the cash kept by commercial entities, is kept by two (2) groups, including one ICSD and one commercial bank that act as cash custodians for four (4) CCPs. In all these cases, almost all cash is kept under arrangements that ensure its collateralisation.

156. When cash and securities are considered, in Figure 27 we see again one (1) large group having a large part of the overall cash/assets under custody, but then more groups taking the remaining share, while in many cases the exposures are mainly driven by the securities custodians. The pictures are further discussed concerning individual currencies below.

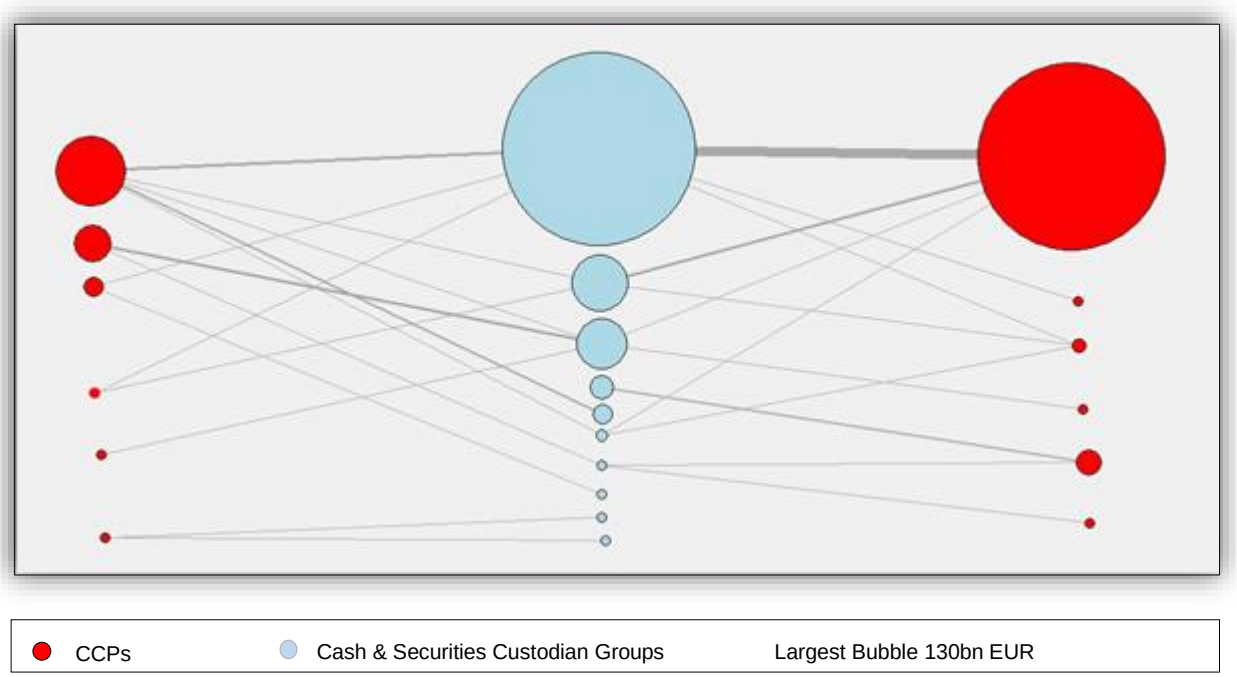


FIGURE 27: NETWORK OF TOP-10 CUSTODIANS – CASH AND SECURITIES – ALL CURRENCIES

157. Looking at individual currencies, the patterns of interconnectedness appear even stronger. For collateral denominated in USD, the EU CCPs do not have access to a central bank acting as a custodian and one can observe a high dependence on commercial entities, including not only ICSDs but also one commercial bank. The charts for cash only (Figure 28) and cash & securities (Figure 29) denominated in USD are presented below, while the ones for EUR and GBP can be found in the Annex. Overall, a high degree of CCPs' dependence on one or a few commercial entities may give rise to potential concerns, including increased credit risk towards specific counterparties or risk of wide-spread disruptions in case of technical difficulties.

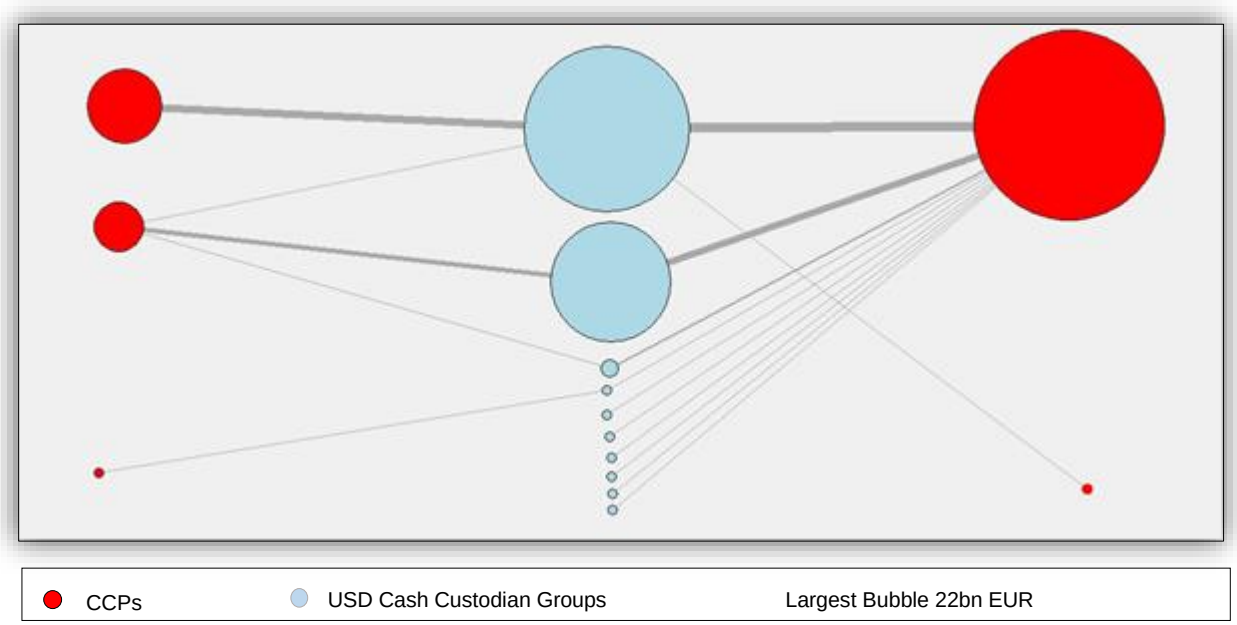


FIGURE 28: NETWORK OF TOP-10 CUSTODIANS – CASH ONLY – USD

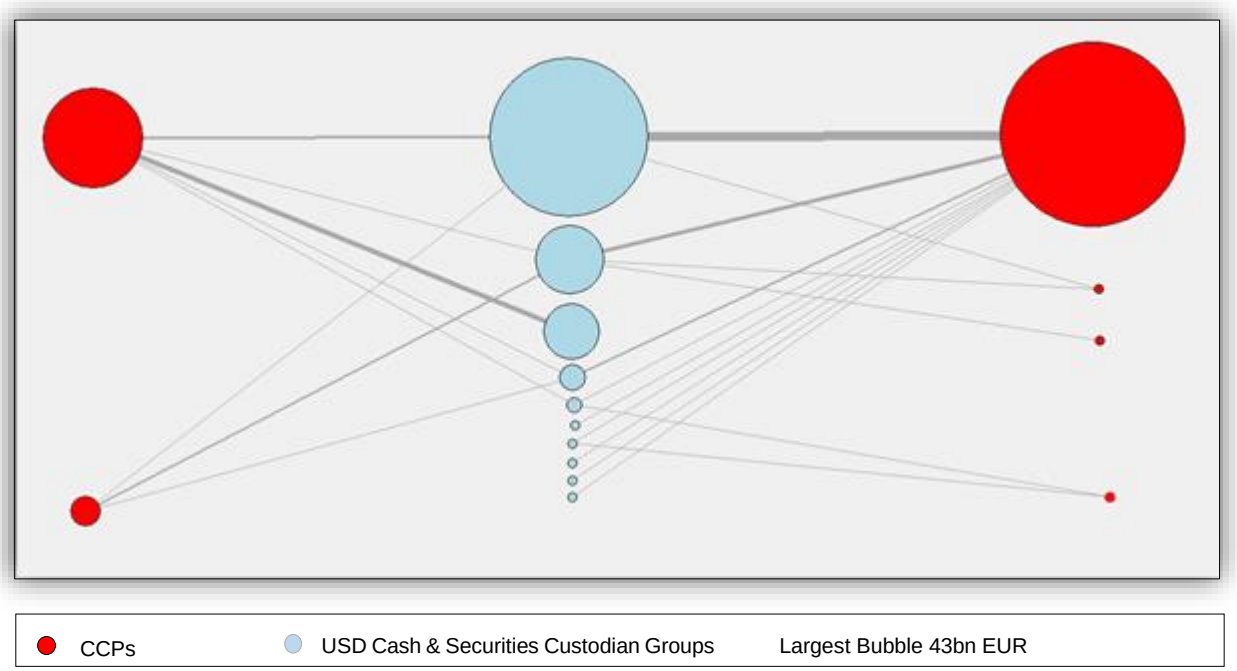


FIGURE 29: NETWORK OF TOP-10 CUSTODIANS – CASH AND SECURITIES – USD

4.2.2.3 Interconnectedness of CCPs through liquidity providers

158. Here we looked at liquidity providers in the form of committed credit lines, committed repos and uncommitted repos, looking in a first step at committed liquidity lines only

(credit + committed repos) and then at all liquidity provided (credit + committed repos + uncommitted repos) with a breakdown by currencies of denomination. Central banks as liquidity providers are again excluded from this analysis. Overall, only a few CCPs reported having committed repo lines from commercial providers. CCPs are facing a limited interconnectedness when looking at committed liquidity only, as they have only a limited number of common liquidity providers, as shown in Figure 30 all currencies and in Figure 31 for EUR (charts for USD and GBP in the annex).

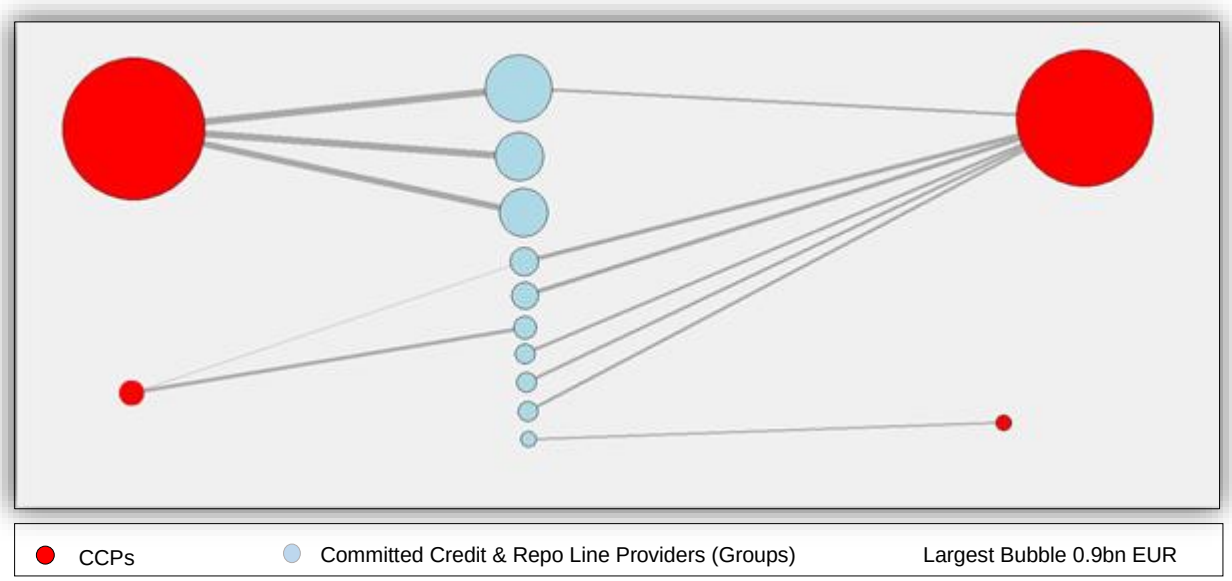


FIGURE 30: NETWORK OF TOP-10 COMMITTED LIQUIDITY LINES – ALL CURRENCIES

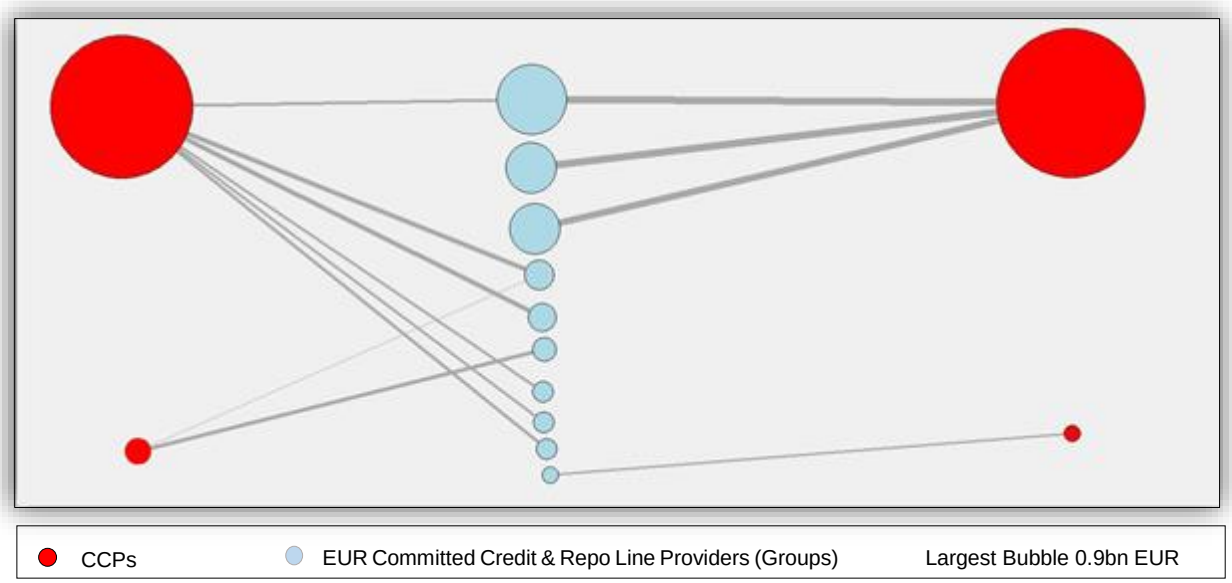


FIGURE 31: NETWORK OF TOP-10 COMMITTED LIQUIDITY LINES – EUR

159. CCPs are more connected when the uncommitted repo lines from commercial banks are added to the picture. Several CCPs are relying on repo lines provided by the same

institutions. This high interconnectedness is consistent across individual currencies. Below the network for all currencies.

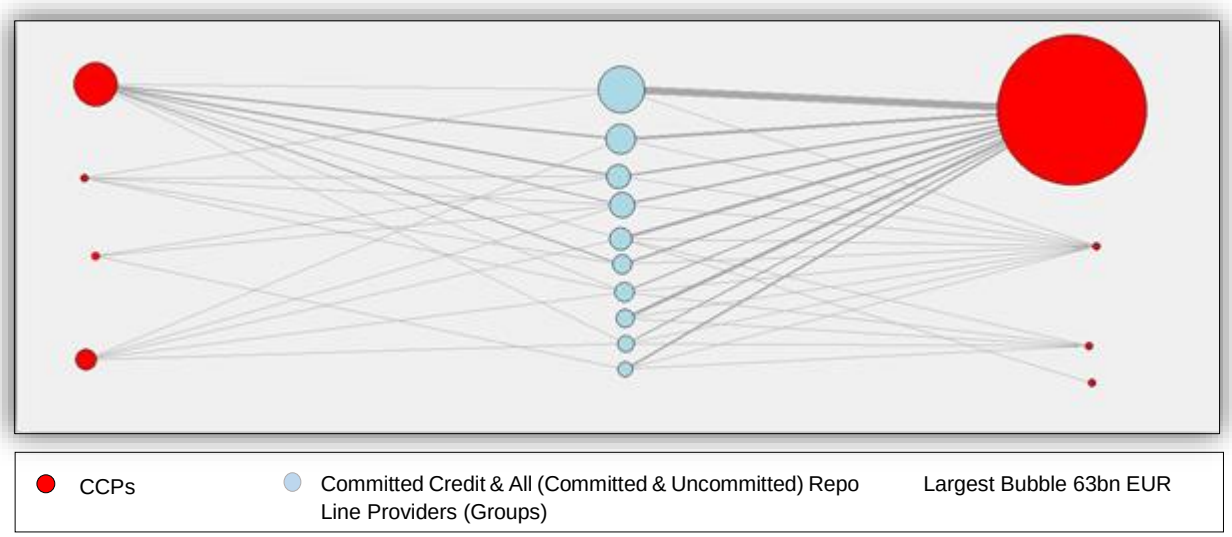


FIGURE 32: NETWORK OF TOP-10 COMMITTED CREDIT LINES AND ALL REPOS (COMMITTED AND UNCOMMITTED) PROVIDERS – ALL CURRENCIES

4.3 Credit Stress Test Results

160. The results of the credit stress test are presented for different combinations of member default scenarios and market stress scenarios. The losses are always a result of simultaneous clearing member defaults and adverse changes of market prices. From a credit risk perspective, a combination of clearing member defaults and simultaneous severe shifts of risk factor prices is needed to put a CCP at risk. If clearing members continue to post margin and meet their obligations, periods of extreme market volatility in isolation will not pose a specific market risk to a CCP[23]. Similarly, defaults of clearing members without simultaneous adverse market shocks should not put a CCP at risk. Clearing members post margins and default fund contributions scaled to a very high confidence level assuring CCPs sufficient resources to manage a default of a clearing member in normal market conditions, and close out the resulting open positions in a stable market before suffering a loss. Therefore, under normal market conditions, the CCPs will have the resources to withstand multiple defaults. Hence, from a credit risk perspective and with the exception of investment risks, only simultaneous defaults and extreme, adverse shifts of market prices could pose potential risk to a CCP. The methodology used to select the defaulting clearing members (member default scenarios) and calculate the losses resulting from extreme market shocks (market stress scenarios) is detailed in Section 3.

[23] with the exception of market risk stemming from its investment policy, which has not been analysed in the credit stress test.

4.3.1 Cover 2 groups per CCP results

161. The first member default scenario explored is the “Cover-2 groups per CCP”. In particular, we select for each CCP individually two (2) corporate groups and assume all the clearing members belonging to those 2 groups as defaulting in that particular CCP. The selected clearing member groups and defaulting entities will be different for each CCP and are not considered to be in default in other CCPs. Thus, this scenario includes the rather unrealistic assumption that an entity would default in only one CCP, but is used to allow the assessment of the resilience of individual CCPs under common market stress scenarios. The groups selected for each CCP are the ones that lead to the highest resource consumption beyond required margin collateral and above the total prefunded mutualised resources, including the total default fund and the dedicated resources (“skin-in-the-game”). Thus, the selection process will select the groups that could lead to a depletion of the prefunded resources and if such pairs of groups are not to be found, will select the two groups that would lead to the highest consumption.

162. This selection procedure is run for each market stress scenario individually, as the clearing members leading to the largest losses will be different under different market conditions. At each CCP, we select the top-2 groups considering all clearing members belonging to the same group. Hence, we can have more than two clearing members defaulting at each CCP. Moreover, for CCPs that have more than one default funds, the clearing members belonging to those groups, may or may not be active in more than one default funds. CCPs were asked to report separately stress losses over the required margin collateral and stress losses over the total available (including excess) margin collateral. The selection of top groups and defaulting entities is always performed using only the required collateral and the same defaulting entities are considered when testing with total (i.e. including excess) collateral.

163. For each market stress scenario (i.e. 1, 2 and 3) the credit stress test results are presented in the form of a Panel, showing for each CCP the following (from bottom to top):

Number of defaulting members

- Number of clearing members defaulting at each CCP
- Number of clearing members defaulting at each CCP having (non-zero) losses under the stress scenario, before applying any margins

Amounts of default waterfall consumption (in mil. EUR)

- Amount (in million EUR) of stress loss covered with the mutualised part of the Default Fund (i.e. non-defaulting members’ contributions) and dedicated CCP resources (“skin-in-the-game”)
- Amount (in million EUR) of stress loss covered with other Default Fund -level resources, where applicable.
- Amount (in million EUR) of stress loss that would need to be covered with non-prefunded resources (powers of assessment).

- Amount (in million EUR) of stress loss covered with other CCP- level resources, where applicable.

% Consumption of Resources

- % Consumption of the Default Fund (including the defaulters' contributions). For CCPs that have more than one default funds, the maximum % consumption is presented.
- % Consumption of Powers of Assessments (called only from non-defaulting members). For CCPs that have more than one default funds, the maximum % consumption is presented

Two flags

- A flag indicating whether there would be uncovered losses after using also non-prefunded resources.
- A flag (top of the panel) indicating whether non-prefunded resources would have to be used.

164. The stress test results for the first market stress scenario, without considering excess margin are presented in the following figure. For example, for the first CCP, four (4) clearing members defaulted, all with non-zero losses, while after using the defaulting clearing members' margin and default fund contributions, an additional amount equal to 1.26bn EUR was consumed from the non-defaulting clearing members' prefunded resources (default fund contributions) and the CCPs dedicated resources ("skin-in-the-game"). These lead to a 42% consumption of the default fund (including the defaulters' contributions), while there was no need to call for additional non-prefunded resources (0% consumption of Assessment Powers).

Cover-2 Groups per CCP (no cross defaulting)
Market Scenario 1 – No Excess Margin

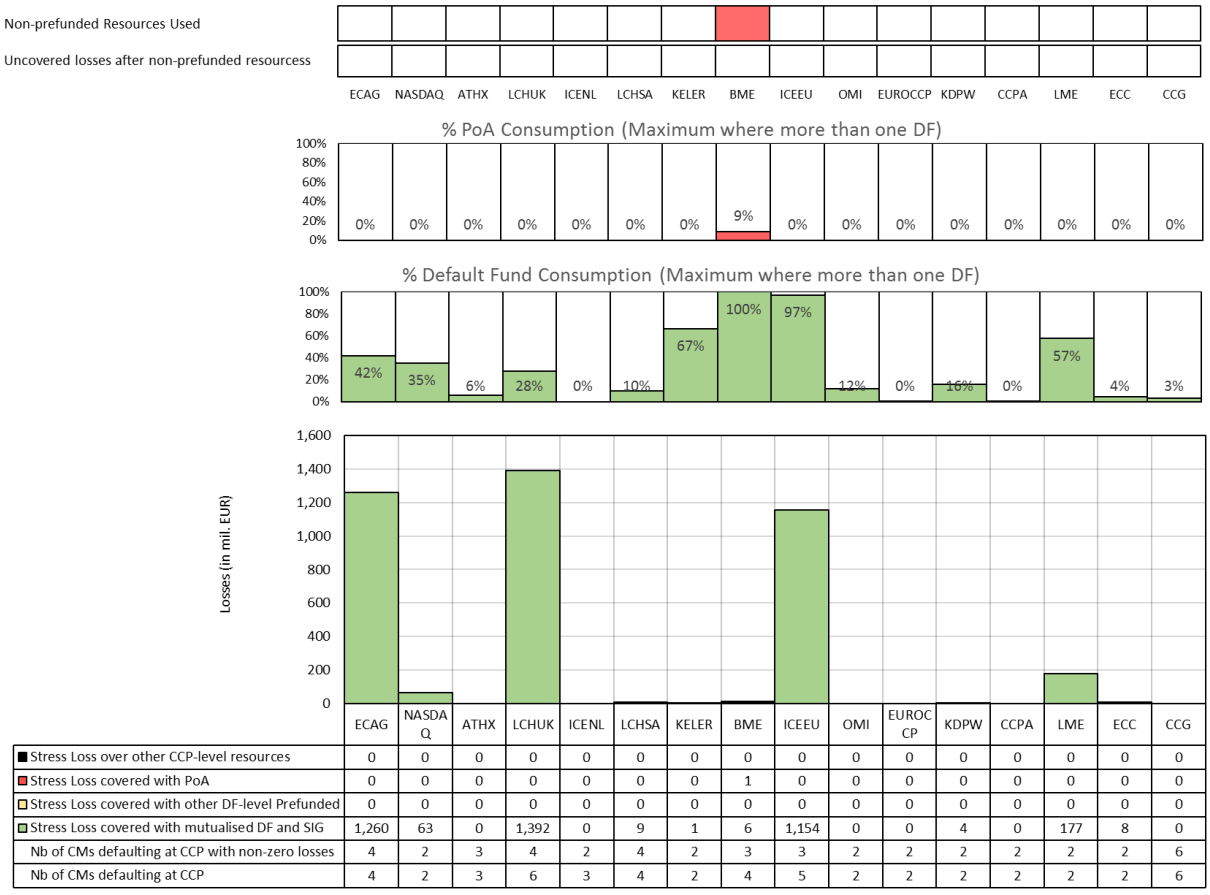


FIGURE 33: COVER-2 GROUPS PER CCP - MARKET SCENARIO 1 – NO EXCESS MARGIN

165. Overall, no shortfall of resources with systemic impact is to be identified, but the results across CCPs are mixed. Not all CCPs have experienced the same level of stress based on this common market scenario. The combination of the default of the top-2 groups per CCP with the shocks defined under Market Stress Scenario 1, would result for one CCP (BME Clearing) to a need to call for additional non-prefunded resources, since the mutualised prefunded resources (default fund and "skin-in-the-game") for one of the default funds would be depleted. It should be underlined that this is only the case for a very small amount (less than 1 million EUR) and for one of the smaller default funds. Therefore, the shortfall is only marginal with no systemic impact. Moreover, it would also not have any practical impact on this particular CCP, as it had access to surplus collateral of the defaulting members in other default funds and excess margin that could in this case, be used to cover this very small shortfall.

166. For some CCPs, the losses can be covered using only the defaulters' collateral (margin and default fund contributions), with no need to resort to mutualised resources. At the same time, other CCPs would need to use a significant part of the default funds contributions. In particular, for one CCP (ICE Clear Europe), although the prefunded resources would be enough, the default of the top-2 groups would lead to a 97%

consumption of the largest of its default funds. Therefore, approximately 1.1bn EUR of mutualised prefunded resources would need to be used and would only marginally be enough to cover the losses. This is the result of the default of five (5) clearing members, belonging to the top-2 groups, with only three (3) out of those recording actually losses from the stress scenario, thus affecting the CCP. The excess margin held in this case, could also be used to significantly reduce the consumption of prefunded resources.

167. If one considers the total available margin collateral (i.e. including excess margin), the stress test results for the same defaulting entities and market stress scenario, change significantly. These are presented in the following figure (Figure 34).

Cover-2 Groups per CCP (no cross defaulting)
Market Scenario 1 – With Excess Margin

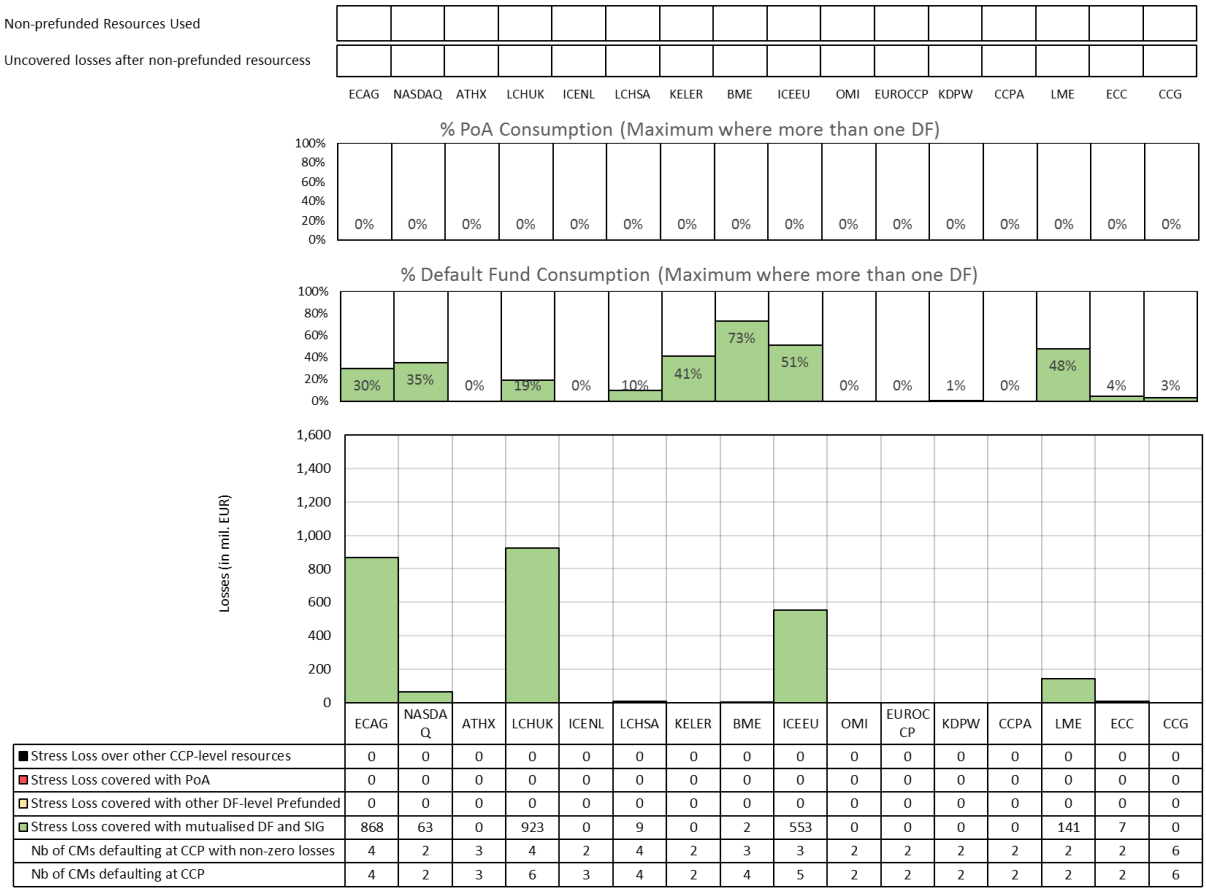


FIGURE 34: COVER-2 GROUPS PER CCP - MARKET SCENARIO 1 – WITH EXCESS MARGIN

168. After considering also the excess collateral, the default fund amounts were in all cases enough to cover the residual losses. It should however be highlighted once more, that any member experiencing financial difficulties would most probably post only the minimum required collateral. Therefore, the results using only the required margin represent a more realistic scenario and the results considering the excess margin are

presented for completeness in order to show what the actual impact would be from a default if all else is assumed unchanged.

169. The results for the two other market stress scenario are presented in the following figures. As it can be seen, the first scenario (Scenario 1 - Figure 33) has produced by far the most severe results. This is because it combines in one single internally consistent scenario severe shocks for many different asset classes that are particular relevant for more than one CCPs. These include Equities, Bonds and Commodities, especially Oil.

Cover-2 Groups per CCP (no cross defaulting) Market Scenario 2 – No Excess Margin

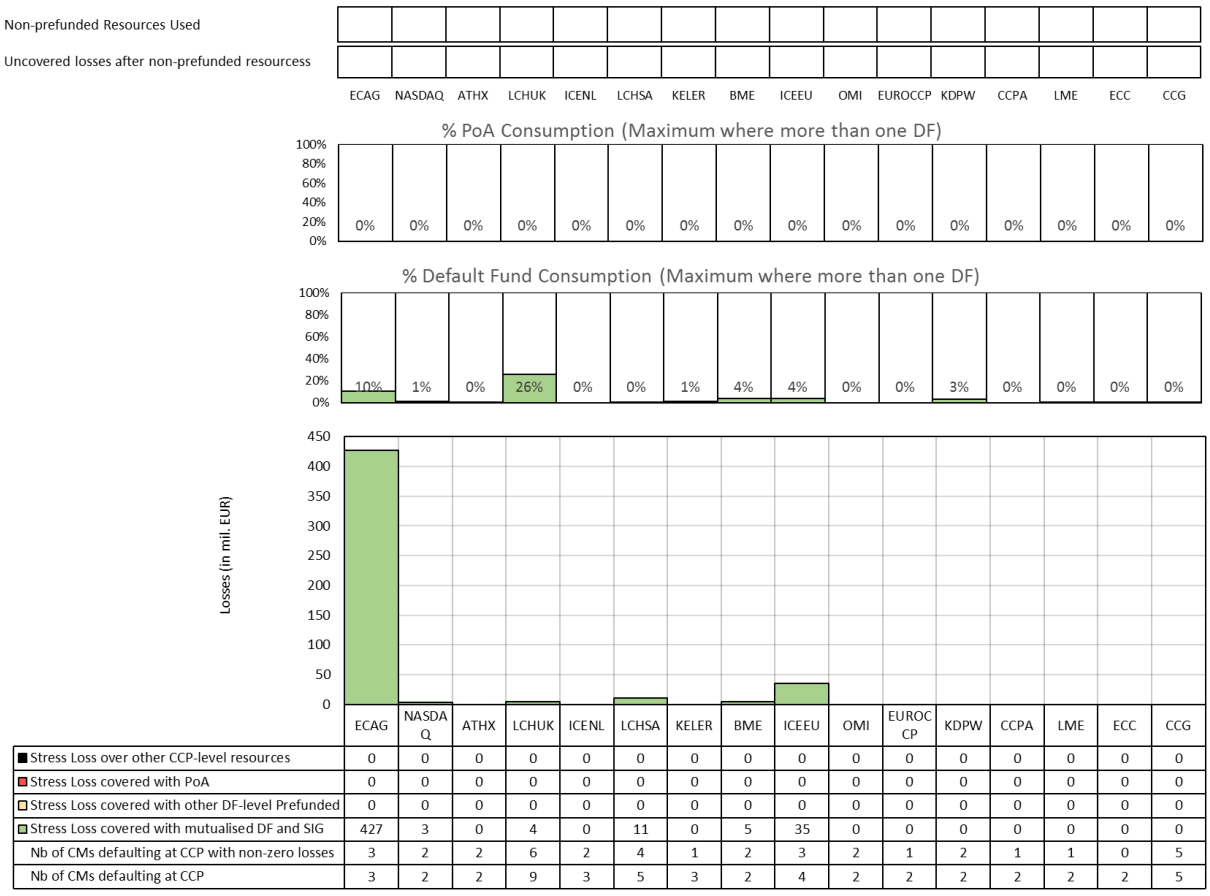


FIGURE 35: COVER-2 GROUPS PER CCP - MARKET SCENARIO 2 – NO EXCESS MARGIN

Cover-2 Groups per CCP (no cross defaulting) Market Scenario 3 – No Excess Margin

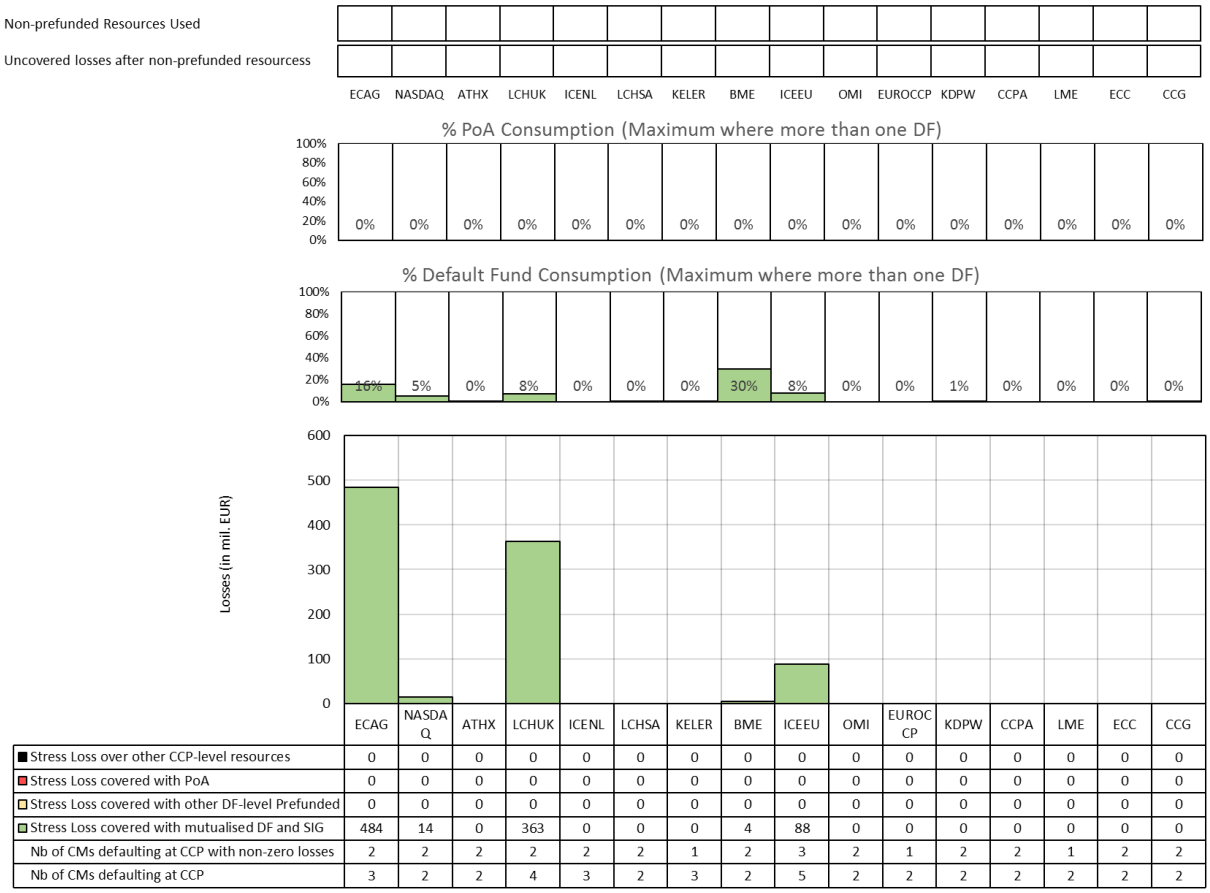


FIGURE 36: COVER-2 GROUPS PER CCP - MARKET SCENARIO 3 – NO EXCESS MARGIN

170. The CCPs, both individually and as a system, experienced no significant stress from Scenarios 2 (Figure 35) and 3 (Figure 36). In many cases, the CCPs would not even have to use the default funds in order to manage the calculated losses and the losses could have been covered with the margin collateral. This can partly be accounted to the fact that these scenarios were calibrated to ensure severe shocks to specific asset classes that may not be relevant for some CCPs. Also in other cases, the products experiencing the most severe shocks may be cleared within a single default waterfall (default fund), with asset classes that were not shocked sufficiently within one of these two internally consistent scenarios. To conclude, even CCPs that do clear products for these asset classes showed resilience to the provided shocks.

4.3.2 MD-A, Cover the Top-2 clearing members per CCP

171. The MD-A member default scenarios involve the default of the top-2 clearing members (individual entities and not groups) per CCP. Each defaulting entity is considered to be in default in all CCPs. Therefore, the number of defaulting entities at each CCP is always greater or equal to two, as this is the initial condition. In practice, the number of defaulting entities is much higher, because of the cross-default condition.

172. The top-2 clearing members selected at each CCP are the ones having the highest losses over margin collateral and own default fund contributions. In other words, we select at each CCP the two entities that would lead to the largest amount to be covered by mutualised resources. For CCPs that have more than one default fund we first calculate the losses over own resources at each default fund and then add across all default funds in order to select the most relevant members. Again, the entities are selected per market stress scenario and using the required margin (excluding excess).

173. A limitation of this selection condition is that it will not always identify pairs of members that could cause a breach of mutualised resources, as it considers only the losses exceeding the defaulters' margin and default fund contributions and not the amount of mutualised resources that is available to cover those[24]. The primary focus of the MD-A scenarios is to explore the systemic implications from extending the regulatory cover-2 condition to all CCPs, through the cross default condition. The "cover-2 groups per CCP" member default scenario has been added to identify pairs of groups that could breach the prefunded resources and assess the resilience of individual CCPs. For that reason, under the MD-A scenarios we try to select entities that have significant exposures across multiple default funds within one CCP.

174. The results of the MD-A member default scenarios for the first market stress scenario (Scenario 1) with and without considering excess collateral are presented below (Figure 37 and Figure 38). The results for the remaining two market scenarios (Scenario 2 and 3) are again by far less severe, raised no concerns and are only presented in the Annex for completeness.

[24] For example, it will not select two clearing members creating a small breach at a small default fund, but focus on two larger clearing members, potentially from different default funds, that would in aggregate create larger losses over own resources.

MD-A (top-2 entities per CCP, cross defaulting at all CCPs) Market Scenario 1 – No Excess Margin

	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	30	303	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	1,621	108	0	1,399	0	27	1	57	1,077	0	0	4	0	224	8	8
Nb of CMs defaulting at CCP with non-zero losses	8	10	2	11	2	12	2	5	9	2	3	3	4	6	6	6
Nb of CMs defaulting at CCP	15	12	3	17	3	14	4	10	14	3	7	4	8	9	8	14

FIGURE 37: MD-A - MARKET SCENARIO 1 – NO EXCESS MARGIN

175. The MD-A results are more severe than the “cover-2 groups” scenarios, because of the cross-default condition that leads to a very large number of members defaulting simultaneously at many CCPs, despite the fact that under MD-A the initial condition is the default of 2 entities and not 2 groups. For two CCPs (BME Clearing and ICE Clear Europe), there would be a need to call for additional non-prefunded resources, as the prefunded mutualised resources of one of their default funds would be depleted.

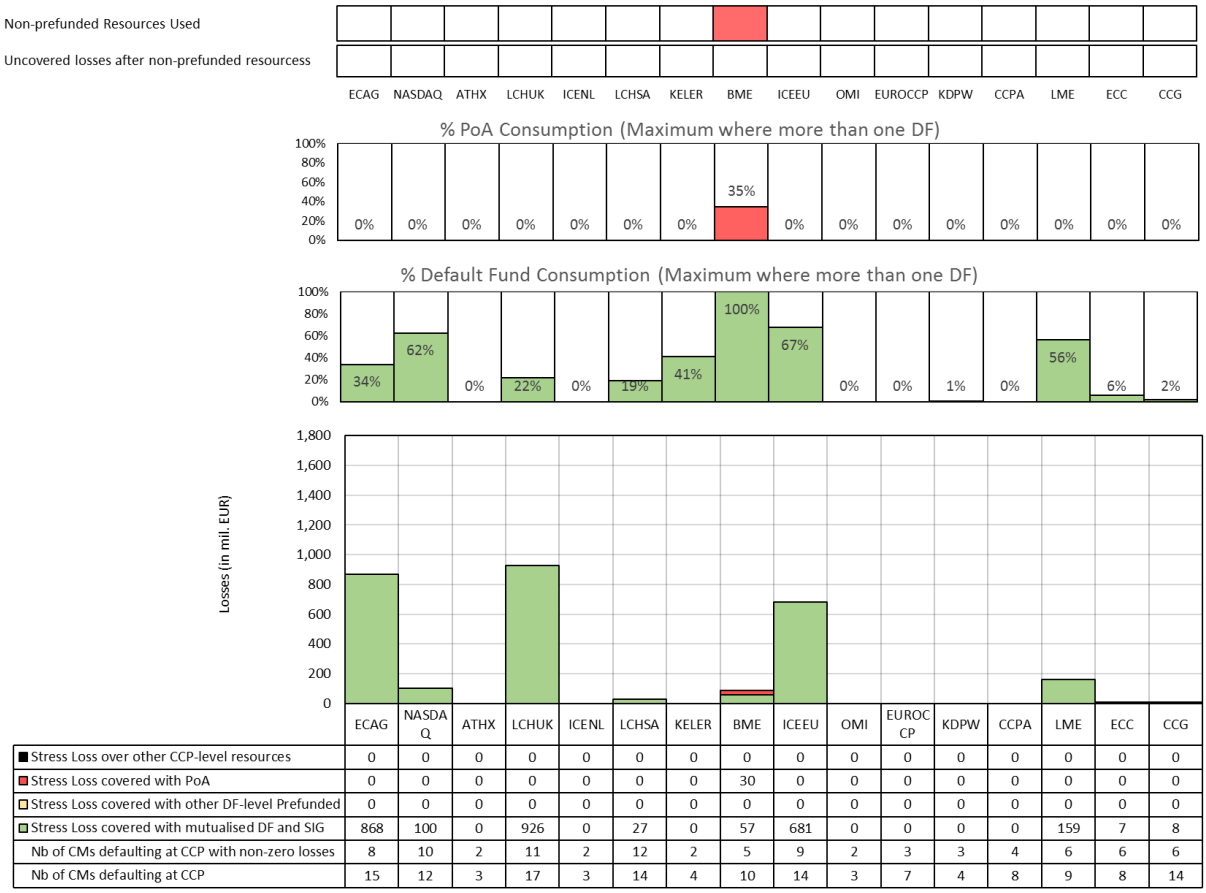
176. In total, the EU-wide aggregate amount that would need to be covered by the prefunded contributions of non-defaulting members and the CCPs dedicated own resources (“skin-in-the-game”) is approximately 4.5bn EUR, leaving 333 mil. EUR to be called in addition from non-defaulting clearing members at two CCPs (303mil. EUR at ICE Clear Europe and 30mil. EUR at BME Clearing). The amount of non-prefunded resources that would need to be called is comfortably within the maximum amounts that can be called by these particular CCPs (35% coverage at BME Clearing and 2% at ICE Clear Europe) and the impact to the non-defaulting clearing members is further explored

in the knock-on analysis presented in the present report. No systemic implications from second round effects via the risk-sharing mechanism of CCPs to non-defaulting members is identified.

177. Moreover, subject to the reservations already discussed, if one considers also the excess collateral, the results presented in Figure 38 show a significant improvement. In particular, only one CCP (BME Clearing) would still need to call for approximately 30 million EUR of additional non-prefunded resources.

178. Overall, the maximum number of members defaulting at a single CCP is between three (3) and seventeen (17) entities, depending on the degree of interconnectedness of individual CCPs. However, it should be noted that, the members that are cross-defaulted from other CCPs do not always expose a CCP to risk or contribute significantly to the losses it may face. It can be that the cross-defaulted members do not have any clearing activity at this CCP or even when they are active, they would not cause any losses under the common scenario. Therefore, the number of members defaulting with non-zero losses is a more appropriate indicator of the severity of the member default scenarios at individual CCPs. Still, the number of entities with losses is in most cases, especially for CCPs that experience significant impact, very high. Although not possible to calculate, the combined probability of such a number of entities defaulting simultaneously is expected to be very low, implying that this scenario goes beyond what can be reasonably considered as plausible.

MD-A (top-2 entities per CCP, cross defaulting at all CCPs) Market Scenario 1 – With Excess Margin



	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	868	100	0	926	0	27	0	57	681	0	0	0	0	159	7	8
Nb of CMs defaulting at CCP with non-zero losses	8	10	2	11	2	12	2	5	9	2	3	3	4	6	6	6
Nb of CMs defaulting at CCP	15	12	3	17	3	14	4	10	14	3	7	4	8	9	8	14

FIGURE 38: MD-A - MARKET SCENARIO 1 – WITH EXCESS MARGIN

4.3.3 MD-B, Cover the Top-2 groups EU-wide

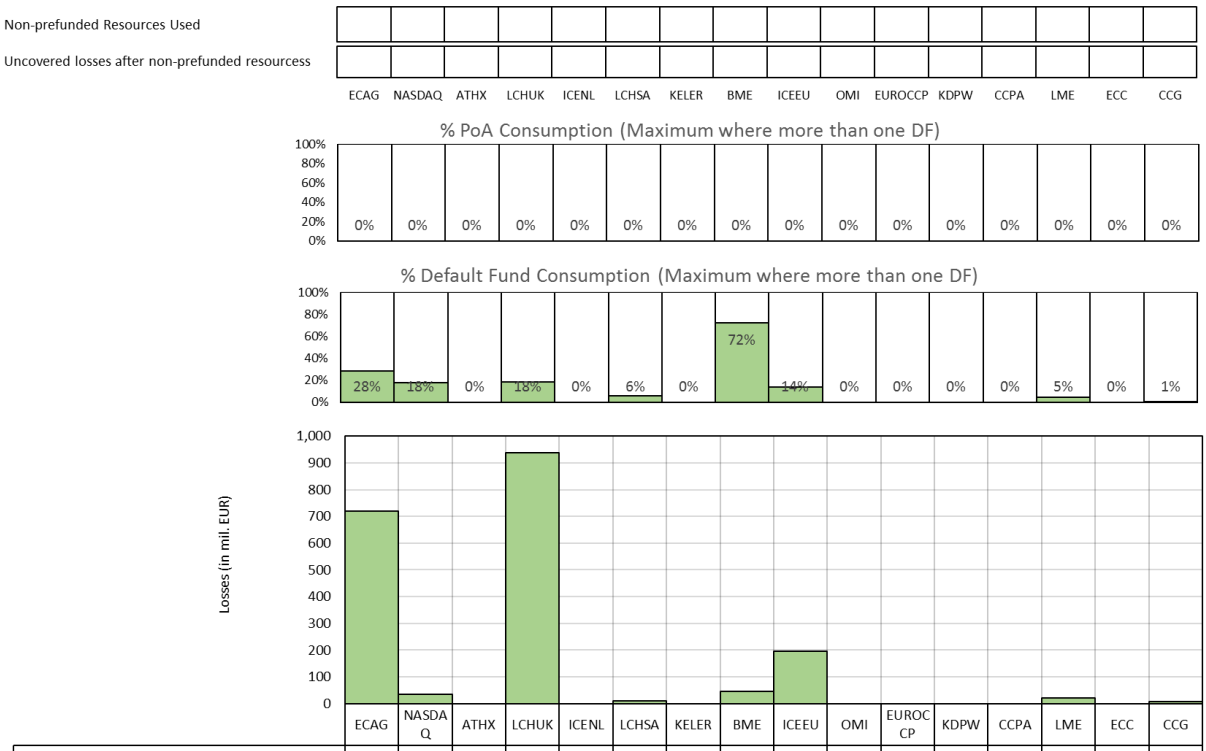
179. The simultaneous default of two (2) groups of clearing members that would cause at an aggregate EU-wide level the largest losses above the defaulting members' collateral is also considered in combination with all the market stress scenarios. In order to select the most relevant groups of clearing members on an EU-wide level, we consider for each clearing member of each group, the aggregate loss over own resources (i.e. required margin collateral and default fund contribution). The two groups selected are the ones that have the highest loss over own resources across all CCPs considering all clearing members belonging to each group. This selection algorithm focuses on the two (2) groups of clearing members showing the highest losses over own resources at EU-wide level. It does not focus on the resilience of individual CCPs, which is assessed using the cover-2 groups per CCP member default scenario.

180. We explored the use of different selection algorithms, including for example selecting the top-2 groups that would cause the largest aggregate breaches of prefunded resources across all CCPs. It was concluded that this would just be a restricted (more lenient) variant of the" top-2 groups per CCP" member default scenario. In particular,

the algorithm would just propagate to all CCPs the default of the two (2) clearing member groups, that would cause the highest breach at a single CCP with very limited systemic implications. This algorithm would fail to adopt a more systemic point of view, as for example exploring the default of pairs of groups that would put simultaneous pressure on multiple CCPs, even if not leading to breaches.

181. The default of two clearing member groups EU-wide in combination with stress market conditions can be considered as an extreme but definitely plausible scenario. Compared to the other scenarios explored, it represents a more likely and systemically relevant scenario to materialise, as it does not assume the simultaneous default of a very large number of entities. The results under market scenario 1 are presented in the following two figure (Figure 39). The results for the other two scenarios are again significantly less severe and can be found in the Annex.

MD-B (top-2 groups EU-wide, defaulting at all CCPs) Market Scenario 1 – No Excess Margin



	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	719	34	0	938	0	9	0	46	197	0	0	0	0	22	0	8
Nb of CMs defaulting at CCP with non-zero losses	5	3	0	4	0	3	0	4	4	0	0	0	1	1	0	2
Nb of CMs defaulting at CCP	5	3	0	7	0	4	1	4	5	0	2	2	2	2	0	4

FIGURE 39: MD-B - MARKET SCENARIO 1 – NO EXCESS MARGIN

182. All CCPs could cover the calculated losses with the already provided prefunded resources. It can be seen that we have CCPs where no clearing members are defaulting. This is because the entities belonging to the selected top groups are not members at those particular CCPs. In three (3) other CCPs, there are defaulting clearing members, but these would not have any losses under the considered scenarios.

183. Overall, the EU-wide aggregate losses exceeding the defaulting clearing members' resources, that would need to be covered by the mutualised resources at all CCPs, are approximately 2bn EUR. These would be absorbed without problems, by the available prefunded resources, as the maximum percentage consumption of a single default fund would be 72% and that only for a relatively small amount. The results indicate that, under the assumptions and limitations of the exercise, there would be no systemic impact from such an event, even if combined with the considered market stress scenarios.

4.4 Clearing Member Knock-on Analysis

184. The clearing member knock-on analysis is an assessment of the impact of CCPs using the mutualised resources (default fund contributions and power of assessments). The aim of this analysis is to assess whether there are potential systemic risk implications from non-defaulting clearing members losing part of their resources because of the loss sharing mechanism of CCPs.

185. ESMA calculated for all clearing members the amount of prefunded and non-prefunded resources that would be lost under different combinations of member default scenarios and market stress scenarios. We then identified the non-defaulting members for which the aggregate loss would exceed a certain absolute amount (20 mil. EUR) and a certain percentage of the clearing member's capital, set at 10%. Taking also into account the limitations described below, these conditions were calibrated in order to focus only on cases with potentially material and systemic implications. As this is an analysis of the impact to individual non-defaulting clearing members across all CCPs, it will be presented using only the two member default scenarios (MD-A and MD-B), where the cross defaulting condition of individual entities is activated. The analysis is again based on the required collateral (excluding excess). The exercise is not performed at the group level, as (a) group capital figures are not available, (b) we would need to incorporate the structure and absorb capital at different entity levels, and (c) we would need to assume that mother companies would always be ready to absorb losses.

186. CCPs were asked via the data request to report the capital figures for their clearing members. Where a CCP was not in a position to report CET1, it was requested to report Tier 1 and if Tier 1 is not available either, the Total Regulatory Capital. The quality of data received was not satisfactory. In several cases, we had inconsistent numbers reported by different CCPs for the same entity, capital type and reference date. Therefore, since for the analysis we needed one amount per entity, where CET1 was not reported or was not reliable (e.g. large deviations between amounts reported by

different CCPs), we used the Tier1 and if that was also not available / reliable, we used the Total Regulatory capital.

187. We identified three (3) non-defaulting clearing members meeting the above mentioned conditions in at least one combination of scenarios. For all combinations of market stress scenarios (Scenario 1, 2 & 3) and member default scenarios (MD-A and MD-B), we present a chart (Figure 40), showing for each one of these members:

- The aggregate amount of prefunded resources (default fund contributions) lost by the clearing member at all CCPs in million EUR and the same amount expressed in % of its reported capital.
- The aggregate amount of prefunded and non-prefunded resources (powers of assessment called) lost by the clearing member at all CCPs in million EUR and the same amount expressed in % of its capital.

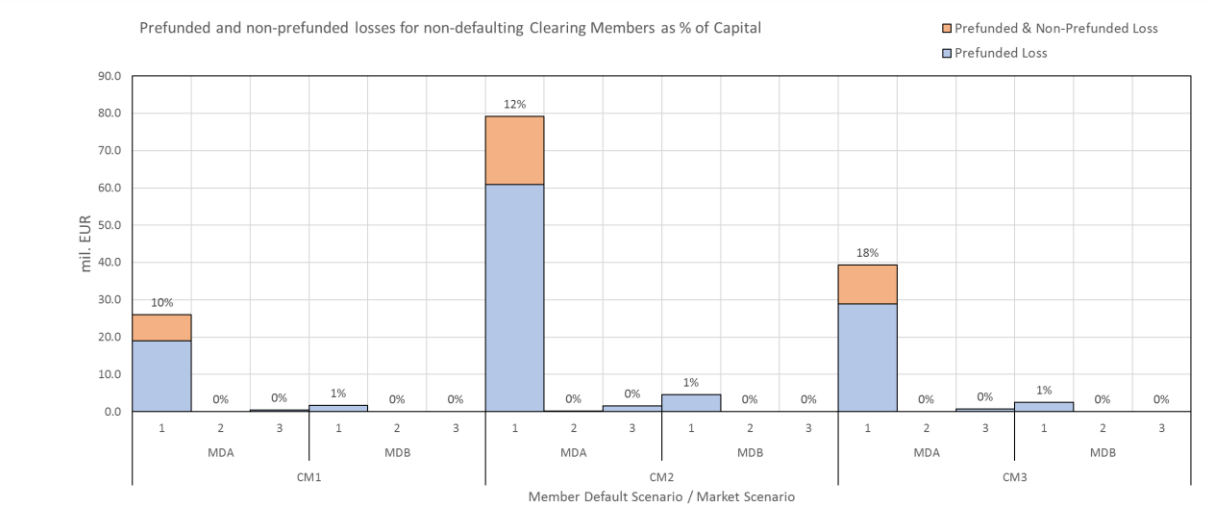


FIGURE 40: LOSSES OF NON-DEFAULTING CLEARING MEMBERS AS % OF CAPITAL

188. Overall, no evidence of systemic implications from second round effects to non-defaulting members via the risk-sharing mechanism of CCPs under the considered stress scenarios was identified. This analysis considers only the non-defaulting members that meet both aforementioned conditions, i.e. loss over capital > 10% and loss > 20mil. EUR. Therefore, it has not been assessed if there are clearing members with smaller losses that can however account for a large part of their capital. In that context, the largest loss as % of capital at one member was 18%, with the largest absolute amount of losses, including prefunded and non-prefunded resources, at another member being approximately 80 mil. EUR.

189. It should be highlighted, that the second round effects due to bilateral relationships between clearing members is generally expected to be far more important, than any adverse effects via the loss-sharing mechanism of CCPs explored here. The bilateral relationships are however beyond the scope of this exercise. The purpose of this analysis was to explore if the risk sharing mechanism can create significant additional

pressure to non-defaulting clearing members and the results of this analysis should be assessed considering that limitation.

4.5 Reverse Credit Stress Test Results

190. For the reverse stress tests, we perform a two-dimensional analysis of the absorption capacity of the system of CCPs by stepwise increasing the number of defaulting entities and the severity of the market shocks in order to identify at which point resources are exhausted. While exploring the different combinations, we go intentionally beyond what is considered as plausible for the purpose of this exercise. We try to capture the sensitivity of the results to the considered stress scenarios and understand how the results are affected by changing the underlying assumptions.

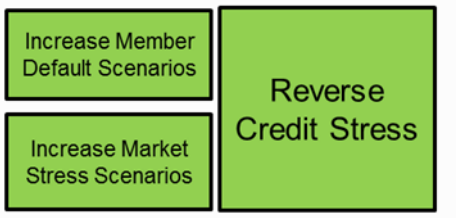


FIGURE 41: REVERSE CREDIT STRESS TEST

191. After all, although the baseline stress scenarios are carefully modelled to simulate extreme market conditions, they are still subject to uncertainties and limitations, as is the case with all modelling procedures. For example, a steep increase of the uncovered losses following a relatively small change in the shocks could indicate a high sensitivity and raise concerns on the robustness, considering the limitations and uncertainties.

192. The focus of this analysis is to identify combinations of market stress scenarios and member default scenarios with systemic risk implications. Results of individual CCPs were only analysed where needed to explore the source of events that may have systemic relevance. The reverse stress analysis is limited to the credit stress component and will not cover the liquidity risk, as it can be very complex and demanding in terms of data. The extension of the scope to liquidity risk can be considered for future exercises.

193. The first EU-wide stress test exercise included a reverse stress test analysis by further increasing the number of defaulting entities under the member default scenarios. A similar approach on the increase of the number of clearing member defaults is maintained. For the reverse credit stress test scenarios, we are considering the default of the EU-wide top-n clearing member groups, where n ranges from one (1) to five (5) groups. All entities belonging to these groups are considered to be in default across all CCPs[25]. We have explored the use of the following selection conditions:

- select the EU-wide top-n groups leading to the highest total consumption of prefunded resources;

[25] We have not considered the "cover-2 group per CCP" default scenarios, as omitting the cross defaulting condition does not serve the purpose of the reverse analysis. The objective is not to assess the resilience of individual CCPs, but rather look for combinations of scenarios with significant systemic implications. Moreover, the MD-A scenarios (top entities selected per CCP and then cross-defaulted across all CCPs) are not used as these lead to a very large, rather unrealistic, number of defaulting members even when only considering the default of 2 members / CCP.

- select the EU-wide top-n groups leading to the highest loss over own resources (margin and default fund contributions of defaulting members);

194. However, since the starting point of the reverse analysis is the breaking point, i.e. the point where CCPs' resources are exhausted, the first is more adequate and is discussed in the report. The reverse stress test results following the second condition, being an extension of the core MD-B scenarios, are presented in the Annex for completeness.

195. In addition, the analysis is complemented by also increasing the market stress shocks. The CCPs were asked to calculate and report the losses also after scaling up the shocks in the provided market scenarios for a number of steps (i.e. x1.2, x1.5, x2)[26].

196. The reverse stress test results are presented in the form of the following two tables, each having 2 dimensions, horizontal: 4 market scenario steps (baseline, x1.2, x1.5, x2) and vertical: 5 member default scenario steps (1…5 groups defaulting)[27].

- Table showing the aggregate amount of losses (billion EUR) over prefunded resources for all CCPs (Figure 42).

- Table showing the aggregate amount of losses (billion EUR) over non-prefunded resources for all CCPs[28] (Figure 43).

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	0.6	2.1
		2	0.0	0.7	2.0	4.4
		3	0.4	1.3	3.0	7.1
		4	0.7	1.9	4.3	10.6
		5	0.8	2.2	5.6	14.3
Scenario 2		1	-	-	-	0.0
		2	-	-	0.0	0.0
		3	-	-	0.0	0.1
		4	-	-	-	0.1
		5	-	-	-	0.1
Scenario 3		1	-	-	0.0	0.1
		2	-	-	0.0	0.9
		3	-	-	0.1	1.6
		4	-	-	0.4	2.1
		5	-	-	0.5	3.6

FIGURE 42: TOTAL LOSSES (BILLION EUR) OVER PREFUNDED RESOURCES, NO EXCESS MARGIN

[26] The CCPs recalculated the losses using the scaled-up shocks and did not scale up directly the P&L as this would not be correct, especially for products with non-linear pay-offs (e.g. options)

[27] When it comes to the member default scenarios, we increase the initial number of groups defaulting and not the final number of clearing members considered to be in default. For example this means that the 4th step will consider the default of the top 4 groups EU-wide and all members belonging to these groups at all CCPs.

[28] The other CCP-level resources have not been considered in the reverse stress test in order to simplify the calculation, but the impact from this assumption is assessed as immaterial in the context of the reverse stress test.

197. It can be seen that under the first market stress scenario (Scenario 1), there is already a very small shortfall of prefunded resources after the default of 2 groups EU-wide under the baseline stress shocks (first column, second row, = 0.0bn EUR). It is the same shortfall of prefunded resources (< 1mil. EUR) identified for one CCP (BME Clearing) under the “cover-2 groups per CCP” member default scenario propagating the same defaulting members across CCPs.

198. However, when the baseline shocks are increased by 20% (x1.2), the shortfall of prefunded resources following the default of 2 groups increases steeply to 0.7bn EUR and becomes significant (second column, second row, = 0.7bn EUR). This shortfall is due to another CCP (ICE Clear Europe). That is a different CCP than the one identified in the previous paragraph. The shortfall would increase further to approximately 2.0bn EUR (third column, second row), if one would use shocks equal to 150% of the baseline stress shocks, leaving the number of defaulting groups unchanged. Again, the majority of these shortfalls of prefunded resources originate from the same CCP, while also the prefunded resources of a second one would be depleted leading to smaller, but still material, shortfalls.

199. If we explore the other dimension, i.e. the number of groups defaulting, shocks equal to 150% of the baseline stress shocks are needed to breach the prefunded resources following the default of only one (1) group EU-wide. The shortfall of prefunded resources would be equal to 0.6bn EUR (third column, first row) and stems from two CCPs, similar to what was observed in the previous paragraph, i.e. the majority from the one CCP, but also a significant amount from the second one.

200. If one uses the baseline stress shocks, but increases the number of defaulting groups to three (3) (first column, third row) the shortfall would be approximately 0.4bn EUR, originating exclusively from the same CCP (ICE Clear Europe), that has shown the highest sensitivity in the reverse analysis.

201. If one considers also the non-prefunded resources (Figure 43) that could have been called from the non-defaulting members, these would be enough under the scenarios discussed above to cover the calculated losses.

202. The results for the two additional market stress scenarios (Scenario 2 and Scenario3), are by far more robust and clearly indicate that a small change in the underlying stress assumption would not lead to a depletion of prefunded resources.

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	0.3
		2	-	-	-	-
		3	-	-	-	0.2
		4	-	-	-	0.8
		5	-	-	-	1.7
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-

FIGURE 43: TOTAL LOSSES (BILLION EUR) OVER NON-PREFUNDED RESOURCES, NO EXCESS MARGIN

203. Overall, the analysis shows that a small increase of either the number of defaulting groups (to 3) or the shocks (to 120% of the baseline stress shocks) leads to material breaches of the prefunded resources at one (1) CCP (ICE Clear Europe). The credit stress test results show that this CCP covered the losses linked to the default of 2 clearing member groups using the defined stress scenarios. However, a relatively small change in the assumptions underlying the stress scenarios would lead to a depletion of the prefunded resources. This CCP shows therefore a high sensitivity to small increases of shocks.

204. One of the key limitations of the reverse analysis is that second round effects are increasingly relevant as scenarios become more extreme, beyond what can be reasonably considered as plausible. However, as in the core credit stress test, second round effects are not accounted for. It should be highlighted that in practice the wide spread effects from such catastrophic events in the financial system cannot be analysed fully only considering the CCPs and the cleared exposures. Therefore, due to its limited scope, this analysis cannot predict the impact from such events. Its purpose is to assess the sensitivity of the CCP stress results to small changes in the scenarios and underlying assumptions.

4.6 Liquidity Stress Test Results

4.6.1 Presentation of the results

205. In line with the framework, the liquidity position of each CCP is assessed per currency, assuming that liquid resources can only be used to cover liquidity requirements of the currency of the resources. We will only report the major currencies (EUR, USD, GBP).

206. The overall liquidity position of each CCP is, however also assessed assuming that FX spot conversions are freely available at the CCP level. A CCP may have a shortfall in one currency, but still be able to cover that shortfall by converting resources held in another currency.

207. Given the large number of variables and currencies to test, providing the results for all combinations of the parameters would not give a clear picture.

208. In order to provide a narrative and intelligibility to the results, we will present them in a cumulative manner by considering different steps or tools.

Tools	Narrative	Comments
A	Including Excess Margins	Most lenient
B	Excluding Excess Margins	
C	Sell off settlement lag of 2 days	
D	Market access delay for liquid resources	Most conservative End of day
E	Central Bank Repo Impact	Assessing reliance on central bank repo lines

TABLE 4: LIQUIDITY TOOLS

209. We start with the most lenient set of assumptions (in A), where we assume full market access, immediate settlement (i.e. settlement on the same day), access to all committed lines and possible usage of excess margins given the reported right of use.

210. We then restrict progressively the options available to the CCP to get to the most conservative end of day assumptions. We finish by assessing the reliance of CCPs on central bank repo lines.

211. As for commercial bank repo lines, it should be noted that uncommitted repo lines are always excluded. Only few CCPs have reported committed repo lines from commercial banks. Committed repo lines are only taken into account when the liquidity provider providing them is not considered in default. Therefore assessing the unavailability of commercial bank repo provided by non-defaulting liquidity providers would have had very limited relevance for the analysis.

212. To illustrate the steps, we analyse the cover 2 overall liquidity position of a CCP under scenario 1.

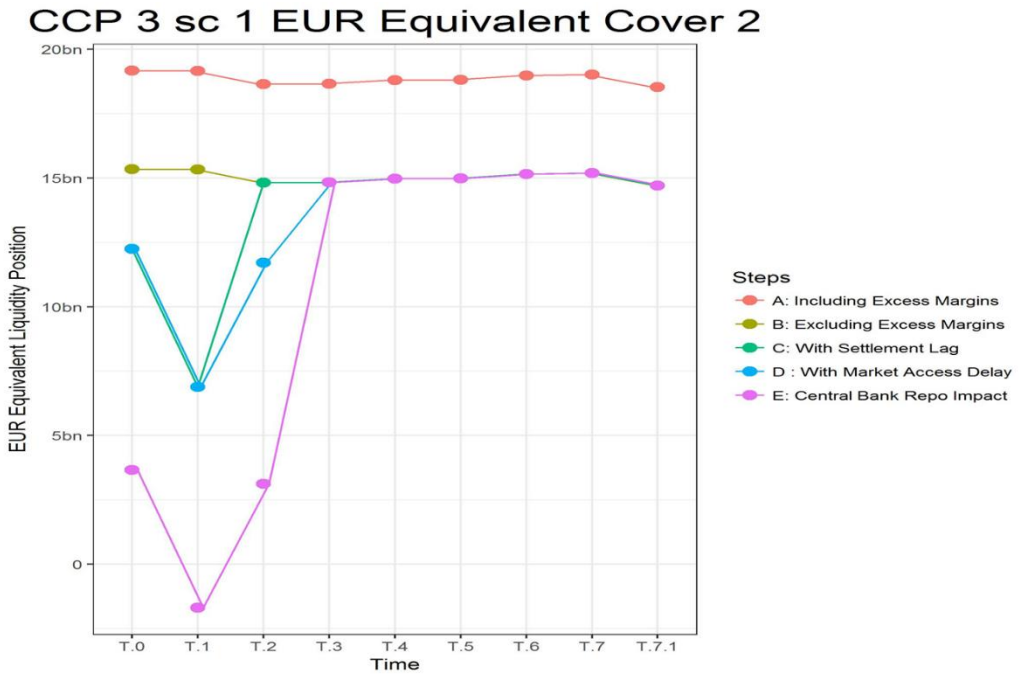


FIGURE 44: EXAMPLE OF A STEP BY STEP ANALYSIS

213. In the example, we can see

214. The impact on the liquidity profile of the removal of excess collateral (step A to B).

215. The impact of introducing a settlement lag of 2 days (step B to C). The liquidity profiles of step B and step C only coincide after T.2. This impact comes from the liquidation of securities that cannot be delivered to a defaulting clearing member or from the liquidation of collateral that cannot put in a repo.

216. The impact of introducing a market access delay of 1 day (step C to D) which together with the settlement lag 2 has an effect up to T.3. The market access delay is only assumed for the collateral that is not used in a repo.

217. Finally, the analysis step E shows that the CCP relies on its central bank repo line. The CCP has a liquidity buffer of 6.9 bn EUR with the repo line, but without it, would have had an outstanding liquidity requirement for an amount of 1.7 bn EUR on T.1.

218. Further analysis on intraday liquidity can be found in Annex 6.5.

4.6.2 Cover 2 results

219. For each CCP and in each of the 3 market scenarios, the 2 entities which together create the worst liquidity position are selected.

4.6.2.1 Capacities of entities selected in Cover 2 analysis

220. For most CCPs, the 2 most important entities for liquidity act as a resource provider (i.e. a clearing member and/or liquidity provider). However, in some cases, no resource

provider is selected. The payment bank capacity alone can be sufficient to get selected. In 2 cases, no resource provider was selected.

CCP.CODE	# RESOURCE PROVIDER	# PAYMENT BANK	# CUSTODIAN	# ISSUER
CCP 1	2	2	2	2
CCP 2	2	1	1	2
CCP 3	2	2	0	1
CCP 4	2	0	2	2
CCP 5	2	0	1	1
CCP 6	2	0	0	0
CCP 7	2	1	0	0
CCP 8	1	0	1	0
CCP 9	2	0	0	0
CCP 10	2	2	2	1
CCP 11	2	2	1	0
CCP 12	2	0	0	0
CCP 13	2	0	0	0
CCP 14	0	2	2	0
CCP 15	2	1	2	0
CCP 16	0	1	0	2

TABLE 5: CAPACITIES OF ENTITIES SELECTED IN COVER 2

221. For the soundness of the exercise, we have therefore not only covered the double default of clearing members in all their capacities ('Cover 2'), but also included the default of other relevant entities which are not clearing members.

222. The same group has entities relevant for 4 CCPs as resource provider. All the other groups would impact significantly 2 CCPs at most.

4.6.2.2 Results

223. In all graphs provided, we only display the CCPs for which there is a remaining liquidity requirement at any point over the liquidity horizon. In other words, CCPs that have their liquidity requirements fully covered are not displayed in the graphs. All CCPs are reported in the tables.

224. The graphs show the remaining available liquidity at CCP level. A CCP that comfortably covers its liquidity requirements in each of its default fund but restricts most of its resources to those default funds will not have a big excess reported at CCP level. In extreme cases, an excess of 0 at CCP level could be reported without it being cause for concern. A negative number however means that a shortfall in at least one default fund could not be covered by default fund and CCP level resources.

225. The tables provide the liquidity position of the CCP before any further tools at its disposal are used, such as use of central bank repo lines, immediate settlements, full market access or use of excess collateral. Of those analysed tools, the use of central

bank repo lines can be considered as highly reliable. The remaining resources overall column reports the liquidity position but assuming that any excess at default level can be used at CCP level.

Overall Cover 2 with access to FX markets

226. In this analysis, we are interested in the overall liquidity position of CCPs, allowing for full FX market access at CCP level. Hence, we report the liquidity position in EUR equivalent after having converted the liquidity positions from the original currency to EUR at the stressed FX rate.

227. CCP 9 requires access to the market with immediate settlement to cover its liqudity needs. This CCP explained that in practice it would apply a fall-back procedure to delay some settlements to prevent overnight liquidity shortages. The CCP stated it has a legal basis for this measure based upon a general provision in its rulebook. However, the instructions of the ESMA stress test require a specific provision to allow delayed settlements in the exercise, which was not found in the rulebook.

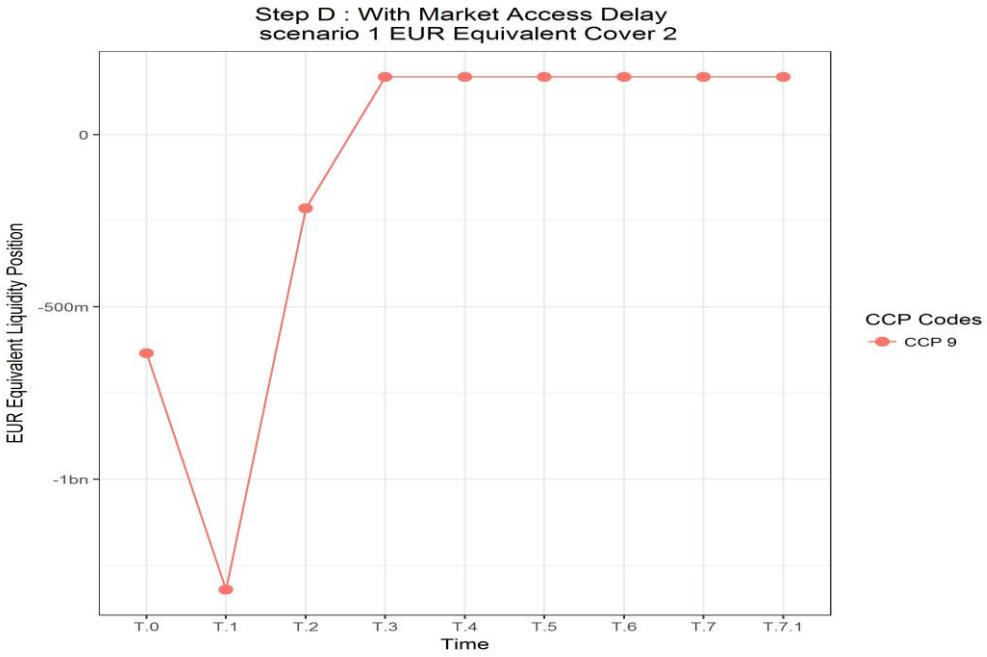


FIGURE 45: COVER 2, STEP D, SCENARIO 1, EUR EQUIVALENT

228. 2 other CCPs cover their liquidity needs by using their existing central bank repo line or standing lending facility. This is the case in all 3 market scenarios. For CCP 3, the remaining liquidity needs would be marginally reduced by relaxing the modelling assumption that excess liquidity generated by inflows are restricted to the default fund level.

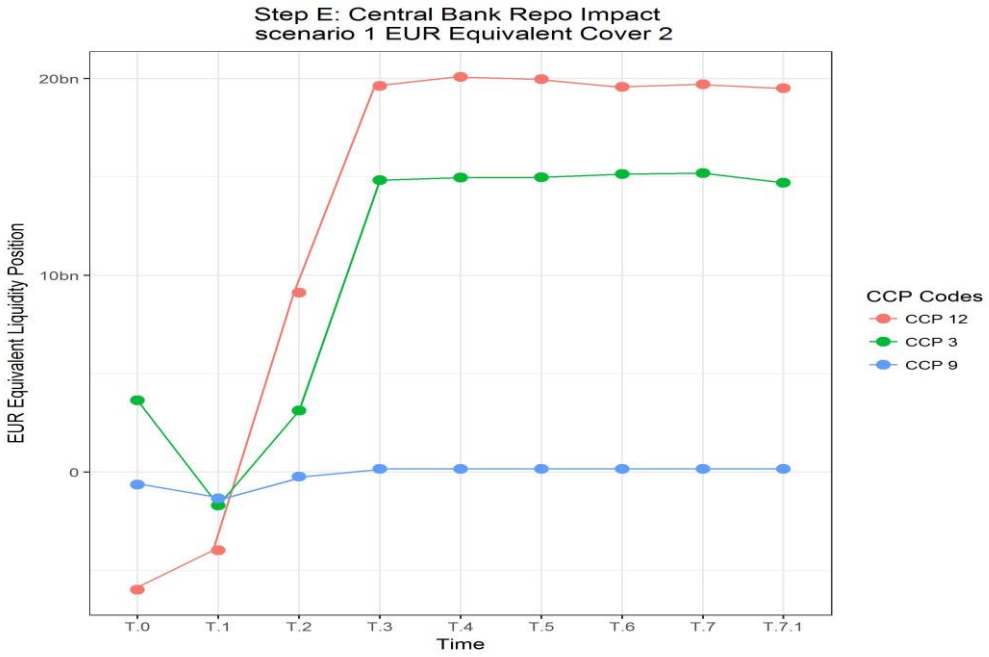


FIGURE 46: COVER2, STEP E, OVERALL LIQUIDITY POSITION

229. The following table picks the worst case market scenario for each CCP and selects the tools that CCPs would need to use to cover the liquidity needs.

230. The central bank repo lines are highly reliable. Therefore, the only tools that may become unavailable are the full market access and immediate settlement.

	STEP E - WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 1	1,181	1,192	1					
CCP 2	17	17	1					
CCP 3	- 1,692	- 1,690	1	X				
CCP 4	11,739	11,897	3					
CCP 5	19	76	1					
CCP 6	1,036	1,036	1					
CCP 7	4	26	1					
CCP 8	6,732	8,002	1					
CCP 9	- 1,321	- 1,183	3		X	X		
CCP 10	26	26	1					
CCP 11	3,931	4,120	1					
CCP 12	- 7,631	- 7,631	2	X				
CCP 13	5	17	1					
CCP 14	2,554	2,554	1					
CCP 15	607	607	2					
CCP 16	42	53	1					

TABLE 6: COVER 2, OVERALL LIQUIDITY POSITION, FX MARKETS ALLOWED

EUR Cover 2

231. Assuming no access to the FX market, for different CCPs, the liquidity needs in EUR are not fully covered by the liquidity resources in EUR under the most conservative scenario.

232. Considering EUR only, the liquidity cushion is reduced for some CCPs compared with the overall position. The same 3 CCPs have remaining liquidity needs in step E under both EUR only and overall analysis. Their needs have the same order of magnitude.

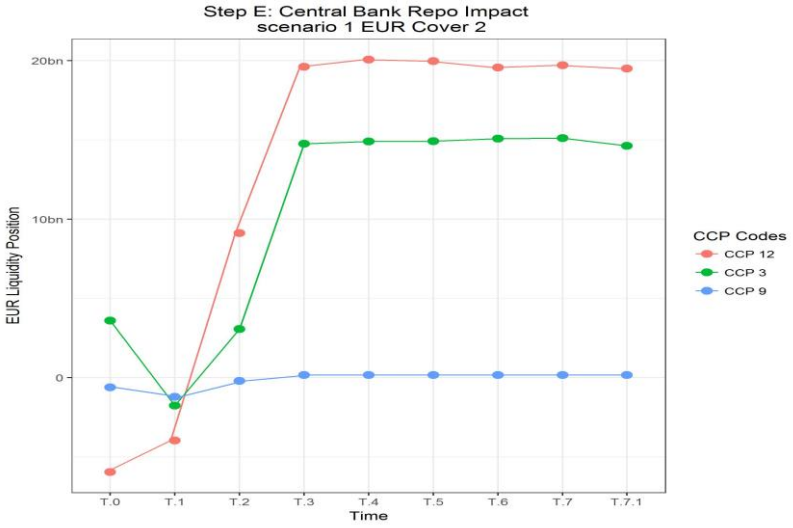


FIGURE 47: COVER2, EUR ONLY LIQUIDITY POSITION

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 1	1,181	1,192	1					
CCP 2	17	17	1					
CCP 3	- 1,762	- 1,762	1	x				
CCP 4	996	996	1					
CCP 5	19	76	1					
CCP 6	1,037	1,037	1					
CCP 7	4	26	1					
CCP 8	6,502	6,570	2					
CCP 9	- 1,210	- 1,210	1		x	x		
CCP 11	281	281	1					
CCP 12	- 7,631	- 7,631	2	x				
CCP 14	293	293	1					
CCP 15	1,078	1,078	1					
CCP 16	42	53	1					

TABLE 7: COVER 2, EUR ONLY LIQUIDITY POSITION

233. The central bank repo lines are highly reliable. Therefore, the only tools that may become unavailable are the full market access and immediate settlement.

USD Cover 2

234. To avoid CCP identification, the CCP coding used in this section is a different one compared to previous sections.

235. Considering USD only, 4 CCPs have remaining liquidity needs under step E. CCP 7, 12 and 13 would have to liquidate securities with immediate settlement to cover their liquidity needs in USD. Moreover, CCP 12 would have to access the FX markets to cover its liquidity needs in USD. CCP 10 has negligible liquidity needs.

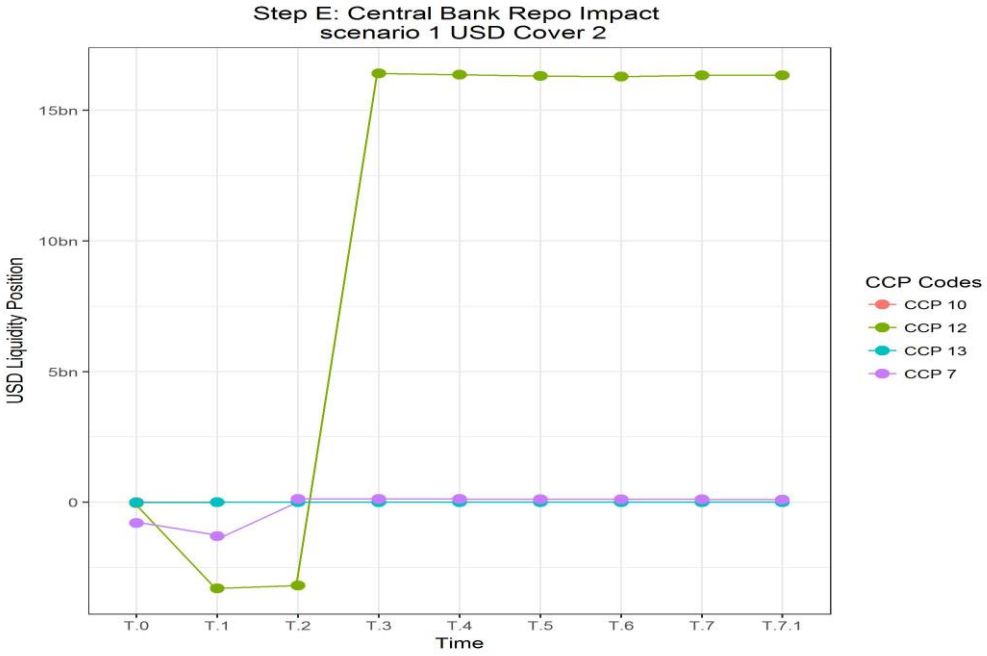


FIGURE 48: COVER 2, USD ONLY LIQUIDITY POSITION

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 1	2,277	2,277	1					
CCP 3	19	19	1					
CCP 5	8,947	9,198	2					
CCP 7	- 1,293	- 1,293	2		X	X		
CCP 9	-	0	1					
CCP 10	- 1	- 1	1					
CCP 12	- 3,298	- 3,194	1		X	X	X	X
CCP 13	- 11	- 11	1		X	X		

TABLE 8: COVER 2, USD ONLY LIQUIDITY POSITION

GBP Cover 2

236. To avoid CCP identification, the CCP coding used in this section has been changed.

237. Considering GBP only, 3 CCPs would need to liquidate securities with immediate settlement to cover their GBP needs with GBP resources. CCP 8 would cover 4.8 bn GBP doing so. There would be no need for access to the FX markets to cover the liquidity requirements in GBP.

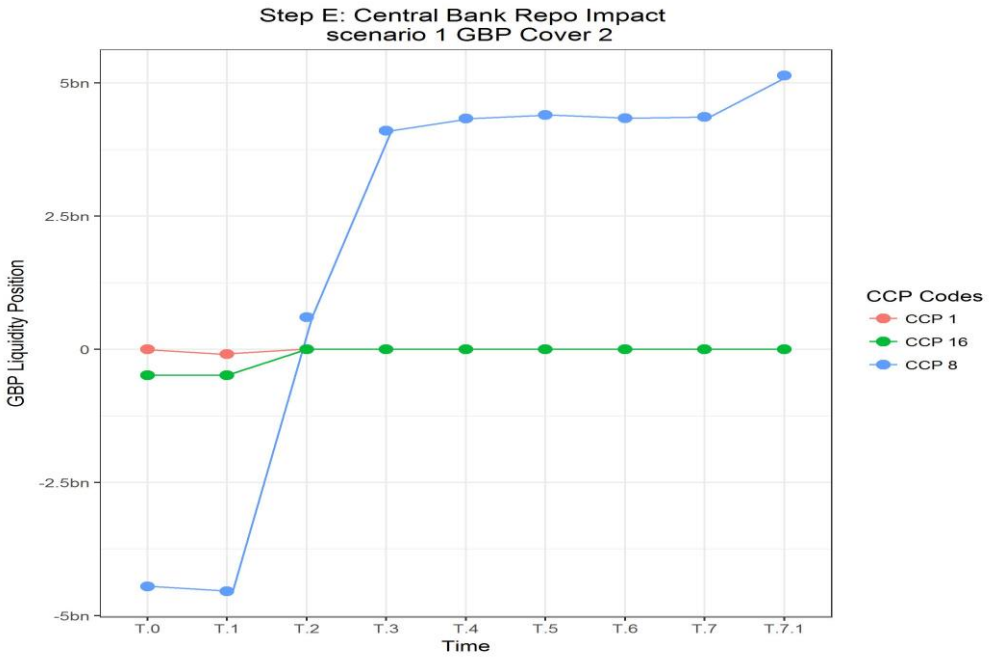


FIGURE 49: COVER2, GBP ONLY, LIQUIDITY POSITION

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 1	- 91	- 91	1		X	X		
CCP 3	2,638	2,638	2					
CCP 7	84	84	1					
CCP 8	- 4,780	- 2,945	2		X	X		
CCP 10	0	0	1					
CCP 16	- 499	- 499	2	X	X	X		

TABLE 9: COVER 2, GBP ONLY, LIQUIDITY POSITION

4.6.3 LDB results

238. The LDB scenario assumes the default of the 2 groups that would impact the most the EU-wide liquidity position of CCPs EU-wide. The Cover 2 analysis was based on only 2 entities defaulting.

239. CCP 9 has moderate remaining liquidity needs remaining in EUR and overall, as soon as we assume delayed settlement.

240. CCP 12 uses its highly reliable central bank repo line to cover its remaining liquidity requirements of 2.4 bn EUR in scenario 2 and 1.1 bn EUR in scenario 3. This is the case even allowing for FX spot market access.

241. Under all market scenarios, CCP 11 has remaining needs between 2.0 and 3.5 bn GBP, which can be covered by immediate liquidation of collateral or access to the FX spot market.

242. CCP 8 has a USD liquidity need in all scenarios, with a maximum of 2.3 bn USD in scenario 1, which can be covered by accessing the FX spot market.

243. The table below provides the sizes of the remaining liquidity needs under step E. The number of defaulting entities relevant for the CCP under the scenario is also provided.

Code	SCENARIO.ID	CURRENCY	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	NB DEFAULTING ENTITIES
CCP 8	1	USD	-2,294	-2,172	4
CCP 8	2	USD	-941	-899	5
CCP 8	3	USD	-720	-633	5
CCP 9	1	EUR	-19	-19	1
CCP 9	1	EUR Equivalent	-19	100	1
CCP 9	2	EUR Equivalent	-10	160	2
CCP 9	2	USD	-2	-2	2
CCP 9	3	EUR Equivalent	-10	154	2
CCP 9	3	USD	-2	-2	2
CCP 11	1	GBP	-2,042	-1,903	6
CCP 11	2	GBP	-3,455	-1,100	7
CCP 11	3	GBP	-3,342	-813	7
CCP 12	2	EUR	-2,408	-2,408	5
CCP 12	2	EUR Equivalent	-2,408	-2,408	5
CCP 12	3	EUR	-1,141	-1,141	5
CCP 12	3	EUR Equivalent	-1,141	-1,141	5

TABLE 10: LDB REMAINING LIQUIDITY NEEDS (OVER 1 MILLION)

EUR Equivalent

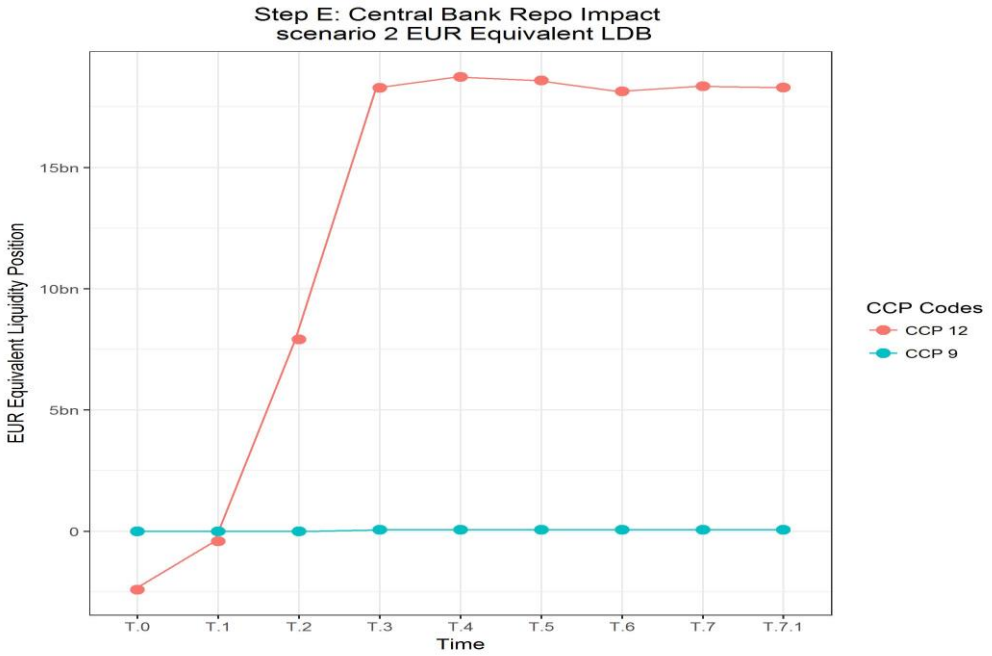


FIGURE 50: LDB, OVERALL LIQUIDITY POSITION

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 1	2,335	2,344	3					
CCP 2	68	70	1					
CCP 3	4,059	4,075	3					
CCP 4	23,034	23,226	3					
CCP 5	19	80	3					
CCP 6	1,289	1,308	1					
CCP 7	4	29	1					
CCP 8	6,766	8,470	1					
CCP 9	- 19	100	1		X	X		
CCP 10	58	58	1					
CCP 11	5,971	6,203	1					
CCP 12	- 2,408	- 2,408	2	X				
CCP 13	6	19	1					
CCP 14	2,995	2,995	1					
CCP 15	1,298	1,300	1					
CCP 16	80	83	1					

TABLE 11: LDB, OVERALL POSITION, FX MARKETS ALLOWED

244. The central bank repo lines are highly reliable. Therefore the only tools that may become unavailable are the full market access and immediate settlement. Only CCP 9 would have a remaining liquidity need requirement under the most conservative assumptions.

EUR Only

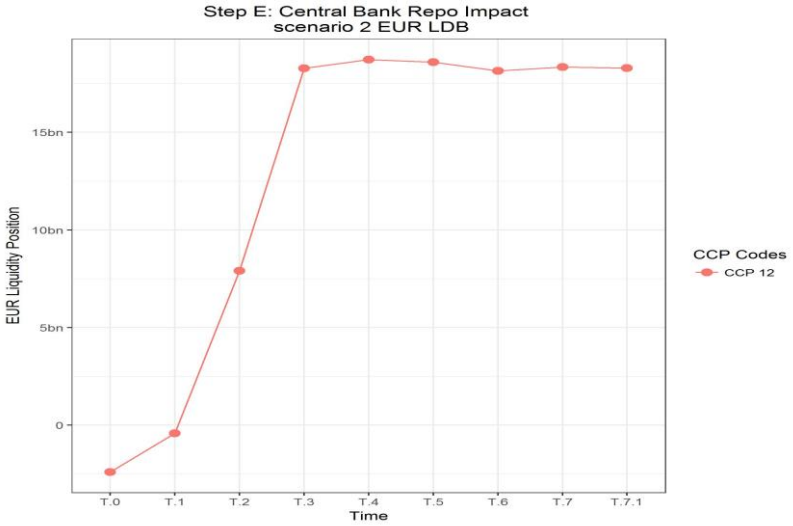


FIGURE 51: LDB, EUR ONLY, SC2, LIQUIDITY POSITION

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 1	2,335	2,344	3					
CCP 2	68	70	1					
CCP 3	3,990	4,006	3					
CCP 4	10,347	10,347	2					
CCP 5	19	80	1					
CCP 6	1,289	1,308	1					
CCP 7	4	29	1					
CCP 8	5,622	5,680	1					
CCP 9	- 19	- 19	1		x	x		
CCP 11	3,031	3,031	1					
CCP 12	- 2,408	- 2,408	2	x				
CCP 14	291	291	1					
CCP 15	1,066	1,066	1					
CCP 16	80	83	1					

TABLE 12: LDB, EUR ONLY, LIQUIDITY POSITION

245. The central bank repo lines are highly reliable. Therefore, the only tools that may become unavailable are the full market access and immediate settlement. Only CCP 9 would have a remaining liquidity need requirement under the most conservative assumptions.

USD Only

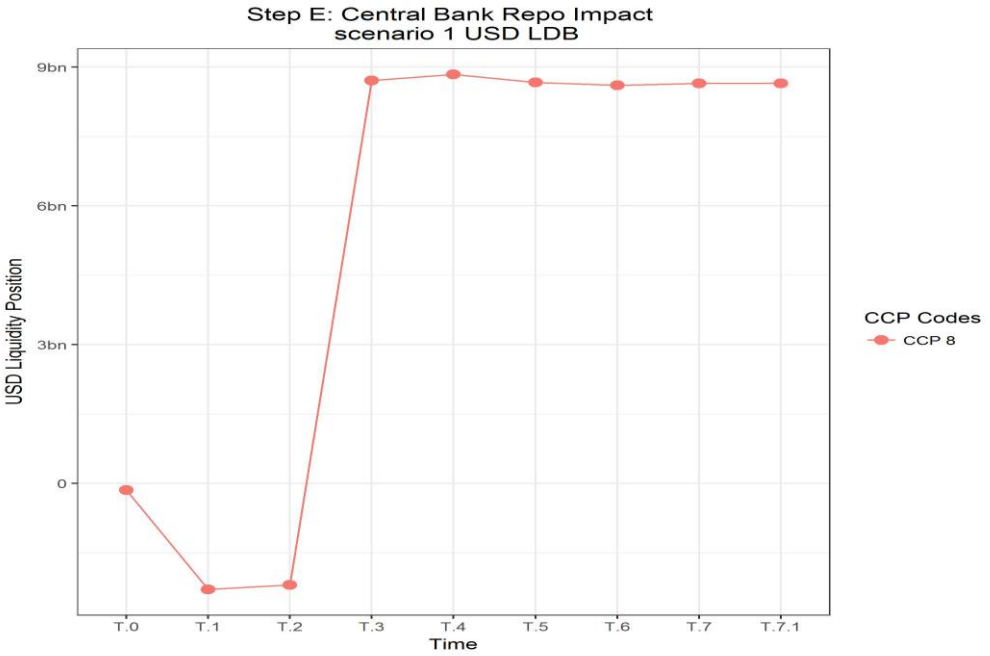


FIGURE 52: LDB, USD only, liquidity position

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 3	- 1	- 1	2					
CCP 4	120	120	1					
CCP 6	- 0	- 0	1					
CCP 8	- 2,294	- 2,172	1		X	X	X	X
CCP 9	- 2	- 2	2					
CCP 11	6,745	6,911	1					
CCP 14	2,777	2,777	1					
CCP 15	18	18	2					

Table 13: LDB, USD only, liquidity position

246. CCP 8 would need to have access to the FX markets to fulfil its liquidity requirements in USD under the most conservative assumptions of the exercise.

GBP only

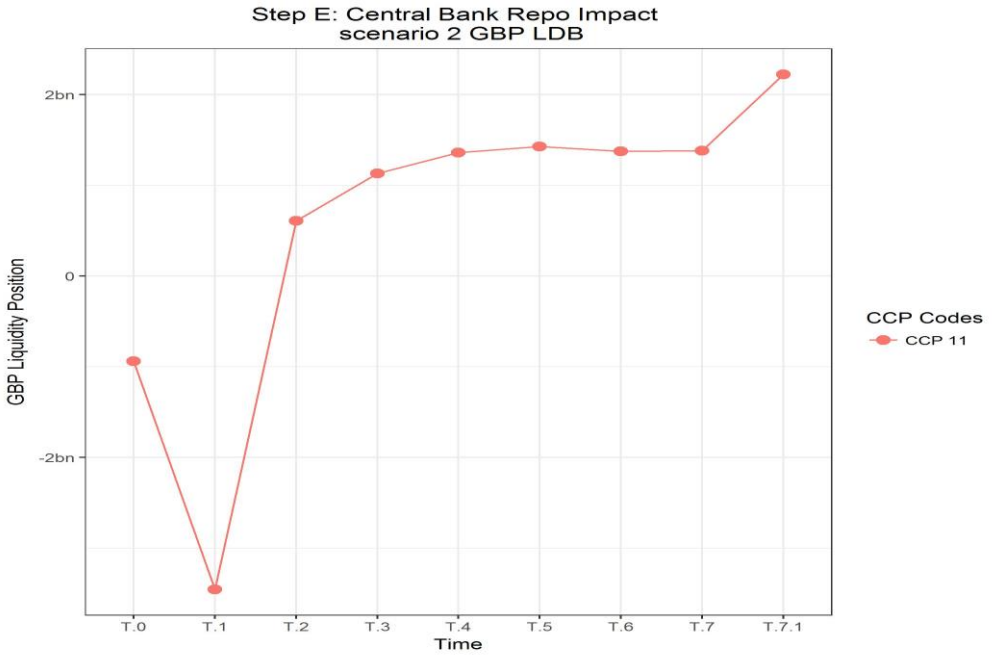


FIGURE 53: LDB, GBP ONLY, LIQUIDITY POSITION

	STEP E WORST CASE			CUMULATIVE TOOLS				
	LIQUIDITY POSITION (mil)	REMAINING RESOURCES OVERALL (mil)	WORST SCENARIO	CENTRAL BANK REPO	FULL MARKET ACCESS	IMMEDIATE SETTLEMENT	EXCESS MARGIN	UNCOMMITTED REPO LINE
CCP 4	- 0	- 0	1					
CCP 6	- 0	- 0	2					
CCP 8	2,637	2,637	2					
CCP 9	-	80	1					
CCP 11	- 3,455	- 1,100	2		X	X		
CCP 14	84	84	1					
CCP 15	- 0	- 0	2					

TABLE 14: LDB, GBP ONLY, LIQUIDITY POSITION

247. To cover its GBP liquidity needs, CCP 11 would need to liquidate securities with immediate settlement in GBP or could access the short-term FX markets.

4.6.4 Liquidity tools review

In this section, we look in more details at two of the tools used by CCPs to cover their liquidity needs.

4.6.4.1 Access to FX market

248. As explained in 3.4.2.4, the liquidity position is assessed for each currency. For example, CCP 8 has 4.8 bn GBP remaining liquidity needs in GBP under scenario 2.

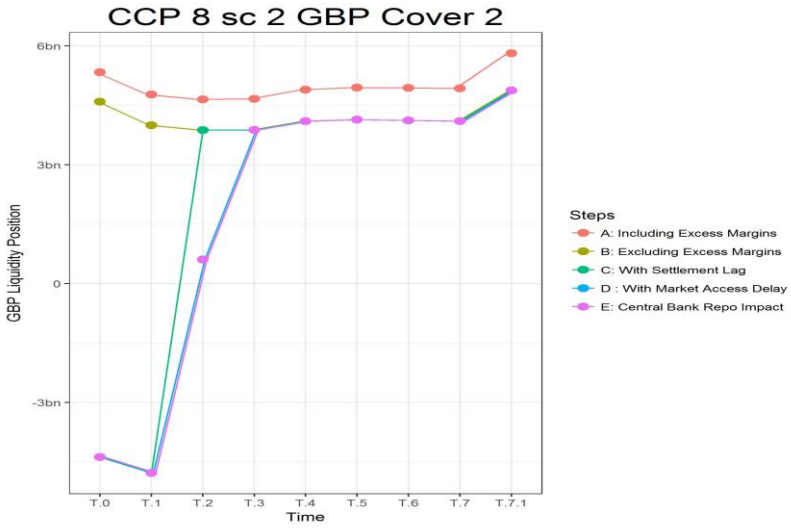


FIGURE 54: COVER 2, GBP ONLY. CCP 8, SCENARIO 2

249. However, if the CCP keeps access to the FX markets, it can cover its liquidity requirement by converting some excess currencies in GBP. Its overall excess liquidity would be almost 8 bn EUR.

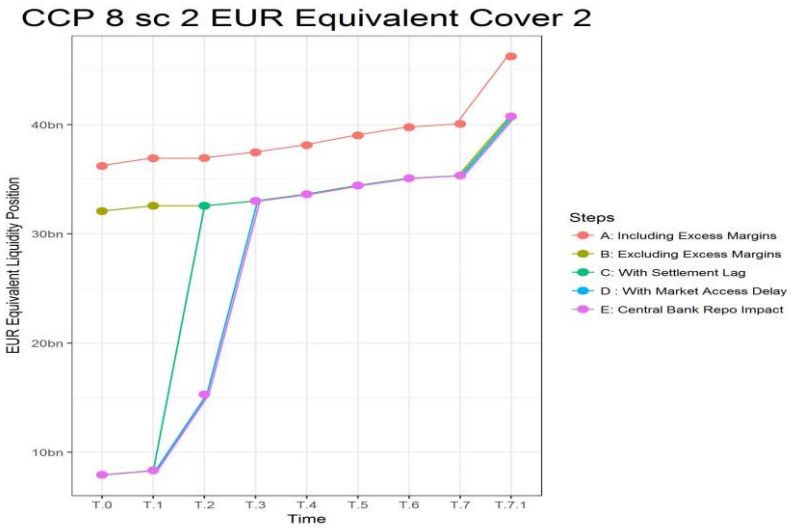


FIGURE 55: COVER 2, OVERALL POSITION. CCP 8, SCENARIO 2

4.6.4.2 Immediate settlement / Central bank repo

250. Some CCP have remaining liquidity requirements as soon as we introduce a settlement lag, as can seen in 4.6.2.2 for CCP 9.

251. When a committed central bank repo line is present, the impact of the settlement lag is only being felt in full when not taking into account the central bank repo line. This impact can be seen below between Step D and Step E.

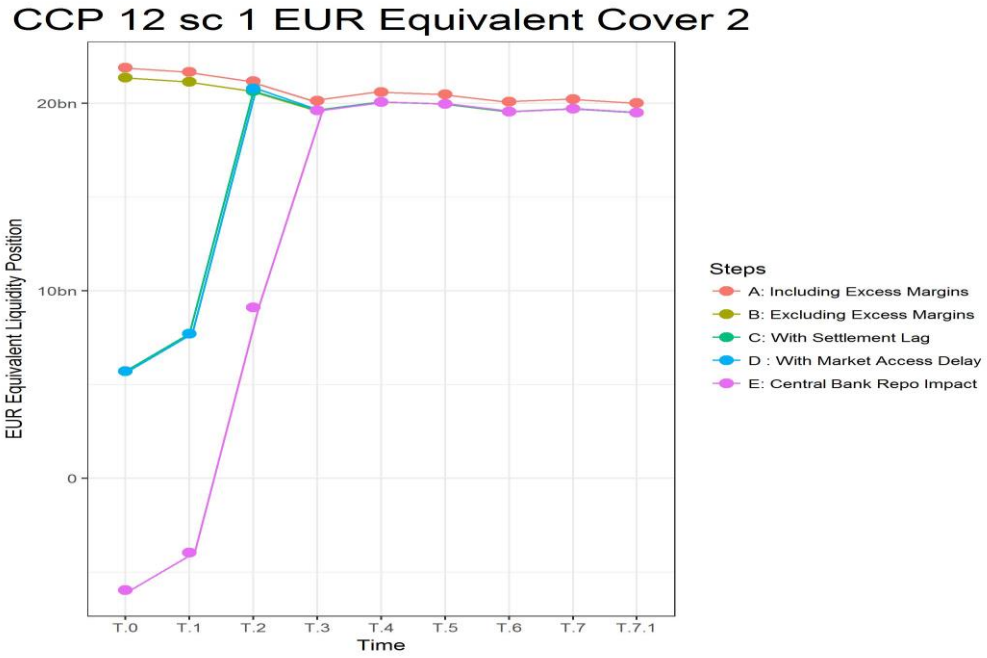


FIGURE 56: COVER 2, OVERALL POSITION. CCP 12, SCENARIO 1

5 Conclusions

252. The methodology and scope of the EU-wide Central Counterparty (CCP) stress test have significantly evolved from the first exercise published in 2016. The key improvements are the extension of the scope to include liquidity risk, the improvement of the stress scenario design, based on common, internally consistent scenarios delivered by the ESRB, and the enhancement of the validation process. The exercise covered all 16 authorised EU CCPs and all cleared products. The enhanced framework has improved the robustness of the exercise, but has at the same time increased the technical complexity and effort required from all participants. The exercise has benefited from a closer involvement of the NCA), whose role was critical to check how the individual CCPs calculated the data based on the common scenarios and instructions.

253. Of course, as with all exercises of this scale and type, not all limitations can be addressed within a single and at the same time practicable design. Counterparty credit risk due to member defaults and liquidity risk are the core types of risks faced by CCPs and are now included in the scope of the exercise. However, CCPs may also be subject to other types of risks that are either not covered or are partially covered and could in isolation or in combination with credit and liquidity risks challenge their resilience. ESMA remains committed to further improve and evolve the methodology and scope of the future CCP stress tests.

254. EU CCPs provided for the purpose of this exercise detailed data on their exposures and financial resources for one reference date. The aggregate amount of resources required and collected by CCPs from clearing members in the form of margin and default fund contributions combined was approximately 270bn EUR. Additional prefunded resources, including CCPs' dedicated own funds ("skin-in-the-game"), accounted overall for a very small share of the default waterfall. On top of the collateral provided to meet CCPs' requirements, some CCPs have also reported significant amounts of excess collateral. These have not been considered in the main stress results, reflecting the assumption that defaulting members would have withdrawn under stressed conditions any collateral exceeding the minimum required. Although only prefunded resources have been considered in the stress results, it has been observed that the total amount of non-prefunded resources (powers of assessment) that can be called is not always capped, even after assuming the theoretical default of a large number clearing members. This could count as a potential source of second-round effects to non-defaulting clearing members, but under the knock-on analysis performed, there was no evidence of systemic implications via the risk-sharing mechanism of CCPs under the considered stress scenarios and member default assumptions. Concerning the allocation of clearing members' collateral, the overall EU-wide picture looks rather reassuring, with close to 93% of the collateral being held in the form of cash or government fixed income securities. The cases that could signal divergent practices or over-reliance to specific types of resources or investing arrangements for individual CCPs will need to be assessed on a case-by-case basis, taking into account the risk profile of the relevant practices, subject of course to the regulatory requirements setting the eligible asset types and additional conditions.

255. Close to 900 individual entities that are clearing members to one or more CCPs have been identified. The analysis of concentration to individual clearing participants, as assessed using the Herfindahl - Hirschmann Index (HHI) methodology, has not evidenced any systemically critical concentration to single clearing members or groups at EU-wide level. The analysis of the network of CCPs and clearing participants has confirmed that, as already highlighted in the first EU-wide stress test exercise, CCPs can be highly interconnected through common clearing members. In particular, the biggest clearing member groups are top members at multiple CCPs. The enhanced interconnectedness analysis has however indicated, that although the top clearing member groups have exposures to multiple CCPs, these exposures would generally not hit simultaneously the default fund waterfall of all these CCPs under one of the common, internally consistent stress scenarios considered in this exercise. It should however be noted that the clearing members' positions and thus the structure and severity of the exposures across CCPs may change significantly even from one day to another. Therefore, this indication cannot be used to draw any conclusions on a forward-looking basis.

256. When looking at interconnectedness via custodians, and subject to the limitations of the exercise, it can be observed that multiple CCPs rely on a small number of cash and securities custodians, including mainly ICSDs and for one particular currency one commercial bank. It should however be noted that, especially concerning the cash deposited at these institutions, the overwhelming majority of the cash was reported as being kept through arrangements that allow its collateralisation with financial instruments. The over-reliance on specific custodians does imply, however, some residual risks including for example operational risks. Concerning common liquidity providers, not many CCPs have reported committed repo lines from commercial entities. Moreover, no strong evidence of single financial groups committing to providing liquidity to many CCPs at the same time has been identified.

257. The results of the credit stress test indicate that, under the simultaneous default of the two groups of clearing members (MD-B) that would cause at an aggregate EU-wide level the largest losses above the defaulting members' collateral, all CCPs could cover the calculated losses with the already provided prefunded resources. Under the most severe of the three considered market stress scenarios, the EU-wide aggregate losses exceeding the defaulting clearing members' resources, that would need to be covered by the mutualised resources at all CCPs, were approximately 2bn EUR. These would be absorbed without problems, by the available prefunded resources. The results indicate that, under the assumptions and limitations of the exercise, there would be no systemic impact from such an event, if combined with the considered market stress scenarios.

258. Under a different member default scenario (Cover-2 groups per CCP), we selected individually for each CCP two corporate groups and assumed all clearing members belonging to those groups as defaulting only in that particular CCP. Overall, no shortfall of prefunded resources with systemic implications was to be found. The results indicate that for one CCP (BME Clearing) the need to call for a limited amount (less than 1 million EUR) additional non-prefunded resources. For another CCP (ICE Clear Europe), the

prefunded resources would be enough, but only marginally enough to cover losses of more systemic relevance. Although the results using only the required margin represent a more realistic scenario, it can be noted for completeness that if one would also consider the excess available collateral, the default fund amounts would in all cases be enough to cover the residual losses.

259. The reverse stress tests analysis assessed the sensitivity of the CCP stress results to small changes in the scenarios and underlying assumptions. Overall, the analysis showed that a relatively small increase of either the number of defaulting groups (to 3) or the shocks (to 120% of the baseline stress shocks) could lead to breaches of the prefunded resources at one CCP (ICE Clear Europe), equal to 0.4bn EUR and 0.7bn EUR respectively. This CCP shows therefore a high sensitivity to small increases of shocks.

260. The liquidity stress testing exercise contributes to a better understanding of the liquidity challenges faced by EU CCPs. It provides an estimate of the liquidity requirements in different currencies and assesses the effectiveness of the tools available to the CCPs under a combination of market price shocks, member and/or liquidity provider default scenarios.

261. The entities considered to be in default under the different scenarios have at least one of the following capacities: clearing members, issuers, custodians, payments banks or repo counterparties. The entities selected as the most relevant for liquidity are not necessarily clearing members.

262. The results of this exercise demonstrates that under all market scenarios, EU CCPs could achieve sufficient liquidity to meet their liquidity needs assuming the default of 2 relevant entities (Cover 2) using a variety of tools. Some large CCPs require access to the short-term FX markets to cover requirements in some major currencies. Some CCPs make use of their access to central bank repo lines.

263. Assuming the default of 2 groups of entities EU-wide, one of the CCPs has moderate liquidity needs if we assume delayed settlement. As in Cover 2, some CCPs would need to access the short-term FX markets or rely on their reported central bank repo line to cover their liquidity needs.

264. As for last year's EU-wide CCP stress test exercise, EU CCPs are overall resilient to common shocks and multiple defaults. However, the exercise revealed in the credit stress test: 1) one minor failure of no systemic relevance and 2) for another CCP, high sensitivity to marginal increases of price shocks or number of defaults that might have systemic relevance. Under the liquidity stress test analysis the exercise revealed that CCPs use different tools to cover their liquidity needs, some are highly reliable as central bank repos, other less, but no particular deficiency was found in the management of liquidity risks by EU CCPs.

6 Annexes

6.1 List of CCPs in the scope of the exercise

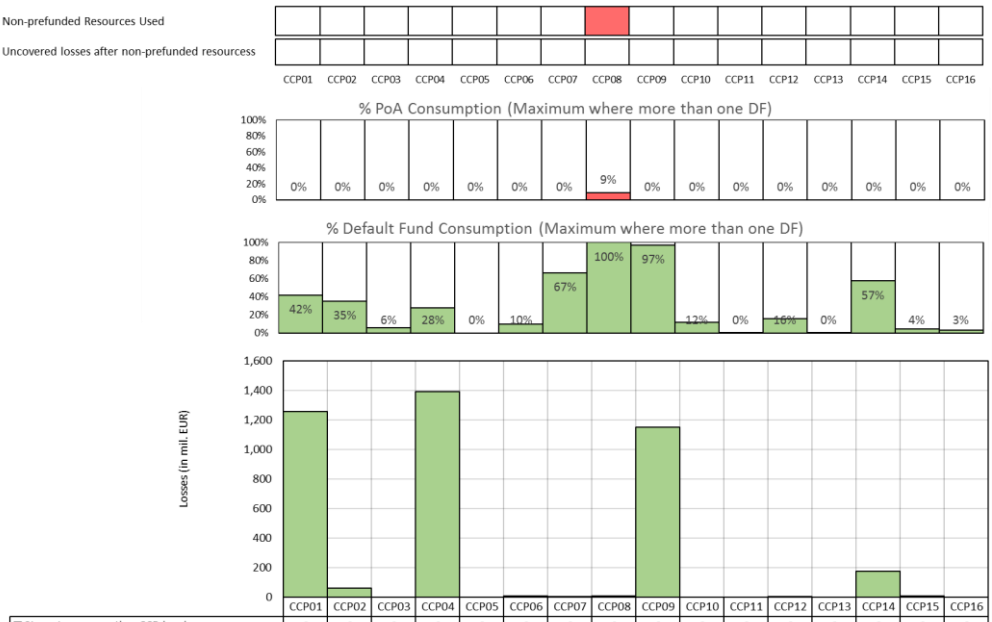
CCP	
ATHX	Athens Exchange Clearing House
BME	BME Clearing
CCG	Cassa di Compensazione e Garanzia S.p.A.
CCPA	CCP Austria Abwicklungsstelle für Börsengeschäfte GmbH
ECC	European Commodity Clearing
ECAG	Eurex Clearing AG
EUROCCP	European Central Counterparty N.V.
ICEEU	ICE Clear Europe
ICENL	ICE Clear Netherlands B.V.
KDPW	KDPW_CCP
KELER	Keler CCP
LCHSA	LCH.Clearnet SA
LCHUK	LCH.Clearnet Ltd
LME	LME Clear Ltd
NASDAQ	Nasdaq OMX Clearing AB
OMI	OMIClear – C.C., S.A.

6.2 Credit Stress Test Results

The full set of credit stress test results, including those that are not discussed exhaustively in the main sections of the report are presented here for reference, per member default scenario, market stress scenario and with/without excess margin collateral.

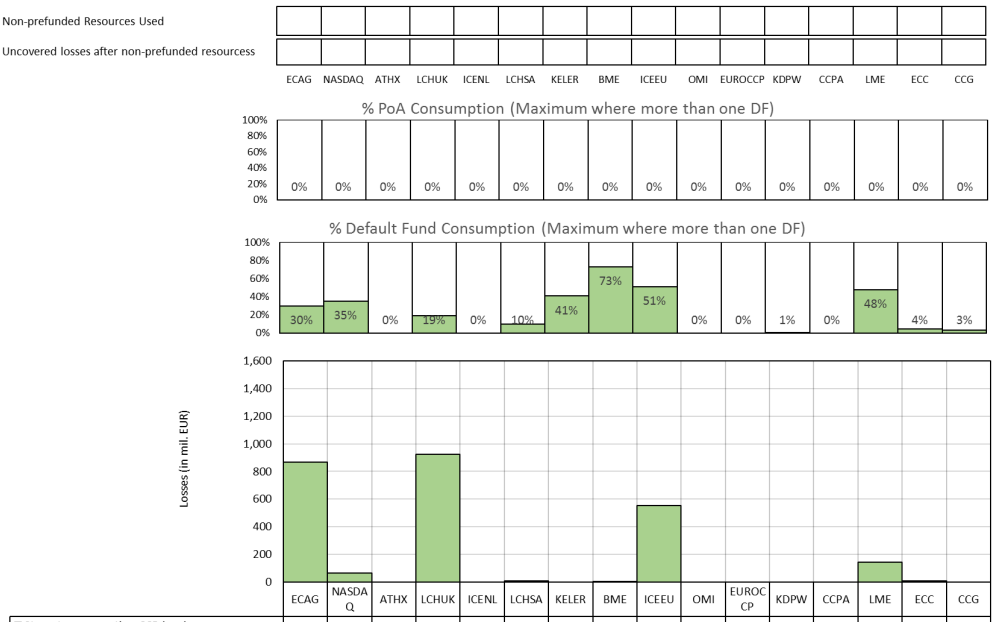
6.2.1 Credit Stress Test Results, cover-2 groups per CCP

Cover-2 Groups per CCP (no cross defaulting), Market Scenario 1
No Excess Margin



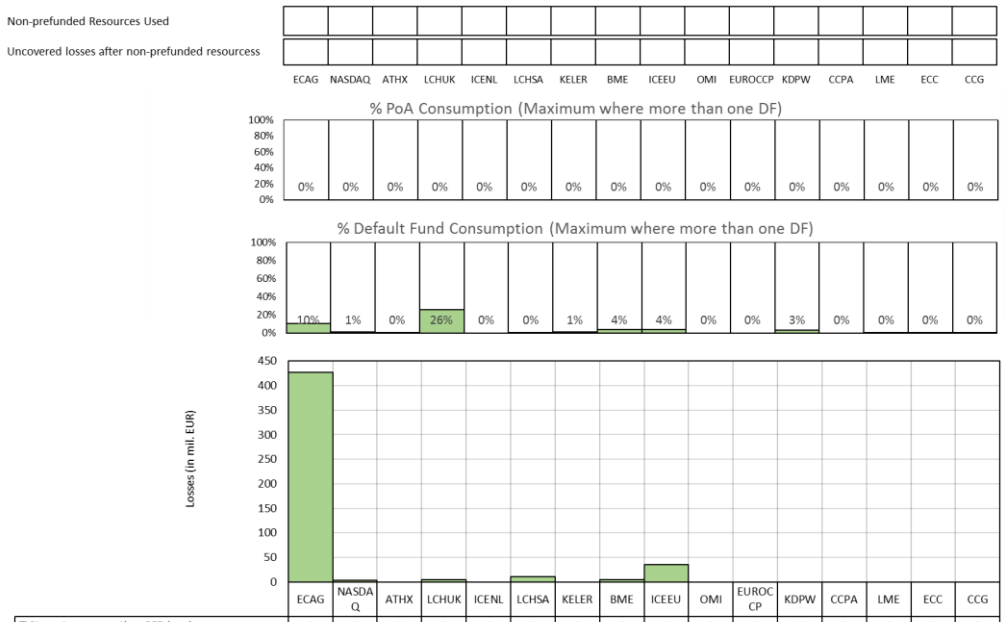
	CCP01	CCP02	CCP03	CCP04	CCP05	CCP06	CCP07	CCP08	CCP09	CCP10	CCP11	CCP12	CCP13	CCP14	CCP15	CCP16
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	1,260	63	0	1,392	0	9	1	6	1,154	0	0	4	0	177	8	0
Nb of CMs defaulting at CCP with non-zero losses	4	2	3	4	2	4	2	3	3	2	2	2	2	2	2	6
Nb of CMs defaulting at CCP	4	2	3	6	3	4	2	4	5	2	2	2	2	2	2	6

With Excess Margin



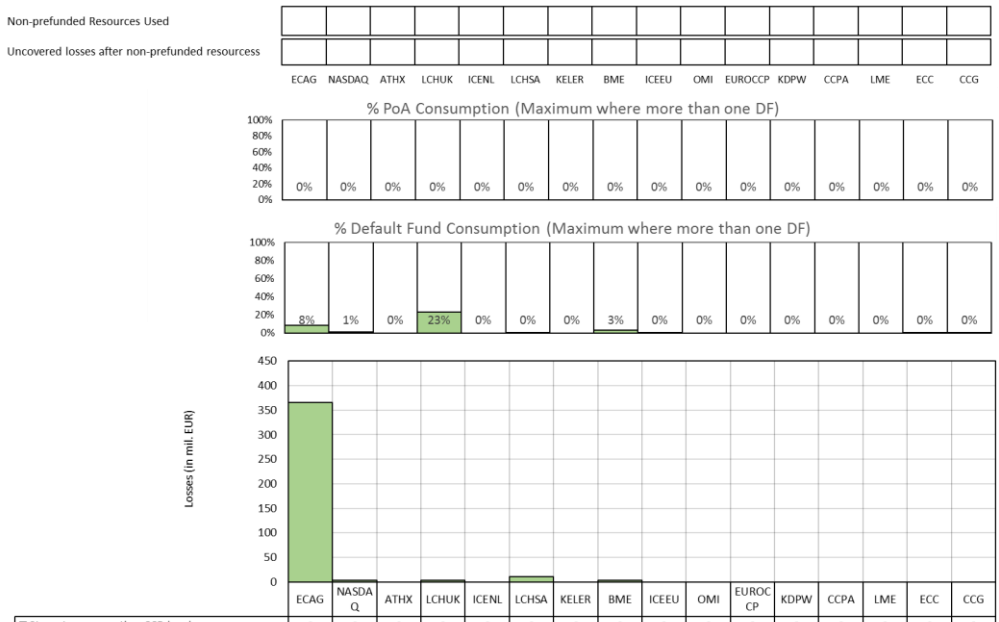
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	868	63	0	923	0	9	0	2	553	0	0	0	0	141	7	0
Nb of CMs defaulting at CCP with non-zero losses	4	2	3	4	2	4	2	3	3	2	2	2	2	2	2	6
Nb of CMs defaulting at CCP	4	2	3	6	3	4	2	4	5	2	2	2	2	2	2	6

Cover-2 Groups per CCP (no cross defaulting), Market Scenario 2
No Excess Margin



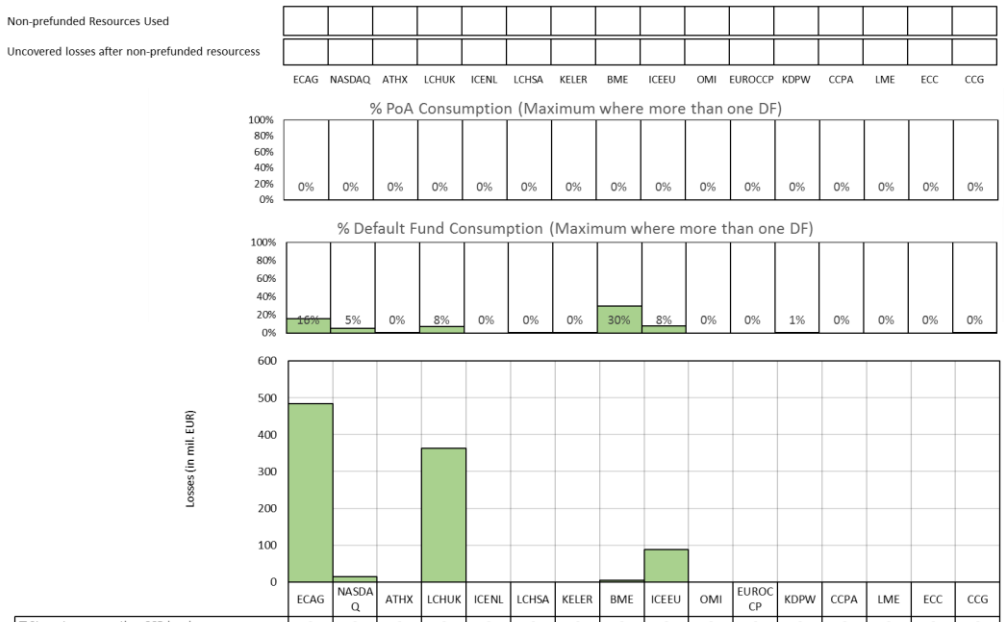
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	427	3	0	4	0	11	0	5	35	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	3	2	2	6	2	4	1	2	3	2	1	2	1	1	0	5
Nb of CMs defaulting at CCP	3	2	2	9	3	5	3	2	4	2	2	2	2	2	2	5

With Excess Margin



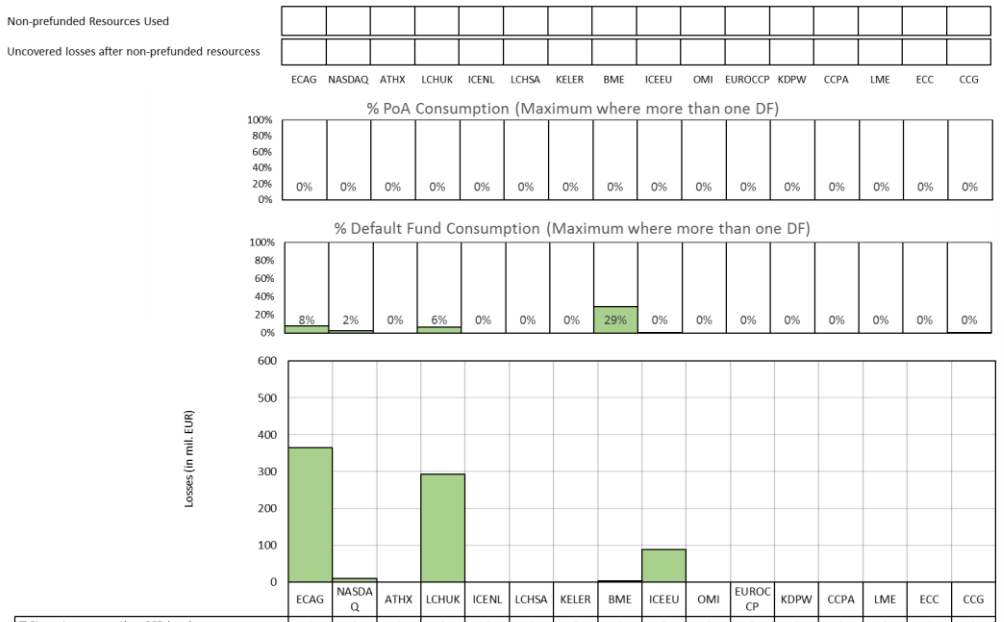
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	366	3	0	3	0	11	0	3	0	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	3	2	2	6	2	4	1	2	3	2	1	2	1	1	0	5
Nb of CMs defaulting at CCP	3	2	2	9	3	5	3	2	4	2	2	2	2	2	2	5

Cover-2 Groups per CCP (no cross defaulting), Market Scenario 3
No Excess Margin



	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	484	14	0	363	0	0	0	4	88	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	2	2	2	2	2	2	1	2	3	2	1	2	2	1	2	2
Nb of CMs defaulting at CCP	3	2	2	4	3	2	3	2	5	2	2	2	2	2	2	2

With Excess Margin



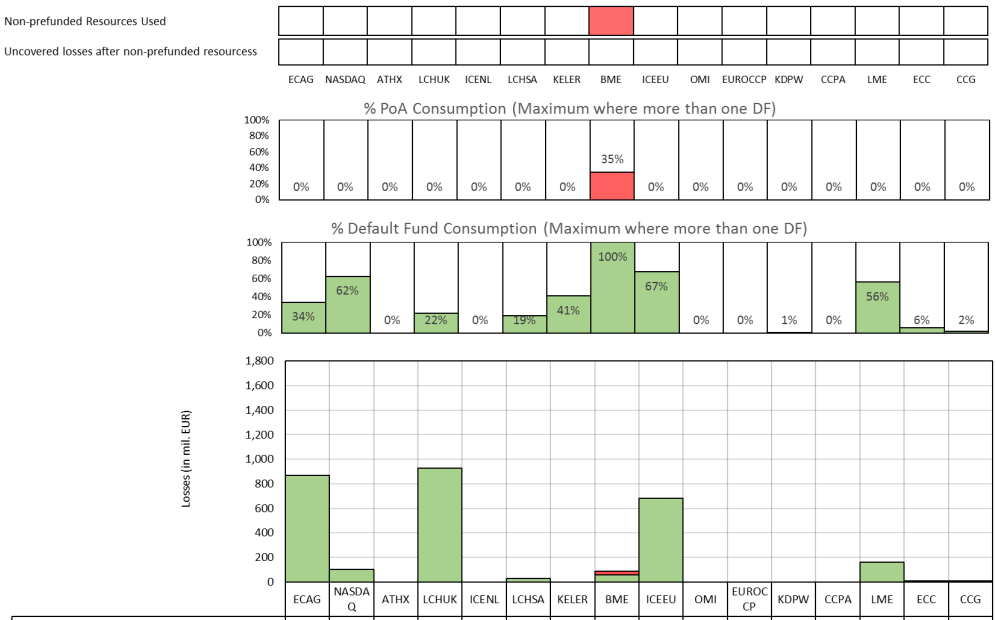
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	364	10	0	293	0	0	0	2	88	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	2	2	2	2	2	2	1	2	3	2	1	2	2	1	2	2
Nb of CMs defaulting at CCP	3	2	2	4	3	2	3	2	5	2	2	2	2	2	2	2

6.2.2 Credit Stress Test Results, MD-A

MD-A, Market Scenario 1
No Excess Margin

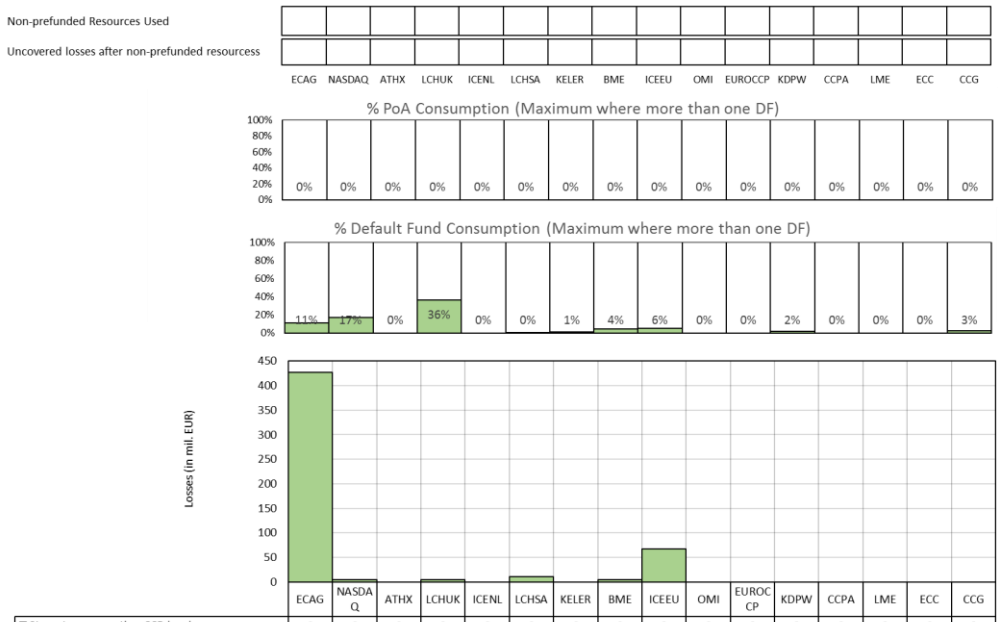
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	30	303	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	1,621	108	0	1,399	0	27	1	57	1,077	0	0	4	0	224	8	8
Nb of CMs defaulting at CCP with non-zero losses	8	10	2	11	2	12	2	5	9	2	3	3	4	6	6	6
Nb of CMs defaulting at CCP	15	12	3	17	3	14	4	10	14	3	7	4	8	9	8	14

With Excess Margin



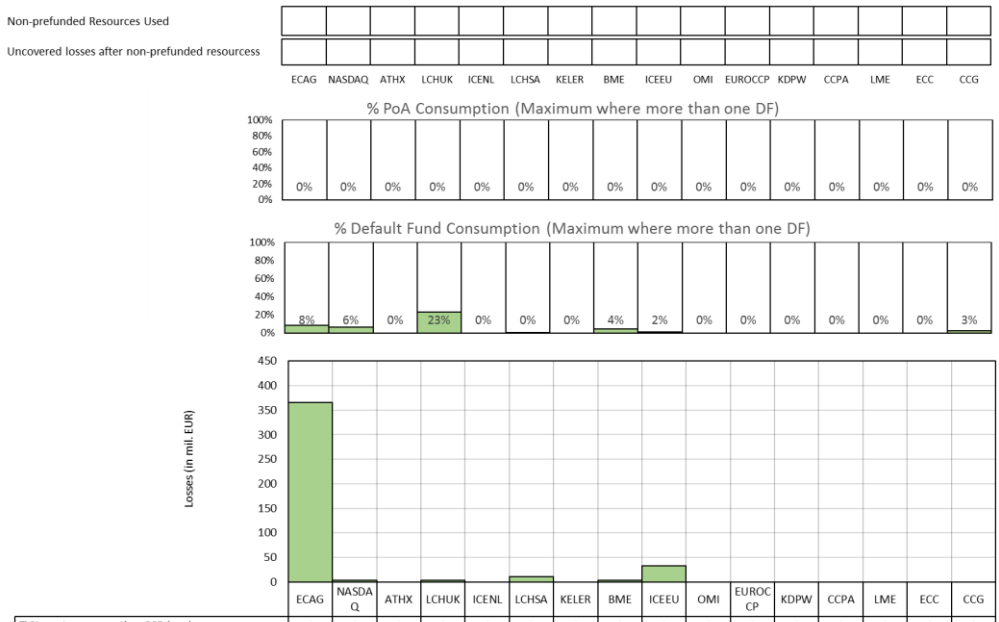
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	868	100	0	926	0	27	0	57	681	0	0	0	0	159	7	8
Nb of CMs defaulting at CCP with non-zero losses	8	10	2	11	2	12	2	5	9	2	3	3	4	6	6	6
Nb of CMs defaulting at CCP	15	12	3	17	3	14	4	10	14	3	7	4	8	9	8	14

MD-A, Market Scenario 2
No Excess Margin



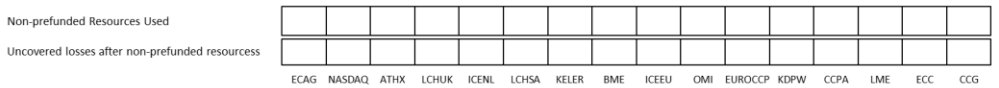
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	427	4	0	5	0	11	0	5	67	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	6	11	2	13	2	12	2	3	9	3	4	3	5	8	6	7
Nb of CMs defaulting at CCP	19	13	3	19	3	17	3	9	15	4	8	4	7	12	10	13

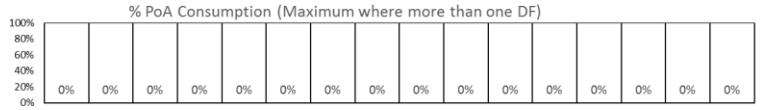
With Excess Margin

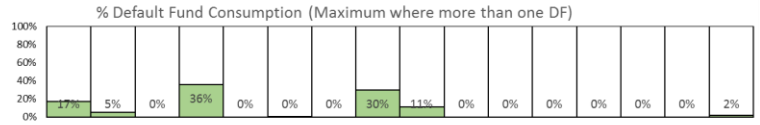


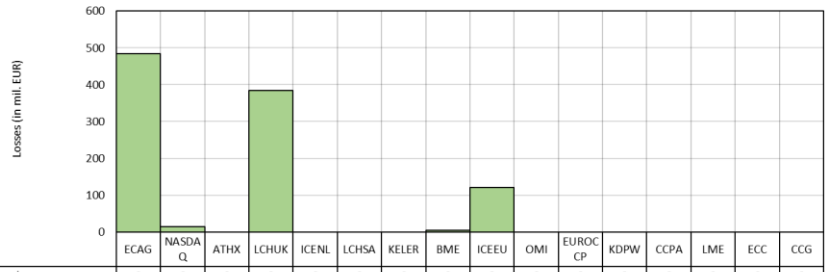
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	366	3	0	3	0	11	0	3	33	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	6	11	2	13	2	12	2	3	9	3	4	3	5	8	6	7
Nb of CMs defaulting at CCP	19	13	3	19	3	17	3	9	15	4	8	4	7	12	10	13

MD-A, Market Scenario 3
No Excess Margin



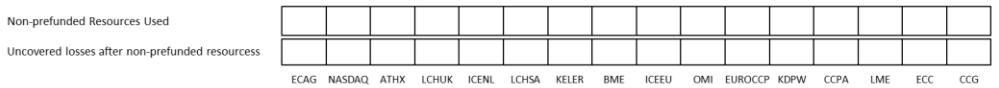


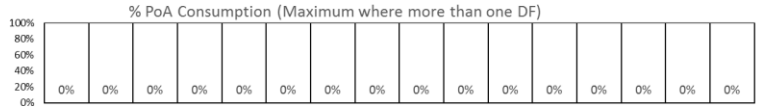


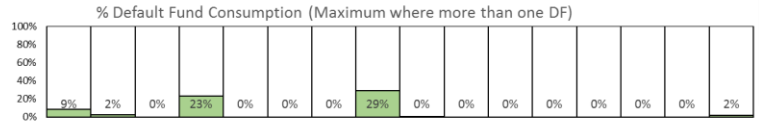


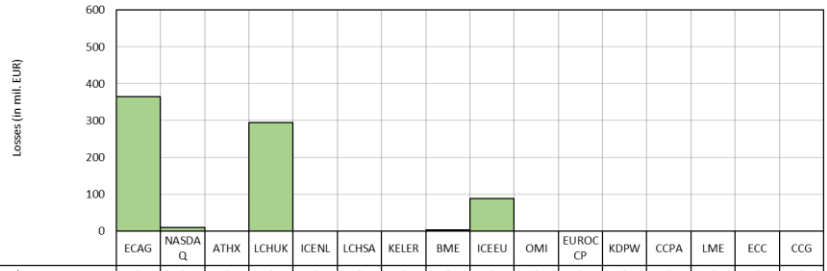
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	484	14	0	385	0	0	0	4	120	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	9	10	2	15	2	12	2	5	9	2	4	3	4	8	6	5
Nb of CMs defaulting at CCP	20	12	3	21	3	19	4	9	14	3	7	4	7	13	10	12

With Excess Margin





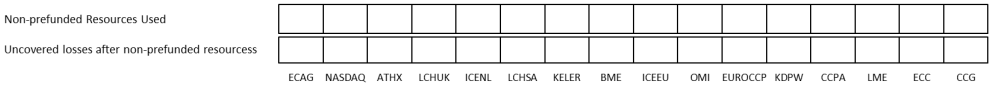


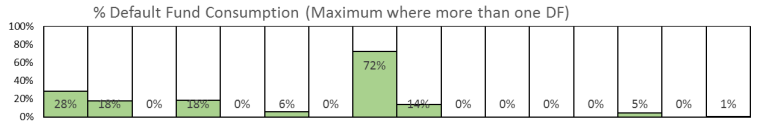


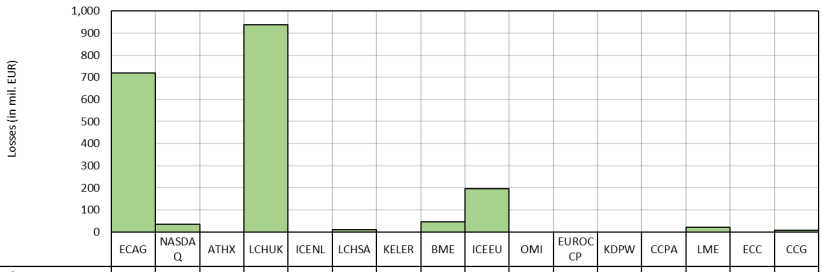
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	364	10	0	295	0	0	0	2	88	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	9	10	2	15	2	12	2	5	9	2	4	3	4	8	6	5
Nb of CMs defaulting at CCP	20	12	3	21	3	19	4	9	14	3	7	4	7	13	10	12

6.2.3 Credit Stress Test Results, MD-B

MD-B, Market Scenario 1
No Excess Margin

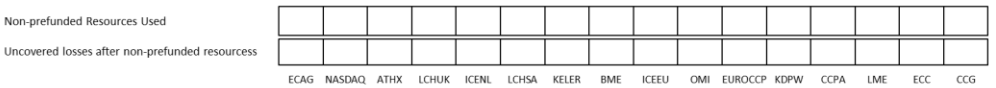


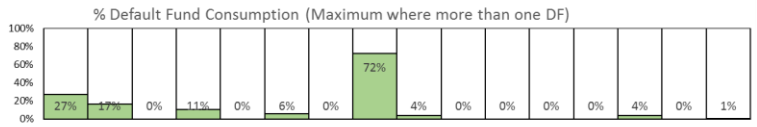


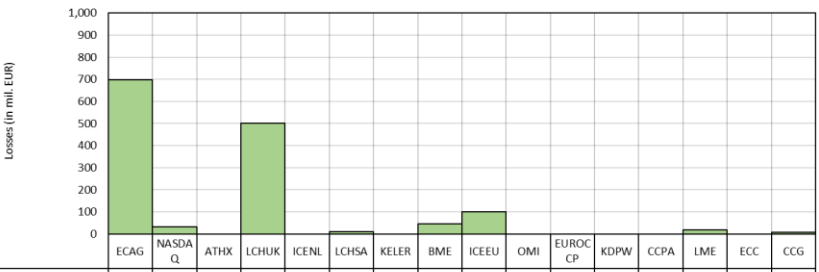


	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	719	34	0	938	0	9	0	46	197	0	0	0	0	22	0	8
Nb of CMs defaulting at CCP with non-zero losses	5	3	0	4	0	3	0	4	4	0	0	0	1	1	0	2
Nb of CMs defaulting at CCP	5	3	0	7	0	4	1	4	5	0	2	2	2	2	0	4

With Excess Margin

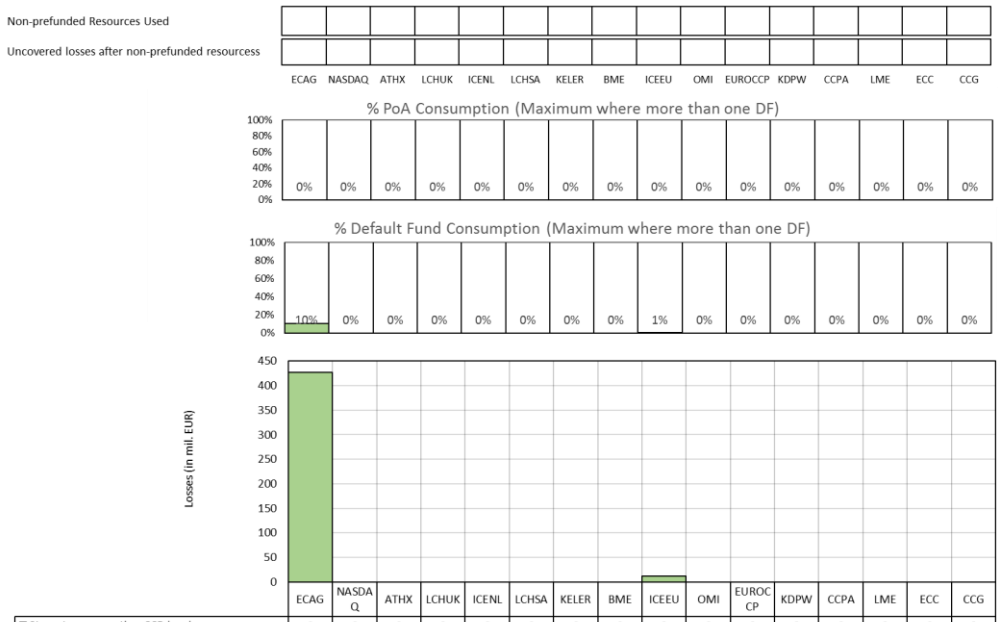






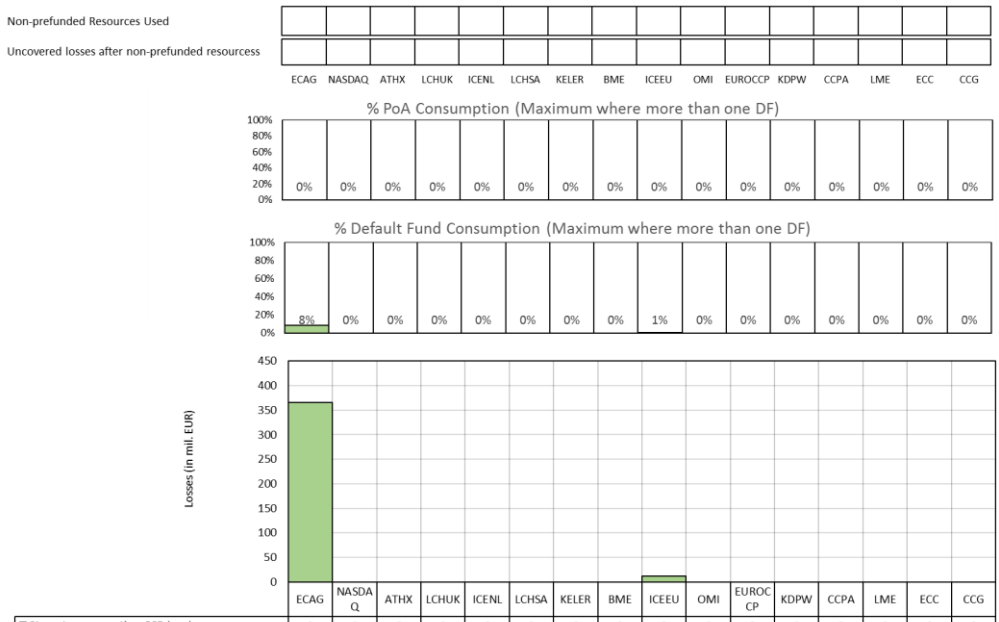
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	699	32	0	501	0	9	0	46	100	0	0	0	0	19	0	8
Nb of CMs defaulting at CCP with non-zero losses	5	3	0	4	0	3	0	4	4	0	0	0	1	1	0	2
Nb of CMs defaulting at CCP	5	3	0	7	0	4	1	4	5	0	2	2	2	2	0	4

MD-B, Market Scenario 2
No Excess Margin



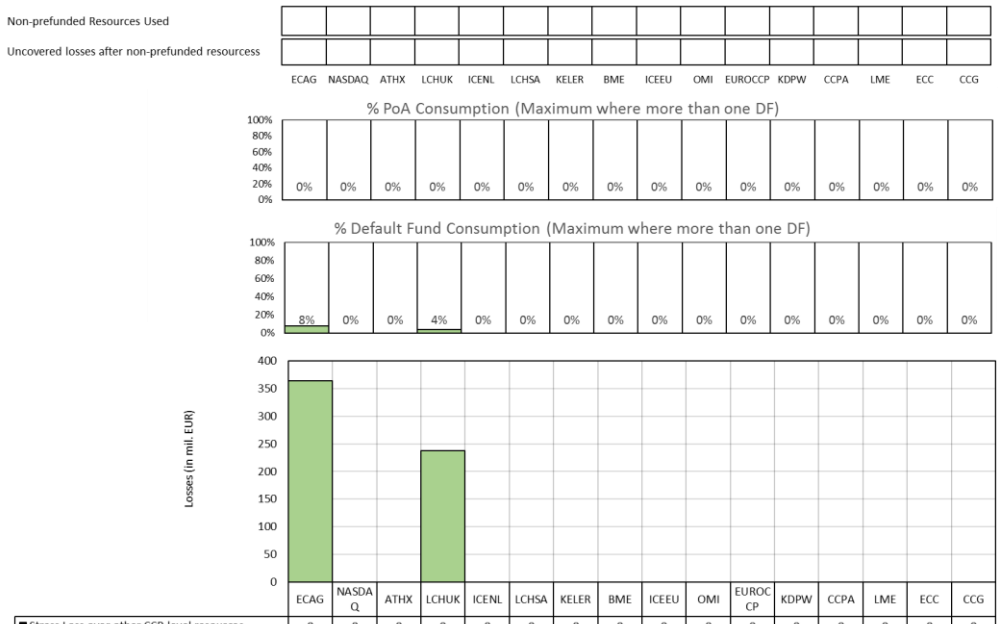
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	427	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	3	1	0	2	0	1	0	0	0	0	0	0	0	0	1	0
Nb of CMs defaulting at CCP	3	1	0	2	0	1	0	0	2	0	0	0	0	1	1	0

With Excess Margin



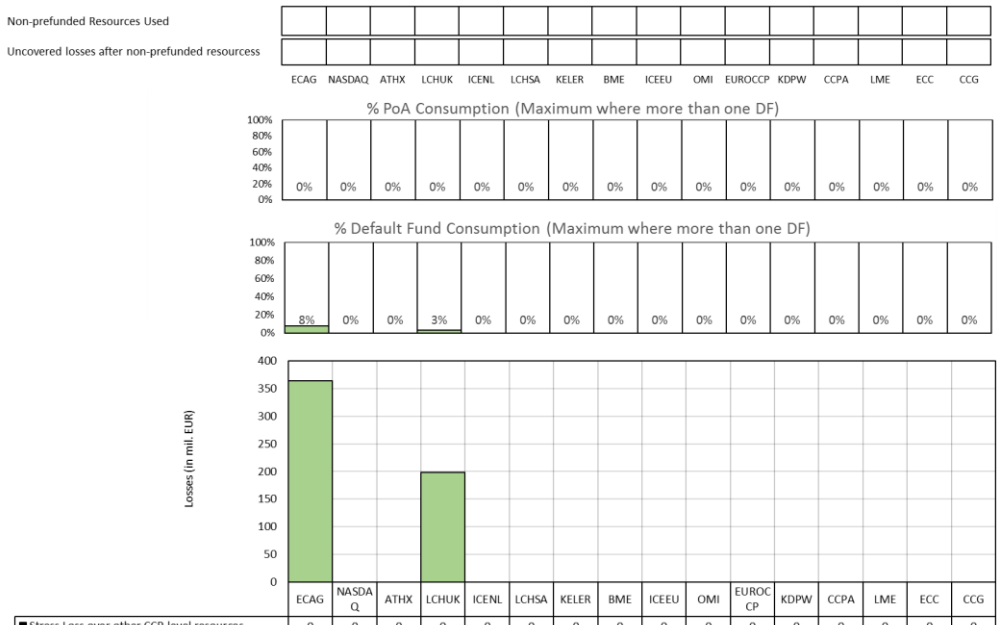
	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	366	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	3	1	0	2	0	1	0	0	0	0	0	0	0	0	1	0
Nb of CMs defaulting at CCP	3	1	0	2	0	1	0	0	2	0	0	0	0	1	1	0

MD-B, Market Scenario 3
No Excess Margin



	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	364	0	0	238	0	0	0	0	0	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	1	1	0	2	0	0	0	0	0	0	0	0	0	0	1	0
Nb of CMs defaulting at CCP	1	1	0	2	0	1	0	0	2	0	0	0	0	2	1	0

With Excess Margin



	ECAG	NASDAQ	ATHX	LCHUK	ICENL	LCHSA	KELER	BME	ICEEU	OMI	EUROCCP	KDPW	CCPA	LME	ECC	CCG
Stress Loss over other CCP-level resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with PoA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with other DF-level Prefunded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress Loss covered with mutualised DF and SIG	364	0	0	198	0	0	0	0	0	0	0	0	0	0	0	0
Nb of CMs defaulting at CCP with non-zero losses	1	1	0	2	0	0	0	0	0	0	0	0	0	0	1	0
Nb of CMs defaulting at CCP	1	1	0	2	0	1	0	0	2	0	0	0	0	2	1	0

6.3 Reverse Credit Stress Test Results

The full set of reverse credit stress test results, including those that are not discussed exhaustively in the main sections of the report are presented here for reference, for two different selection algorithms and with/without excess margin collateral.

Select the top-n groups leading to the highest total consumption of prefunded resources.

Loss over prefunded resources in billion EUR - No Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	0.6	2.1
		2	0.0	0.7	2.0	4.4
		3	0.4	1.3	3.0	7.1
		4	0.7	1.9	4.3	10.6
		5	0.8	2.2	5.6	14.3
Scenario 2		1	-	-	-	0.0
		2	-	-	0.0	0.0
		3	-	-	0.0	0.1
		4	-	-	-	0.1
		5	-	-	-	0.1
Scenario 3		1	-	-	0.0	0.1
		2	-	-	0.0	0.9
		3	-	-	0.1	1.6
		4	-	-	0.4	2.1
		5	-	-	0.5	3.6

Loss over non-prefunded resources in billion EUR - No Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	0.3
		2	-	-	-	-
		3	-	-	-	0.2
		4	-	-	-	0.8
		5	-	-	-	1.7
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-

Select the top-n groups leading to the highest total consumption of prefunded resources.

Loss over prefunded resources in billion EUR - With Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	0.3	1.8
		2	-	0.1	1.3	3.4
		3	-	0.6	2.2	4.8
		4	-	1.0	2.7	7.8
		5	-	1.3	3.1	10.3
Scenario 2		1	-	-	-	0.0
		2	-	-	-	0.0
		3	-	-	-	0.1
		4	-	-	-	0.1
		5	-	-	-	0.0
Scenario 3		1	-	-	0.0	0.0
		2	-	-	0.0	0.3
		3	-	-	-	0.8
		4	-	-	-	1.2
		5	-	-	-	2.1

Loss over non-prefunded resources in billion EUR - With Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	0.3
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	0.4
		5	-	-	-	0.6
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-

Select the EU-wide top-n groups leading to the highest loss over own resources (margin and default fund contributions of defaulting members).

Loss over prefunded resources in billion EUR - No Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	0.0
		2	-	-	-	1.1
		3	-	0.0	2.1	6.2
		4	-	0.8	3.3	10.4
		5	0.5	1.8	5.6	14.0
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	0.9
		5	-	-	-	2.8

Loss over non-prefunded resources in billion EUR - No Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	0.2
		4	-	-	-	0.5
		5	-	-	-	1.1
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-

Select the EU-wide top-n groups leading to the highest loss over own resources (margin and default fund contributions of defaulting members).

Loss over prefunded resources in billion EUR - With Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	0.0
		2	-	-	-	0.6
		3	-	0.0	1.5	4.2
		4	-	0.3	2.1	7.6
		5	-	0.9	3.1	10.6
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	1.2

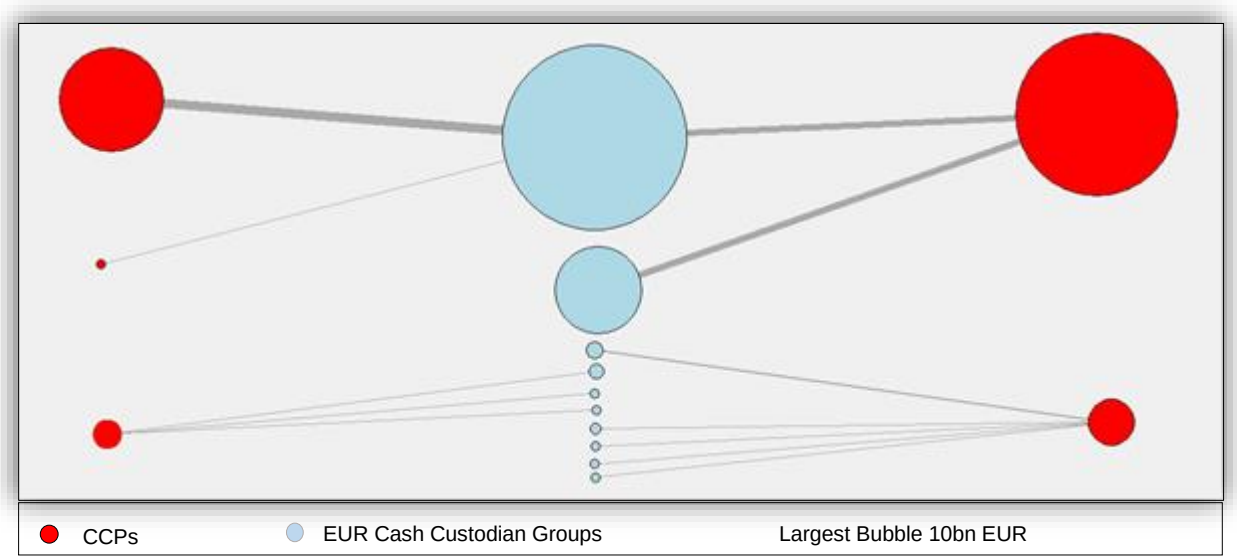
Loss over non-prefunded resources in billion EUR - With Excess Margin

			1	x1.2	x1.5	x2
Scenario 1	Number of Member Groups defaulting at EU-wide level. All Group entities default in all CCPs.	1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	0.2
		4	-	-	-	0.5
		5	-	-	-	0.9
Scenario 2		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-
Scenario 3		1	-	-	-	-
		2	-	-	-	-
		3	-	-	-	-
		4	-	-	-	-
		5	-	-	-	-

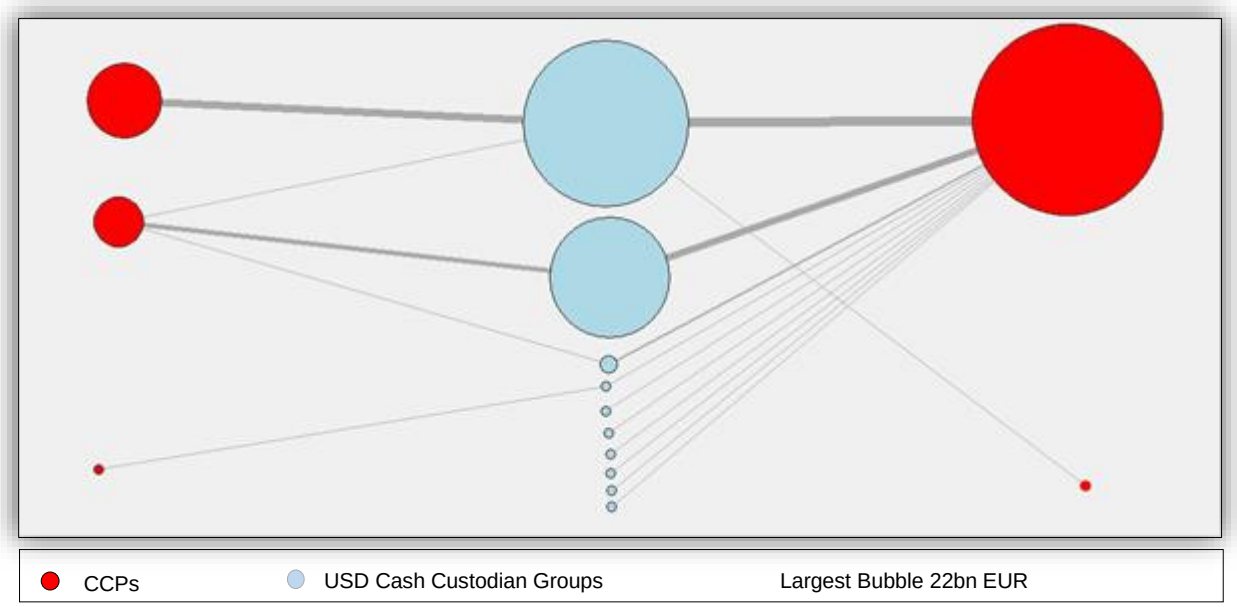
6.4 Interconnectedness Networks

6.4.1 Interconnectedness through custodians of Cash per Currency

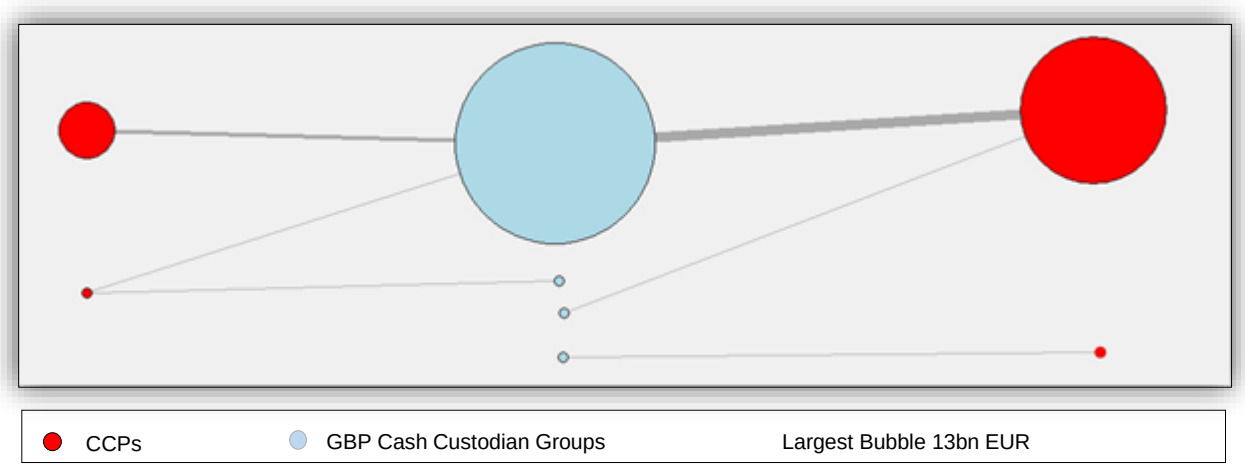
6.4.1.1 Interconnectedness through custodians of Cash per Currency - EUR



6.4.1.2 Interconnectedness through custodians of Cash per Currency - USD

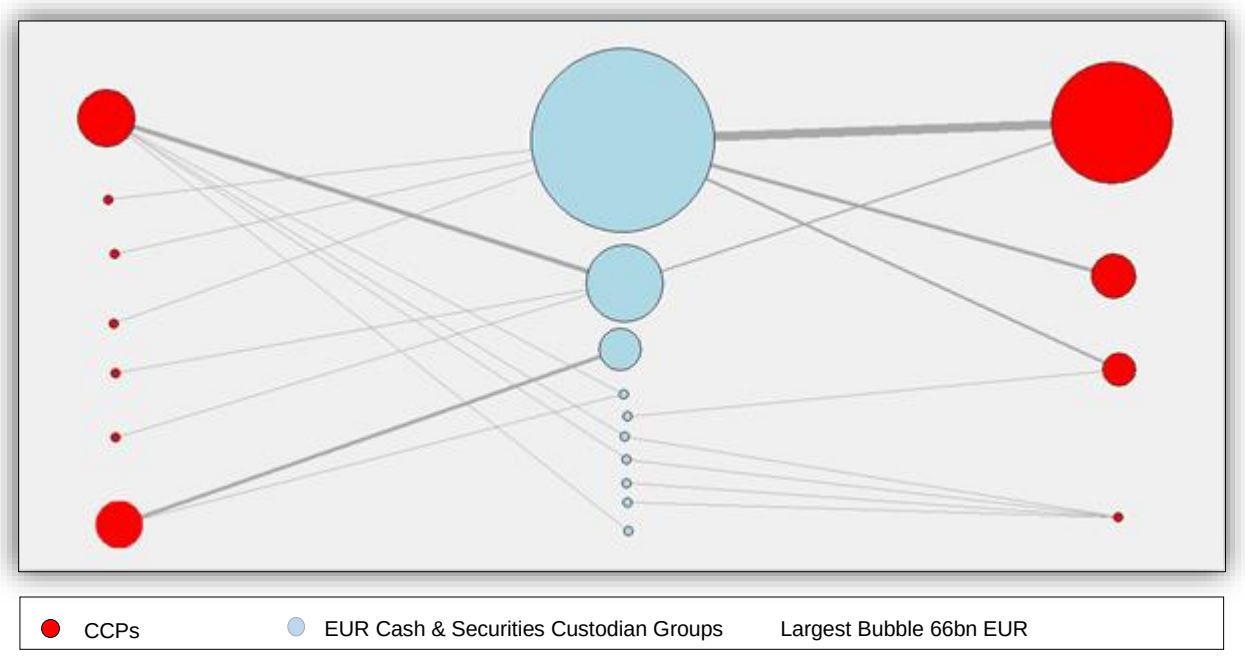


6.4.1.3 Interconnectedness through custodians of Cash per Currency - GBP

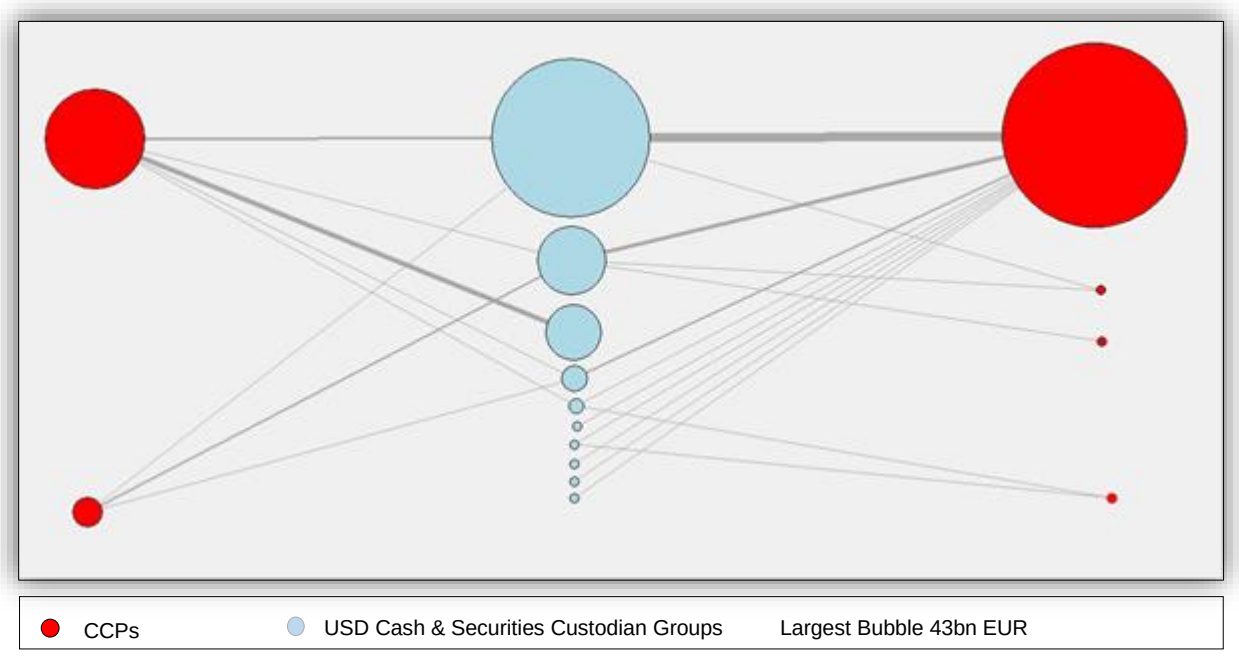


6.4.2 Interconnectedness through custodians of Cash & Securities per Currency

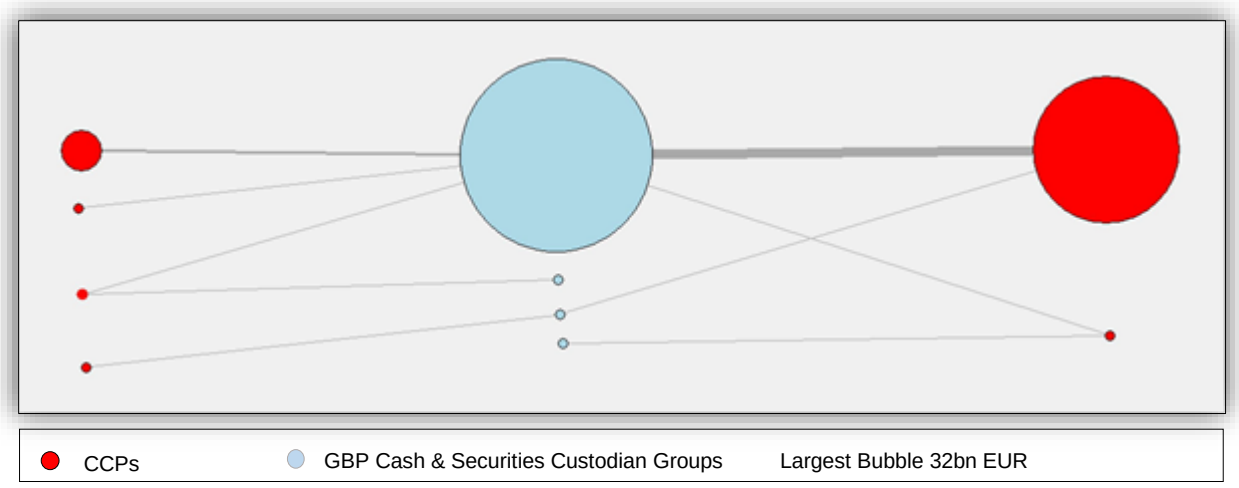
6.4.2.1 Interconnectedness through custodians of Cash & Securities per Currency - EUR



6.4.2.2 Interconnectedness through custodians of Cash & Securities per Currency - USD

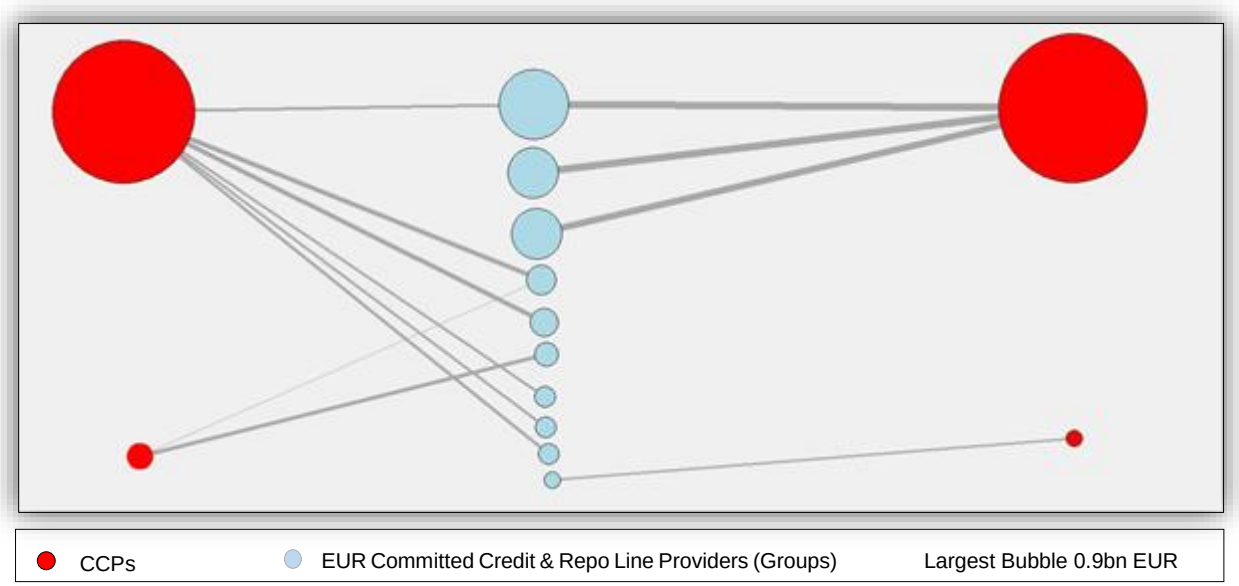


6.4.2.3 Interconnectedness through custodians of Cash & Securities per Currency - GBP

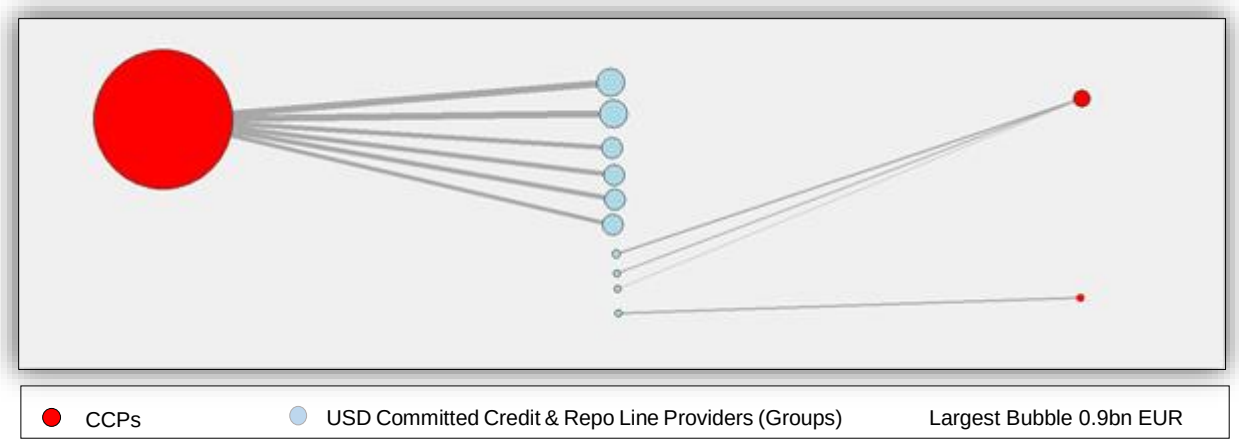


6.4.3 Interconnectedness through Liquidity providers (committed credit and repo lines only) per Currency

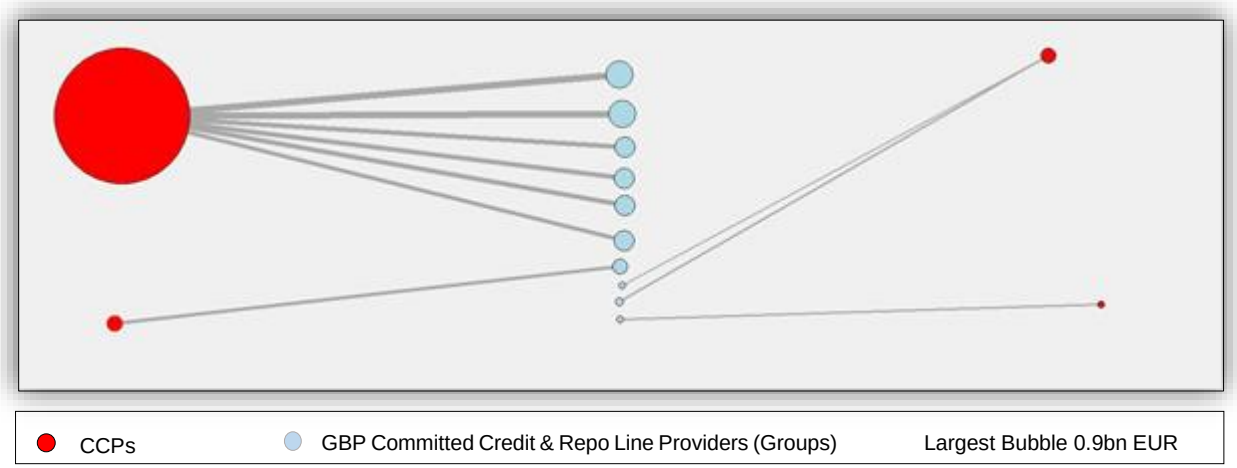
6.4.3.1 Interconnectedness through Liquidity providers (committed credit and repo lines only) per Currency – EUR



6.4.3.2 Interconnectedness through Liquidity providers (committed credit and repo lines only) per Currency – USD



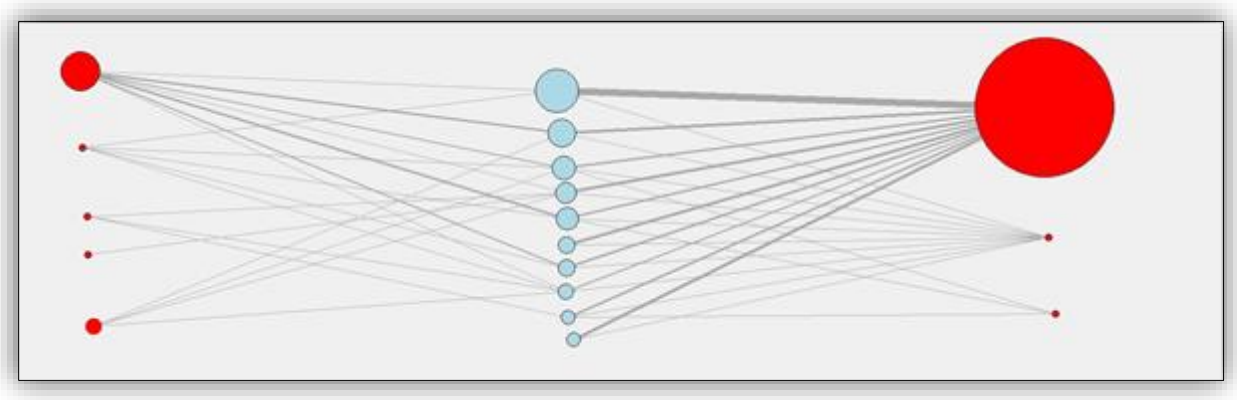
6.4.3.3 Interconnectedness through Liquidity providers (committed credit and repo lines only) per Currency – GBP



CCPs | GBP Committed Credit & Repo Line Providers (Groups) | Largest Bubble 0.9bn EUR

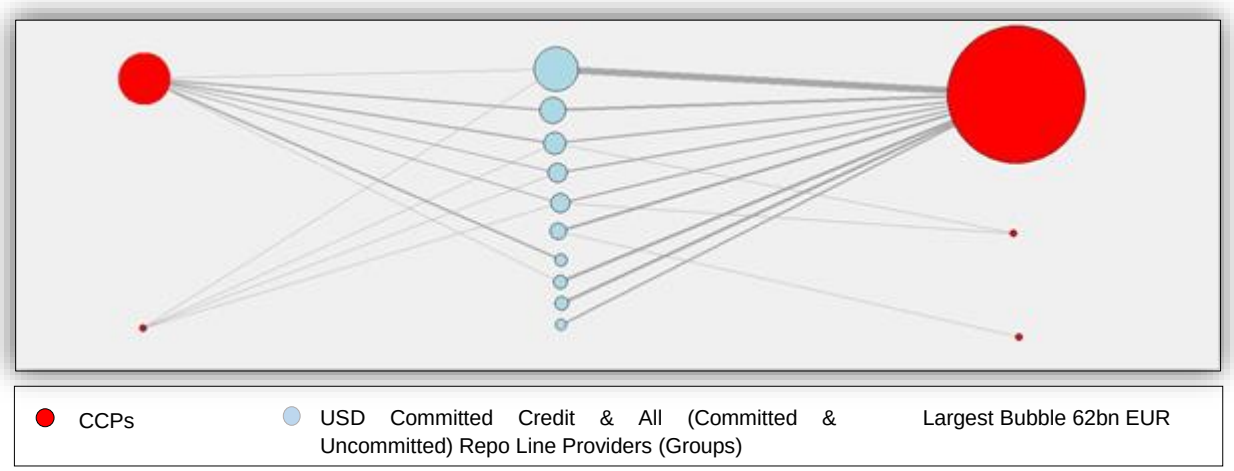
6.4.4 Interconnectedness through Liquidity providers (committed credit and committed & uncommitted repo lines) per Currency

6.4.4.1 Interconnectedness through Liquidity providers (committed credit and committed & uncommitted repo lines) per Currency – EUR

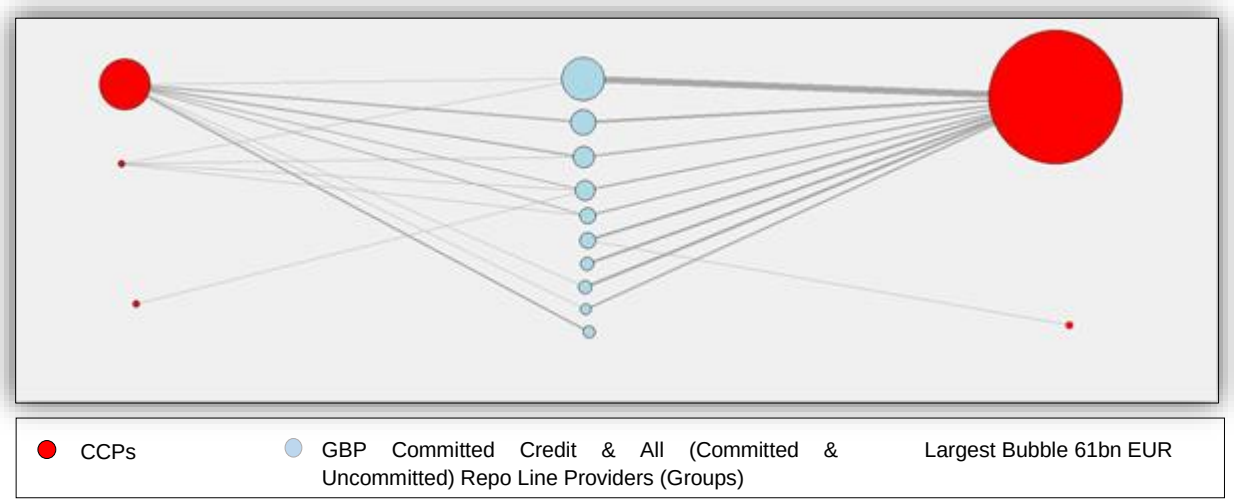


CCPs | EUR Committed Credit & All (Committed & Uncommitted) Repo Line Providers (Groups) | Largest Bubble 64bn EUR

6.4.4.2 Interconnectedness through Liquidity providers (committed credit and committed & uncommitted repo lines) per Currency – USD



6.4.4.3 Interconnectedness through Liquidity providers (committed credit and committed & uncommitted repo lines) per Currency – GBP



6.5 Intraday liquidity

265. In this exercise, we model the intraday liquidity assuming that there is no further intraday liquidity provided by the liquidity providers beyond what is available overnight.

266. In order to assess the additional impact of intraday liquidity, we assume that the securities that were to be delivered by a defaulting clearing member are going to be settled in a given number of settlement cycles.

267. Before entering a settlement cycle, we assume that the CCP would need to have acquired and settled the securities to be delivered. The more settlement cycles, the fewer securities are to be bought.

268. The number of securities to be bought is inversely proportional to the number of assumed settlement cycles. The more settlement cycles the less significant the intraday impact will be.

269. The value of the securities to be bought during one cycle are added to the end of day position.

270. We can see in the example below that the results are very sensitive to the assumptions, with an impact of 272 m EUR for 10 cycles and 544 m EUR for 5 cycles.

271. At the limit, assuming an infinite number of settlement cycles, there no intraday liquidity needs beyond the end of day needs.

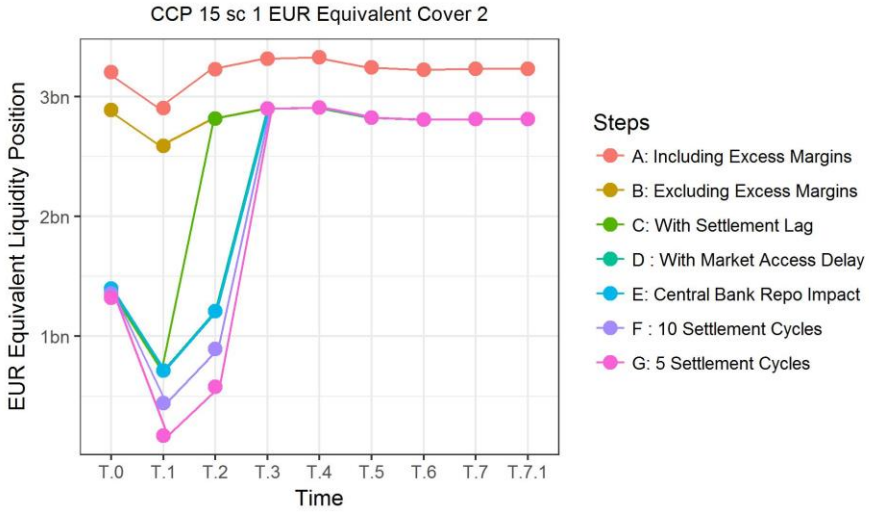


FIGURE 57: COVER 2, EXAMPLE OF INTRADAY IMPACT

272. This intraday modelling only affects CCPs that deal with non-cash settled instruments. The effect can be sizeable.

273. This topic could be explored further in future exercises.