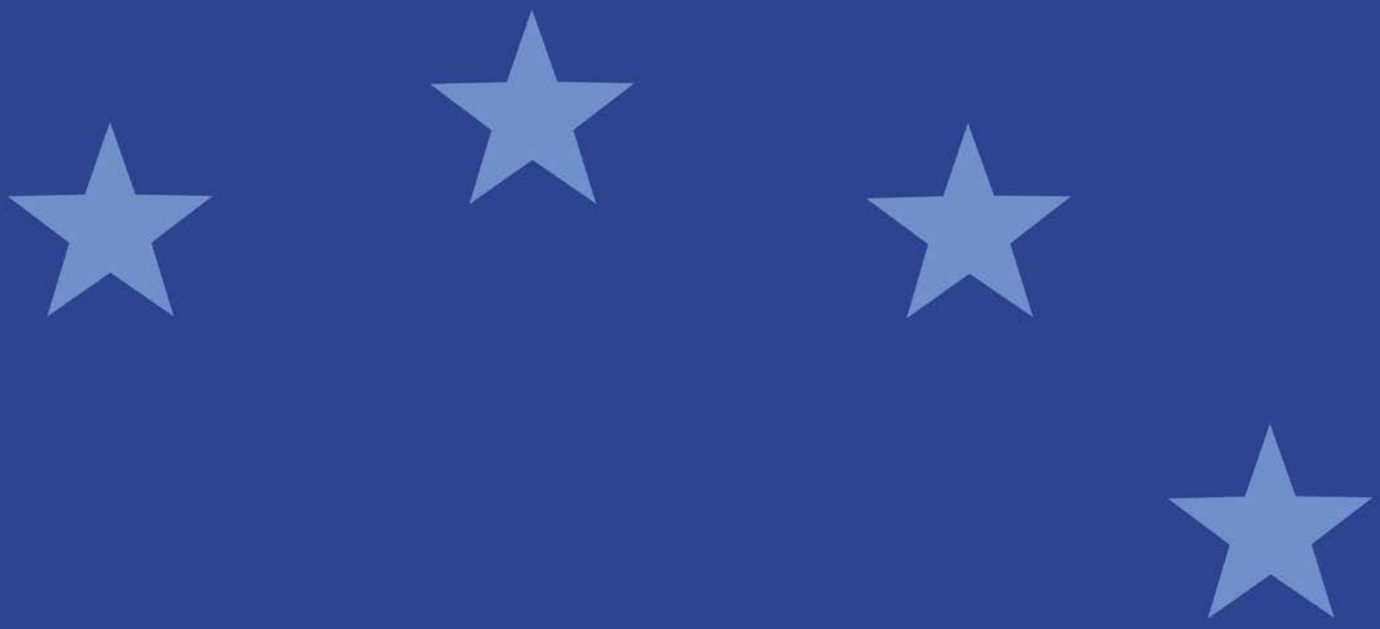
esma European Securities and Markets Authority

Report

EU-wide CCP Stress test 2015



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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
ESA	European Supervisory Authorities
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	Dedicated CCP Resources (“Skin in the game”)
MD-A	Member default scenario assuming that the top-2 clearing members per CCP will default simultaneously
MD-B	Member default scenario assuming that the top-2 groups of clearing members EU-wide in terms of exposure will default simultaneously
MD-C	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
HypA	Hypothetical market scenario derived by scaling margin requirement to a higher confidence level (normal distribution)
HypB	Hypothetical market scenario derived by scaling margin requirement to a higher confidence level (heavy tailed distribution)
RT	Reverse Stress Test Scenario
PD	Probability of default
LGD	Loss given default

PoA	Powers of Assessment (not-prefunded additional resources that can be called by CCPs from non-defaulting members)
HHI	Herfindahl-Hirschmann index used for the assessment of concentration

1 Executive Summary

In accordance with Article 21(6) 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), ESMA has initiated and coordinated the first Union-wide assessment of the resilience of CCPs to adverse market developments. The report presents the results of the first EU-wide stress exercise that assessed the resilience of 17 CCPs, including all authorised EU CCPs, for 3 dates in October, November and December 2014 with a focus on the counterparty credit risk that EU CCPs would face as a result of multiple clearing member defaults and simultaneous market price shocks. The exercise was also complemented with an analysis of the concentration of CCPs' exposures and of the potential spill-over effects to non-defaulting clearing members assessing the likelihood of additional defaults triggered by the loss absorption mechanism of CCPs. Given that this is the first EU-wide stress test exercise for CCPs, that no similar exercise has ever been conducted by other jurisdictions, ESMA is committed to improve and evolve the methodology and the scope of its future annual stress tests.

The report covers the objectives, the scope, a detailed description of the methodology followed and of its benefits and limitations. The results of the stress exercise are set out in Section 4. Keeping in mind the limitations of the exercise, the results indicate that for the reporting dates the system of European CCPs can overall be assessed as resilient to the scenarios used to model extreme and plausible market developments. In particular, the prefunded resources of CCPs would be sufficient for the reporting dates to cover the losses resulting from the considered historical and hypothetical market stress scenarios after the default of the top-2 EU-wide groups selected in terms of exposure and also in terms of exposure weighted by their probability of default. The member default scenarios assuming the default of the top-2 members per CCP in terms of exposure, combined also with the considered historical and hypothetical market stress scenarios are significantly more extreme due to the cross-default condition (the assumption that if one clearing member defaults, it does so in all CCPs in which it is a member). That is, the members identified as top-2 in one CCP are considered to be in default in all CCPs leading to an unprecedented and rather implausible number of entities simultaneously defaulting at EU-wide and CCP level, as a result of which the CCPs would need to call for not-prefunded resources leaving also a small amount of residual uncovered losses (<0.1bn EUR).

A set of "modelled" market stress scenarios was also tested in combination with the member default scenarios and was found to produce more severe results compared to the considered historical and hypothetical market stress scenarios. These results should be interpreted also considering the limitations linked to the market stress modelling procedure that could lead to a significant overestimation of the calculated losses and thus resulting CCPs exposures. Especially when these are combined with the EU-wide default of the top-2 members per CCP, the combined probability of highly extreme and rather implausible member default assumptions with extreme market stress scenarios is expected to be low, implying that this combination of scenarios can be reasonably expected to be implausible. Any shortfalls following the default of the top-2 groups at EU-wide level combined with the modelled

scenarios are in a systemic risk context limited, considering also the severity and the limitations linked to the modelling procedure. The reverse stress test scenarios constructed by further increasing the number of member defaults have not revealed plausible scenarios with systemic impact. Also the analysis of the concentration of exposures in CCPs does not suggest emerging systemic risks at the CCP or EU-wide level. Moreover, following the analysis of potential knock-on effects to clearing members, no significant systemic impact is easily identified as the number of highly affected members is rather limited and the corresponding amounts not systemically significant. It should however be noted that the stress exercise has focused on the counterparty credit risk that EU CCPs would face as a result of multiple clearing member defaults and simultaneous market price shocks. The CCPs are also subject to other types of risks, such as liquidity, investment and operational risks that could in isolation or in combination with counterparty credit risk challenge their resilience. Being this the first EU-wide CCP stress test, it was decided to focus on the counterparty credit risk aspect of the CCPs and leave the additional risk dimensions for future exercises.

ESMA has identified potential shortcomings and included some recommendations addressed to National Competent Authorities in order to conduct the necessary supervisory follow up. In particular, although EU CCPs seem with respect to the considered scenarios, and taking into account the limitations described in the report, overall well equipped to face extreme scenarios, a significant part of that protection are pools of resources by the non-defaulting clearing members, which could face significant losses in extreme cases. If these extreme circumstances materialise, this could trigger second round effects via additional losses at the CCP level and the default of additional members. The assessment by CCPs of the creditworthiness of clearing members taking also into account their potential exposures due to their participation in other CCPs is essential in order to identify sources of increased exposure. Furthermore, in the course of the analysis of the data provided by CCPs, ESMA has also identified that in a number of cases the stress price shocks applied by CCPs for some of their cleared products as part of their own stress testing framework are not at least as conservative as the minimum shocks defined for this exercise or do not replicate the most extreme historic price changes observed, in order to ensure the on-going resilience of CCPs. For these reasons, the recommendations addressed to the NCAs focus on: 1) the assessment by CCPs of the creditworthiness of clearing members considering exposures to other CCPs; and 2) the revision of CCPs' price shocks used in their stress test methodologies where gaps have been identified in the course of the exercise.

2 Background, objectives and scope of the EU-wide stress tests

2.1 Background

1. CCPs play a significant role in the financial system. 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.
2. In this respect, EMIR and the technical standards drafted by ESMA established stringent organisational, prudential and conduct rules that CCPs need to fulfil on an on-going basis. One of the provisions for ensuring safe and resilient CCPs in the EU is for ESMA to initiate and coordinate Union-wide assessments of the resilience of CCPs to adverse market developments and to issue the necessary recommendations in case such an assessment exposes shortcomings in the resilience of one or more CCPs (Article 21(6) of EMIR).
3. The Union-wide assessment of resilience of CCPs to adverse market developments needs to be conducted in accordance with Article 32(2) of Regulation (EU) No 1095/2010 (ESMA Regulation) which states that ESMA, in cooperation with the ESRB, shall develop the following:

   (a) common methodologies for assessing the effect of economic scenarios on the financial position of a financial market participant;

   (b) common approaches to communication on the outcomes of these assessments of the resilience of financial market participants;

   (c) common methodologies for assessing the effect of particular products or distribution processes on the financial position of a financial market participant and on investors and customer information.

4. Additionally Article 23 of the ESMA Regulation states that ESMA in cooperation with the ESRB shall develop an adequate stress testing regime which includes an evaluation of the potential for systemic risk posed by financial market participants to increase in situation of stress.

5. The above requirements have been reflected in the Union-wide ESMA stress test exercise presented in detail in chapters 3 and 4.

2.2 Objectives of the stress exercise

6. Several objectives have guided the design, implementation and execution of the Union-wide stress test of CCPs. The overarching goal of the stress testing exercise is to assess the resilience of CCPs to severe shocks and the impact on their clearing members. This

objective results directly from the legal mandate given to ESMA under EMIR and explained in Section 2.1. In particular, it has been an objective of the exercise to determine whether extreme but plausible scenarios exist under which the level of losses exceeds prefunded or unfunded resources of the CCPs.

7. The losses of the CCP have been defined as arising under a scenario of simultaneous defaults of clearing members and adverse changes of market prices. In other words, the goal of the exercise was the identification of events and estimation of their severity that would bring the exhaustion of CCPs resources and could potentially have a severe, adverse impact on the economy. In fact, from a credit risk perspective, only the combination of clearing member defaults and simultaneous severe shifts of risk factor prices put a CCP at risk. A CCP acts as a buyer to each seller and a seller to each buyer and does not have any open positions as long as no buyers or sellers default. A CCP has a perfectly matched book as long as clearing members do not default. By design a CCP does not enter any open market positions which could incur gains or losses linked only to fluctuations of market prices. Periods of extreme market volatility in isolation do in principle not pose a specific market risk to a CCP (with the exception of its investment policy which has not been analysed in the stress test exercise) if clearing members are able at all times to honour their commitments and continue to post margin. Similarly, defaults of clearing members without simultaneous market shocks do in principle not put a CCP at risk. Clearing members post margins and default fund contributions scaled to a very high confidence level assuring CCP 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 CCPs will have the resources to withstand multiple defaults of clearing members. Hence, from a credit risk perspective and with the exception of investment risks, only simultaneous defaults and extreme, adverse shifts of market prices potentially depleting CCP resources pose potential risk to a CCP.

8. Besides the above, the design, implementation and analysis of results of the Union-wide CCP stress test aimed at the assessment of the potential systemic risk, which might be embedded in the European system of CCPs. The systemic risks have been defined as the severity of potential “knock-on” effects to the wider financial system caused by the depletion of CCP resources under predefined range of stress test scenarios. This objective of the exercise has been mandated to ESMA directly under EMIR as well.

9. Additionally, as part of the exercise, ESMA examined the stress testing methodologies of individual CCPs in order to detect and address potential divergent or insufficient practices or general shortcomings of the individual stress testing methodologies.

10. All the above objectives have been reflected throughout the process of stress test conception, implementation and results analysis. A range of different scenarios have been developed in order to assess the resilience of CCPs to simultaneous defaults of the clearing members and extreme but plausible adverse price shocks. The data aggregation logic designed for the purpose of the stress test exercise allows identifying potential “knock-on” effects passed on to the clearing members subject to depletion of CCPs’ resources. The severity of “knock-on” effects in relation to Tier 1 capital base of the clearing members has been estimated across a range of stress test scenarios. The

application of the minimum price shocks list by CCPs and the governance of communication throughout the exercise have contributed to the process of harmonisation of the Union-wide CCP stress testing methodology. Communication along the data collection process has contributed to the identification of possible shortcomings in the existing methodology of individual CCPs.

2.3 Scope

11. The stress test data requests have been addressed to 17 European CCPs via the National Competent Authorities of the countries in which the CCPs are registered. The surveyed group consists of 16 authorised CCPs and one entity ICE Clear whose authorisation is still pending. The following CCPs were included in the scope of the ESMA stress test exercise:

- Athens Exchange Clearing House
- BME Clearing
- Cassa di Compensazione e Garanzia S.p.A.
- CCP Austria Abwicklungsstelle für Börsengeschäfte GmbH
- CME Clearing Europe Ltd
- European Commodity Clearing
- Eurex Clearing AG
- European Central Counterparty N.V.
- ICE Clear Europe
- ICE Clear Netherlands B.V.
- KDPW_CCP
- Keler CCP
- LCH.Clearnet SA
- LCH.Clearnet Ltd
- LME Clear Ltd
- Nasdaq OMX Clearing AB
- OMIClear – C.C., S.A.

12. National Competent Authorities from Austria, France, Germany, Greece, Hungary, Italy, the Netherlands, Poland, Portugal, Spain, Sweden and the United Kingdom took part in the Union-wide ESMA stress testing exercise. There are several risk dimensions that can be addressed in an exercise of this sort (counterparty risk, market risk, investment risk, liquidity risks). Being this the first EU-wide CCP stress test, it was decided to focus on the counterparty credit risk aspect of the CCPs and leave some other risk dimensions for future exercises. Therefore, the different stress scenarios have been designed to reflect

the risk of defaults of clearing members and simultaneous extreme shifts of risk factor prices[1]. This is justified by the fact that defaults in the clearing member community typically would happen in periods of very high market volatility. It is also justified by the fact that CCPs are in principle immune to defaults of clearing members taken in isolation of the potential market price shocks, as explained above. Similarly CCPs are in principle immune from risks due to price shocks in absence of clearing members defaults. To be more precise, in absence of clearing members defaults, the risk of very high market volatility manifested by extreme shifts of risk factor prices would only affect CCPs' investment policies. This risk has not been assessed in the current ESMA stress test. Liquidity risk resulting from but not limited to shocks to funding or repo markets has also not been embedded in the current stress testing exercise and will be pursued in the design of future assessments. Risk of adverse correlation effects between cleared exposures and default probabilities of clearing members or issuers of collateral, called wrong-way risk, has been left for future exercises as well. Operational and legal risks are considered to be idiosyncratic in nature and hence they have also not been reflected in the current stress test exercise.

13. . The aggregation logic of scenario results was designed to highlight any potential "knock-on" effects across the Union-wide system of CCPs. It has been analysed how material the loss mutualisation mechanism embedded in the default waterfall is to the stability of the financial system. The stress test methodology and results are presented in chapters 3 and 4.

3 Methodology

14. There are not many precedents of EU-wide stress tests of financial infrastructures or institutions. One exercise that has some common elements is the stress test exercise on EU credit institutions. Over the last few years, EBA performed EU-wide stress tests yearly, the latest of which was synchronised with an "Asset Quality Review" exercise run in view of the operationalisation of the Single Supervisory Mechanism. However, the two types of stress tests are not directly comparable as important differences are observed which led ESMA to conclude that the methodology should have specific features, differentiating it from the one applied in the banking sector.

15. First and foremost, CCPs have been performing stress tests daily for decades and they are required to continue to do so by EMIR. There is considerable expertise, track record and systems in the field of CCP stress tests which mirror those of the banking sector. Similarly to banks, stress testing methodologies implemented by CCPs rely on transformations of variables which are based on complex modelling techniques in which price shocks impact the exposures of clearing members in multiple CCPs and where price shocks need to be combined with scenarios of multiple clearing member defaults

[1] By "risk factor prices" we refer to variables attached to a particular risk factor that has an influence on the exposure of the CCP to market movements. Risk factor prices can be observed or implied and include items such as prices of financial instruments, interest rates in certain parts of the yield curve, correlations between different prices or rates, volatility levels, etc.

(as explained in section 3.3). The key difference between banking and CCP stress tests is the distinct time window in which a CCP faces risks that would put its financial viability at risk when compared to a bank. For the banking sector a typical scenario of gradual deterioration of asset values and increase in delinquency rates over several months and their impact in relation to the capital held is a realistic one. Differently, CCPs need to measure the impact of extreme, almost instantaneous market movements that, in a matter of one or two trading days (combined with the default of one or several clearing members) would put the CCP in default. For this reason a stress test scenario driven by even drastic changes of macroeconomic variables is very difficult to translate into an extreme market volatility scenario which would be able to put a CCP at risk. Micro scenarios introducing short term extreme shocks to financial systems need to be introduced to assess the resilience of CCPs as opposed to banking institutions. Moreover, an additional crucial element that needs to be reflected in CCP stress tests is the network effect between CCPs and clearing members. While in a banking stress test one can assume that certain categories of assets (say, mortgage loans or bond portfolio values) deteriorate at a certain rate (irrespective of who is the exact counterparty, client or issuer that originates the loss/deterioration), in the CCP world the scenarios need to contemplate specific, concrete defaulting entities that would expose the CCP to concrete real losses in identified positions. These elements, among others, show that the two types of stress tests are not directly comparable and explain why ESMA decided to approach a CCP stress test from a different angle compared to a bank stress test.

16. The overall approach followed by ESMA in the design of the Union-wide stress test exercise is a combination of top-down and bottom-up methodologies.

17. In a typical regulatory driven top-down stress test scenario the regulator would develop scenarios from scratch, distribute them among participating agents, which would need to apply them directly in their computations and send them back to the regulator. Under this approach participants would be required to use a homogenous methodology or in some cases just submit the data to the regulator who would perform the calculation on an aggregate basis. In case of the Union-wide stress test of CCPs conducted by ESMA a full top-down approach would face significant methodological difficulties. Given the extreme diversity of cleared products and maturities, it would translate into the definition of over 30 thousand products price shifts and would require the synchronisation of the risk margining models of 17 surveyed CCPs. The only way to run a pure top-down approach would be to ensure that the risk model on which the price shifts are tested are identical (differences in the risk model can have greater impact on the results than some risk factors contained in the scenario). EMIR allows CCPs to use different risk methodologies (just as an example, SPAN and VaR models coexist currently in the EU for similar products). Moreover, moving to a new methodology would be a major investment requiring lengthy preparations and substantial costs. Against this background, forcing CCPs to converge on the risk methodology for the exclusive purpose of the stress test exercise was considered suboptimal, even though such an approach would make the EU-wide aggregation of consistently calculated results easier. The above is even more true as, at this stage, an exercise of such a scale would not be operationally feasible neither for ESMA nor for individual CCPs. Another overarching principle of the Union-

wide stress testing of CCPs was to keep the additional workload and impact on the stakeholders of the exercise within reasonable limits. ESMA decided to reuse, as much as practically feasible and conform to the objectives, concepts existing at the time of the stress testing exercise. This has been especially valid in the process of price shock and scenario definition described in the next two sections.

18. A pure bottom-up approach in the context of the CCP stress test exercise would on the other hand translate into the submission of stress test results already calculated by the CCPs based on their individual models and individually estimated shocks of risk factor prices. A meaningful and consistent aggregation of results submitted within a purely bottom-up driven stress testing approach would be difficult, as no common baseline could be established to compare results from different CCPs.

19. For these reasons ESMA decided to build the Union-wide CCP stress testing framework around a combination of top-down and bottom-up approaches trying to limit the main disadvantages of both methods. CCPs were requested to submit results based on their individual methodologies (which are assumed to be EMIR compliant) for 3 reporting dates[2]. These individual methodologies complemented with analysis of historical data and input from the ESRB (see section 3.1 for more details) were used to build a list of specific minimum price shocks for the exercise. The common list of minimum shocks of risk factor prices made it possible to harmonise the minimum severity of scenarios across the CCPs. However, these minimum price shocks do not prevent some CCPs from applying tougher ones (above the minimum).

20. Given that this is the first EU-wide stress test exercise for CCPs, that no similar exercise has ever been conducted by other jurisdictions and that some limitations have been experienced with the adopted methodology, ESMA is committed to improve and evolve the methodology and the scope of its future annual stress tests.

3.1 Definition of scenarios of risk factor price shocks

21. The first stage of the scenario definition for the purpose of the Union-wide CCPs stress test was based on benchmarking sets of risk factors price shocks and respective results calculated by individual CCPs. The EU-wide CCP stress test conducted by ESMA in 2015 followed an approach where stress losses were calculated by CCPs within their framework of extreme but plausible market conditions first. Then losses were aggregated to calculate CCP losses under stress at the EU level, combining a variety of member default and risk factor stress scenarios. The purpose of the benchmarking exercise was to review the underlying CCP scenarios for plausibility and comparability. The preliminary scenario data submitted by CCPs and reviewed by ESMA was used to give conclusive answers to the following questions:

[2] The exposures of CCPs are dynamic and can change significantly within a period of one or more days. The three reporting dates are the three end-of-month dates for October, November and December 2014. For 1 CCP that was only authorised after the reporting dates, the results of 3 subsequent dates were used.

(a) Is the set of individual CCP stress scenarios comprehensive, i.e. does it cover all relevant risk factors?

(b) Are scenarios for common risk factors consistent between different CCPs?

(c) Is the severity of scenarios consistent with historical market data and reasonable assumptions for plausible future scenarios?

(d) Does the set of CCP stress scenarios used in this exercise cover both historical and potential future (hypothetical) scenarios?

22. To address the above questions it was necessary to compress and harmonise the scenario information submitted by CCPs. In the following paragraphs we explain the format of the scenario data submitted by CCPs, the harmonised representation of the data and the steps involved in transforming the submitted data into the harmonised format. Finally, it is explained how the harmonised data was used to design the setting of minimum expected risk factor scenarios.

23. CCPs were asked to submit their complete set of stress scenarios at individual product level. For each product and scenario a price (or rate) shock and, where relevant, an implied volatility (for options) were expected. CCPs were also asked to provide a description of scenarios and of product identifiers, e.g. by providing an ISIN number. Across the 17 CCPs around 700,000 scenario product combinations were received.

24. In order to achieve a harmonised presentation of scenarios ESMA implemented the following processes:

    a. ESMA defined a list of common market risk factors covering 36 risk factors across asset classes: interest rate, commodity, equity, FX and credit. The list was set up with the objective to cover all relevant risk factors for the entire population of surveyed EU CCPs while striking a balance between granularity and practicability.

    b. ESMA differentiated between different types of scenarios. The first differentiation had been made between hypothetical and historical scenarios. Within the class of hypothetical scenarios ESMA distinguished between hypothetical scenarios which are included in the CCP stress scenario submission and hypothetical scenarios that are obtained from CCP product level margin parameters by scaling the results with parametric multipliers raising the confidence levels at which values are estimated. The logic behind the hypothetical scenarios applying parametric multipliers is explained in section 3.3.

25. Mapping of the data submitted by CCPs constituted the second stage of the definition of minimum price shock scenario list by ESMA. It consisted of the following steps:

    a. The first step was to map each CCP product to one of the common risk factors from the harmonised list. ESMA relied on the product description provided by CCPs. In many cases the mapping proved straightforward and unambiguous, e.g. all currency products were either mapped to ‘G7’ (all currencies belonging to the G7 group) or ‘Emerging’ (all other cases). Commodity products were mapped based on the underlying of the contract. In some cases when the product

description was missing or ambiguous, mapping to a risk factor required expert judgement e.g. where ISINs where provided, these were used to categorize equity products by sector or mapped as “Other” if ISIN or additional information was missing.

b. The next step was to determine for each CCP and each risk factor the most extreme scenario that had been applied to the risk factor. This scenario was assumed to represent the range of extreme but plausible events, defined as price shocks of risk factors that the CCP had covered in its stress test framework. The identification was straightforward if only one product was mapped to a single risk factor. In such a case the most extreme risk factor scenario was given by the most extreme product scenario. In cases where many products were mapped to a risk factor a representative product had to be selected. The selection of the representative product was performed on a case-by-case basis depending on the nature of the data. In general, one of the following three different selection procedures was applied: identification of the benchmark product based on expert knowledge, selection of the most extreme product scenario across products mapped to the risk factor (this is the most conservative choice), or selection of the median, in cases where many products are mapped to one risk factor, e.g. for equity sectors. The final result of this step was a set of unique scenarios representing the extreme shocks applied to each identified risk factor per individual CCP.

c. The scenario identification procedure described above was performed separately for historical and hypothetical scenarios submitted by surveyed CCPs. In the next step the lists of unique scenarios of risk factor shocks were aggregated across the CCPs in order to obtain a common list of minimum price shocks. Differentiation between historical and hypothetical scenarios was performed by ESMA, based on the scenario description submitted by CCPs.

d. The analysis under steps b) and c) was performed separately for risk factor price (or rate) scenarios and risk factor implied volatility scenarios.

The end result of the analysis is the minimum scenario list. It represents the minimum shifts of risk factors ESMA expected the CCPs to apply while completing the stress test exercise. For the avoidance of doubt, a CCP risk factor scenario is only expected where the CCP clears products exposed to the respective risk factor.

26. The identification of minimum risk factor begins with a comparison of the identified scenarios across CCPs reflecting both hypothetical and historical scenarios. Where these scenarios are comparable across CCPs a representative value in the covered range is set. These settings are complemented by prior expert knowledge: it is generally expected, for instance, that bond price changes increase with duration and that the volatility of short term interest rates is higher than long term rates. In cases where significant divergence between CCPs was observed, ESMA used historical time series of price shifts quoted by market data providers (e.g. Bloomberg) to found its judgement on

plausible stress scenarios. This analysis was performed in particular for interest rates and bond prices (long maturities).

27. The final step of the analysis consisted of validating the ESMA derived minimum scenarios against the set of risk factor scenarios provided by the ESRB. ESMA and the ESRB closely cooperated for more than one year on the design of the scenarios. Due consideration was given on how to incorporate a macroeconomic scenario into an EU-wide stress test exercise, given the starting point of the exercise (i.e. the compliance of CCPs with the minimum EMIR requirements) and the difficulty to design plausible scenarios in a multi clearing members defaulting event. The section below describes the approach followed by the ESRB given the highlighted constraints and the way in which ESMA could incorporate the ESRB contribution in its analysis.

28. The ESRB has followed a twofold approach with respect to risk factor distributions and the derivation of shock sizes for the purpose of the Union-wide stress test exercise conducted by ESMA:

    - derivation of shock sizes corresponding to certain quantiles, which are meant to serve as benchmarks for shock sizes that ESMA considered. This was done by considering both parametric and non-parametric distributional assumptions;
    - provision of 'multipliers' that reflect a move from the 99% to the 99.9% quantile for all factors, conditional on different distributional assumptions. The multipliers could be used by ESMA to scale, if desired for the sake of additional conservatism, the shock sizes reported by the industry which correspond to a 99th percentile up to a 99.9th percentile.

29. The distributions that were employed include a Gaussian and a t-distribution on the parametric side, as well as a nonparametric one. The Gaussian distribution has the shortcoming that it features tails, which are not thick enough to capture the fat tails that distributions of financial market data normally exhibit. The t-distribution is more leptokurtic, captures financial markets data in a more realistic manner and has been introduced for this reason. The nonparametric approach is fully agnostic as to the shape of the distribution, i.e. there is no risk to miss-specify the shape of the distribution.

30. The risk factors that were contained in the analysis included 98 variables, which can be grouped into 6 broad categories: interest rates, bonds, equities, FX, commodities, and CDS. Interest rates and bonds covered both deposit and swap rates for Euro, US-Dollar, British Pound, and Swiss franc and sovereign bond yields for G7 countries plus Switzerland and Canada. Equities contained European indices and sectoral sub-indices as well as a volatility index and dividend yields. FX contained the exchange rates of the Euro against the US-Dollar, the British Pound, Swiss Franc. Moreover, the exchange rates of the Euro vis-à-vis the Russian Rubel and the Brazilian Real were included to cover emerging markets. Commodities covered a wide range from freight rates over grains to oil and gas. Finally, the CDS category contained CDS single names and indices for non-financial and financial corporates as well as sovereign CDS.

31. The ESRB results were reported to ESMA for two different quantiles, namely for the 99% quantile and the 99.9% quantile, distinguishing between Value at Risk (VaR) and

Expected Shortfall (ES) estimates. In addition, multipliers were included which were computed as the ratio of the shock size at the 99.9% quantile and the 99% quantile. For all the simulations, the forward horizon was set to two business days.

32. The ESRB has provided ESMA with a comprehensive data analysis of risk factor shocks for a more granular set of risk factors. The ESRB data set distinguished interest rates in a wider range of different currencies or different equity indices as opposed to the original ESMA minimum scenario list for instance. In general, ESMA validated its risk factor scenarios against all relevant ESRB scenarios. Only in cases where different ESRB scenarios corresponding to a risk factor according to ESMA taxonomy exhibited a too significant variation and when no proper justification in terms of macroeconomic scenario leading to that shift was provided, ESMA decided to validate its results against the most relevant ESRB risk factor. Furthermore the ESRB provided scenarios for each risk factor derived from analysis of historical data based on different methodologies. ESMA decided to consistently validate its scenarios against the ESRB scenario which corresponds to the worst empirical observation at the 99.9% confidence level, averaging upward and downward moves. The advantage of this non-parametric approach against fitted-to-model approaches is that it is free from statistical modelling assumptions. ESMA incorporated the ESRB shocks by increasing the relevant minimum risk factor shock whenever the identified ESRB shocks where more severe than the ones arrived at after analysing the data provided by CCPs. As explained above, it should be noted that in some cases the shocks provided by the ESRB were more specific for individual risk factor groups than the minimum scenario list adopted by ESMA. In a reduced number of these cases, the specific risk factor shock applicable to one product was not representative of the broader category used by ESMA. Therefore ESMA adopted the most representative price shock for the broader category, rather than the highest price shock provided by the ESRB by aggregating the shocks provided for different products.

33. The ESRB considers also an internally consistent adverse macro-financial scenario. This is derived from non-parametric simulations carried out for the purpose of calibrating the EBA bank stress test scenario. The initial shocks of the internally consistent scenario were originally calibrated with a one-quarter horizon. They were re-scaled to align with the two-day horizon of CCP stress testing, keeping the original severity unchanged. Because of this rescaling, the shocks implied by this scenario are far less severe than the ones implied by the minimum scenario list, with only 2 exceptions out of the 100 granular risk factors. These two exceptions are of limited relevance for the broader categories applied in the minimum scenario list and for the stress test exercise as a whole. Therefore it can be concluded that the already applied minimum risk factor shocks are already more conservative and the stress results would not be impacted by the inclusion of this scenario.

34. In the next stage of the data submission and validation process ESMA compared the results submitted by CCPs to the minimum scenario list described above. Whenever a CCP was not meeting the minimum price shocks, a communication process via its National Competent Authority (NCA) was triggered requesting the CCP to provide updated results or justification for the level of price shock applied within a specific scenario. The communication process included a number of interactions with NCAs and

CCPs and CCPs were provided multiple occasions to provide updated results or the relevant justifications for the data already submitted. ESMA relied only on the information provided by individual CCPs via NCAs to assess the severity of price shocks applied. In some cases the new data provided to fill the gaps did not result in material changes in the exposures, which raises doubts on the way gaps were filled, i.e. whether the augmented price shocks were applied to the existing stress test framework of the CCP or if they were calculated in isolation. ESMA did not have the data, technical capacity or the powers necessary to verify how data were computed by CCPs to fill the gaps. ESMA relied on the NCAs to ensure the quality of the data submitted by CCPs to ESMA via the NCAs.

3.2 Treatment of gaps in data provided by CCPs

35. In several cases CCPs did not submit stress test results reflecting shocks of specific risk factors although their lists of cleared products would have suggested that sensitivity to these risk factors cannot be ignored. Some of those observed data gaps resulted from the absence of either historical or hypothetical scenarios. The CCPs that had not implemented historic stress scenarios for relevant historical market stress events or did not introduce hypothetical price shocks which were severe enough to comply with ESMA's minimum price shocks were asked to complete their scenarios accordingly and recalculate the resulting losses and stress exposures.

36. For the exercise to be meaningful, ESMA needed to estimate the impact of the gaps that were not filled by CCPs, i.e. for the cases in which data were not provided or the data provided were below the minimum price shocks.

37. Where gaps were not filled, following different interactions with NCAs and CCPs, ESMA had to assess the materiality of the gaps in order to:

    a. Size the EU-wide dimension of the problem;

    b. Test all CCPs based on the same minimum bound;

    c. Ensure a level playing field amongst CCPs.

38. For these reasons, ESMA applied an internally designed methodology to incorporate a conservative estimate of the impact implied by the unresolved gaps and uncertainties. This allowed ESMA to estimate the potential impact considering also the deviation of the identified scenarios from the minimum shifts.

39. In particular, for the unresolved identified gaps, CCPs were asked to provide the share (%) of the margin requirement for products, where a gap had been identified, compared to the margin requirement for all products in the same default fund. In order to conservatively factor-in any potential uncertainties linked to this procedure, a quality assurance adjustment add-on (QAA) of 10% was also applied while scaling up the provided exposures. This adjustment was applied both in cases where the uncertainty had been linked to an identified gap with the minimum scenarios and in cases where there were other types of data problems that could challenge the severity of the final results. If the CCP did not provide a reliable figure to estimate the share of the affected

products, then ESMA reverted to information received through the colleges or publicly available information, such as Open Interest values in order to conservatively estimate this impact. The detailed calculation methodology used for the adjustment is presented in Annex 7.4.

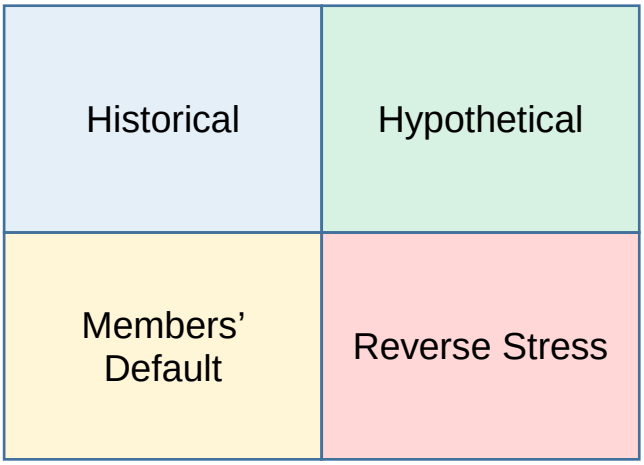
40. Submission of maturity spread scenarios by CCPs had been sparse. The respective table in the annex hence only highlights the risk factors and CCPs for which any data was received. Due to the limited data available, ESMA found it impossible to set meaningful benchmark values, hence no figures were communicated.

41. ESMA recognises that the process used to arrive at the minimum requirements is not algorithmic and that expert judgement is relied upon. A purely algorithmic approach is not feasible given the complexity of the underlying data.

3.3 Scenario Overview

42. The stress test exercise has the following components: Member Default, Market Scenarios consisting of Historical and Hypothetical variants and Reverse Stress Test. They will be explained in detail in the following sections. These scenarios are then complemented by a clearing member knock-on analysis, i.e. checking the impact of the CCP stress test on non-defaulting clearing members.

FIGURE 1: STRESS TEST COMPONENTS



43. As explained above, ESMA adopted a stress testing methodology integrating, the characteristics of bottom-up and top-down approaches. For the purpose of this exercise, a stress test is a combination of a clearing member default and a market risk factor scenario. The following variants of member default (MD) scenarios have been tested:

Scenario	Description
Clearing member default scenarios	
MD-A	For each CCP n_A clearing members (set to 2) with the highest exposure under the selected set of risk factor scenarios are identified. These members are defaulted across all CCPs. This means that a CCP can face multiple members (more than 2) defaulting at the same time.
MD-B	EU-wide n_B corporate groups (set to 2) with the highest aggregate exposure under the selected set of risk factor scenarios are identified. All group members are assumed to default for all CCPs. Also in this case this may count for more than 2 members per CCP.
MD-C	EU-wide n_B corporate groups (set to 2) with the highest aggregate default probability weighted exposure under the selected set of risk factor scenarios are identified. The weighting is based on the multiplication of exposures with default probabilities (which is not contemplated in MD-B). All group members are assumed to default for all CCPs. Also in this case this may count for more than 2 members per CCP.

44. As explained above, clearing members defaults without price movements or price movements without clearing members defaults have, from a credit risk perspective and with the exception of investment risks, no impact on CCPs. Therefore the MD scenarios have been tested against the following price shock scenarios:

Market risk factor scenarios	
Historical scenarios – HiS	Historical scenarios as defined by individual CCPs' stress testing framework to be at least as severe as the minimum scenario list.
Hypothetical scenarios – Hyp	Hypothetical scenarios as defined by individual CCPs' stress testing framework to be at least as severe as the minimum scenario list.
Hypothetical scenarios – Hyp A	Clearing member exposure under stress derived by scaling margin requirement to a higher confidence level with a multiplier (normal distribution[3]).

[3] For the normal distribution scenario, value measured at 99% confidence level is assumed to be 2.33 standard deviations from the expected value, whereas the value measured at 99.9% confidence level represents 3.09 standard deviations. The multiplier is calculated as a ratio of 3.09/2.33 = 1.33. The logic behind leptokurtic t-Student multiplier is identical.

Hypothetical scenarios – Hyp B	Clearing member exposure under stress derived by scaling margin requirement to a higher confidence level with a multiplier (heavy tailed distribution[4]).

45. The Union-wide stress test exercise has been completed by a set of reverse stress tests. In the reverse stress test the number of entities (individual clearing members or groups) that will need to default to exhaust prefunded and total (including not-prefunded) financial resources is determined. For this purpose the number of members and groups are varied from 2 to 10.

Reverse Test	Description
RT	Number of defaulting entities required to exhaust prefunded and total (including not-prefunded) financial resources.

46. The RT scenarios are tested against the same market stress scenarios (price shocks) as the clearing member default scenarios, i.e. HiS, Hyp, HypA, HypB.

3.3.1 Identification of Clearing Members

47. The identification of clearing members for the purpose of Union-wide stress testing exercise conducted by ESMA was based on names and Legal Entity Identifiers (LEI) submitted by CCPs via respective Stress Result files (SR). In the first step ESMA identified unique clearing members across all CCP addressing any data.

48. Several problems have been observed in course of the process. For some clearing member names reported in the SR files no valid LEI has been submitted or a unique member name matching the LEI information could not be found or LEI/name differences of the same clearing members were observed either across CCPs or within individual CCPs.

49. ESMA used an external LEI database (https://www.gleif.org/en/services/gleif-services/access-lei-data/lei-download) in order to synchronise clearing member names for a given LEI submitted in SR files. In cases where the LEI information was missing completely ESMA relied on names provided in the SR file. In some cases ESMA staff researched additionally published clearing member names on the CCP internet sites in order to arrive at unique and correct name and LEI mapping. An additional quality check was performed for those clearing members which were tested as defaulting in clearing member default scenarios (MD-A, MD-B and MD-C).

50. The clearing member information was used to identify group relationships on EU level which has been particularly important for MD-B and MD-C scenarios. As none of the LEI databases contained satisfying information on group structures, ESMA staff decided to base the mapping of individual clearing members to financial groups on the identified

[4] Student t distribution with degree of freedom set to 5.

clearing members' names. This manual process included researching clearing members' corporate structure charts and analysis of Bloomberg static data. Additional ECB staff helped to reconcile this information against internal data sources.

3.3.2 Clearing Member Default Scenarios (MD-A)

51. This scenario tests the default of the two largest clearing members per CCP. It translates at EU level the cover 2 principle established in Article 43 of EMIR and Article 53 (1) of the RTS (Regulation EU No 153/2013), which states: "A CCP's stress-testing programme shall ensure that its combination of margin, default fund contributions and other financial resources are sufficient to cover the default of at least two clearing members to which it has the largest exposures under extreme but plausible market conditions."

52. The MD-A stress scenario assumes that all clearing members with "2 largest exposure under extreme market conditions" for each CCP default simultaneously. When the cover 2 principle is applied simultaneously in all the surveyed CCPs, it could theoretically translate into up to 34 simultaneous clearing member defaults at EU level. The selection of the respective clearing members was based on default fund exposures (after the total available collateral of the defaulting member has been used up). Default fund exposures are calculated on an aggregated level in case a CCP has more than one default fund. Individual CCPs submitted loss results per clearing member. ESMA implemented the selection algorithm to identify the clearing members belonging to the "2 largest exposure under extreme market conditions" group per each CCP. Cases of multiple memberships have been accounted for under MD-A scenarios. If a clearing member of a CCP A is among the 2 largest clearing members of the CCP B, its default will automatically be assumed at the CCP A as well, even though its sheer exposure does not rank it among the top-2 clearing members for CCP A under this scenario. Separate MD-A stress test calculations are performed for each market risk factor scenario: historical and hypothetical (His, Hyp, Hyp-A and Hyp-B).

53. The algorithm to select the clearing members assumed to default in the MD-A scenarios is composed of three steps. In step 1 the two worst default fund exposures per CCP and calculation date are selected for each price shock scenario group (His, Hyp, Hyp A and Hyp B). In step 2 unique clearing member names are identified across CCPs. Finally in step 3, the default of all clearing members calculated in line with the first two steps will be assumed. This means that on top of 2 clearing members with largest exposures to an individual CCP any additional clearing members identified in steps 1 and 2 and also members to the individual CCP were assumed defaulted. Losses of a CCP were aggregated at this level and compared to the resources each CCP had at its disposal to manage defaults in the clearing member community at the assessment stage of the exercise described in more detail in section 3.4.

3.3.3 Clearing Member Default Scenarios (MD-B)

54. MD-B stress test scenarios are based on the assumption of default of 2 EU-wide clearing member groups with the largest aggregate exposure to surveyed CCPs. At first clearing members of surveyed CCPs are aggregated to European-wide groups according to the procedure described in 3.3.1. Then for each clearing member of the group the highest exposure per CCP and date will be selected. The aggregated results lead to EU-wide exposure on the group level. The selection of two European-wide clearing member groups assumed to default is made with regard to the highest aggregate scenario loss of the clearing members belonging to individual groups. Separate MD-B stress test calculations are performed for each market risk factor scenario: historical and hypothetical (Historical, Hypothetical, Hyp-A and Hyp-B described in detail in section 3.3). The following example will help to visualise the calculation logic of the MD-B scenario.

	CM 1	CM 2	CM 3	CM 4	CM 5
CCP 1	300	200	100	Not a CM	150
CCP 2	250	Not a CM	200	150	Not a CM
CCP 3	100	150	250	250	150

55. CM2 and CM3 belong to a group X and CM4 and CM5 belong to group Y. The group exposures across the CCPs are the following:

- CM1 = 650
- Group X = CM2 + CM3 = 900
- Group Y = CM4 + CM5 = 700

56. X and Y with clearing members CM2, CM3, CM4 and CM5 are the two groups with the largest exposures assumed to default under the MD-B scenario. The defaulting clearing members per CCP are therefore the following:

- CCP 1 = CM2 + CM3+ CM5 (three defaults, CM4 is not a member of CCP 1)
- CCP 2 = CM3+ CM4 (only two defaults, CM2 and CM5 are not members at CCP 2)
- CCP 3 = CM2 + CM3 + CM4 + CM5 (four defaults).

57. The results of the MD-B stress test scenarios are presented and commented in section 4.3.2.2.

3.3.4 Probability Weighted Clearing Member Default Scenarios (MD-C)

58. Both Clearing Member Default scenarios (MD-A and MD-B) presented in the paragraphs above are based on the assumptions that the clearing members or the clearing member groups with the largest exposures to CCPs would default. None of the scenarios reflect

the likelihood of default of individual clearing members. By way of example, it is worth considering two CCP clearing members with equal CCP exposures but one facing a materially higher risk to default than the other one. The two CCP members would attain equal ranks if based on their exposure only, while the riskier one would rank higher if their PDs are taken into consideration. It was decided to include the probability of default (PD) element into the ranking of clearing members, to capture not only the size of exposures but also the risk of CCP members to default. It was an ESRB proposal embraced by ESMA to implement an additional scenario (MD-C) based on PD weighted exposures of European-wide clearing member groups. The ranking measure was arrived at by multiplying the exposure calculated the way presented already in previous section on MD-B scenario with the measure of probability of default of the individual clearing member.

59. In the context of technical discussions with ESMA, ESRB proposed to consider a specific ranking scheme for CCP members, based on which ESMA designed its probability-weighted clearing member default stress test scenarios (MD-C). The ESRB considered two approaches to quantify the PDs for all clearing members. At first, PDs from Merton-type models were considered where the PDs are determined based on a model combining a stochastic process defining the value of equity of an obligor across time and of its debt. Secondly implied PDs were calculated based on CDS spreads (5-year term was selected as the most liquid tenor). Both of these approaches have advantages and disadvantages. While CDS-implied PDs are available for a large number of institutions, they are not a clean measure of default probability. CDS-implied PDs have the following advantages: i) they can very easily be computed from observed CDS spreads, without any further input data being required (such as balance sheet information); ii) they can be obtained for a comprehensive list of institutions as CDS tend to be traded also for institutions without traded equity (which is a prerequisite for being in a position to compute Merton-type model PDs). The disadvantages of the method are: i) that CDS spreads, and hence the implied PDs, are contaminated by the general market price of risk, i.e. a premium that reflects the general risk aversion of investors, liquidity risk, credit risk of the protection seller etc., which would let implied PDs be higher than the ”real” PDs for the institutions at stake; ii) on the other hand they can be contaminated as a result of implicit or explicit government guarantees, which is a concern in particular for large institutions, whose CDS-implied PDs would for that reason be expected to be downward biased. PD calculated on the basis of Merton-type models are a clean measure of “real-world” PD. Their advantages mirror the CDS-implied PDs’ disadvantages, i.e. they should not be contaminated by guarantees or the general risk aversion premium. Their main disadvantage lies in the fact that they are available for only a smaller number of institutions as their computation requires reliable balance sheet information and that firms are traded. ESMA decided to apply only the CDS implied probabilities of default. The decision was made due to the coverage of a much higher number of clearing members by the CDS-implied measure. ESRB submitted a report explaining the details of both methods. The mathematical formula for calculation of PDs implied by CDS spreads is presented in the Annex 7.5

60. The methodology of probability weighted clearing member default scenario (MD-C) is similar to the logic applied under MD-B scenario. The main difference under MD-C is that the ranking of European-wide clearing member groups to default is based not on pure group-wide exposure figures as was the case under MD-B but on exposures multiplied with default probabilities of clearing member groups. The following example visualises the difference:

61. The following default probability information is added to the numerical data on clearing members' and groups exposures provided in the example presented in section 3.3.3:

- PD of CM1 = 0.25
- PD of group X(CM2 + CM3) = 0.20
- PD of group Y(CM4 + CM5) = 0.15

62. Using this information default probability weighted exposure can be arrived at:

	CM 1	CM 2	CM 3	CM 4	CM 5
CCP 1	300 * 0.25 = 75	200 * 0.2 = 40	100 * 0.2 = 20	Not a CM	150 * 0.15 = 22.5
CCP 2	250 * 0.25 = 62.5	Not a CM	200 * 0.2 = 40	150 * 0.15 = 22.5	Not a CM
CCP 3	100 * 0.25 = 25	150 * 0.2 = 30	250 * 0.2 = 50	250 * 0.15 = 37.5	150 * 0.15 = 22.5

63. The default probability weighted group exposures across the CCP under this scenario are:

- CM1 = 162.5
- Group X (CM2 + CM3) = 180
- Group Y (CM4 + CM5) = 105

64. The two groups with largest exposures assumed to default under the MD-C scenario are CM1 and X with clearing members CM1, CM2, and CM3 defaulting. This changes the number of defaulting clearing members per CCP compared to scenario MD-B:

- CCP 1 = CM1 + CM2+ CM3
- CCP 2 = CM1+ CM3
- CCP 3 = CM1 + CM2 + CM3.

65. After the selection of defaulting clearing members the stress test exposures are calculated analogously to scenarios MD-A and MD-B. The results of the MD-C stress test scenarios are presented and commented in section 4.3.2.3.

3.4 Assessment methodology

66. ESMA assessed potential losses calculated within scenarios of the Union-wide stress testing exercise, defined in Section 3.3, against consecutive lines of defence of the default waterfall of CCPs. Article 45 of EMIR defines the default waterfall of a CCP and prescribes the order in which its different resources may be used by CCPs to absorb losses resulting from the default of a clearing member. Any losses not covered by margins posted by the defaulting clearing member must be absorbed by the contribution to the default fund of that clearing member before additional resources may be used. Following the depletion of total resources funded by the defaulting clearing member (margins and contribution to the default fund) the dedicated amounts of the CCP, called skin in the game (SITG) absorb the losses resulting from default. After depletion of the skin in the game, the default fund contributions of the non-defaulting clearing members will be used. The aforementioned resources need to be fully collateralised and are hence called prefunded resources of the CCP. In case prefunded resources cannot cover the losses resulting from the default of the clearing member the CCP may have powers of assessment, being able to call additional funds from the non-defaulting clearing members. The powers of assessment are the unfunded resources of the CCP.

67. The assessment of results of the ESMA stress testing exercise reflects the design of the default waterfall of CCPs in order to analyse the sufficiency of financial resources of surveyed CCPs under stress scenarios. The stress scenario losses are assessed against prefunded resources first. An additional analysis highlights how unfunded resources would cover the losses not absorbed by prefunded lines of defence.

68. An additional Uncovered Loss Absorption (ULA) assessment was performed with the aim of demonstrating how the CCPs' lines of defence were absorbing stress scenario losses and in order to estimate the magnitude of potential losses not covered by the prefunded resources in the default waterfall of CCPs.

3.5 Clearing member knock-on analysis

69. The clearing member Knock-On (CMKO) analysis was performed to assess the systemic risk caused by defaults in the CCPs' clearing member communities. It was aimed to quantify the potential spill-over effects to the remaining, healthy network of clearing members assessing the likelihood of additional defaults triggered by the loss absorption mechanism of CCPs. In order to measure the spill over effects, the contributions of non-defaulting clearing members to the default waterfall of each individual CCP were computed against the Tier 1 capital base or equity of the clearing members. The Tier 1 capital as defined in CRR was collected from balance sheet statements of the clearing members by ESMA and reconciled with ECB data. In case capital figures were missing, ESMA used as a proxy equity values on public market data sources (e.g. Bloomberg). Any potential contribution to absorbed default waterfalls exceeding 20% of Tier 1 capital of a non-defaulting clearing member and higher than the amount of 100 million EUR are highlighted in Figure 13 and Figure 14.

3.6 Limitations

70. The Union-wide stress test exercise conducted by ESMA has certain limitations which need to be highlighted while interpreting the results of the exercise. The limitations can be directly linked to either the data provided to ESMA by surveyed CCPs via NCAs or to the stress testing methodology applied by individual CCPs or the aggregation logic designed by ESMA.

71. ESMA developed an approach allowing the reuse of stress testing results developed by individual CCPs under the assumption of their EMIR compliance, subject also to the scenarios being at least as conservative as the shifts set in the minimum scenario list. This approach has put a number of constraints on the data submitted by CCPs and used for the exercise:

    - The risk factor shocks applied to clearing member exposures by individual CCPs are not uniform across all central clearing counterparties. ESMA mitigated the risk of aggregating scenario results based on heterogeneous shifts by imposing the minimum scenario list described in detail in Section 3.1. The list is merely a set of minimum shifts with most CCPs applying more severe scenarios. The results of stress scenarios presented in Chapter 4 of this report need to be interpreted as losses arising subject to occurrence of market scenarios as severe (or worse) as the shifts implied by the minimum ESMA list.

    - ESMA designed the minimum scenario list of risk factor price shifts based on the product scope cleared by surveyed CCPs. It was not operationally feasible to replicate the individual lists of risk factors of all product groups across 17 surveyed CCPs as the number of factors would have exceeded 700,000 individual factors. It was essential to compare CCPs clearing different products within a broader category of risk factors.

    - Submission of stress shifts on maturity spreads on the basis of the template provided by ESMA was scarce, not allowing a comprehensive assessment of the policies applied by individual CCPs. Therefore no minimum shifts were set with regards to the maturity spreads and the analysis of related risks will be performed in further exercises. Also the asset correlation as a specific risk factor was not reflected in the minimum scenario list for similar reasons.

72. Some limitations are linked to the divergent methodologies of stress test computation applied by individual CCPs and the fact that ESMA had to aggregate the results based on heterogeneous methodologies into common EU-wide scenarios:

    - The data submitted to ESMA by individual CCPs did not always allow to consistently analysing the price shocks applied by individual CCPs. Some CCPs applied the price shocks for specific scenarios in isolation to volatility of other risk factor prices, creating hypothetical scenarios of adverse price shocks of only selected product groups. This contradicts the empirical observation that situations of severe market stress are manifested by extreme volatility of diverse product

groups. In isolated cases this might have led to underestimations of stress scenario result for individual CCPs.

- An additional limitation is linked to the historical/hypothetical market scenarios and the worst scenario selection algorithm. The worst scenario is first selected for each CCP, scenario type (historical/hypothetical) and reporting date. It is the scenario that would produce the largest combined default fund exposure after the default of 2 clearing members of the CCP. The exposures resulting from these scenarios are then used to calculate the stress results across all member default scenarios. For example, under MD-B member default scenarios, the default fund exposures from these market scenarios are aggregated for all members into EU-wide clearing member Groups and the 2 Groups with the largest combined exposure are considered to be in default. For each CCP, the identified scenario producing the largest combined default fund exposure after the default of 2 clearing members is always used to identify the losses for all members of defaulting Groups. This aggregation procedure does not ensure that the scenario selected as the worst for cover 2 exposures per CCP is also always the worst in terms of total exposures, e.g. there can be scenarios with larger combined exposures after the default of 3 clearing members belonging to 2 groups. The modelled (HypA/HypB) market scenarios do not suffer from this limitation.
- The initial margin calculation models applied by individual CCPs are calibrated on the basis of values of parameters that differ between individual products and sometimes also go beyond the minimum requirements. They use statistical models calibrated at potentially different confidence levels, look-back periods, liquidation periods and offsets across financial instruments. Some of the market stress test scenarios applied by ESMA (HypA and HypB) rely on scaling margins with multipliers (presented in section 3.3). This approach can have a penalising effect on CCPs that calibrate their models on the basis of more conservative assumptions, such as higher confidence levels, as multipliers are uniform across all CCPs. Furthermore, the margins are calculated per clearing account to reflect the exposure of the CCP under the position-specific worst case scenario and subject to the aforementioned calibration parameters. Thus, the margins for different accounts can correspond to exposures that would be realised under different and sometimes also contradicting market scenarios. This methodological limitation will lead to an overestimation[5] of the calculated exposures under the scaled (HypA/HypB) market scenarios. The scaled market scenarios are however a very useful component of the stress exercise as these do not suffer from the limitations linked to the historical and hypothetical scenarios.
- In several cases CCPs did not submit results reflecting the ESMA minimum price shift list. In these cases ESMA estimated prudential add-ons. The logic behind the

[5] As a mitigation measure, members that would not have a loss under the worst hypothetical scenario are also considered as not having losses under the scaled market scenarios (HypA/HypB).

add-on calculation is explained in detail in section 3.2. The estimated results need to be treated as a conservative estimation only.

- Stress testing of additional risk dimensions (liquidity risk, wrong way risk for instance) has been left for further exercises due to operational constraints on the side of the CCPs and ESMA.

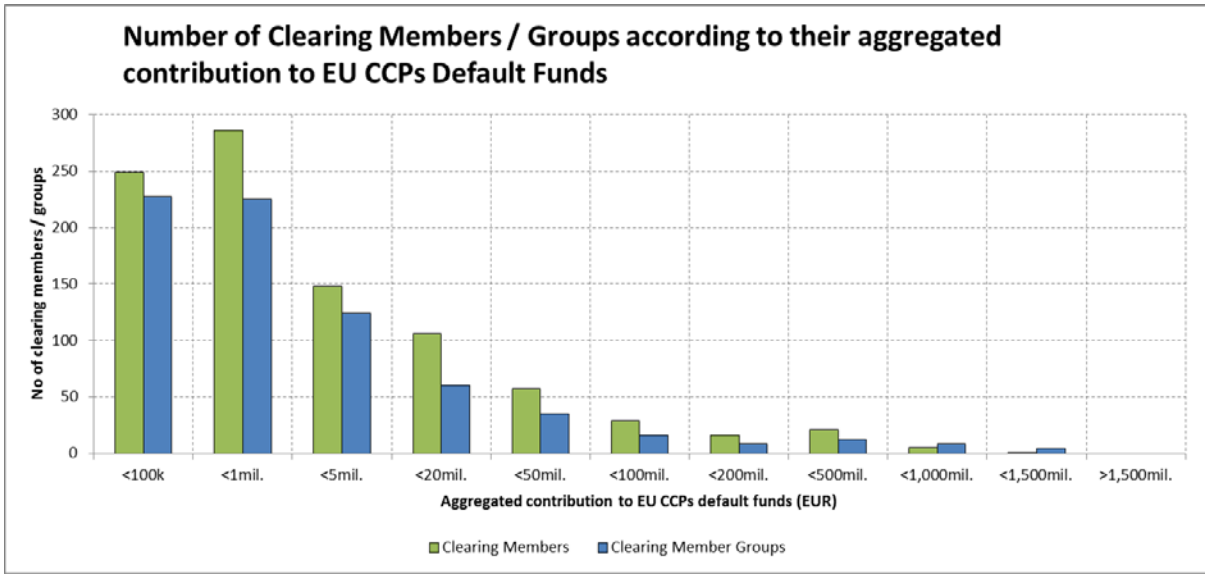
4 Stress test results

4.1 Background information

73. The 17 CCPs included in the scope of the stress exercise provided exposure data on individual member level for 3 reporting dates. More than 900 individual entities being members to one or more CCPs were identified. Approximately 85% of the entities are members to only one CCP, while 11 entities were members to 10 or more CCPs. In many cases, groups of financial institutions are participating through multiple group entities, also at individual CCPs or even default funds. For 13 groups of financial institutions with European wide presence, the group entities are members of 10 or more CCPs.

74. The number of individual clearing members and groups [6] of entities being clearing members at European CCPs are presented in Figure 2 according to their aggregate EU-wide contributions to the different default funds of all CCPs included in the scope of the exercise.

FIGURE 2: NUMBER OF CLEARING MEMBERS / CLEARING MEMBER GROUPS[7]



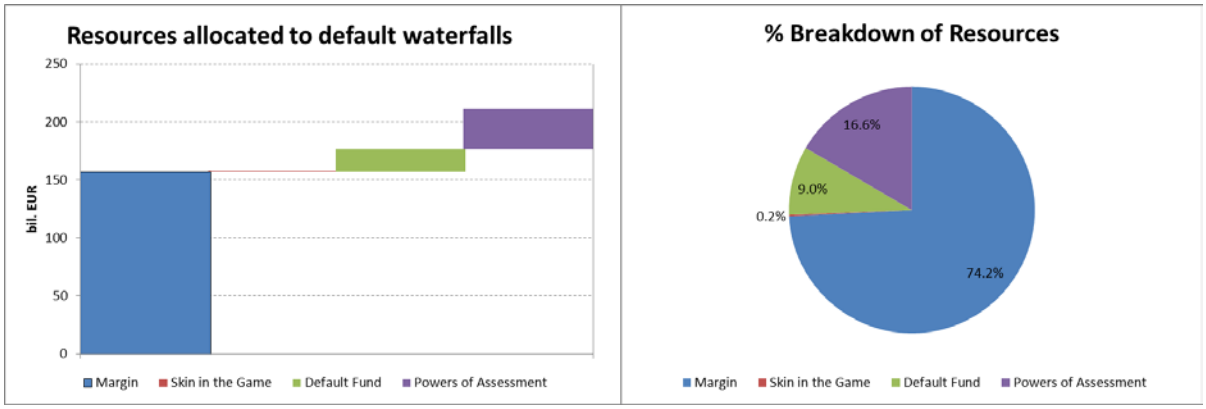
[6] all clearing members that were not assigned to one of the identified groups are also considered as a group that consists of 1 entity.
[7] December 2014 data

75. Approximately 60% of all clearing members and groups have an aggregate contribution of up to 1mln EUR, with 95% contributing less than 100mln EUR. For 1 clearing member its aggregate contribution is more than 1bn EUR. At group level, 4 groups have been identified having through the different group entities a total contribution of more than 1bn EUR, with the maximum total contribution from a single group of clearing members being 1.2bn EUR. The 5% of members that have an aggregate contribution of more than 100mln EUR provide approximately 70% of the mutualised resources[8] across all CCPs. The level of concentration of the CCPs' mutualised resources to individual clearing members is further analysed in 4.2.2 using the Herfindahl-Hirschmann index (HHI).

76. The resources that are considered as part of the default waterfall of CCPs in the stress exercise consist of margins provided by defaulting clearing members, the dedicated resources of the CCP (skin in the game) that shall absorb losses exceeding the defaulter's collateral, the prefunded default fund contributions of non-defaulting clearing members and not-prefunded additional resources (powers of assessment) that can be called by CCPs from non-defaulting clearing members subject to their rules. Other types of resources, beyond margin, default fund contributions, skin in the game and powers of assessment, such as parental guarantees or additional CCP capital have not been taken into account in this exercise.

77. The total resources aggregated across CCPs at EU-wide level as provided by CCPs are presented in Figure 3.

FIGURE 3: TOTAL AND BREAKDOWN (%) OF EU-WIDE CCPS RESOURCES



78. It should be noted that the resources presented in Figure 3 can only be used according to their priority in the default waterfall and subject to the limitations provided in EMIR, which are duly considered when losses are allocated in the stress exercise.

[i] i.e default fund contributions that can be used to cover losses from other member defaults within one default fund

4.2 Interconnectedness and Concentration

4.2.1 Interconnectedness

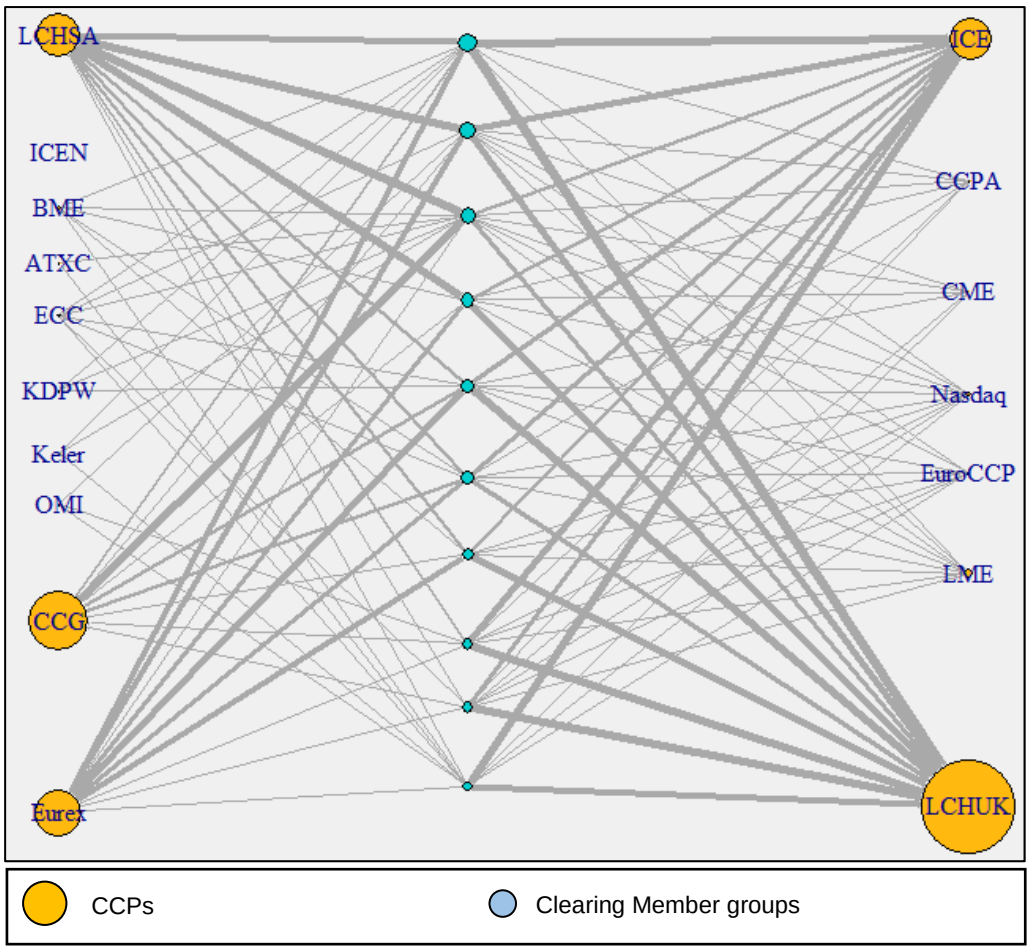
79. CCPs were set up to reduce systemic risks resulting from bilateral counterparty connections, that could form a network susceptible to spillovers of idiosyncratic shocks that could possibly result in a cascade of defaults of interconnected counterparties. On the other hand, CCPs are still expected to be interconnected through their clearing members and a series of defaults at one CCP could potentially endanger other CCPs and the financial system in general. The following figure provides a visual representation of the CCPs' interconnectedness arising from common clearing members.

80. Under Figure 4, Interconnectedness between two CCPs is taking the form of common clearing members, belonging to the top-10[9] groups of clearing members EU-wide, that provide approximately 50% of the EU-wide default fund contributions. The thickness of the line between a CCP and clearing member group is proportional to the sum of the contributions of all members belonging to this group to the default fund(s) of the CCP. The size of each node representing each CCP is also proportional to the total amount of the default fund(s) of this CCP.

81. It can be seen that the top-10 groups are connected to all larger CCPs, but also to some of the smaller CCPs. These groups always have one or more entities that are members in the largest CCPs being also amongst the top default fund contributors. Even for this reduced scope, it can be expected that a default of one of the top groups would trigger a simultaneous default of one or more entities in most of the European CCPs with potentially systemic implications. Therefore, the default of the top-2 EU-wide groups is one of the member default scenarios considered in the stress exercise and the results are analysed and discussed in 4.3.2.2 and 4.3.2.3.

[9] For the purpose of this illustration, the top-10 groups are selected on the basis of their aggregate contribution to all CCPs, considering all members that belong to each group. The number of groups considered is limited to the top-10 in order to improve the visibility of the provided illustration. This choice is not expected to affect the qualitative conclusions drawn from this illustration.

FIGURE 4: NETWORK MAP ON INTERCONNECTEDNESS OF CCPS THROUGH CLEARING MEMBERS BELONGING TO THE TOP-10 EU-WIDE GROUPS



4.2.2 Concentration risks

82. In addition to the core stress test exercise we carried out an analysis to assess the degree of concentration of CCPs mutualised resources. The mutualised resources consist of the contributions of individual members to the CCPs' default funds and the following analysis is conducted to investigate whether there is a high degree of concentration to a very small number of individual clearing members across CCPs which are part of the stress test exercise. The degree of concentration is calculated using the Herfindahl-Hirschmann index (HHI), a measure developed and used in industrial economics to assess concentration (and thus the extent of competition) in a particular industry.

83. A high degree of concentration would mean that in case of losses exceeding the defaulters collateral, the remaining losses will mostly affect a small number of entities (potentially for substantial amounts) that would lose part or all of the prefunded contributions and would also be expected to provide additional resources (powers of assessment[10]), subject to the rules of individual CCPs. The potential implications from such losses to non-defaulting entities with large exposures to one or more default funds are further analysed and discussed in 4.4. Furthermore, a high degree of concentration in the mutualised resources could also signal for a potential build-up of a high degree of concentration in terms of the actual exposures, as the default fund contributions are required under EMIR to be proportional to the exposures of each clearing member. The rationale is that higher concentration could entail higher risk in case of default of individual entities. The more concentrated available resources are, the higher is the probability that stress in one member institution will significantly impact CCPs and the financial system as a whole. Therefore, analysing the concentration of mutualised resources can be informative from a financial stability perspective.

84. HHI is defined at two different levels:

- At CCP level (HHI_{CCP}): the weighted sum of the HHI calculated at default fund level (HHI_{WA}) and the maximum value of the HHI calculated per default fund (HHI_{MAX}[11]).
- At EU-wide level (HHI_{EU}).

Details on the computation of the index are included in the Annex (7.1)

85. Across the 17 CCP considered in the analysis there are only few for which, according to the HHI methodology and the thresholds used, collateral can be considered to be highly concentrated on a limited number of clearing members (Table 1).

86. In the (HHI_{WA}) case there is only one CCP showing high levels of concentration (red) because of the small number of clearing members. The overall exposure is from a systemic perspective limited and the small number of members is not expected to give

[10] The amount of not-prefunded resources to be called from non-defaulting members is usually set as a multiple of the original contribution at the time of the default.
[11] [11] HHI_{MAX} and HHI_{CCP} will be the same for CCPs that have only 1 default fund.

rise to systemic risk. Five CCPs result to be moderately concentrated (yellow). For all five CCPs, however, the concentration level is only slightly above the lower threshold (moderate concentration is observed for values between 1,000 and 2,000, see Annex 7.1 for more details). For the rest of the eleven CCPs no concentration (green) is identified, with the degree of concentration being much lower than the upper threshold (1,000).

87. Concentration levels are different when the maximum value for the HHI per DF (default fund) is considered rather than the weighted average across DFs. Besides the CCP with the high degree of concentration in the HHI_{WA} case, whose degree of concentration remains the same (4,512), there are two other CCPs whose HHI levels are above the upper threshold. For one of the two CCPs, the degree of concentration is well above the lower threshold (2000), at 4,007. The level of HHI_{MAX} is determined by the one DF that is highly concentrated. Differently, when HHI_{WA} is considered, the level of concentration is much smaller as it is a weighted average across the different DFs, which have very small levels of concentration. Regarding the second of the two CCPs, the degree of concentration also increases in the case of HHI_{MAX} to 2,538 still close to the lower threshold indicating high concentration (2,000). For this CCP also, the results are driven by one default fund, the other DFs are respectively moderated or no concentrated. Two CCPs shift from no concentration to moderate concentration when the HHI_{MAX} rather than the weighted average HHI is considered. The increase in concentration is again driven by individual default funds.

88. The increase in the degree of concentration in the HHI_{MAX} case, for those CCPs that have more than one default funds is related to the fact that, differently from HHI_{WA}, it is not the total default fund contributions per CCP that is considered, but the contributions allocated for each specific DF. It is worth noting, that resources cannot be used across different default funds.

89. Finally, the last specification, HHI_{EU}, looks at the overall concentration level in EU, both at clearing member and at group level (Table 2, *Panel a* and *Panel b*). The HHI by clearing member (group) is defined as the sum of the squares of the DF share by clearing member (group) across the 17 CCPs considered in the analysis. Results show that, at the EU-level, there is no concentration either at clearing member level or at group level. As expected, by moving from clearing member to group level the HHI index increases.

TABLE 1: CONCENTRATION BY CCP[12]

	HHI (WA)	HHI (Max)
CCP1	730	757
CCP2	1,435	1,435
CCP3	422	422
CCP4	1,267	1,400
CCP5	1,115	1,141
CCP6	1,285	1,285
CCP7	322	4,007
CCP8	361	361
CCP9	4,512	4,512
CCP10	597	906
CCP11	1,099	2,538
CCP12	689	689
CCP13	269	269
CCP14	983	983
CCP15	439	439
CCP16	786	1,706
CCP17	733	1,138

Note: HHI (WA)=weighted sum of the HHI calculated by DF type per CCP using as weights the DF size ratio (DF size by individual DF over total DF per CCP); HHI (MAX)=Max of HHI across the different DFs. Red indicates significant concentration levels (> 2,000); Yellow, small concentration levels (1,000 - 2,000); Green, no significant concentration (0 - 1,000). Computations at 31 December 2014.

TABLE 2: CONCENTRATION AT EU-WIDE LEVEL

Panel a - HHI by clearing member			
	Oct 2014	Nov 2014	Dec 2014
HHI- EU wide	170	170	169
Panel b - HHI by group			
	Oct 2014	Nov 2014	Dec 2014
HHIEU wide	305	304	296

[12] The Codes used for CCPs (i.e. CCPxx) are random.

4.3 Results on sufficiency of financial resources

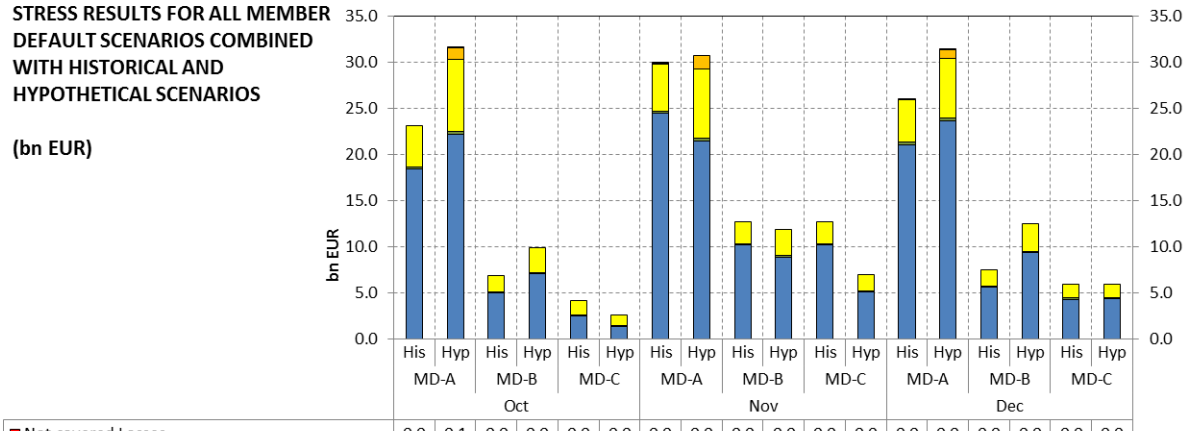
4.3.1 Aggregate results on sufficiency of financial resources

90. Stress results at EU-wide level for the sufficiency of financial resources under stress scenarios for all member default scenarios combined with Historical/Hypothetical [13] (Figure 5) and scaled HypA/HypB (Figure 6) market stress scenarios are provided in the following figures.

91. For example, in Figure 5 under the "MD-A - Hypothetical - Oct" scenario, the total loss across all CCPs, before using the available resources, is 31.6bn EUR, which is then covered by the defaulting members collateral (22.2bn EUR), the dedicated resources of the CCP, i.e. "Skin in the game" (0.3bn EUR), the prefunded mutualised resources provided by the non-defaulting members, i.e. Default Fund contributions (7.9bn EUR) and non-prefunded resources, i.e. Powers of Assessment (1.2bn EUR). This leaves approximately 0.1bn EUR of losses that are not covered by the prefunded or not-prefunded dedicated resources of the CCPs default waterfall. Under this scenario, a total of 30 members are considered to be in default EU-wide, with a maximum of 16 individual members defaulting at CCP level. The maximum number of defaulting members per CCP and default fund is 14, out of which a maximum of 12 members actually cause losses per default fund. Defaulting members that do not have open positions or have positions that would profit from the considered scenarios are not counted towards these 12 members. It can be seen that the number of simultaneous members defaulting under this scenario is extremely high due to the cross default condition. That is, the members identified as top-2 in one CCP are considered to be in default in all CCPs leading to an unprecedented and rather implausible number of entities simultaneously defaulting at EU-wide and CCP level, as a result of which the CCPs would need to call for not-prefunded resources leaving also a small amount of residual uncovered losses (<0.1bn EUR).

[13] Where it has been assessed that the CCPs' scenarios (either historical or hypothetical) did not include stress shifts that are at least as conservative as the identified minimum price shifts, ESMA has either received from CCPs additional/updated scenarios that provide for shifts that are at least as severe as the identified minimums or has adjusted the CCPs' stress results to conservatively reflect the potential impact.

FIGURE 5: STRESS RESULTS FOR ALL MEMBER DEFAULT SCENARIOS COMBINED WITH HISTORICAL AND HYPOTHETICAL MARKET STRESS SCENARIOS



	Oct						Nov						Dec					
	His	Hyp	His	Hyp	His	Hyp	His	Hyp	His	Hyp	His	Hyp	His	Hyp	His	Hyp	His	Hyp
	MD-A		MD-B		MD-C		MD-A		MD-B		MD-C		MD-A		MD-B		MD-C	
Not covered Losses	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loss covered by non-prefunded resources(PoA)	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.1	0.9	0.0	0.0	0.0	0.0
Loss covered by mutualised default fund	4.5	7.9	1.8	2.7	1.5	1.1	5.1	7.5	2.3	2.9	2.3	1.7	4.6	6.5	1.7	3.0	1.5	1.5
Loss covered by CCP's skin in the game	0.3	0.3	0.2	0.1	0.1	0.1	0.3	0.3	0.2	0.1	0.2	0.1	0.2	0.3	0.2	0.2	0.1	0.1
Loss covered by defaulting Members Collateral	18.4	22.2	4.9	7.0	2.5	1.3	24.4	21.5	10.1	8.9	10.1	5.1	21.0	23.6	5.5	9.3	4.3	4.3
Total Scenario Loss	23.1	31.6	6.9	9.8	4.1	2.5	29.8	30.6	12.6	11.9	12.6	6.9	25.9	31.3	7.4	12.4	5.9	5.9
No of Memb defaulting EU-wide	30	30	14	10	7	3	30	28	12	9	12	4	29	28	14	12	9	4
Max no of Memb defaulting / CCP	18	16	7	7	4	2	20	18	7	8	7	3	22	18	8	7	3	3
Max no of Memb defaulting / CCP&DF	18	14	6	5	3	2	18	15	6	6	6	2	21	15	8	6	3	2
Max no of Memb defaulting / CCP&DF with losses	15	12	4	3	3	2	13	11	3	5	3	1	16	10	5	3	3	2

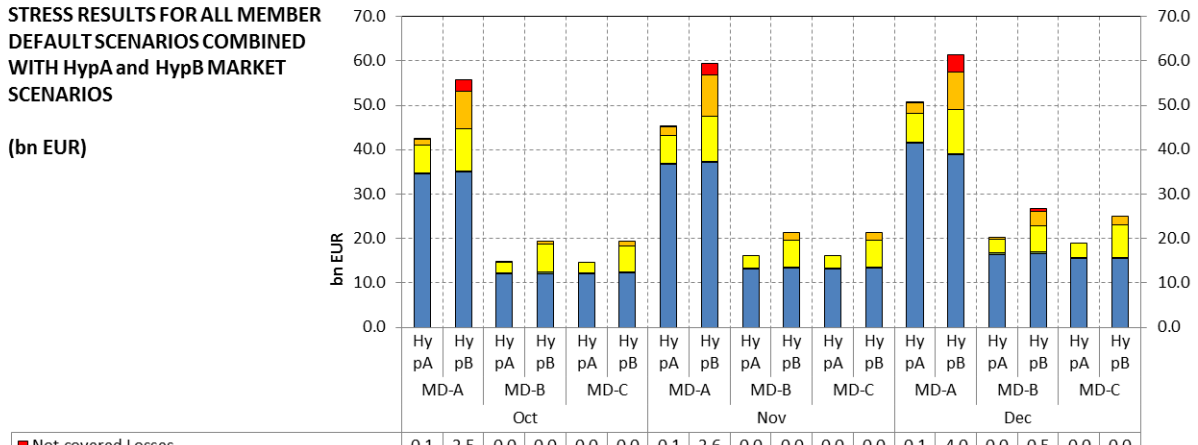
92. The MD-A member default scenarios consistently produce significantly more severe stress losses. This can be explained by the number of actual defaults considered under the different members default scenarios. In particular, under the MD-A scenarios combined with Historical and Hypothetical stress price scenarios, up to 30 (14 for MD-B and 12 for MD-C) members are considered to be in default with a maximum of 16 (5 for MD-B and 3 for MD-C) defaulting members causing losses at a CCP and Default Fund level. By construction, under the MD-A member default scenarios, all top-2 members per CCP are considered to be also in default in all other CCPs. This means that theoretically up to 34[14] members would be considered to be in default in the case where all top-2 members identified per CCP would be different. In practice, the actual number of defaulting members causing losses is smaller mainly because of common top-2 members across CCPs and a number of top-2 members that have no activity in other CCPs or their positions would not generate losses under the worst case market price scenario considered. On the other hand under MD-B scenarios the members belonging to the top-2 EU-wide groups, in terms of exposures, are considered to be in default. This leads to a considerably smaller number of members actually defaulting when compared to MD-A. Moreover, under MD-C the number of defaulting entities is even smaller mainly because in some cases the members belonging to groups that have a higher probability of default are CCP-specific and do not have membership or activity across multiple CCPs.

[14] 34 = 17 CCPs * 2 members / CCP

93. In terms of the sufficiency of the financial resources, under MD-B and MD-C member default scenarios combined with historical and hypothetical market stress scenarios the results indicate that for the three reporting dates the losses are expected to be covered by prefunded resources of the CCPs waterfall. On the other hand, a shortfall of the prefunded resources is observed in all MD-A hypothetical scenarios with the maximum shortfall being equal to 1.4bn EUR for November. The CCPs could call for additional not pre-funded resources from the non-defaulting members to cover this shortfall, leaving a maximum of uncovered losses of less than 0.1bn EUR for the October date, where the top-2 members for each CCP are considered to be in default adding up to a total of 30 distinct members defaulting across Europe. The scenarios leading to a shortfall in pre-funded resources, involve a very large number of members defaulting at EU-wide, CCP and default fund level and the results are further analysed in paragraphs 4.3.2.1 - 4.3.2.3.

94. The summary stress results for the scaled HypA/HypB market stress scenarios are also presented in the following figure. As oppose to the historical/hypothetical scenarios where the stress results have been provided by the CCPs, the clearing members' exposures for these scenarios are derived by scaling up margin requirements to target a higher confidence level. The HypA scenarios are calibrated assuming a normal distribution and the HypB assuming a more heavy tailed distribution. The detailed methodology and assumptions underlying the construction of these scenarios are presented in 3.3.

FIGURE 6: STRESS RESULTS FOR ALL MEMBER DEFAULT SCENARIOS COMBINED WITH SCALED (HYPA/HYPB) MARKET STRESS SCENARIOS



	Oct						Nov						Dec					
	MD-A		MD-B		MD-C		MD-A		MD-B		MD-C		MD-A		MD-B		MD-C	
	HypA	HypB	HypA	HypB	HypA	HypB	HypA	HypB	HypA	HypB	HypA	HypB	HypA	HypB	HypA	HypB	HypA	HypB
Not covered Losses	0.1	2.5	0.0	0.0	0.0	0.0	0.1	2.6	0.0	0.0	0.0	0.0	0.1	4.0	0.0	0.5	0.0	0.0
Loss covered by non-prefunded resources(PoA)	1.2	8.4	0.0	0.7	0.0	1.2	1.8	9.2	0.0	1.8	0.0	1.8	2.5	8.3	0.3	3.3	0.0	1.9
Loss covered by mutualised default fund	6.3	9.5	2.4	6.3	2.4	5.8	6.3	10.1	2.8	6.1	2.8	6.1	6.4	10.0	3.1	6.0	3.2	7.3
Loss covered by CCP's skin in the game	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.1	0.2	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Loss covered by defaulting Members Collateral	34.4	35.0	12.0	12.1	12.1	12.2	36.7	37.1	13.2	13.3	13.2	13.3	41.4	38.8	16.5	16.6	15.4	15.5
Total Scenario Loss	42.4	55.7	14.7	19.4	14.7	19.5	45.2	59.4	16.1	21.4	16.1	21.4	50.7	61.5	20.2	26.7	18.9	25.0
No of Memb defaulting EU-wide	31	32	9	9	8	8	28	29	8	8	8	8	30	27	11	11	8	8
Max no of Memb defaulting / CCP	16	16	7	7	7	7	17	15	7	7	7	7	20	16	8	8	7	7
Max no of Memb defaulting / CCP&DF	12	13	5	5	5	5	13	11	5	5	5	5	13	11	6	6	5	5
Max no of Memb defaulting / CCP&DF with losses	9	10	3	3	3	3	11	9	4	4	4	4	9	9	3	3	3	3

95. As it can be observed in Figure 6, also for the scaled market scenarios (HypA/HypB), the MD-A member default scenarios cause significantly higher losses when compared to the other member default scenarios, involving a larger number of individual members

defaulting at EU (32 for MD-A (Oct), 11 for MD-B (Dec) and 8 for MD-C (all 3 dates)) and CCP level (maximum of 20 members for MD-A, 8 for MD-B and 7 for MD-C). In terms of market price scenarios, the Hyp-A price scenarios are also by construction less severe than the Hyp-B scenarios and as expected it can be seen that they produce lower losses and shortfalls for the same number of clearing member groups defaulting.

96. Therefore the combination of MD-A member default scenarios with Hyp-B market stress scenarios drives the results not only for all the scaled price scenarios, but also for all considered scenario combinations. In particular, the maximum shortfall in total resources is 4.0bn EUR for the December date after using a total of 49.1bn EUR pre-funded and 8.3bn of not pre-funded resources to cover an initial loss of 61.5bn EUR. This loss is accounted to up to 9 clearing members at the CCP & default fund level. In total, 27 distinct clearing members have been considered to be in default at the EU-wide level, with a maximum of 16 members defaulting at the CCP level. The results are further analysed in paragraphs 4.3.2.1 - 4.3.2.3.

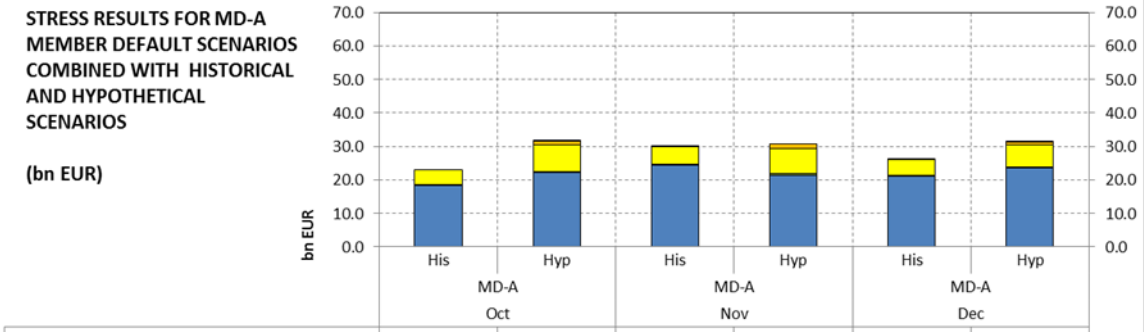
4.3.2 Scenario level results on sufficiency of financial resources

97. In this section the scenarios presented before, i.e. historical/hypothetical and HypA/HypB are further analysed per member default scenario.

4.3.2.1 Sufficiency of financial resources following the default of top two members per CCP (MD-A)

98. The stress results for the top-2 per CCP (MD-A) member default scenarios combined with the worst historical and the worst hypothetical market scenario are presented in Figure 7.

FIGURE 7: MD-A STRESS RESULTS ON SUFFICIENCY OF FINANCIAL RESOURCES FOR HISTORICAL/HYPOTHETICAL MARKET SCENARIOS



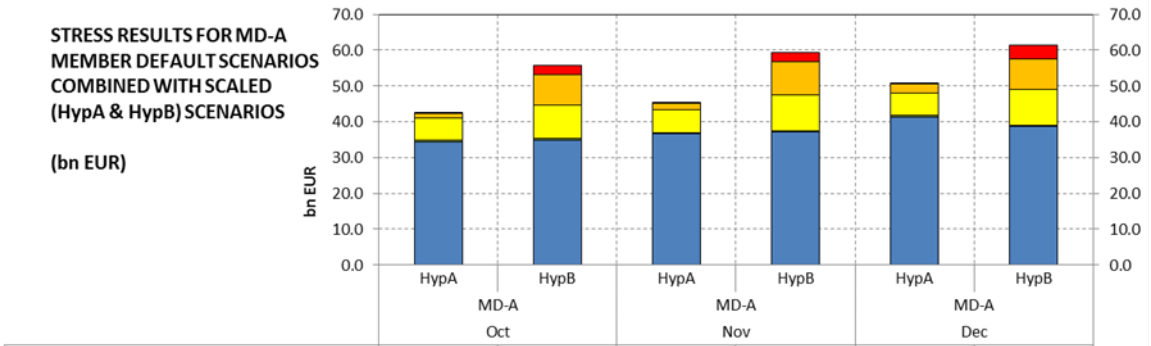
	MD-A Oct		MD-A Nov		MD-A Dec	
	His	Hyp	His	Hyp	His	Hyp
Not covered Losses	0.0	0.1	0.0	0.0	0.0	0.0
Loss covered by non-prefunded resources(PoA)	0.0	1.2	0.0	1.4	0.1	0.9
Loss covered by mutualised default fund	4.5	7.9	5.1	7.5	4.6	6.5
Loss covered by CCP's skin in the game	0.3	0.3	0.3	0.3	0.2	0.3
Loss covered by defaulting Members Collateral	18.4	22.2	24.4	21.5	21.0	23.6
Total Scenario Loss	23.1	31.6	29.8	30.6	25.9	31.3
No of Memb defaulting EU-wide	30	30	30	28	29	28
Max no of Memb defaulting / CCP	18	16	20	18	22	18
Max no of Memb defaulting / CCP&DF	18	14	18	15	21	15
Max no of Memb defaulting / CCP&DF with losses	15	12	13	11	16	10

99. The number of defaulting members for each CCP is at least 2, as this is the initial condition for MD-A scenarios. However, for several CCPs the cross default condition leads to a very large number of individual members defaulting at the CCP level (up to 22 members defaulting in one CCP). 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 if they are active, they would not cause any losses under the worst case market scenarios considered for this particular CCP. As a better indicator of the severity of the member default scenarios, the defaulting members with losses are identified for each CCP & default fund and the maximum number across all default funds and CCPs is also reported. Under the scenario leading to not covered residual losses (0.1bn EUR), the maximum number of members with non-zero losses for a single default fund is 12.

100. For the hypothetical and historical market stress scenarios, the total amount of losses exceeding the total available resources, after using the not-prefunded resources, is less than 0.1bn EUR and is considered as non-material in a systemic risk context, while the maximum shortfall of pre-funded resources (1.4bn EUR) would be realised after the default of a very large number of entities.

101. With regards to the scaled (HypA and HypB) market stress scenarios, the HypB scenarios are by construction more severe. Thus, the stress results for the top-2 per CCP (MD-A) member default scenarios combined with the HypA/HypB market stress scenarios are also presented in Figure 8.

FIGURE 8: MD-A STRESS RESULTS ON SUFFICIENCY OF FINANCIAL RESOURCES FOR SCALED (HYPA & HYPB) MARKET SCENARIOS



	MD-A Oct		MD-A Nov		MD-A Dec	
	HypA	HypB	HypA	HypB	HypA	HypB
Not covered Losses	0.1	2.5	0.1	2.6	0.1	4.0
Loss covered by non-prefunded resources(PoA)	1.2	8.4	1.8	9.2	2.5	8.3
Loss covered by mutualised default fund	6.3	9.5	6.3	10.1	6.4	10.0
Loss covered by CCP's skin in the game	0.3	0.3	0.3	0.3	0.3	0.3
Loss covered by defaulting Members Collateral	34.4	35.0	36.7	37.1	41.4	38.8
Total Scenario Loss	42.4	55.7	45.2	59.4	50.7	61.5
No of Memb defaulting EU-wide	31	32	28	29	30	27
Max no of Memb defaulting / CCP	16	16	17	15	20	16
Max no of Memb defaulting / CCP&DF	12	13	13	11	13	11
Max no of Memb defaulting / CCP&DF with losses	9	10	11	9	9	9

102. As already discussed, the MD-A scenarios trigger, also in combination with the scaled market scenarios, a very large number of individual defaulting entities both at the EU-wide level and at the individual CCP level, especially for the larger CCPs that have a wider membership base. For the December date, combined with HypB scenarios where the largest uncovered loss has been calculated, for some of the less inter-connected CCPs the final number of defaulting members is limited to 2, even after taking into account the cross-default condition. The maximum number of individual members defaulting at a single CCP for HypB scenarios is 16, while the maximum number of defaulting members per CCP & Default Fund is 13. When limited to members that actually cause losses, the maximum number per CCP & Default fund is 10.

103. The maximum shortfall in total resources is observed for the December HypB scenario (4.0bn EUR), after calling for 8.3bn EUR of not-prefunded resources. Thus, a total of 12.3bn EUR would not be covered by the available prefunded resources. The defaulting members' collateral, including also their contributions to the default fund, would cover 63% of the initial losses. The CCPs dedicated resources (skin in the game) would be hit by 0.3bn EUR covering 0.5% of the losses. Non defaulting members would lose 10.0bn EUR out of their contributions to the default funds and would be expected to provide 8.3bn EUR in the form of additional not-prefunded resources to be used to cover the already recorded losses. The maximum amount that will be called from one clearing member across all CCPs is approximately 0.5bn EUR. The potential effect of this on the non-defaulting members is further analysed in 4.4. The shortage of the CCPs resources could be explained by the increased severity of the scaled market stress scenarios in combination with the very large number of members assumed as defaulting under the MD-A scenarios. The assumptions and limitations leading to an increased severity of the scaled market stress scenarios when compared to the hypothetical scenarios that CCPs

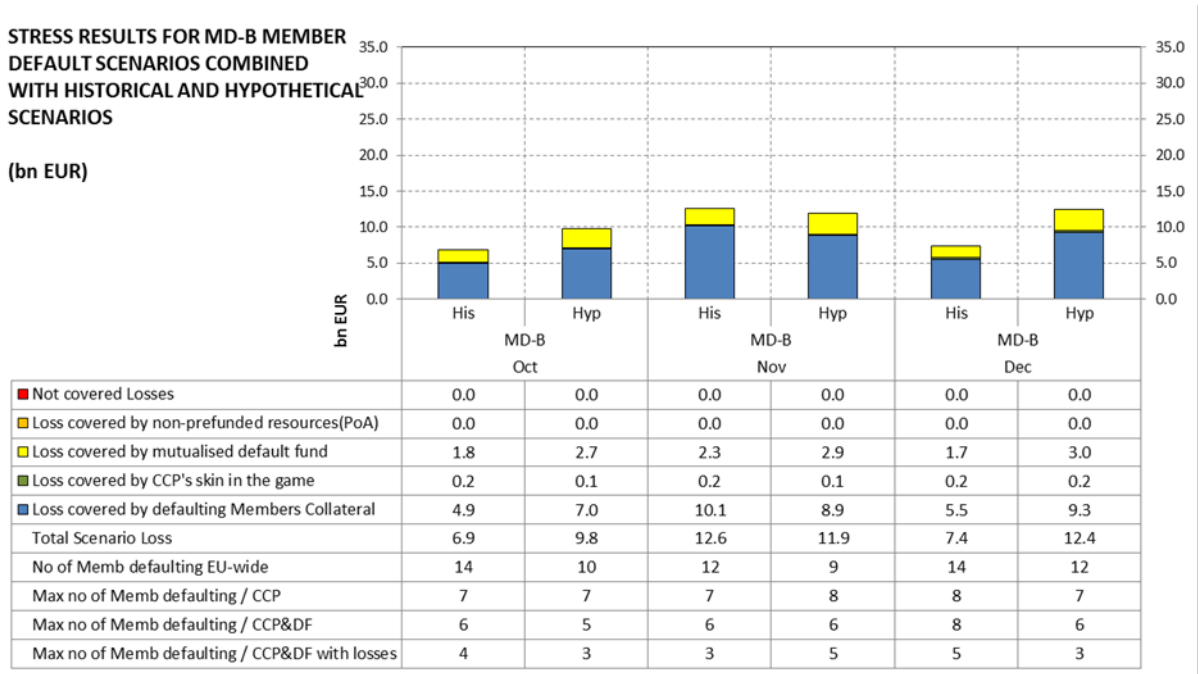
are expected to use in order to size their resources are analysed in detail in Section 3. Furthermore, as already discussed, the MD-A member default scenarios lead to a very large number of members defaulting both at EU-wide and at the individual CCPs level. The combined probability of such a number of entities defaulting simultaneously is expected to be low implying that this scenario goes beyond what can be reasonably considered as plausible.

4.3.2.2 Sufficiency of financial resources following the default of members belonging to the top two groups EU-wide (MD-B)

104. The default of the 2 groups of clearing members that would cause on an aggregate EU-wide level the largest loss above the defaulting members' collateral is also considered in combination with all the market stress scenarios. The clearing members belonging to these groups are considered to be in default in all CCPs. The results are further analysed in this section in terms of the sufficiency of the prefunded and total resources under Historical / Hypothetical Scenarios (Figure 9) and scaled market stress scenarios (Figure 10).

105. For the 4 analysed market stress scenarios across the 3 reporting dates, 7 different groups have been identified as belonging to one of the top-2 groups with the largest exposures. Four out of these groups were identified in more than one scenario / date combinations and these particular groups belong to the top-10 default fund contributors EU-wide.

FIGURE 9: MD-B STRESS RESULTS ON SUFFICIENCY OF FINANCIAL RESOURCES FOR HISTORICAL/HYPOTHETICAL MARKET SCENARIOS



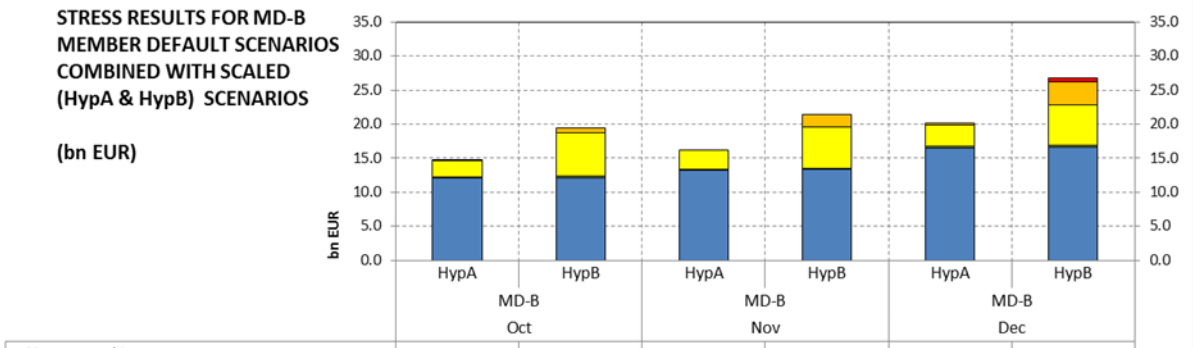
	MD-B Oct His	MD-B Oct Hyp	MD-B Nov His	MD-B Nov Hyp	MD-B Dec His	MD-B Dec Hyp
Not covered Losses	0.0	0.0	0.0	0.0	0.0	0.0
Loss covered by non-prefunded resources(PoA)	0.0	0.0	0.0	0.0	0.0	0.0
Loss covered by mutualised default fund	1.8	2.7	2.3	2.9	1.7	3.0
Loss covered by CCP's skin in the game	0.2	0.1	0.2	0.1	0.2	0.2
Loss covered by defaulting Members Collateral	4.9	7.0	10.1	8.9	5.5	9.3
Total Scenario Loss	6.9	9.8	12.6	11.9	7.4	12.4
No of Memb defaulting EU-wide	14	10	12	9	14	12
Max no of Memb defaulting / CCP	7	7	7	8	8	7
Max no of Memb defaulting / CCP&DF	6	5	6	6	8	6
Max no of Memb defaulting / CCP&DF with losses	4	3	3	5	5	3

106. For hypothetical and historical market scenarios, combined with the MD-B market default scenarios the losses would be covered using only the prefunded resources. The

worst 2 market scenario/date combinations selected on the basis of the largest initial stress loss are November for Historical and December for Hypothetical. The losses before applying any of the available resources are considerably smaller than the losses recorded for MD-A scenarios, because of the smaller number of members defaulting. In particular, under MD-B scenarios combined with historical and hypothetical scenarios, the maximum number of entities defaulting at the EU-wide level is 14, while in each of the 'worst' 2 scenarios a total of 12 entities would default. This leads to a maximum of 7 members defaulting at the CCP level, out of which a maximum of 3 would actually cause losses under the market scenarios considered at the CCP & Default fund level. The maximum initial loss for all CCPs is observed for the November date combined with Historical market stress scenarios and equals to 12.6bn EUR. Overall, no impact on not-prefunded resources is indicated by the results at CCP and EU-wide level for the three reporting dates and therefore, under the assumptions and the limitations of the exercise, there is no evidence for potential systemic risk.

107. As described in 3.6, the selected market scenarios for MD-B member default scenarios are not selected as the scenarios that would cause the largest losses for the specific defaulting members, but the scenarios that would cause the largest losses for any combination of 2 members defaulting. This means that there could be market scenarios that would cause higher losses for some of the CCPs following the default of these particular members. On the other hand, the scaled (HypA / HypB) market scenarios are agnostic to the scenario selection and do not suffer from this particular limitation. As already discussed, the scaling procedure does however impose additional limitations that could lead to a significant overestimation of the calculated losses and thus resulting CCPs exposures. The results for these market scenarios combined with the MD-B member default scenarios are presented below.

FIGURE 10: MD-B STRESS RESULTS ON SUFFICIENCY OF FINANCIAL RESOURCES FOR SCALED (HYPA & HYPB) MARKET SCENARIOS



	MD-B Oct		MD-B Nov		MD-B Dec	
	HypA	HypB	HypA	HypB	HypA	HypB
Not covered Losses	0.0	0.0	0.0	0.0	0.0	0.5
Loss covered by non-prefunded resources(PoA)	0.0	0.7	0.0	1.8	0.3	3.3
Loss covered by mutualised default fund	2.4	6.3	2.8	6.1	3.1	6.0
Loss covered by CCP's skin in the game	0.3	0.3	0.1	0.2	0.3	0.3
Loss covered by defaulting Members Collateral	12.0	12.1	13.2	13.3	16.5	16.6
Total Scenario Loss	14.7	19.4	16.1	21.4	20.2	26.7
No of Memb defaulting EU-wide	9	9	8	8	11	11
Max no of Memb defaulting / CCP	7	7	7	7	8	8
Max no of Memb defaulting / CCP&DF	5	5	5	5	6	6
Max no of Memb defaulting / CCP&DF with losses	3	3	4	4	3	3

108. In terms of the scaled market scenarios combined with the top-2 EU-wide groups defaulting, the results for the two dates with the highest losses not covered by pre-funded resources are further analysed below. As already discussed, the HypB market scenarios are more severe than the Hyp-A scenarios. For all 3 dates combined with Hyp-B market scenarios, not–prefunded resources would have to be called as part of the default waterfall. The available resources including also not-prefunded resources would not be sufficient to cover the losses for 1 of the reporting dates (December). The losses under HypB scenarios are derived by scaling up margin requirements and the calculated losses are considerably higher than the losses reported for historical and hypothetical scenarios. The estimated total amount of not-prefunded resources that would have to be called by all CCPs under this scenario is 3.3bn EUR. On a member level, the maximum amount that would have to be called from a single member taking into account all the CCPs it participates is approximately 170mln EUR.

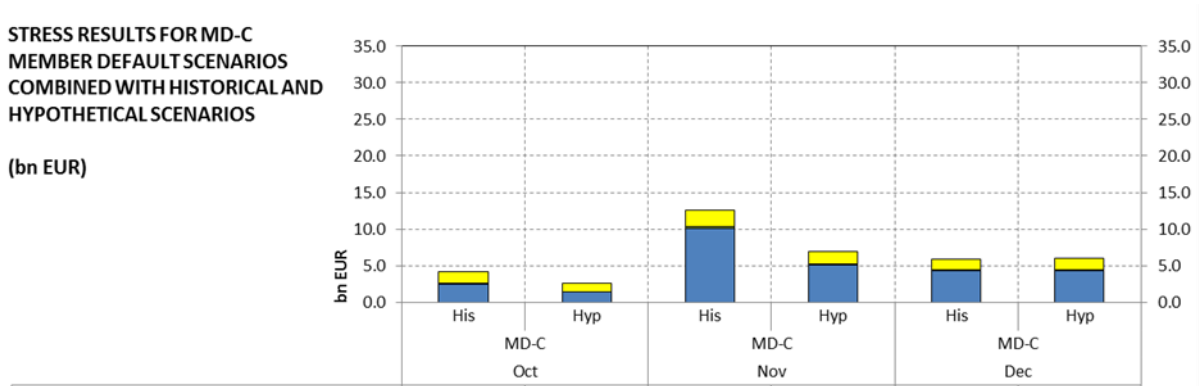
109. Despite the fact that in one case the default of the top 2 EU-wide groups combined with the scaled scenarios would cause a shortfall in the total resources, this should be interpreted also considering the limitations linked to the market stress modelling procedure that could lead to a significant overestimation of the calculated losses and thus resulting CCPs exposures. The shortfall is in a systemic risk context rather limited and is not expected to trigger systemic risks. The potential second round effects from calling for additional not pre-funded resources are further analysed in 4.4.

4.3.2.3 Sufficiency of financial resources following the default of top-2 groups with the largest expected exposure

110. When it comes to the default of 2 EU-wide groups and the clearing members that belong to these groups, an alternative selection procedure of the defaulting entities is used under MD-C members default scenarios. In particular, we consider the default of the top-2 EU-wide groups in terms of loss over defaulter's collateral, weighted also by their respective probability of default. This is used as a measure of the expected loss. The full exposure is always used to calculate stress losses. The weighted exposure is only used to rank and eventually select the defaulting groups. Therefore, the MD-C scenarios are expected to provide stress results that are by construction less severe than the MD-B results. This set of scenarios is however based on a sequence of defaults that is expected to have a much higher probability of realisation. Furthermore, it can highlight the impact of the default of a different set of members than the ones considered under the MD-B scenarios, which is particularly relevant when analysing the impact on non-defaulting members. The results for the MD-C scenarios in combination with different sets of market stress scenarios are presented in Figure 11 and Figure 12.

111. With regards to the MD-C scenarios, for the 4 analysed market stress scenarios across the 3 reporting dates, 8 different groups have been identified using the aforementioned selection procedure. In particular, 4 additional groups were identified that were not highlighted under the MD-B scenarios. The 4 groups that were highlighted under both member default scenarios (MD-B and MD-C) belong to the top-10 default fund contributors EU-wide and their weighted exposures were primarily driven by the actual exposure and not the probability of default. For the 4 additional groups selected on the basis of the weighted exposure, for 2 of those, the default PD value has been used.

FIGURE 11: MD-C STRESS RESULTS FOR HISTORICAL/HYPOTHETICAL MARKET SCENARIOS



	MD-C Oct		MD-C Nov		MD-C Dec	
	His	Hyp	His	Hyp	His	Hyp
Not covered Losses	0.0	0.0	0.0	0.0	0.0	0.0
Loss covered by non-prefunded resources(PoA)	0.0	0.0	0.0	0.0	0.0	0.0
Loss covered by mutualised default fund	1.5	1.1	2.3	1.7	1.5	1.5
Loss covered by CCP's skin in the game	0.1	0.1	0.2	0.1	0.1	0.1
Loss covered by defaulting Members Collateral	2.5	1.3	10.1	5.1	4.3	4.3
Total Scenario Loss	4.1	2.5	12.6	6.9	5.9	5.9
No of Memb defaulting EU-wide	7	3	12	4	9	4
Max no of Memb defaulting / CCP	4	2	7	3	3	3
Max no of Memb defaulting / CCP&DF	3	2	6	2	3	2
Max no of Memb defaulting / CCP&DF with losses	3	2	3	1	3	2

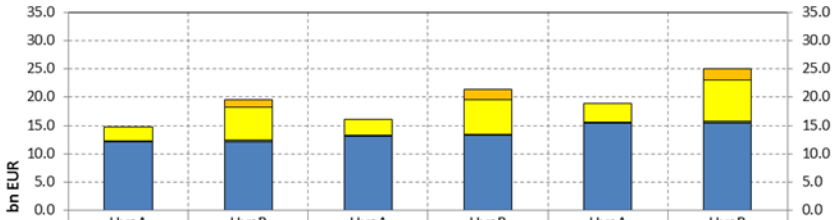
112. Under all combinations of hypothetical & historical market stress scenarios with the MD-C member default scenario and for the 3 reporting dates, the pre-funded resources were sufficient to cover the calculated losses. The highest initial losses were calculated for the November date on the basis of Historical scenarios (12.6bn EUR). The losses under this scenario/date are considerably higher than any other combination. This is explained by the fact that in this case the two groups having the largest weighted exposures are also the two groups having the largest un-weighted exposures. In fact, the results for November/Historical scenarios are the same with November/Historical scenarios calculated under MD-B.

113. For all the other scenario/date combinations, the losses are smaller than the ones calculated under the respective MD-B scenarios. The results indicate that for the three reporting dates and under the assumptions and the limitations of the exercise there would be no systemic impact from these events combined with the implemented historical and hypothetical price shocks.

FIGURE 12: MD-C STRESS RESULTS FOR SCALED (HYPA & HYPB) MARKET SCENARIOS

STRESS RESULTS FOR MD-C MEMBER DEFAULT SCENARIOS COMBINED WITH SCALED (HypA & HypB) SCENARIOS

(bn EUR)



	MD-C Oct		MD-C Nov		MD-C Dec	
	HypA	HypB	HypA	HypB	HypA	HypB
Not covered Losses	0.0	0.0	0.0	0.0	0.0	0.0
Loss covered by non-prefunded resources(PoA)	0.0	1.2	0.0	1.8	0.0	1.9
Loss covered by mutualised default fund	2.4	5.8	2.8	6.1	3.2	7.3
Loss covered by CCP's skin in the game	0.2	0.3	0.1	0.2	0.3	0.3
Loss covered by defaulting Members Collateral	12.1	12.2	13.2	13.3	15.4	15.5
Total Scenario Loss	14.7	19.5	16.1	21.4	18.9	25.0
No of Memb defaulting EU-wide	8	8	8	8	8	8
Max no of Memb defaulting / CCP	7	7	7	7	7	7
Max no of Memb defaulting / CCP&DF	5	5	5	5	5	5
Max no of Memb defaulting / CCP&DF with losses	3	3	4	4	3	3

114. When using the scaled (HypA/HypB) market stress scenarios, the initial losses recorded at CCP and aggregate EU-wide level are considerably higher compared to losses from the historical and hypothetical scenarios. For all HypA/HypB scenarios across the reporting dates, the same 2 groups are assumed to be in default having the largest exposure weighted by the probability of default. The smaller number of individual members defaulting at EU-wide and CCP level is explained by the smaller number of entities linked to these 2 groups.

115. Across all scenario/date combinations, there are no uncovered losses, while for HypA market scenarios the pre-funded resources are also sufficient to cover the defaulting members. On the other hand, for the more severe HypB scenarios there is a shortfall in pre-funded resources for all reporting dates. The largest initial losses (25.0bn EUR) and also the largest shortfall of pre-funded resources (1.9bn EUR) are observed for the

December date. The total resources are sufficient to cover the losses of the top-2 groups on the basis of the scaled market scenarios. Furthermore, the estimated amount of not pre-funded resources that would need to be called on the basis of the provided results is rather limited and would not be expected to fuel additional systemic risks.

4.4 Clearing member knock-on results

116. Any loss above the defaulting clearing members' collateral needs to be covered by the mutualised resources of remaining clearing members after using the CCP's dedicated resources (skin-in-the-game). For the purpose of this analysis the prefunded or not-prefunded contributions absorbed due to the default are considered as a loss for the non-defaulting clearing members hitting their capital. These losses[15] are either caused by only prefunded (Default Fund contributions) or prefunded & additional calls for not-prefunded resources (Powers of Assessment).

117. The following figures show the % of capital absorption (left axis) following the loss of only prefunded or total (prefunded and not-prefunded) resources for all member default scenario combinations and the respective dates for selected clearing members. The loss in terms of total resources[16] is also reported in the right axis. The individual entities have been selected as the clearing members that have, at least in one combination of scenarios and date, aggregated (across all CCPs) losses of prefunded or not-prefunded resources that exceed 100mln EUR and 20% of their capital. The maximum absorption has been selected across Historical/Hypothetical (Figure 13) and scaled (Figure 14) market stress scenarios[17].

[15] Some of the non-defaulting members would also face at the same time large losses from their own portfolios making it more challenging for them to respond to additional calls. This has not been considered as it would require estimating the losses of the overall net proprietary position of each member, including also the positions in non-cleared derivatives.
[16] Total loss from default fund contributions and not-prefunded resources
[17] For the cases where a zero (0) absorption is reported, this could be the result of no loss or the member defaulting under this particular combination of scenarios.

FIGURE 13: NON-DEFAULTING CLEARING MEMBER KNOCK-ON RESULTS FOR HISTORICAL AND HYPOTHETICAL MARKET STRESS SCENARIOS

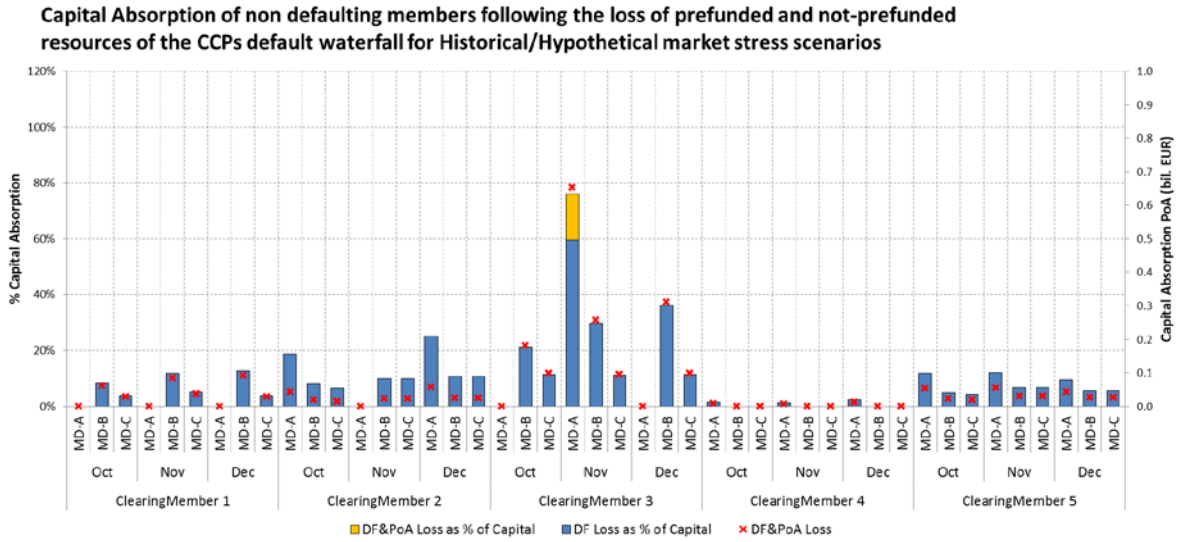
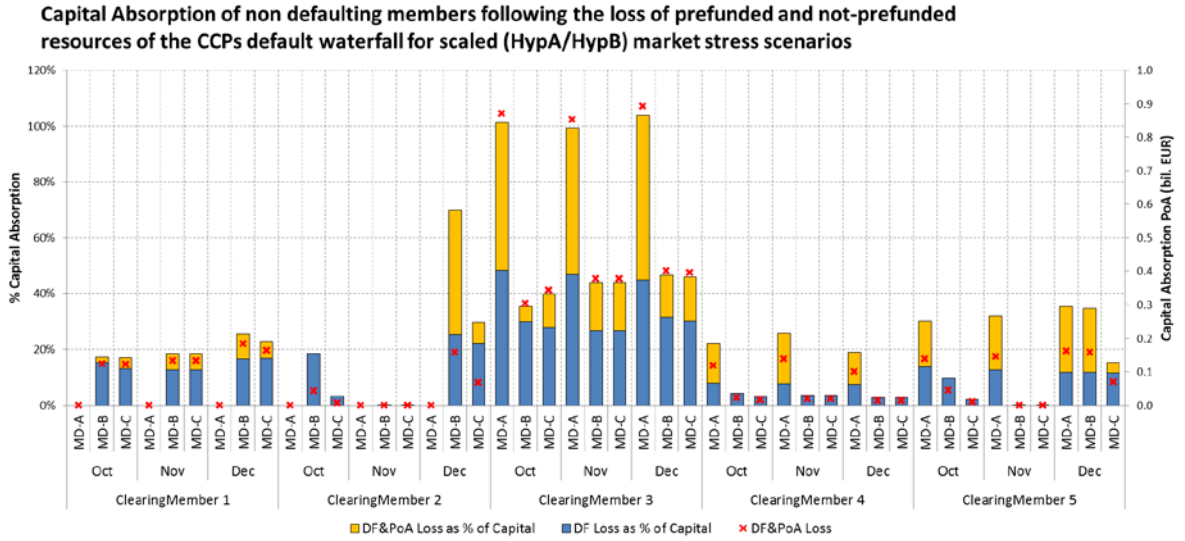


FIGURE 14: NON-DEFAULTING CLEARING MEMBER KNOCK-ON RESULTS FOR SCALED (HYP-A/HYP-B) MARKET STRESS SCENARIOS



118. As already discussed, the results for the scaled market scenarios and MD-A member default scenarios are more severe. Overall, for 5 members in at least one scenario combination the aforementioned conditions[18] are met. For 2 out of these members the capital absorption is at least in one scenario greater than 50%, with the maximum being recorded for CM3 slightly above 100%. In terms of amounts, the maximum amount of total loss for 1 member (CM3) is approximately 0.9bn EUR, out of which 0.4bn EUR are

[18] i.e. (%) absorption>20% and (EUR) absorption>100mln EUR

default fund contribution losses and 0.5bn EUR calls for additional resources. For this member approximately 85% of the total amount would be lost at 2 CCPs.

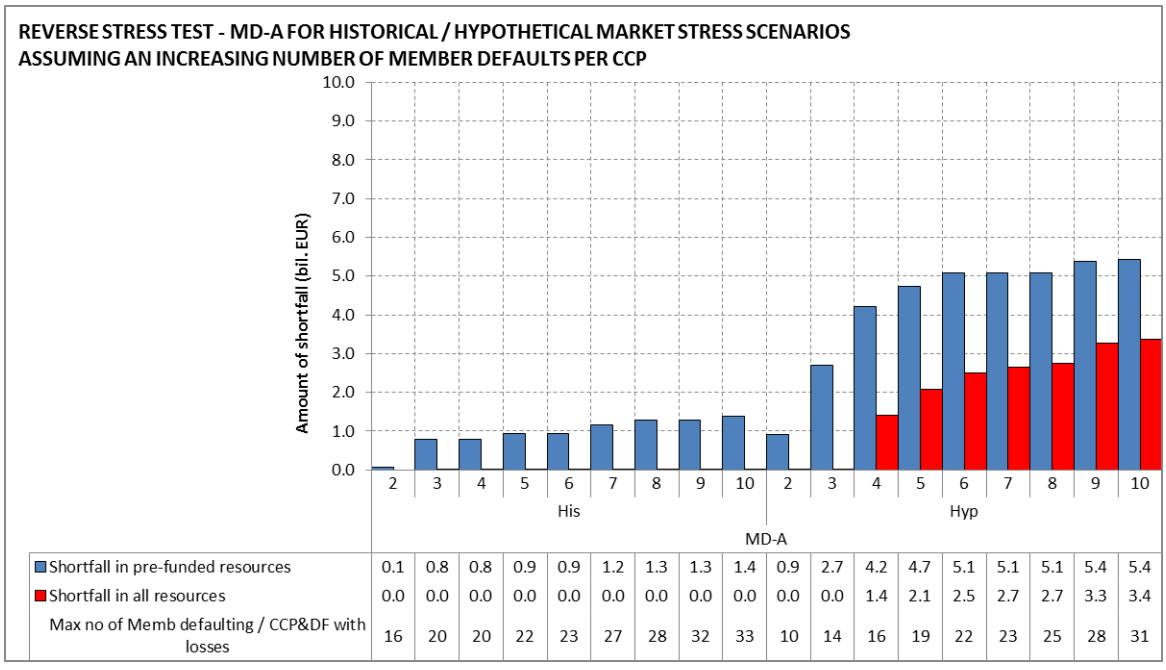
119. For the historical / hypothetical market scenarios, only for 1 member (CM3) the total loss would be above 20% of their capital and above 100mln EUR in absolute terms. This would mean that under these extreme but plausible historical and hypothetical scenarios, this clearing member might face difficulties in raising the required amounts, considering also that according to EMIR requirements these amounts would be expected to be provided in cash or other highly liquid collateral. If these extreme circumstances materialise, this could trigger second round effects via additional uncovered losses at the CCP level and the default of additional members. However, no significant systemic impact is expected as the number of highlighted members is rather limited and the corresponding amounts not systemically significant.

4.5 Reverse stress testing results

4.5.1 Historical / Hypothetical Scenarios that would lead to a shortfall in prefunded or all resources

120. The following figures (Figure 15 – Figure 17) show the losses that would not be covered by prefunded resources (blue) and all resources including also not-prefunded (red), for each member default scenario combined with Historical / Hypothetical market stress scenarios assuming an increasing number of entities (>2 Members per CCP for MDA and >2 groups EU-wide for MDB&MDC) defaulting for end December 2014 (Reverse Stress Tests).

FIGURE 15: RT - MD-A – REVERSE STRESS TEST RESULTS FOR HISTORICAL AND HYPOTHETICAL MARKET STRESS SCENARIOS ASSUMING AN INCREASING NUMBER OF MEMBERS DEFAULTING PER CCP

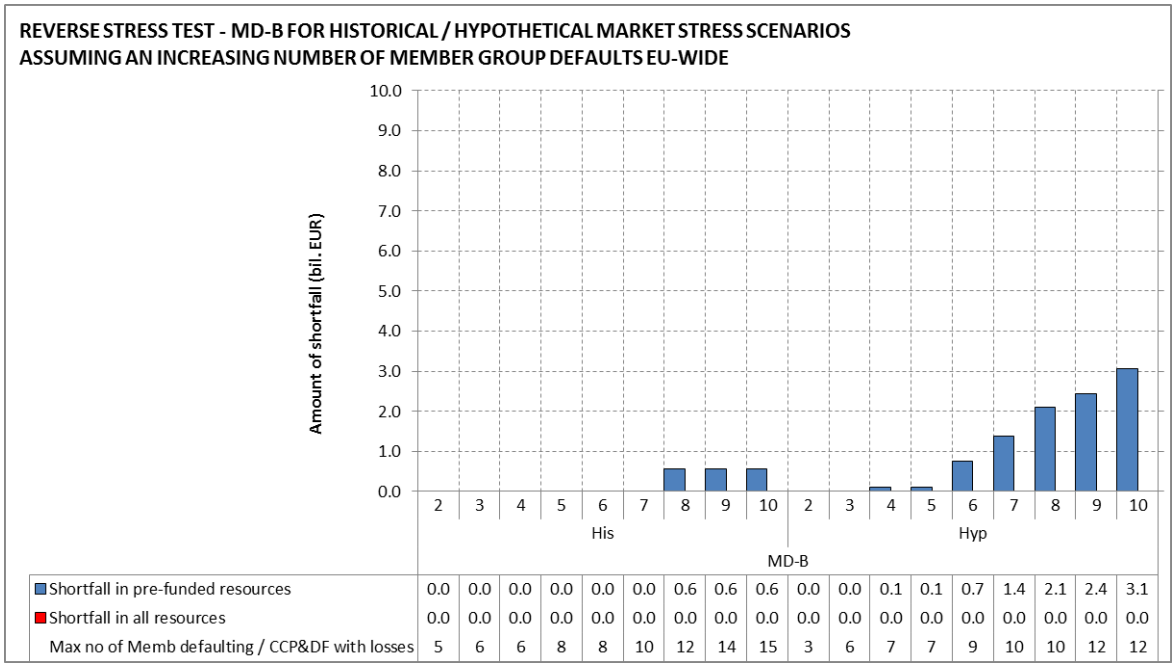


	2	3	4	5	6	7	8	9	10	2	3	4	5	6	7	8	9	10
Shortfall in pre-funded resources	0.1	0.8	0.8	0.9	0.9	1.2	1.3	1.3	1.4	0.9	2.7	4.2	4.7	5.1	5.1	5.1	5.4	5.4
Shortfall in all resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.1	2.5	2.7	2.7	3.3	3.4
Max no of Memb defaulting / CCP&DF with losses	16	20	20	22	23	27	28	32	33	10	14	16	19	22	23	25	28	31

121. When the MD-A member default scenarios are combined with Historical market stress scenarios, no shortfall of the total resources (i.e. after using the not-prefunded resources) is observed, even when the initial number of member defaults is increased up to 10. A very small (<0.1bn EUR) shortfall is observed in term of prefunded resources following the default of 2 members for each CCP, which increases to 0.8bn EUR when assuming the default of 3 members per CCP. This leads to 3 - 29 members defaulting per CCP and 0 - 26 members defaulting per default fund. A maximum of 20 members with losses would default in a single default fund. When increasing the initial number of members defaulting up to 10 per CCP, the maximum total shortfall of prefunded resources is 1.4bn EUR.

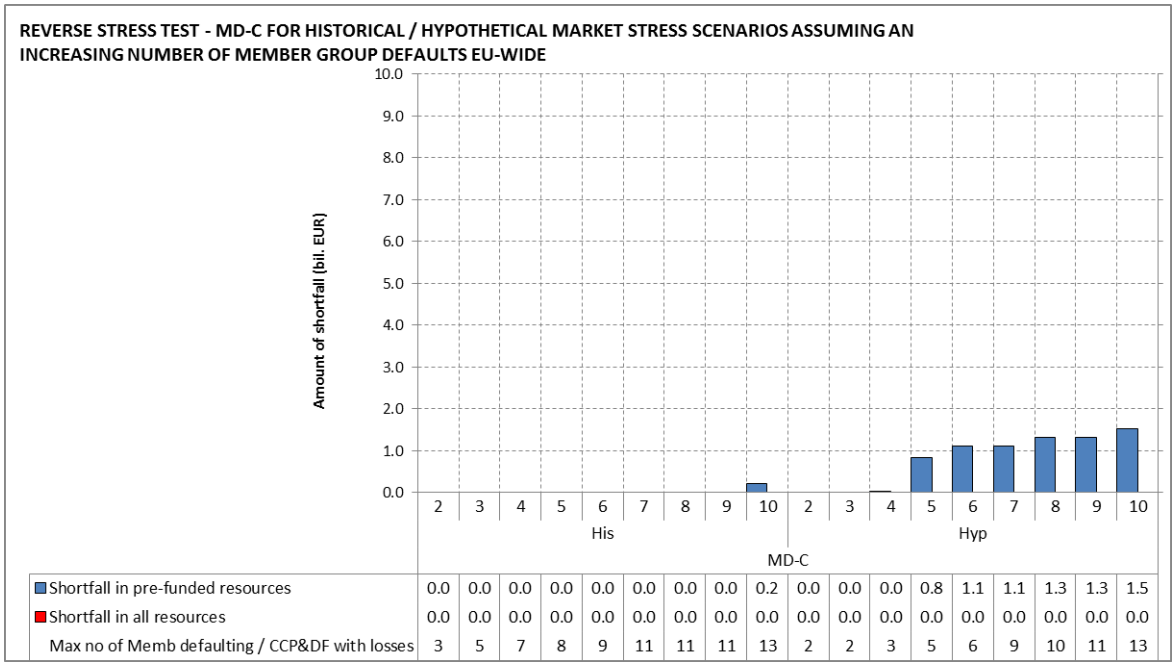
122. Under the Hypothetical market stress scenarios, a material (i.e. >0.1bn EUR) exhaustion of the total resources is only observed after the default of 4 members per CCP, where there is a shortfall of 1.4bn EUR in total resources and 4.2bn EUR in prefunded resources. This scenario is triggering the default of 3 - 33 members defaulting per CCP and 0 - 23 members defaulting per default fund, while a maximum of 16 members with losses would default in a single default fund.

FIGURE 16: RT – MD-B – REVERSE STRESS TEST RESULTS FOR HISTORICAL AND HYPOTHETICAL MARKET STRESS SCENARIOS ASSUMING AN INCREASING NUMBER OF GROUPS DEFAULTING AT EU-WIDE LEVEL



123. When the default of an increasing (up to 10) number of groups at the EU-wide level is considered (Figure 16), no shortfall of the total resources (i.e. after using the not-prefunded resources) is observed. Under historical scenarios, the prefunded resources are exhausted after the default of 8 groups (0.6bn EUR shortfall) and under hypothetical scenarios after the default of 4 groups (0.1bn EUR shortfall). The number of defaulting members at EU-wide and CCP level following these scenarios is very high and is further analysed in 4.5.3.

FIGURE 17: RT – MD-C – REVERSE STRESS TEST RESULTS FOR HISTORICAL AND HYPOTHETICAL MARKET STRESS SCENARIOS ASSUMING AN INCREASING NUMBER OF GROUPS DEFAULTING AT EU-WIDE LEVEL



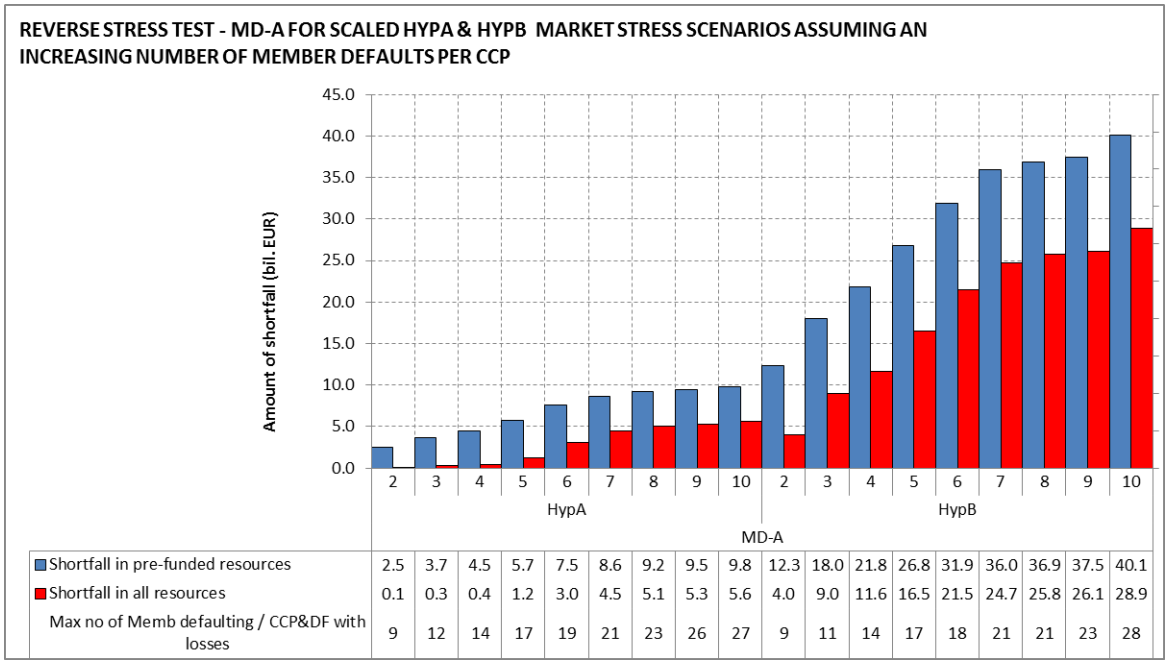
MD-C	His									Hyp							
	2	3	4	5	6	7	8	9	10	2	3	4	5	6	7	8	9	10
Shortfall in pre-funded resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.8	1.1	1.1	1.3	1.3	1.5
Shortfall in all resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max no of Memb defaulting / CCP&DF with losses	3	5	7	8	9	11	11	11	13	2	2	3	5	6	9	10	11	13

124. If the probability of default (PD) is also considered in selecting an increasing (up to 10) number of groups at the EU-wide level (Figure 17) the results are, as expected, less severe compared to selecting the top groups irrespectively of their probability of default. Again, no shortfall of the total resources (i.e. after using the not-prefunded resources) is observed, while under historical scenarios, the prefunded resources are now only exhausted after the default of 10 groups (0.2bn EUR shortfall). For hypothetical scenarios, a material shortfall of prefunded resources is only observed after the default of 5 groups (0.8bn EUR shortfall). The shortfall under the MD-C default scenarios combined with historical and hypothetical market stress scenarios is not systemically significant for CCPs even after the default of 10 groups at the EU-wide level (maximum of 1.5bn EUR shortfall in prefunded resources), especially after considering the probability of the events leading to such a large number of defaulting entities.

4.5.2 Scaled Market Stress Scenarios (HypA/HypB) that would lead to a shortfall in prefunded or all resources

125. The following figures (Figure 18 to 20) further show the losses that would not be covered by prefunded resources (blue) and all resources including also not-prefunded (red), also for scaled HypA/HypB market stress scenarios assuming again an increasing number of entities defaulting for end December 2014.

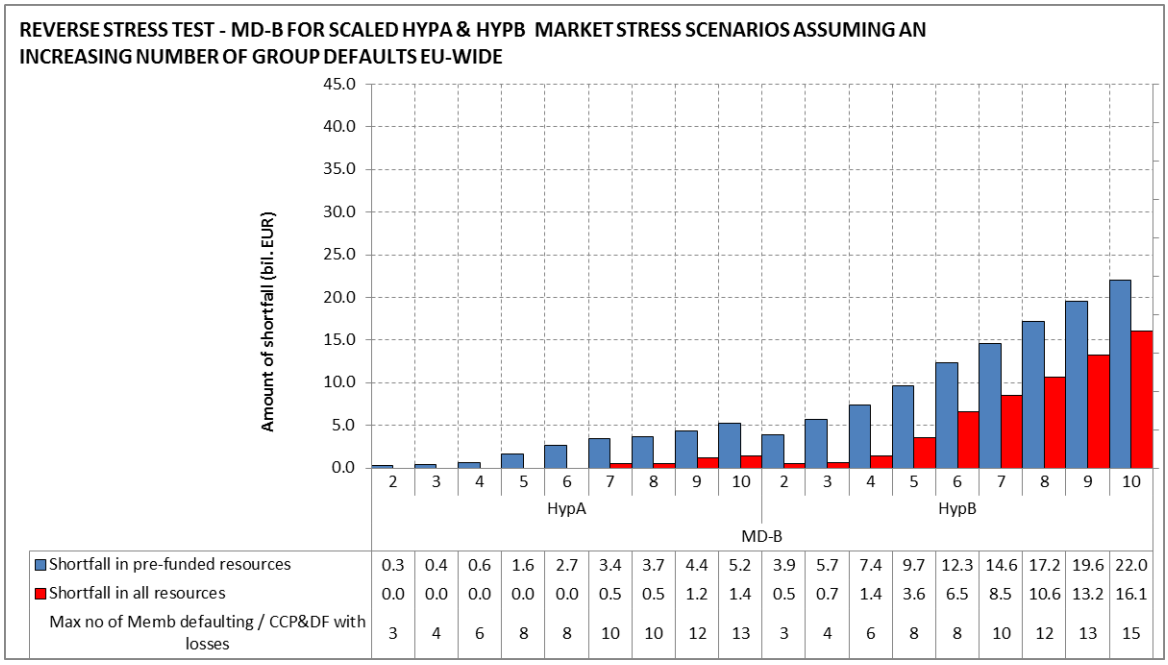
FIGURE 18: RT - MD-A – REVERSE STRESS TEST RESULTS FOR SCALED (HYPA/HYPB) MARKET STRESS SCENARIOS ASSUMING AN INCREASING NUMBER OF MEMBERS DEFAULTING PER CCP



	2	3	4	5	6	7	8	9	10	2	3	4	5	6	7	8	9	10
Shortfall in pre-funded resources	2.5	3.7	4.5	5.7	7.5	8.6	9.2	9.5	9.8	12.3	18.0	21.8	26.8	31.9	36.0	36.9	37.5	40.1
Shortfall in all resources	0.1	0.3	0.4	1.2	3.0	4.5	5.1	5.3	5.6	4.0	9.0	11.6	16.5	21.5	24.7	25.8	26.1	28.9
Max no of Memb defaulting / CCP&DF with losses	9	12	14	17	19	21	23	26	27	9	11	14	17	18	21	21	23	28

126. The reverse stress test results change significantly under the scaled market stress scenarios (Figure 18). As already discussed in 4.3, the combination of MD-A member default scenarios with the HypB scaled market scenario produce the most severe results across all scenario combinations. A shortfall of prefunded resources is already observed starting from 2 members being initially defaulted for each CCP and then each defaulting member also cross-defaulted in all other CCPs. The total shortfall in prefunded resources peaks at 9.8bn EUR for HypA and at 40.1bn EUR for HypB market stress scenarios when up to 10 members at each CCP are initially defaulting. More than 100 members are actually considered to be in default under this theoretical and clearly not-plausible scenario at the EU-wide level. This result gives however a good indication of the resulting exposure when the stress conditions themselves are stressed to the limits, illustrating in a way the maximum size of the exposure under very extreme possible but not plausible circumstances. In terms of losses exceeding the total resources (prefunded and not-prefunded), the total shortfall will exceed 1.0bn EUR only after the default of 5 groups for HypA market scenarios and already after the default of 2 groups for HypB scenarios. For the latter, more severe case, the shortfall of total resources is calculated at 4.0bn EUR involving the default of 27 member EU-wide, 2 – 16 members per CCP and a maximum of 9 members at the CCP & Default fund level with losses.

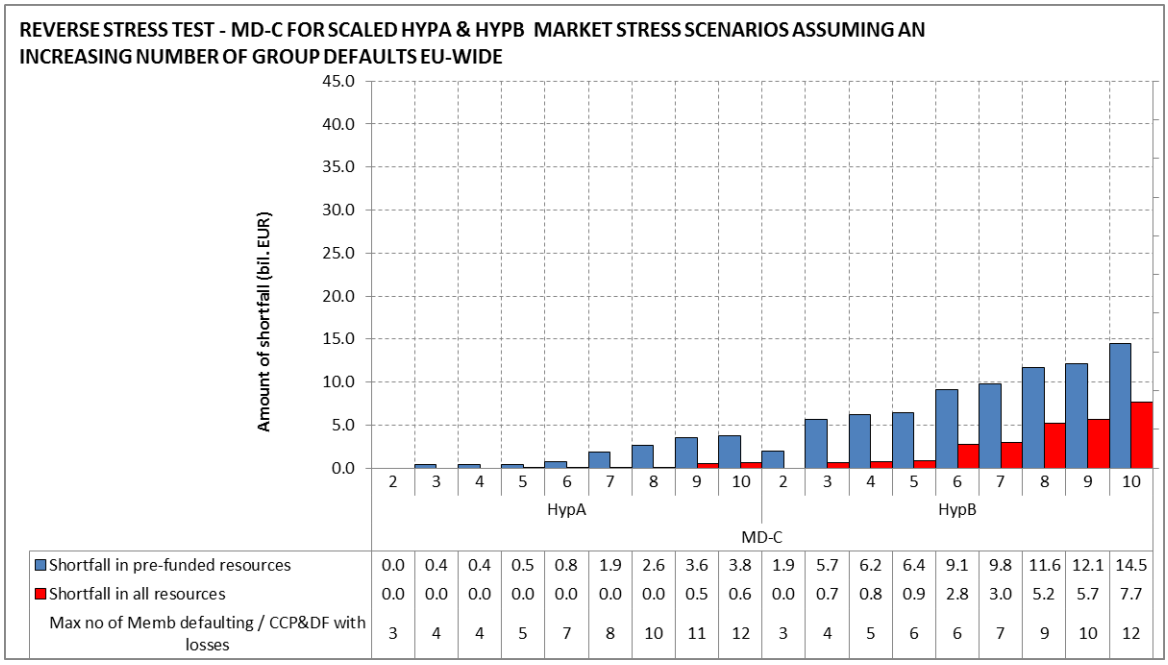
FIGURE 19: RT – MD-B – REVERSE STRESS TEST RESULTS FOR SCALED (HYPA/HYPB) MARKET STRESS SCENARIOS ASSUMING AN INCREASING NUMBER OF GROUPS DEFAULTING AT EU-WIDE LEVEL



127. The reverse stress test results are significantly less severe when the initial member default condition changes to assuming the default of an increasing number of groups and related entities at the EU-wide level. In particular, under the HypA market stress scenarios, a breach in the total resources is only observed after the default of the top 7 EU-wide groups (0.5bn EUR), after using a total of 2.9bn EUR of not-prefunded resources. The default conditions lead to a default of up to 41 members at the EU-wide level, 0-26 members defaulting at each CCP and up to 22 members defaulting at the CCP & Default fund level, out of which a maximum of 10 members would actually cause losses at any default fund.

128. On the other hand, for the more severe HypB market stress scenarios, a relatively small shortfall in total resources (0.5bn EUR) is already reported when the top-2 EU-wide groups are considered to be in default. Out of the 26.7bn EUR initial losses, estimated on the basis of the scaling procedure, 22.9bn EUR would be covered by prefunded and 3.3bn EUR by not-prefunded resources. The shortfalls rise proportionally to the number of defaulting groups and the maximum shortfall in total resources is 16.1bn EUR following the default of 10 groups at the EU-wide level, where up to 15 members would default with losses at the default fund level.

FIGURE 20: RT – MD-C – REVERSE STRESS TEST RESULTS FOR SCALED (HYPA/HYPB) MARKET STRESS SCENARIOS ASSUMING AN INCREASING NUMBER OF GROUPS DEFAULTING AT EU-WIDE LEVEL



	HypA									HypB							
	2	3	4	5	6	7	8	9	10	2	3	4	5	6	7	8	9	10
Shortfall in pre-funded resources	0.0	0.4	0.4	0.5	0.8	1.9	2.6	3.6	3.8	1.9	5.7	6.2	6.4	9.1	9.8	11.6	12.1	14.5
Shortfall in all resources	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.0	0.7	0.8	0.9	2.8	3.0	5.2	5.7	7.7
Max no of Memb defaulting / CCP&DF with losses	3	4	4	5	7	8	10	11	12	3	4	5	6	6	7	9	10	12

129. When selecting the defaulting groups on the basis of the exposure weighted by their probability of default, a significant (2.7bn EUR) shortfall in the total resources is only calculated after the default of 6 groups under the HypB market stress scenarios. The default of these 6 groups would trigger at CCPs the default of 0-18 members, with up to 6 members defaulting with losses at the default fund level.

130. In terms of sufficiency of prefunded resources, a significant shortfall (>1bn EU) is observed for HypA scenarios only after the default of the 7 groups with the highest weighted exposure (1.9bn EUR), but already after the default of 2 groups under the HypB market scenarios (1.9bn EUR). This result is linked to the scaling procedure producing considerably higher losses than the ones expected under the historical and hypothetical scenarios.

4.5.3 Assessment of reverse stress results

131. The sufficiency of prefunded and total resources has been tested by considering an increasing number of defaulting entities in order to assess whether there is a plausible combination of member default and market stress scenarios that could lead to a systemically significant shortfall in the available resources. The results are summarised graphically in the following figures.

132. In Figure 21, the scenarios that lead to a significant (>1bn EUR) shortfall in prefunded resources are indicated in terms of the number of defaulting EU-wide members (y-axis) and the maximum number of defaulting members actually causing losses at one of the CCPs' default funds (x-axis). The shortfall in prefunded resources (i.e. all losses that are

not covered by prefunded resources) under each scenario is represented by the size (width) of the circle. The amount of significant uncovered losses (i.e. losses exceeding the not-prefunded resources by more than 1bn EUR) are also summarised in Figure 22.

FIGURE 21: REVERSE STRESS TEST RESULTS, SHORTFALL IN PREFUNDED RESOURCES AND NUMBER OF DEFAULTING ENTITIES FOR ALL SCENARIO COMBINATIONS

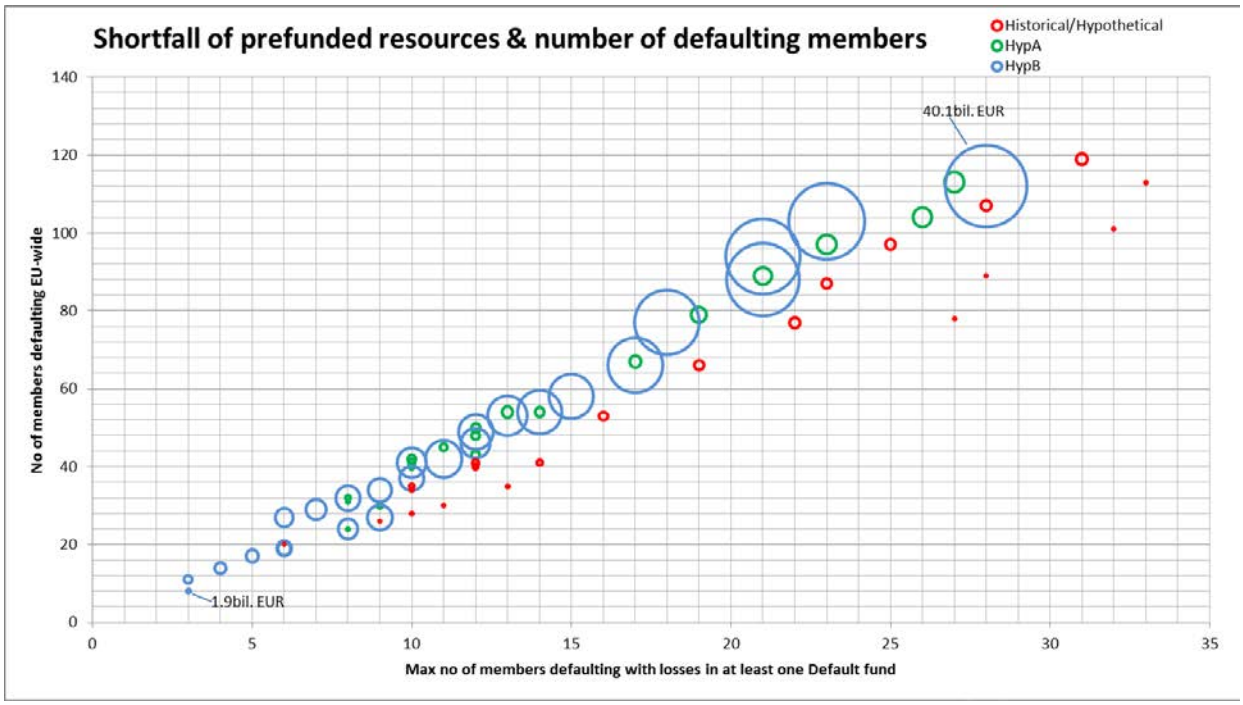
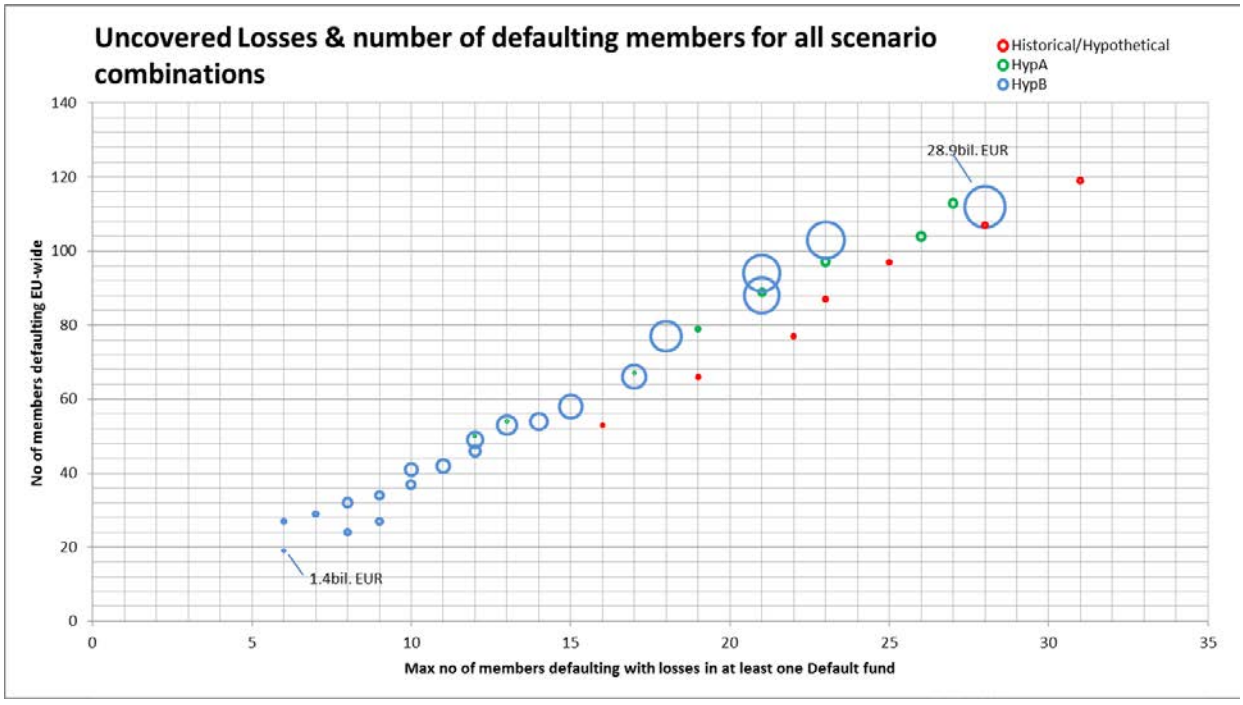


FIGURE 22: REVERSE STRESS TEST RESULTS, UNCOVERED LOSSES AND NUMBER OF DEFAULTING ENTITIES FOR ALL SCENARIO COMBINATIONS



133. It can be observed that the considered reverse stress test scenarios lead to the default of an extremely large number of entities both at EU-wide and at individual CCP level. This is especially the case for MD-A member default scenarios where the initial condition of 2 members defaulting at each CCP is increased up to 10, leading to more than 100 defaulting individual entities at EU-wide level and more than 25 entities causing losses in at least one default fund. Definitely, such a high number of simultaneous member defaults cannot be considered as plausible. The actual impact on the wider financial system from such an unprecedented, not plausible and catastrophic event would not be limited to the CCP industry and is therefore not possible to assess or even estimate. From a theoretical point of view, the analysis is however useful to estimate the mathematical limit of the shortfalls following any systemic wide event involving a large number of multiple simultaneous defaults of entities. In this context, under the stress market scenarios considered, the maximum shortfall in prefunded resources is approximately 40bn EUR. The amount of uncovered losses following the call and use of not-prefunded resources would be limited to approximately 29bn EUR, but it should be noted that under such a highly implausible and catastrophic scenario it cannot be reasonably assumed that all non-defaulting members would be able to meet successfully the calls for additional resources.

134. The scaled HypB market stress scenarios, modelled on the basis of a fat-tailed distribution of market shocks, trigger significantly higher shortfalls than the HypA and historical/hypothetical scenarios. In particular, the maximum shortfall in prefunded resources is approximately 10bn EUR under HypA scenarios and 5.4bn EUR under historical/hypothetical scenarios. Excluding HypB results, all scenarios leading to a shortfall of prefunded resources that is greater than 3bn EUR are based on an assumption of more than 40 members defaulting at the EU-wide level and more than 10 members hitting one default fund with losses. But also, for the HypB market scenarios, the member default scenarios leading to a shortfall of prefunded resources that is greater than 5bn EUR are based on an assumption of 14 or more members defaulting at the EU-wide level and 4 or more members hitting one default fund with losses. The combined probability of a large number of simultaneously defaulting entities and extreme market shocks going beyond a 99.9% confidence level, especially on the basis of a fat-tailed distribution of instantaneous shocks, is very low. The combined probability of such events could be estimated on the basis of mathematical modelling, but the analysis would be subject to material and severe limitations. Nevertheless, any internally consistent paths of macro-economic variables that would lead to the realisation of such extreme events are expected to be non-plausible.

135. When the analysis is focused on a theoretical, highly extreme but less improbable assumption of less than 15 members defaulting at the EU-wide level and less than 5 members hitting a default fund with losses, the maximum shortfall of prefunded resources is less than 6bn EUR, while no uncovered losses exceeding 1bn EUR are identified. Thus, no scenarios have been identified that are expected to be plausible and have at the same time a destabilising systemic impact on an EU-wide level.

5 Conclusions

136. Central counterparties were setup to reduce systemic risk resulting from bilateral counterparty relationships. As the CCPs are the counterparties to all their clearing members, any shortcomings in risk management practices leading to a failure to mitigate risks arising from the default of one or more of their clearing members could however exacerbate systemic risk. It has been identified that CCPs are highly interconnected through common clearing members. Thus, a default of one of the top members or groups is expected to trigger a simultaneous default of one or more entities in most of the EU CCPs with potentially systemic implications. Therefore, the EU-wide stress test is an extremely useful tool in assessing their resilience. The first EU-wide stress exercise has focused on the counterparty credit risk that EU CCPs would face as a result of multiple clearing member defaults and simultaneous market price shocks. It should however be noted that the CCPs are also subject to other types of risks, such as liquidity, investment and operational risks that could in isolation or in combination with counterparty credit risk challenge their resilience. These additional types of risks have not been considered in this year's exercise. Furthermore, the compliance of the CCPs with the regulatory requirements is one of the starting points of this exercise as it is expected to be ensured through the supervisory process involving the National Competent Authorities and the Colleges. This stress test exercise has not reviewed and cannot conclude on whether individual CCPs meet the minimum regulatory requirements, including also the requirement to have adequate resources to withstand the default of at least the two clearing members to which they have the largest exposures under the extreme but plausible market conditions that would have exposed each individual CCP to the greatest financial risk. Also potential shortcomings in policies and practices of individual CCPs, such as for example in the operationalisation of default handling procedures can also challenge their resilience beyond what has been considered in the course of this exercise.

    Given that this is the first EU-wide stress test exercise for CCPs, that no similar exercise has ever been conducted by other jurisdictions and that some limitations have been experienced with the adopted methodology, ESMA is committed to improve and evolve the methodology and the scope of its future annual stress tests.

137. The degree of concentration of CCPs' mutualised resources and thus exposures to individual members or groups has been assessed both at the individual CCP and at the EU-wide level using the Herfindahl-Hirschmann index (HHI). At the CCP level, a high degree of concentration has only been identified in one CCP that has a very small number of members and in other very specific cases of individual default funds where the high level of concentration was the result of relatively small overall exposures to a limited number of members. Furthermore, at the EU-wide level, no sign of high concentration either at clearing member level or at group level has been identified on the basis of the aforementioned methodology.

138. The sufficiency of the resources available to CCPs has been assessed under a combination of different extreme member default scenarios and market stress scenarios for three reporting dates. The results indicate that the prefunded resources of CCPs

would be sufficient for the reporting dates to cover the losses resulting from the considered historical/hypothetical market stress scenarios after the default of the top-2 EU-wide groups, selected either on the basis of the largest aggregate exposure or also after weighting by their probability of default. When the scenarios considering the default of the top-2 members by CCP are combined with historical and hypothetical scenarios, the CCPs would need to call from clearing members additional not-prefunded resources of up to an estimated amount of 1.4bn EUR to cover the losses exceeding the prefunded resources leaving a small total of uncovered losses, i.e. (<0.1bn EUR). The ESRB has noted that an internally-consistent macro-financial scenario combining the simultaneous defaults of a large number of clearing members with market developments would be implausible. This result should be interpreted in conjunction with the fact that the scenario based on the default of the top-2 members per CCP (MD-A) is significantly more extreme and lead, due to the cross-default condition, to an unprecedented and rather implausible number of entities simultaneously defaulting at EU-wide and CCP level. Taking this into account and keeping in mind the above-mentioned limitations on the scope and on the methodology of the exercise, the results indicate that for the three reporting dates the system of European CCPs can overall be assessed as resilient to the considered historical and hypothetical market stress scenarios.

139. With regards to the modelled market scenarios, the combination of the modelled scenario targeting a 99.9% confidence level on the assumption of a fat tailed distribution, with the member default scenario assuming the default, across CCPs, of the top 2 members/CCP, produce the largest shortfalls in prefunded (12.3bn EUR) and total resources (4.0bn EUR). When the modelled market scenarios are combined with the default of the top-2, in terms of aggregate exposure, EU-wide groups, the maximum estimated shortfall in prefunded resources (3.9bn EUR) and maximum estimated total uncovered losses (0.5bn EUR) are significantly reduced. Furthermore, when the top-2 defaulting groups were selected after weighting by their probability of default, no uncovered losses are calculated and the maximum call for not-prefunded resources across all members and CCPs is 1.9bn EUR. The modelled market stress scenarios produce overall consistently more severe results and should be interpreted also considering the limitations linked to the modelling procedure that could lead to a significant overestimation of the calculated losses and thus resulting CCPs exposures. With regards to the member default assumptions, the number of individual defaulting entities assumed under the top-2 members/CCP scenarios is due to the cross-default condition extremely high both at the CCP and EU-wide level. The combined probability of highly extreme and rather implausible member default assumptions with extreme market stress scenarios is expected to be low, implying that this combination of scenarios can be reasonably expected to be implausible. The shortfalls following the default of the top-2 groups at EU-wide level combined with the modelled scenarios are also in a systemic risk context limited, considering also the severity and the limitations linked to the modelling procedure.

140. In order to also assess whether there are any potential systemic risk implications linked to non-defaulting members losing mutualised prefunded and not-prefunded resources, their capital was compared to the amount of expected losses under the considered

scenarios. The results indicate that under the historical/hypothetical market scenarios 1 member will face losses that will be higher than 20% of its capital and higher than 100mln EUR in absolute terms, with the maximum loss amounting to 76% and 0.7bn EUR. If limited to the scenarios considering the default of the top-2 groups at EU-wide level, for the same non-defaulting clearing member the maximum loss would amount to 36% of its capital and 0.3bn EUR. Under the more severe modelled market stress scenarios, 5 members are highlighted with the maximum loss being slightly higher than 100% and 0.9bn EUR. Again if limited to the scenarios considering the default of the top-2 groups at EU-wide level, the list contains 4 members with a maximum percentage of 70% and a maximum individual amount of 0.4bn EUR. The results indicate that a limited number of members could face severe difficulties in absorbing the losses, considering also that according to EMIR requirements these amounts would be expected to be provided in cash or other highly liquid collateral. If these extreme circumstances materialise, this could potentially trigger second round effects via additional uncovered losses at the CCP level and the default of additional members. It should be noted that although EU CCPs seem with respect to the considered scenarios and above-mentioned limitations overall well equipped to face extreme scenarios, a significant part of that protection are pools of resources (pre-funded or not) by the non-defaulting clearing members, which could face significant losses in extreme cases. However, no significant systemic impact is easily identified as the number of highlighted members is rather limited and the corresponding amounts not systemically significant. Nevertheless, according to EMIR the CCPs are required to ensure that clearing members have sufficient financial resources to meet the obligations arising from participation in a CCP.

141. The stress exercise was also complemented with a set of reverse stress test scenarios that were designed to further increase the number of defaulting entities to look for extreme but plausible scenarios with systemic impact (i.e. how many clearing members need to default simultaneously to bring down a CCP). In many cases, the reverse stress test scenarios lead to the hypothetical default of an extremely large number of entities both at EU-wide and at individual CCP level. The actual impact on the wider financial system from such an unprecedented, implausible and catastrophic event would not be limited to the CCP industry and is therefore not possible to assess or even estimate. From a theoretical point of view, the analysis is however useful to estimate the mathematical limit of the shortfalls following any systemic wide event involving a large number of multiple simultaneous defaults of entities. In this context, under the stress market scenarios considered, the maximum shortfall in prefunded resources is approximately 40bn EUR. When the analysis is focused on a theoretical, highly extreme but less improbable assumption of less than 15 members defaulting at the EU-wide level and less than 5 members hitting a default fund with losses, the maximum shortfall of prefunded resources is less than 6bn EUR, while no uncovered losses exceeding 1bn EUR are identified.

142. In the course of the analysis of the data provided by CCPs, ESMA has also identified a number of practices that could potentially diminish the resilience of individual CCPs. These are related to the stress scenarios used by CCPs to test the sufficiency of their resources on a daily basis. In a number of cases, it has been identified that the stress

price shocks applied by CCPs for some of their cleared products, are not at least as conservative as the minimum shocks defined for this exercise or do not replicate the most extreme historic price changes observed. Furthermore, for financial instruments that are sensitive to volatility shifts (e.g. options), some CCPs do not apply implied volatility stress scenarios, apply only positive shifts or apply shifts that were lower than the minimum shocks defined for this exercise. For the purpose of this exercise, where it was identified that hypothetical or historical risk factor shocks applied are not at least as conservative as the minimum shocks defined, the existing scenarios were complemented with updated/additional scenarios or the results were adjusted to reflect the potential impact on the basis of conservative assumptions. This however does not ensure that the CCPs will test the sufficiency of their resources on an on-going basis using scenarios that are at least as severe as the minimum scenarios.

6 Recommendations

143. ESMA recommends that the National Competent Authorities ensure that supervised CCPs consider in their participation requirements and as part of the initial and on-going assessment of the credit worthiness of their clearing members, the amount of losses that their members could be exposed to, due to their participation in multiple CCPs taking into account the potential losses of mutualised prefunded and not-prefunded resources, on the basis of data that need to be provided by clearing members.

144. ESMA recommends National Competent Authorities to ensure that where gaps were identified in the performance of this exercise, the CCPs they supervise review the price shocks applied to test the sufficiency of their resources on a daily basis taking into account the minimum price shifts and the specific characteristics of the products they clear, in particular where historical price shocks or appropriate implied volatility shifts are not included in the stress test methodologies applied by the supervised CCPs. It should be stressed that the minimum price shifts are only based on a set of high level risk factor groups and should not be interpreted as the minimum requirements that could ensure compliance with EMIR. The individual CCPs shall review their existing scenarios and specify extreme and plausible market conditions tailored to their individual product offering and based at least on a range of both historical, by replicating historic stress shocks, and hypothetical scenarios, also on the basis of the detailed requirements set out in EMIR and RTS.

145. ESMA will follow-up on the implementation of these recommendations as part of its role in CCP colleges.

7 Annexes

7.1 Herfindal-Hirschmann Index as a measure of concentration

In general, in competition, the HHI is defined as the sum of the squares of market shares (s) of the k firms within an industry:

$$\mathrm{HHI} = \sum_{k=1}^{N} s_k^2$$

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 instead of other simple concentration ratios. That is because the HHI has the property of assigning additional weight to firms with larger size (market shares are squared before being summed up).

In order to identify thresholds to assess the degree of concentration, the analysis uses as a reference the HHI levels defined in the EC 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 can be observed
> 2000	significant concentration

Within the CCP framework, we define the HHI at two different levels:

- at CCP level (HHI_{CCP}):
- At EU-wide level (HHI_{EU}).

The HHI_{CCP} is calculated following two methods:

- As the weighted sum of the HHI calculated at individual DF level (HHI_{DF}). Weights are calculated from the DF size ratio (DF size by individual DF over total DF per CCP);
- Taking the maximum value of the HHI_{DF} per individual DF. In case of CCPs with one DF, this will correspond to the DF_{CCP}; for those cases in which a CCP has several DFs the highest HHI value is considered.

[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.

HHI_{DF} is defined as the sum of the squares of the DF share by individual DF (i.e., fixed income, CDS, etc.) within a CCP. The share is calculated as the DF contribution provided by each clearing member for a particular DF over the total DF collateral held by a CCP. As an example, if there were only one clearing member allocating DF collateral in a CCP, the DF collateral concentration would be 100% and the HHI would equal 10,000 (100^2). If there were thousands of clearing members in a CCP, the allocated DF collateral would have nearly 0% concentration and the HHI would be close to zero.

7.2 Minimum scenario list

a. Price/Rate scenarios:

Asset class	Risk Factor	Unit[20]	Scenario
1	2	3	4
Interest Rate CHF, GBP, USD, EUR	Interest Rate 1M	Bp	60
	Interest Rate 3M	Bp	60
	Interest Rate 1Y	Bp	50
	Interest Rate 5Y	Bp	40
	Interest Rate 10Y	Bp	40
Bonds G7 + CH	Long	Pct	3.0%
	Medium	Pct	2.0%
	Short	Pct	0.5%
Commodity	Certificate	Pct	45%
	Coal	Pct	15%
	Agriculture	Pct	15%
	Freight	Pct	15%
	Metal	Pct	15%
	Natural Gas	Pct	26%
	Gas Liquid	Pct	25%
	Oil	Pct	19%
	Power	Pct	29%
	Soft Com	Pct	12%
Equity G7	Consumer	Pct	15%
	Energy	Pct	15%
	Health	Pct	15%
	Financial	Pct	15%
	Communication	Pct	15%
	Tech	Pct	15%
	Utility	Pct	15%
	Material	Pct	15%
	Industrial	Pct	15%
	Other	Pct	15%
	Index	Pct	15%
	Volatility	Pct	60%
	Dividend	Pct	26%
FX	G7	Pct	6%
	Emerging	Pct	10%
Credit	Single Name	Bp	100
	Index	Bp	80
	Sovereign	Bp	100

[20] The 'Unit' column explains the definition of the risk factor scenario. 'Bp' refers to an additive basis point shift of the risk factor. 'Pct' refers to a relative (percentage) change of the risk factor. All implied volatility scenarios are defined as a relative change.

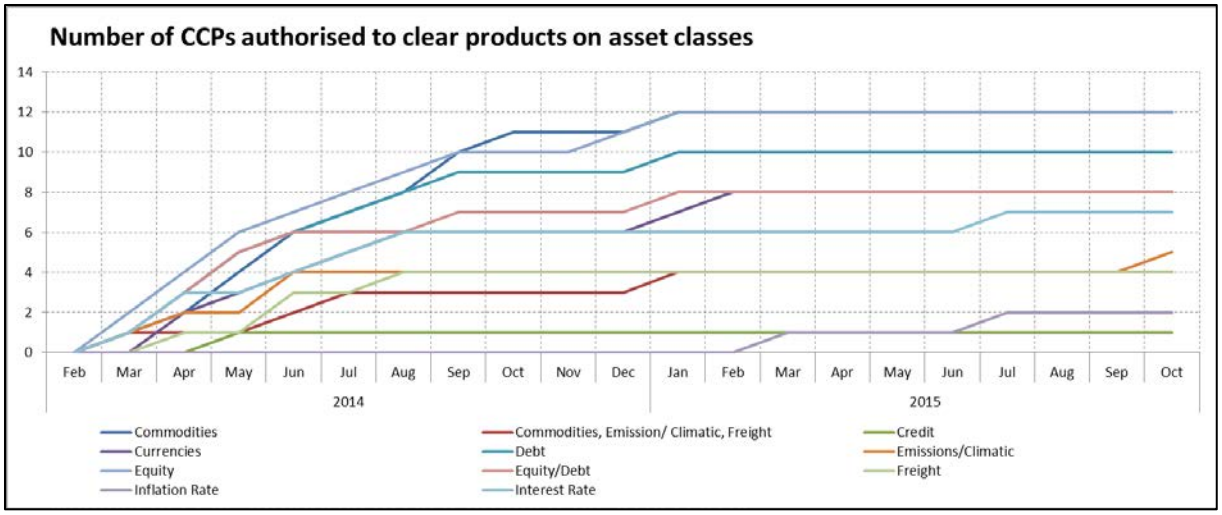
b. Implied Volatility scenarios:

Asset Class	Risk Factor	Unit[21]	Scenario
1	2	3	4
Interest Rate CHF, GBP, USD, EUR	Interest Rate 1M	Pct	50%
	Interest Rate 3M	Pct	50%
	Interest Rate 1Y	Pct	50%
	Interest Rate 5Y	Pct	50%
	Interest Rate 10Y	Pct	50%
Bonds G7 + CH	Long	Pct	25%
	Medium	Pct	25%
	Short	Pct	50%
Commodity	Certificate	Pct	25%
	Coal	Pct	50%
	Agriculture	Pct	25%
	Freight	Pct	50%
	Metal	Pct	50%
	Natural Gas	Pct	50%
	Gas Liquid	Pct	25%
	Oil	Pct	50%
	Power	Pct	50%
	Soft Com	Pct	25%
Equity G7	Consumer	Pct	50%
	Energy	Pct	50%
	Health	Pct	50%
	Financial	Pct	50%
	Communication	Pct	50%
	Tech	Pct	50%
	Utility	Pct	50%
	Material	Pct	50%
	Industrial	Pct	50%
	Other	Pct	50%
	Index	Pct	50%
	Volatility	Pct	50%
	Dividend	Pct	NN
FX	G7	Pct	30%
	Emerging	Pct	NN

[21] The 'Unit' column explains the definition of the risk factor scenario. 'Bp' refers to an additive basis point shift of the risk factor. 'Pct' refers to a relative (percentage) change of the risk factor. All implied volatility scenarios are defined as a relative change.

7.3 Number of authorised CCPs and products cleared

FIGURE 23: NUMBER OF CCPS AUTHORISED TO CLEAR PRODUCTS ON ASSET CLASSES



7.4 Add-on formula for identified gaps

$$\text{GFExposureScaled}_{\text{m,GF}} = \max \begin{cases} \text{DFExposure}_{\text{m,GF}} \cdot \left(1 + \sum_{\text{p}} \left\{ \text{PercGapImpact}_{\text{p}} \cdot \left[PercOI_p \text{ or } PercMargin_p \right] \right\} \cdot (1 + GUF_{DF}) \right) \cdot (1 + DUF_{DF}) \\ \left[\text{StressLoss}_{\text{m,DF}} \cdot \left(1 + \sum_{\text{p}} \left\{ \text{PercGapImpact}_{\text{p}} \cdot \left[PercOI_p \text{ or } PercMargin_p \right] \right\} \cdot (1 + GUF_{DF}) \right) \cdot (1 + DUF_{DF}) \right] - \text{Margin}_{\text{m,DF}} - \text{GFCollateral}_{\text{m,DF}} \\ 0 \end{cases}$$

m: Member

DF: Default Fund

p: product where a gap has been identified

GUF_{DF} : Gap uncertainty factor = 10%, if gaps exist for products cleared in that DF and 0 otherwise.

DUF_{DF} : Data uncertainty factor = 10%, if critical data issues[22] have been identified in that DF and 0 otherwise.

$\text{DFExposure}_{\text{m,DF}}$: Stress Loss exceeding the Margin and the DF contribution of member m, in Default Fund DF, under delivered scenarios

$\text{DFExposureScaled}_{\text{m,DF}}$[23]: adjusted DFExposure

$\text{StressLoss}_{\text{m,DF}}$, $\text{Margin}_{\text{m,DF}}$, $\text{GFCollateral}_{\text{m,DF}}$: Stress Loss, Margin and DF contribution of member m, in Default Fund DF, under delivered scenarios

$\text{PercGapImpact}_{\text{p}}$: (MinimumShift/CurrentShift -1), where a shift has been identified and the shift is below the minimum requirement or 100% if no shifts have been identified or identified shifts only cover positive (or negative) changes and negative (positive) changes are 0 or very small.

$\text{PercMargin}_{\text{p}}$: (Margin for products with gaps) / (Margin for all products in the same DF)

PercOI_{p}: (Open Interest[24] for products with gaps) / (Total Open Interest for all products in the same DF)

[22] if no Historical (or hypothetical) scenarios have been identified for a GF, the Hypothetical scenarios will be replicated as Historical or vice versa. DUF=0%.
[23] Where no stress results have been delivered for an entire default fund, the adjustment will be applied to all remaining DFs, where PercOI/PercMargin will reflect the share of the products cleared in this DF compared to all other products, GUF=10% and DUF=0%.
[24] Open Interest or any other available metric if the Margins and Open Interests are not available. A conservative approach will be used if the metric is not available at the desired aggregation level.

7.5 Formula for computation of CDS-implied probabilities of default

To compute CDS-implied PDs data on 5-year CDS spreads and the following formula is used:

$$CDS - implied\ P \cong \frac{\left(1 - e^{-\left(\frac{CDS \times T}{10000}\right)}\right)}{LGD}$$

where T denotes the maturity of the CDS and LGD denotes the loss-given-default of the clearing members. Given that the 5-year CDS spreads were used, T is set equal to 5. Moreover, to not distort the ranking given by the CDS spreads a uniform LGD of 0.8 is assumed.