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Final Report

Fifth ESMA Stress Test Exercise for Central Counterparties

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Acronyms used

bps	Basis points
CCPs	Central Counterparties
CDS	Credit Default Swap
CSD	Central Securities Depositories
DF	Default Fund
EACH	European Association of CCP Clearing Houses
ECB	European Central Bank
EMIR	European Market Infrastructure Regulation – Regulation (EU) 648/2012 of the European Parliament and Council on OTC derivatives, central counterparties and trade repositories
ESMA	European Securities and Markets Authority
ESRB	European Systemic Risk Board
ETD	Exchange Traded Derivatives
EUA	European Union Allowance
EU	European Union
FX	Foreign Exchange
GC	General Collateral
GEST	Group of Experts on CCP Stress Testing
HQLA	High Quality Liquid Assets
IMF	International Monetary Fund
IR	Interest Rate
ISIN	International Securities Identification Numbers
LEI	Legal Entity Identifier
NACE	Statistical Classification of Economic Activities in the European Community
NCA	National Competent Authority
NLV	Net Liquidation Value
OTC	Over-the-counter
PnL	Profit and Loss
PoA	Powers of Assessment (not-prefunded additional resources that can be called by CCPs from non-defaulting members)
pp	Percentage points
RT	Reverse Stress Test Scenario
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)
SIG/SITG	Dedicated CCP Resources (“Skin in the game”)
TEC	Transition Exposure Coefficients
TTF	Title Transfer Facility (for natural gas)
WWR	Wrong-Way Risk

For CCP codes, please refer to Annex 8.1.

1 Executive summary

The European Market Infrastructure Regulation (EMIR) mandates the European Securities and Markets Authority (ESMA) to initiate and coordinate assessments of the resilience of Central Counterparties (CCPs) to adverse market developments. This report presents the results of the fifth ESMA CCP stress test exercise that includes both EU and Tier 2 CCPs.

Contents

ESMA published on 31 May 2023 the framework for the fifth CCP Stress Test Exercise[1], presenting its scope and methodology. This exercise covers credit, concentration, and liquidity risks to which CCPs are exposed, as well as an analysis of the clearing ecosystem, with improvements of the methodology compared to the previous exercises. In addition, the exercise includes for the first time an analysis of CCPs' exposures to climate risk.

As with previous exercises, the objective of the ESMA stress test exercise is to assess the resilience of CCPs to adverse market developments because of the default of multiple clearing members and simultaneous market price shocks. This exercise is not aimed at assessing the compliance of the CCPs with regulatory requirements, nor at identifying any potential deficiency of the stress testing methodology of individual CCPs, but at assessing the resilience of the system of CCPs as a whole. Still, it may expose individual shortcomings in the resilience of CCPs, in which case ESMA will issue the necessary recommendations.

The European Systemic Risk Board (ESRB), in close collaboration with the European Central Bank (ECB) and ESMA, has designed the adverse market scenario, which is used in the credit and liquidity risk assessments and common across all CCPs.

Given the scope and nature of this exercise, a number of limitations remain and have been highlighted in the report. This is particularly true for the climate risk analysis, which is exploratory in nature and where the methodology and assumptions reflect the limited availability of data. As the analysis may not cover all interlinkages between climate risks and CCPs the results are presented on an anonymous basis and should be interpreted in the context of its limited scope.

Key Findings

EU and Tier 2 CCPs proved to be overall resilient towards the different types of risks under the considered scenarios and assumptions. The overall high level of collateral that was collected by CCPs during the reference period may have contributed to the positive results.

In addition to the ESRB market scenario, the introduction of additional scenarios identified on the basis of CCPs' activity for the credit risk component, as well as the extension of reverse stress testing to concentration and liquidity risks added to the robustness of the exercise.

[1] https://www.esma.europa.eu/press-news/esma-news/esma-launches-fifth-stress-test-exercise-central-counterparties

The additional scenarios confirm that CCPs are resilient against an extended set of market stress and correlation breakdown assumptions. The reverse credit stress test indicates a resilient clearing system for which substantial additional stress in terms of market shocks, number of defaulting member groups or concentration costs is needed to go beyond CCPs' lines of defence.

The concentration risk analysis found that liquidation costs for large positions can significantly contribute to losses from credit risk. Some gaps persist in the coverage of this risk across CCPs and asset classes, notably for commodity derivative positions. The analysis identified some modelling assumptions that are likely to be a major factor in these gaps, such as the recognition of benefits from offsets across products during the liquidation phase.

The liquidity risk component did not evidence gaps in available liquid resources for CCPs under the applied liquidity stress scenarios. The exercise includes for the first time an assessment of interoperable links assumed to be temporarily unavailable and finds that the liquidity risks would be substantial; however, they are sufficiently addressed through available liquid resources. The reverse stress test shows that CCPs clearing securities markets would be most impacted by higher stressed flows. Finally, this exercise found that investment activities of CCPs may impact their liquidity profile, for example, through their bond investments and cash lending activities through reverse repos.

The climate risk analysis shows that CCPs' exposures to climate risk depend heavily on the type of markets they clear, especially where directly exposed to transition risk, such as commodity and energy contract clearing. The majority of sampled CCPs have started to integrate climate risk into their stress testing framework, capturing the potential impact of acute physical risks on assets' prices. This exploratory analysis should be understood as a yardstick for further action with regard to climate risks' monitoring.

The ecosystem analysis provided further insights on the clearing landscape, especially on collected financial resources, how they were invested by CCPs, and linkages between and behaviours of CCPs and other market participants in various markets, such as large clients active through multiple clearing members or CCPs.

Credit Stress Test

The results of the credit stress test are presented in section 3. Two default scenarios have been run, combined with a common market stress scenario based on CCPs' positions as of two different dates: 16 December 2022 and 17 March 2023. On top of the profit and loss stemming from this scenario, concentration costs and costs related to wrong-way risk were also considered for the second date. New this year is also the inclusion of additional market stress scenarios that were identified on the basis of the reported positions. Under the first default scenario ESMA assumes the default of two clearing member groups separately at each CCP (cover-2 per CCP). For the second default scenario, ESMA assumes the default of the same two groups for all CCPs system-wide (All-CCPs Cover-2). The defaulting entities are selected as the groups which maximize the shortfall of prefunded resources, or alternatively the groups which maximize the consumption of prefunded resources. Overall, the results across the different tests indicate a resilient system of CCPs.

Under the Cover-2 per CCP scenario and the common stress shocks, the prefunded resources were sufficient to cover the losses resulting from the core credit stress test scenarios with relatively low or moderate consumptions of the prefunded resources, also when taking into account concentration costs and wrong-way risk impact. The sensitivity analysis also indicated that the conclusions seem robust to relatively small changes in the baseline shocks.

Where scenarios assumed the default of the same two clearing member groups for all CCPs system-wide, most CCPs did not experience a significant stress. This indicates that while CCPs are highly interconnected, the exercise did not highlight any pairs of groups that are at the same time and under the common tested scenario highly impactful at multiple CCPs.

The results using additional scenarios also confirm that CCPs are resilient against an extended set of market and correlation breakdown shocks based on some of the most severe historical market stress events. Only for a few hypothetical scenarios and where shocks were scaled up beyond historically observed levels, some CCPs would have experienced theoretical breaches. None of these impactful hypothetical scaled-up scenarios would affect more than one CCP at the same time, confirming that there is limited overlap between CCPs in terms of significant exposures to similar products or risk factors.

In the reverse stress analysis, ESMA intentionally goes beyond what was considered as plausible for the purpose of this exercise by stepwise increasing the number of defaulting entities and the severity of the market shocks and concentration costs. Results show that substantial additional stress is needed to breach CCPs' resources, which strengthens the confidence in the resilience of CCPs.

Concentration risk analysis

The results of the concentration stress tests are presented in section 4.

At system-wide level, the concentration analysis shows that concentrated positions have the potential for generating significant liquidation costs for CCPs. This risk is not uniformly distributed across the system but is especially relevant at one or a small cluster of CCPs dominating each asset class, in line with the findings of the previous exercise.

A majority of CCPs address concentration risk explicitly through charging dedicated margin add-ons. However, a few CCPs still do not. Other CCPs, while charging concentration add-ons at CCP level, do not do that for all the asset classes where the risk exists.

The market impact (liquidation cost) was estimated on one reference date (17 March 2023) for all identified concentrated positions based on data provided by CCPs for positions, trading volumes and unit liquidation costs. In this exercise the analysis included a special focus on model risk.

System-wide across CCPs, the largest concentration risk can be found in interest rate derivatives, with concentration risk modelled at around 33bn EUR of market impact on liquidation. Bonds (including positions from repo clearing services) come next with 11bn EUR. Concentration in commodity derivatives and in the equity segment (securities and derivatives) is very significant as well, with respectively around 9bn EUR and 4bn EUR of modelled market impact.

The adequacy of CCPs' concentration add-ons versus the modelled market impact presents a mixed picture, with some CCPs charging add-ons well in excess of the model's estimates and others significantly below. Significant variability was also observed at asset class level, sometimes with contrasting results for the same CCP in different asset classes. This variability is likely to result at least in part from the diversity of CCPs' model practices with regard to the estimation of concentration risk. While this is not necessarily a weakness, it points to model risk as a material consideration in this area.

ESMA identified three key modelling assumptions with material impact on estimates of concentration costs, which might account for part of the variability observed in the results. These assumptions are the treatment of highly concentrated positions that account for large multiples of the assumed market capacity, the accuracy of the market capacity estimate itself (e.g. average daily volume or notional amount), and the modelling of offsetting across different positions during the liquidation phase. These assumptions are needed to guide model behaviour in areas of limited observability. The last of the three in particular, concerning the extent to which established relationships between assets may break down in unusual or stressed market circumstances, is likely to be a root factor behind the shortfalls noted for some CCPs. These observations suggest that CCPs should strive to carefully calibrate, support and document model choices and parameter calibration for concentration risk models.

Liquidity Stress Test

The results of the liquidity stress tests are presented in section 5.

Overall, the liquidity results show CCPs to be resilient under the implemented scenarios and tested assumptions. Each CCP maintained a positive liquidity balance at an aggregate currency level and in the major currencies (EUR, GBP, USD) when assuming no access to FX markets. Only a few CCPs would need access to FX market to cover specific needs in other currencies, which means that they would need to transform some of their resources available in one currency into another currency to match their liabilities in a timely manner. However, the amounts are not material compared to the depth of the spot FX market.

As with the credit component, two default scenarios have been run, a "Cover 2 per CCP" scenario, and a "system-wide Cover 2" scenario. Both scenarios have been run on a single reference date common to all components (17 March 2023). Selected defaulting entities are the ones which maximize the consumption of liquidity resources when all assumptions are applied (no excess margin, 1-day market access delay, 2 days settlement lag).

In addition, a reverse stress test was performed where stressed flows were multiplied by coefficients ranging up to 2, while ESMA also assessed liquidity impacts stemming from the temporary unavailability of interoperable CCPs. The system also proved to be resilient under the assumed reverse stress test scenario as only two CCPs are experiencing a small theoretical liquidity shortfall when stressed flows are doubled. As expected, CCPs clearing cash products and/or collecting significant amounts of non-cash collateral are more sensitive to liquidity stress shocks.

Finally, the impact of interoperable CCPs' unavailability on CCPs' liquid resources is found to be large but the risks seem manageable given that the interoperable CCPs reported sufficient liquid resources.

ESMA European Securities and Markets Authority

Climate risk analysis

The climate risk analysis, displayed in section 6 is exploratory in nature. As outlined in the February 2022 call for evidence by ESMA on climate risk stress testing for CCPs[2], the impact of climate risk for centrally cleared derivative markets might manifest itself along various lines. ESMA limited the scope of such analysis to a selection of four climate-related risks transmission channels: (i) impact of transition risk on business model risk, (ii) impact of transition risk on collateral requirement, (iii) impact of physical risk on CCPs' operations, and (iv) impact of physical risk on markets. This analysis differs from a regular stress test since it does not aim at providing any quantitative impact on CCPs but to gain an understanding and raise awareness on climate risks and potential associated vulnerabilities. This analysis is still at an early stage of development and will improve along the availability of adequate and reliable data. It should therefore be understood as a yardstick for further action regarding climate risks' monitoring.

The analysis finds that CCPs' business models are exposed to transition risk to varying degrees under a longer-term scenario with a gradual phasing-in of sustainability policies. Under such a scenario, transition risks could negatively impact mainly four CCPs whose business model heavily depends on the clearing of assets directly exposed to transition risk, under the assumption that their activity, significantly linked to commodity and energy contracts, remains the same. Those CCPs are therefore expected to develop adequate strategies, governance, and level of risk management to identify, monitor, and mitigate the identified exposures.

The impact of potential climate risk on the remaining transmission channels is deemed immaterial. On the one hand, the potential impact of transition risk on the collateral collected from clearing members, mostly composed of cash and government bonds, is deemed irrelevant. Also, no critical vulnerabilities have been identified to operational risk based on the headquarters' locations of the CCPs and their top 10 clearing members. Moreover, such risks are expected to be captured by CCPs' business continuity measures.

Finally, the analysis found that the majority of sampled CCPs have started to integrate climate risk into their stress testing framework, capturing the potential impact of acute physical risks on assets' prices. The maturity of the scenarios is correlated to the product mix cleared by the CCPs, with CCPs clearing commodities, energy and freight derivatives being first in line. Among the four aforementioned CCPs whose product mix is directly and significantly exposed to climate risk, two did not report having climate market stress test scenarios. ESMA is encouraging CCPs to consider whether acute physical risk could negatively impact the value of the instruments they clear, and to complement the scenarios used to size prefunded resources with adequate market stress scenarios designed to capture and monitor these risks.

Ecosystem analysis

Section 7 presents an analysis of the clearing ecosystem, providing insight into its structure and evolution, while also exploring specific areas with potential spill-over effects to the broader financial system, including clearing members, their clients, and financial markets.

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[2] https://www.esma.europa.eu/sites/default/files/library/esma91-372-1785_call_for_evidence_on_ccp_climate_stress_tests.pdf

The total amount of resources in the ecosystem of EU and Tier 2 CCPs and their clearing members has increased significantly compared to the precious exercise. In particular, the total amount of required margin increased from 392bn EUR in March 2021 to 612bn EUR in March 2023 (+56%). The relatively high increase can probably be attributed to the stress events in recent years and resulting episodes of volatility surge. The increase contributes further to the systemic importance of the central clearing system as a whole. The amount of default fund contributions shows a lower increase. The top nine clearing member groups provided each more than 20bn EUR required margin, which accounts on aggregate for 59% of the total required margin. Comparison with data reported at previous exercises indicates that there is no further notable increase in the concentration of resources provided by the top clearing member groups, but rather a more generalized increase of margin for all clearing members.

An analysis into large clients of multiple clearing members and CCPs, using derivative exposures reported from EU counterparties to Trade Repositories under the EMIR reporting obligation, contributed to a further understanding of client concentrations in the central clearing ecosystem of the EU. The analysis starts by reconstructing for specific asset classes, namely equity, power, gas and European Union emission allowances (EUA) derivatives, a network view of the clearing ecosystem and estimating a numerical score of the importance of each node. With the exemption of equity derivatives, there is typically a small number of clearing members playing a dominant role in the considered markets, while in many cases the same clients are normally active in both energy (gas and power) and EUA derivatives. The analysis, while being exploratory and not strictly aiming to stress exposures, provided new insights into the client-clearing ecosystem and potential implications for EU financial stability helping to better understand the characteristics and behaviour of participants in cleared derivative markets, to also evaluate concentration and market dominance.

Available data also allowed for an analysis of the origins of variation margins in stress conditions and how the variation margin calls are distributed across different market participants. Stressing variation margins under the common market stress scenario, ESMA found that 90% or more of these flows were concentrated in the top three CCPs and were denominated in EUR, USD and GBP. The distribution of stressed variation margins between client and house accounts significantly varies across CCPs. Financial institutions in the EU, US and UK were exposed to most of stressed variation margins. The top clearing member groups are large financial institutions, and based on their size, it would be reasonable to expect that the net reported flows could be well covered by their hiqh-quality liquidity asset (HQLA) holdings. The data provided didn’t allow to extend this analysis to estimate the share of stressed variation margin flows impacting specific types of clients, such as clients that are not financial institutions.

A last analysis concerned the impact of CCPs’ investments of cash resources in the various markets. On CCPs’ investments in bonds, ESMA found, using code developed in collaboration with IMF staff, that market risk stemming from the liquidation of bond portfolios in stressed market conditions seems limited. However, for repos ESMA noted that haircuts applied to reverse repos are small overall and smaller than the haircuts applied to CCP collateral, which could expose CCPs to counterparty credit risk, should they need to liquidate repo collateral of failing counterparties under stressed market conditions to retrieve cash.

2 Introduction

2.1 Background

1. CCPs are systemically important, and their resilience is critical to the stability of the financial system in the EU. By their nature, CCPs are counterparties to all their clearing members. Failure of CCPs to mitigate risks could potentially lead to spill-over effects and may exacerbate systemic risk. Moreover, as evidenced in previous ESMA stress test exercises, CCPs are highly interconnected through common stakeholders, which may propagate failures in one CCP throughout the system. Stress testing CCPs, both individually and at financial system level, is an important supervisory tool to ensure the sector is safe and resilient to a wide range of risks including credit and concentration, liquidity, and climate risk. This 5^{th} exercise was also the opportunity to explore the central clearing ecosystem from new angles, such as identifying large clients or potential risks linked to CCPs' investments.

2. The ESMA supervisory stress test is different than the stress tests of individual CCPs. CCPs run daily stress tests on the basis of stringent prudential requirements that focus on their own environment, including participants and cleared products. The individual CCP's stress test cannot consider how the default of one of its clearing members or third-party providers impacts other CCPs. Therefore, the ESMA stress test is a critical tool in assessing the systemic implications of system-wide events and thus the resilience of the system of European CCPs.

3. One of the objectives of Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories (EMIR) is to promote central clearing and ensure safe and resilient CCPs. Therefore, ESMA shall at least annually, in cooperation with the ESRB, initiate and coordinate assessments of the resilience of CCPs to adverse market developments. Following the amendments to Regulation (EU) No 648/2012 in 2019, these assessments should include both EU and third-country Tier 2 CCPs.

4. In accordance with the requirements, ESMA has assessed the resilience of all CCPs in scope, individually and as a system. This was done on the basis of, as much as possible, common methodologies and criteria. The ESMA CCP stress testing exercise is not aimed at assessing the compliance of the CCPs with regulatory requirements nor at identifying any potential deficiency of the stress testing methodology of the CCPs. It may however expose individual shortcomings, in which case ESMA will issue the necessary recommendations.

5. The present report sets out the results of the 5th ESMA system-wide stress test exercise in the following sections, following a brief description of the objectives and methodology for each component.

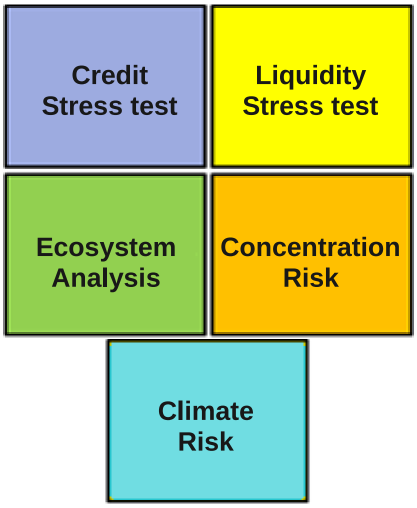
2.2 Scope and Objectives

6. The objectives of the ESMA stress test exercise result directly from the legal mandate given to ESMA under EMIR. The objectives are to:

- Assess the resilience of CCPs to adverse market developments,
- Identify any potential shortcomings in the CCPs' resilience, and
- Issue recommendations as appropriate.

7. The exercise covers 16 CCPs, including all authorised EU CCPs (14) as well as Tier 2 CCPs (2). New in this exercise is the Croatian CCP SKDD.[3]

8. The scope of the stress test exercise developed over the years, also considering ESMA's evolving mandate. This stress test exercise has the following components:



- **Credit stress test**: Assess the sufficiency of CCPs' resources to absorb losses under a combination of market price shocks and member default scenarios.
- **Concentration risk**: Assess the impact of liquidation costs derived from concentrated positions.
- **Liquidity stress test**: Assess the resilience of CCPs to market wide and idiosyncratic liquidity stress events.
- **Climate risk**: Assess the degree to which the CCP's business model is affected by the transition to a carbon-neutral economy, the consequences of the transition on the collateral posted by clearing members, and explore the impact of physical risk on CCPs.
- **Ecosystem analysis**: Monitor the CCP system as a whole and explore spill-over of losses between CCPs, clearing members, their clients, financial markets and the broader financial system.

9. A common stress test date has been considered for all components (17 March 2023), while a second date was also used for the credit component (16 December 2022).

2.3 Process and cooperation

10. ESMA followed the same approach as during the previous exercises and key steps are further discussed in the next paragraphs.

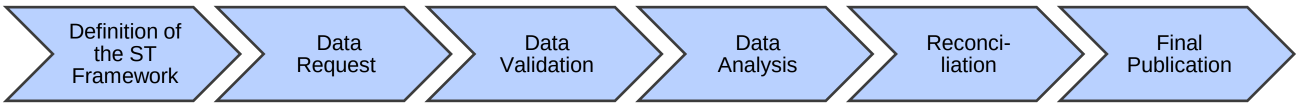


Figure 1: Overview of the Process

11. ESMA issued on 31 May 2023, the framework for the fifth CCP Stress Test Exercise[4], presenting the scope, the methodology and the details of the project. A market stress scenario

[3] Due to its limited activity, some stress test components are not relevant for ICENL.
[4] https://www.esma.europa.eu/press-news/esma-news/esma-launches-fifth-stress-test-exercise-central-counterparties

for CCPs was built by the ESRB in close collaboration with the ECB and ESMA. During the data request, CCPs were provided with templates as well as detailed instructions on how to calculate and report the required information, including the calculation of profit and loss for cleared positions per account (PnL) using the market stress scenario.

12. The existing Group of Experts for CCP Stress Testing (GEST) under the CCP Supervisory Committee, with representatives from national competent authorities for CCPs (NCAs), contributed during the different steps of the project. ESMA cooperated with the Bank of England under the relevant Memorandum of Understanding during the different steps of the exercise involving UK Tier 2 CCPs. ESMA also consulted the European Association of CCP Clearing Houses (EACH) on the overall framework and more specifically on the data request templates and the instructions.

13. The data request was launched on 31 May 2023 and the CCPs were asked to deliver by 18 August 2023 the completed data templates to the NCAs (EU CCPs) or both ESMA and the Bank of England for UK CCPs.

14. The receipt of the files on 18 August 2023 was followed by the first data validation phase, where NCAs and the Bank of England validated the submitted data against the instructions and according to a common set of validation rules. ESMA also coded and offered to run a validation algorithm to facilitate this task. Each authority appointed one officer that was the single point of contact. Where needed, the appointed officers were in contact with ESMA staff and fellow officers from other NCAs in order to facilitate the consistent implementation of the framework across all CCPs. Moreover, in order to facilitate the convergence of the validation practices across different authorities, ESMA staff compiled and shared with the authorities a list of frequently asked questions, together with the respective answers.

15. The first validation phase was concluded with the delivery of the data templates in mid October 2023 to ESMA that acted as a second line of defence in terms of data quality assurance. ESMA checked at least on a sample basis, that the reported data were consistent, reasonable and conform to the requirements included in the instructions. It finally assessed the overall plausibility of results, including a comparison between CCP results, to detect any outliers. This second validation phase was scheduled to last a total of 10 weeks. While the first set of findings were identified and addressed within this period, there were a significant number of issues that had to be followed-up, while in some cases, the correction of issues or the progress of the analysis raised new issues.

16. When sufficient progress was made on data validation and analysis, the GEST set the sensitivity parameters used in the concentration component in January 2024. ESMA then calculated and analysed the results of the stress test.

17. ESMA cooperated with the ECB on the assessment of physical risk (climate risk component) and the benchmarking of the concentration risk model. ESMA also collaborated with the International Monetary Fund (IMF) to assess risks stemming from CCP's investments in bonds purchases as part of the ecosystem analysis.

18. The preliminary results of the stress test were first discussed in March and April 2024 with the GEST and then at the CCP Supervisory Committee in April 2024, followed by the Bank of England for UK CCPs. As a final step, ESMA also reconciled in April 2024 the core stress results with each individual CCP to reconfirm their robustness. The reconciliation exercise was focused on CCP specific data. Sufficient time and effort were devoted to the reconciliation process in line with the previous exercise, in order to ensure that the participants had the time

and information needed to confirm the interpretation of the sourced data and the correctness of the results.

19. To a significant extent, the quality of the data and results still rely on the data submitted by the CCPs and the primary checks performed by the NCAs as ESMA lacks direct access to the CCPs under the applicable EMIR Regulation.

2.4 Market Stress Scenarios

20. Similar to the previous stress test exercises, the ESRB's Task Force on Stress Testing, in close collaboration with the ECB and ESMA, has developed the narrative and has calibrated the adverse scenario for the 5th stress test exercise[5]. The shocks were produced using the tool that is employed for the calibration of financial shocks for adverse scenarios at the ECB and has been in use for the calibration of financial shocks for the EBA, EIOPA and ESMA scenarios.

21. The scenario that was produced reflects the triggering of one or more of the sources of systemic risk to the EU financial system identified by the ESRB. These risks could materialise simultaneously and reinforce each other. The results are derived using a methodology that takes into account the joint empirical distribution of the risk factors deemed relevant to the CCPs in scope of the ESMA exercise.

BOX 1: NARRATIVE OF THE SCENARIO AS PROVIDED BY ESRB

The aggravation of the ongoing geopolitical tensions and polarisation due to Russia's invasion of Ukraine is assumed to result in continued disruptions of the global supply chain. This in turn impedes the ability to meet global demand for raw materials, energy, gas and food, resulting in an abrupt repricing of commodities. This effect is intensified by the resurgence of COVID-19 cases, which further affects supply across sectors.

Higher production costs resulting from supply constraints are partly passed on to consumers, inducing broad-based rises in inflation. This increase in current and expected inflation triggers expectations of further policy responses, which are manifested in higher market interest rates. The shift in market interest rates, combined with elevated public sector debt levels as a result of increased public spending during the coronavirus (COVID-19) pandemic, heightens sovereign debt sustainability concerns. Along with higher costs of commodities and a weaker economic outlook, this also increases expectations of defaults in the private sector. The public and private debt sustainability concerns in turn give rise to a sharp increase in credit risk premia and a widening of credit spreads worldwide,[6] including for financial institutions.

The generalised tightening of financing conditions leads to a further deterioration in the macro-financial environment and generates a spike in volatility across asset

[5] https://www.esrb.europa.eu/mppa/stress/shared/pdf/esrb.stress_test230531~e7eaca7ddf.en.pdf

[6] The calibration takes into account the fact that the availability of the Transmission Protection Instrument (TPI) is expected to reduce the volatility of euro area sovereign bond spreads, regardless of whether it is activated or not. The announcement of the TPI per se reduces the probability of self-fulfilling crisis episodes in sovereign debt markets.

markets. This, along with reduced market liquidity, causes disorderly and abrupt asset price corrections. Such conditions are also reflected, and amplified, in less regulated markets (e.g. for crypto-assets).

22. The system-wide stress scenarios should not be bound to only replicate past historical scenarios, but also use past observations in combination with a narrative that reflects the assessment of prevailing sources of systemic risk for the EU financial system, including the two Tier 2 CCPs in the UK, to produce shocks that model potential future market conditions.

23. The stress test is a scenario-based analysis measuring how CCPs would fare under hypothetical adverse economic developments. The scenario has been designed to be severe to meet CCP-specific regulatory requirements. When modelling the stress scenario, it is not possible to cover all possible movements of different risk factors and their co-movements within and across asset classes. In the 5th exercise the stress test results derived from the common market stress scenario were complemented by identifying additional theoretical market stress scenarios and assessing their impact on CCPs as part of an exploratory analysis (3.2.5).

3 Credit Stress Test

3.1 Objectives and overview of methodology

25. The credit stress test is designed to evaluate the resilience of CCPs in the face of extreme market conditions, combining price shocks with clearing member defaults. The test aims to assess whether CCPs hold sufficient financial resources to cover the losses that would be experienced under these scenarios.

Overview of Methodology

26. From a conceptual point of view, the credit stress test is a simulation where it is assumed that:

- There is a shock to market prices of the different products cleared by CCPs, hence creating profits and/or losses for the cleared portfolios of clearing members.
- There is a default of a number of clearing member groups (including clearing members and their affiliates) requiring the CCP to honour the missed payments.

27. After the assumed default (which occurs during the weekend), no payments would be exchanged between the CCP and the defaulting members. Trading access is assumed to have been revoked in the weekend, so that no position changes were accepted after the last novation cycle of Friday. The open positions would therefore reflect the positions as of Friday end-of-day, including all transactions that were accepted for novation during Friday. All price movements are assumed to happen instantaneously at the time the defaults are announced.

28. Under these assumptions, ESMA identifies the clearing member groups with the top exposures and assesses the sufficiency of CCPs' resources to withstand the simulated losses, using the applicable account segregation rules and default waterfall structure.

29. When assessing the resilience of CCPs, excess margin is removed from the available resources, only considering the required margin that members and clients need to keep in the CCP to support their cleared exposures. It is assumed that a defaulting clearing member would not have posted any excess margin in practice.

Cover-2 assessment of market scenario losses

30. In the Cover-2 assessment of market scenario losses, the resilience of CCPs is assessed for two different dates, using the baseline ESRB market stress scenario shocks and the assumption that two clearing member groups default simultaneously. The selection of defaulting clearing members is done both by identifying the top-2 clearing member groups with the highest exposure at each CCP individually (for the cover-2 per CCP results) or by considering the aggregated exposures across all CCPs (for the cover-2 all CCPs results).

31. The market stress scenario is defined for a set of high-level risk factors across different asset classes. The profit and losses were computed by CCPs using their internal models and the common risk factor shocks. This assessment considers only the impact from the repricing of products based on the provided shocks. This assessment has the limitation of not taking into account additional losses for the CCP that would be realized due to the cost of liquidating concentrated portfolios and wrong-way risk losses.

Inclusion of concentration and wrong-way risk

32. In the Cover-2 assessment with concentration and wrong-way risk, the resilience of CCPs is assessed for one date, incorporating also estimates of these additional costs for cleared positions and collateral. Such costs are considered when selecting the defaulting clearing members.

33. The profit and losses implied by the provided market stress scenario shocks are again computed by CCPs using their internal models. ESMA computes estimates of the additional market liquidation costs for concentration positions and collateral by applying the methodology used in the concentration component of this stress test (4.1). Wrong-way risk costs for both positions and collateral are computed for equities, corporate / covered bonds, single-name credit default swaps (CDS) and bank guarantees whenever the issuer or one of its affiliates were assumed to be in default. The different elements are aggregated and propagated through the CCP's default waterfall by ESMA using the applicable account segregation rules.

34. The result is a more comprehensive assessment of the potential costs that would be faced by a CCP in case of multiple defaults.

Testing for additional markets stress scenarios

35. The ESRB common market stress scenario is the basis of the assessment of resilience of CCPs to shocks reflecting the triggering of one or more of the sources of systemic risk to the EU financial system as identified by the ESRB. However, CCPs may also be exposed to more asset-specific or even CCP-specific risks, sometimes also linked to particular positions or strategies.

36. When modelling stress scenarios, it is not possible to test for all possible co-movements between risk factors for all CCPs. Hence, there is a need to focus on additional scenarios that would be most relevant or impactful for in-scope CCPs. For this purpose, historical stress scenarios are identified based on the most important risk factors for the different CCPs, also complemented with hypothetical scenarios inspired from such past stress events. The methodology used to identify such additional scenarios is summarised below in Box 2.

37. The shocks implied by the additional scenarios are then used to simulate the profits and losses for already reported clearing members' positions. The resilience of CCPs is assessed for one date, using a set of historical and hypothetical scenarios defined by ESMA and the assumption that two clearing member groups default simultaneously. The selection of defaulting clearing members is done by finding the top-2 clearing member groups with the highest exposure for the given scenario and for each CCP individually.

38. The profit and losses are computed by ESMA through approximation methods, using the reported cleared portfolios and the set of relevant historical and hypothetical market stress scenarios. Only the losses from the repricing of products under the considered scenarios are taken into account for this assessment without the concentration and wrong way risk costs.

39. For this 5th stress test report, the results for the Cover-2 assessment with additional scenarios are presented in an aggregated manner for all CCPs.

Box 2: Methodology of additional market stress scenarios

Methodology of additional market stress scenarios

The additional scenarios are constructed following a five-step process:

1 Identify key Risk Factors

Identify the top (at least 4) risk factors in terms of maximum net risk-weighted exposure.

2 Construct Theoretical Scenarios

Construct theoretical Scenarios by assigning a weight [1, 0 or -1] to each of the top factor and building all possible combinations at asset class, sub-asset class and risk factor level.

3 Select the most impactful Theoretical Scenarios

The most impactful theoretical scenarios are selected for each CCP as the top scenarios with the largest cover-2 stress loss above Margin.

4 Identify relevant Historical Additional Scenarios

The selected theoretical scenarios are algorithmically constructed, purely theoretical and include shocks only for a few risk factors. In order to overcome these limitations, the identified theoretical scenarios are matched back to actually observed similar historical moves. For this purpose, the available history is scanned, looking for dates where the actual historical shocks were the closest to the modelled theoretical scenarios. Mathematically, this is done by calculating for each available historical date the Euclidian distance of the historical shocks from the modelled theoretical shocks (normalised). For each theoretical scenario the top dates with the minimum distance are selected. This process provides shocks for all risk factors that are plausible (replicating history) and as close as history allows to the theoretical impactful scenarios.

5 Construct Hypothetical Additional Scenarios

Historical Scenarios are run against CCPs' resources. However, these only replicate past historical shocks and give restricted information on how CCPs perform under different stress events that could include shocks of higher magnitude or breakdown of historical correlations. In order to serve this purpose, the following hypothetical additional scenarios are constructed: (a) Scaled-up hypothetical scenarios: Scaling-up the shocks of historical scenarios, e.g. x1.25, x1.50 to assess the sensitivity to shocks of increased magnitude, while at the same time preserving the historical stressed correlation, (b) Inverse (Antithetical) hypothetical scenarios: Switch the sign of historical shocks, to assess the sensitivity to shocks of opposite direction, (c) Sampled hypothetical scenarios: Randomly select for each risk factor a historical shock from one of the impactful historical scenarios, to explore the impact of changes to the correlation structure, while at the same time preserving the magnitude and direction of historical shocks for individual risk factors

Reverse stress testing and sensitivity testing

40. Reverse stress testing and sensitivity testing techniques are used in order to complement the main results and assess the effect of changing the underlying assumptions.

41. A sensitivity analysis for the level of market risk shocks is performed for the Cover-2 per CCP assessments. The objective is to test whether relatively small changes to the assumed shocks could significantly impact the results and therefore the conclusions drawn from the core stress test. For this purpose, the cover-2 per CCP assessment is performed using risk factor shocks that are scaled by different factors (e.g., x0.7, x1.2, x1.5). The selection of defaulting clearing members for the sensitivity tests is done by finding the top-2 clearing member groups with the highest exposure for each CCP individually.

42. The reverse stress test analysis is used to assess the absorption capacity of the system of CCPs under more severe assumptions, allowing these to go beyond what was considered as extreme but plausible for the purpose of this exercise. The analysis considers different parameters and scaling factors stressing the underlying assumptions along three dimensions, (i) the severity of the market shocks (x0.7, x1, x1.2, x1.5, x2), (ii) the market liquidation costs from concentrated positions (x0.7, x1, x1.2, x1.5, x2), and (iii) the number of clearing member group defaults (1, 2, 3, 4, 5).

43. The selection of defaulting clearing members for the reverse stress test is done by finding the top-n clearing member groups with the highest aggregated exposure across all CCPs, hence focusing on the systemic risk, instead of the resilience of individual CCPs. The objective of this analysis is to assess whether there could be plausible combinations of stress assumptions with systemic risk implications.

Key assumptions for the Credit Stress Test

44. Investment risks, including market and credit risk assumed as a result of CCPs' investments are not assessed in the credit stress test component. The exercise does incorporate an assessment of the market risk for provided collateral using the market stress scenarios and an adjustment for the wrong-way risk resulting from margin collateral issued by clearing members. Any additional market or credit risks, also resulting from the re-investment of provided collateral are not covered. These limitations are due to the fact that these risks are linked to the individual actions and rules of the CCP and are thus difficult to model consistently across CCPs.

45. The credit stress test exercise has evolved to include the concentration cost for positions and collateral for one of the stress dates. However, the estimation of this impact is subject to limitations, which are described in the relevant methodology, including due to the restricted modelling of the default management procedure, the model granularity and the uncertainties around the estimation of the market impact parameters.

46. The wrong-way-risk adjustment is applied for one of the stress dates and has been enhanced to also reflect the risk from margin collateral issued by another defaulting clearing member. However, the estimation of this impact is subject to limitations, including due to uncertainties in the estimation of the recovery values. Moreover, in the interest of avoiding complexity, the wrong-way risk effects on cleared index products are not modelled.

47. Operational risks, including those that may lead to increased credit risks, such as the operationalisation of default procedures, are also not reflected in the credit stress test results. Any further second round effects to prices following the default of entities or the default of additional entities due to losses accumulated from non-cleared portfolios will not be modelled.

3.2 Results

48. This section presents the full range of credit stress test results assessing the sufficiency of CCPs' resources to absorb losses under a combination of market shocks and member default scenarios.

BOX 3: DESCRIPTION OF THE CREDIT STRESS TEST CHART

The credit stress test results are presented in the form of a panel, showing for each CCP the following (from bottom to top):

Amounts of default waterfall consumption (in mil. EUR)

Loss covered with DF, SITG and other DF-level resources: amount of stress loss (in million EUR) covered with the default fund (including defaulting and non-defaulting members' contributions), dedicated CCP resources ("skin-in-the-game" or SITG) and other prefunded and committed default-fund-level resources that the CCP may have. Where the CCP has more than one default fund, this amount is the sum of amounts calculated per default fund. It is illustrated in green in the chart.

Loss covered with other CCP-level resources: amount of stress loss (in million EUR) covered with other prefunded and committed CCP-level resources, where applicable. The CCP-level resources are resources that can be used across default funds where the CCP has more than one default fund. It is illustrated in yellow in the chart.

Loss covered with power of assessment (PoA): amount of stress loss (in million EUR) that would need to be covered with non-prefunded resources (powers of assessment). Where the CCP has more than one default fund, this amount is the sum of amounts calculated per default fund. Only the non-defaulting members are assumed to provide additional non-prefunded resources. It is illustrated in red in the chart.

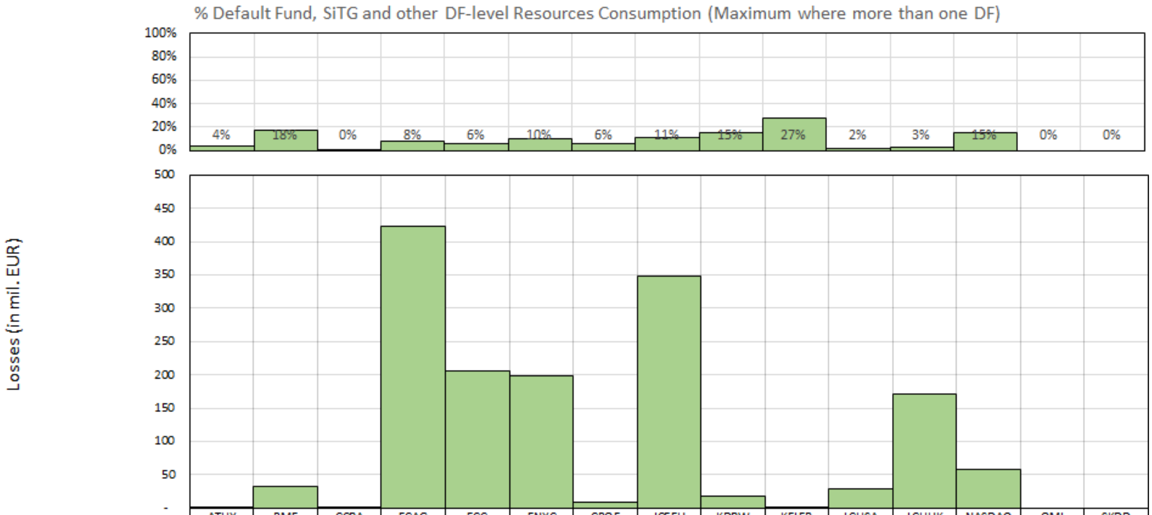
Loss after PoA: amount of stress loss (in million EUR) left uncovered after using prefunded and non-prefunded resources. This amount is again the sum of all uncovered amounts where the CCP has more than one default fund. It is illustrated in black in the chart.

% Consumption of resources

% Consumption of the default fund (including the defaulters' contributions), the skin-in-the-game and other prefunded and committed default-fund-level resources that the CCP may have. For CCPs that have more than one default fund, the maximum % consumption is presented.

3.2.1 Cover-2 assessment of market scenario losses

Cover-2 per CCP for December 2022



	ATHX	BME	CCPA	ECAG	ECC	ENXC	CBOE	ICEEU	KDPW	KELER	LCHSA	LCHUK	NASDAQ	OMI	SKDD
Stress Loss after PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with other CCP-level Resources	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss above Margin covered with DF, SiTG and other DF-level Resources	1	32	0	422	206	199	8	348	17	1	28	172	58	-	-

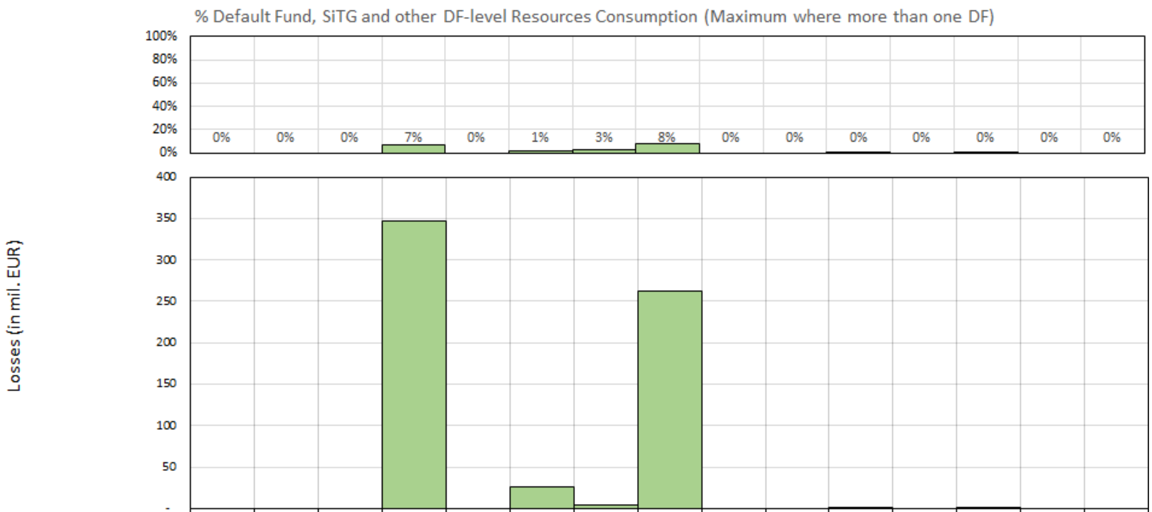
Figure 2: Cover-2 Groups per CCP – date: December 2022

49. The results of the credit stress test results for the December 2022 date (Figure 2) do not indicate a shortfall of prefunded resources for any of the CCPs in scope of the exercise. The consumption of prefunded resources across CCPs is limited, indicating a high level of resilience to the market stress scenario.

50. The maximum default fund consumption is 27%. In terms of losses in monetary (EUR) amounts, the largest losses are identified at two of the largest CCPs. Yet all CCPs had by far sufficient prefunded resources to cover such losses, with very low % consumptions of available resources. Hence, the implemented market stress scenario, before accounting for any additional losses due to concentration and wrong-way risk, has not put for the December date any of the in-scope CCPs to significant stress and all CCPs had sufficient prefunded resources to cover such losses.

51. The pair of defaulting clearing member groups under this assessment is selected separately for each CCP based on the relevant exposures. Twenty different clearing member groups were selected in total as defaulting across all CCPs and only five out of those were selected among the top-2 defaulters at more than one CCP, with none at more than two CCPs. In all cases, no pair of selected defaulters was the same at multiple CCPs. This indicates that while CCPs may be interconnected through common clearing members, such members would not be amongst the ones with top exposures at many CCPs under the considered scenario. This is further tested in the following Cover-2 All CCPs assessment.

Cover-2 All CCPs for December 2022



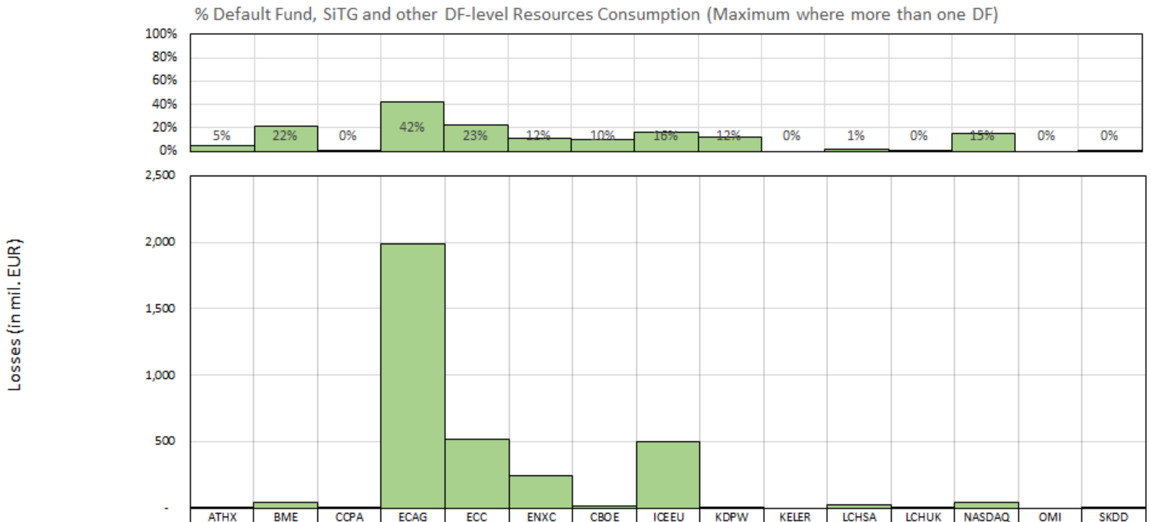
	ATHX	BME	CCPA	ECAG	ECC	ENXC	CBOE	ICEEU	KDPW	KELER	LCHSA	LCHUK	NASDAQ	OMI	SKDD
Stress Loss after PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with other CCP-level Resources	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss above Margin covered with DF, SITG and other DF-level Resources	-	-	-	347	-	27	4	262	-	-	1	-	0	-	-

FIGURE 3: COVER-2 GROUPS ACROSS ALL CCPS – DATE: DECEMBER 2022

52. Assuming that the same two clearing members groups would default at all CCPs simultaneously, there is again no shortfall of prefunded resources (Figure 3). When looking at the pair of clearing member groups that would cause the highest resources consumption across CCPs for the December date, the results don't show any relevant concerns for the system of CCPs, as almost all resources consumption could be covered with margin resources. The maximum default fund consumption is small and less than 10%.

53. In this assessment (Cover-2 All CCPs) the individual results of each CCP are by design equally or less severe than the results calculated under the "cover-2 per CCP" assumption. The reason is that here the same two clearing member groups are selected as defaulting across all CCPs. In this case, the selected pair of defaulting groups is none of the pairs that would maximise the losses at any individual CCP. The algorithm focuses on a pair that maximises the aggregate impact across all CCPs.

Cover-2 per CCP for March 2023



	ATHX	BME	CCPA	ECAG	ECC	ENXC	CBOE	ICEEU	KDPW	KELER	LCHSA	LCHUK	NASDAQ	OMI	SKDD
Stress Loss after PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with other CCP-level Resources	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss above Margin covered with DF, SiTG and other DF-level Resources	2	46	0	1,989	519	244	13	504	12	-	23	2	48	-	0

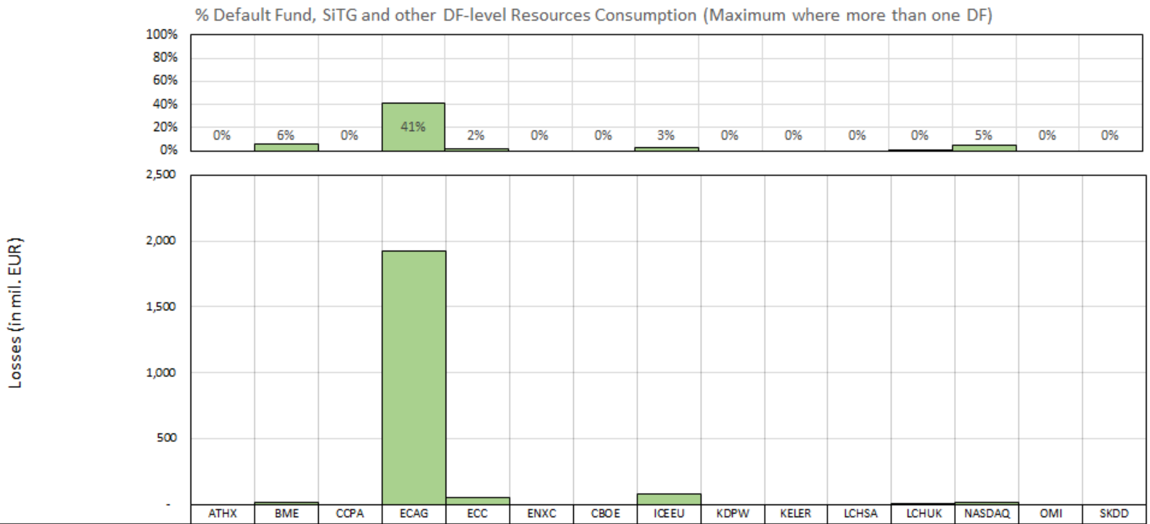
FIGURE 4: COVER-2 GROUPS PER CCP – DATE: MARCH 2023

54. The results of the credit stress test for the March 2023 date (Figure 4) show a similar pattern to the December 2022 results, with no shortfall of prefunded resources for any of the CCPs in scope of the exercise.

55. The maximum consumption of prefunded resources for a single CCP increases slightly with respect to the December 2022 date, with one CCP reaching a consumption of 42% of prefunded resources. Furthermore, for two CCPs there were no losses above required margin. Overall, all CCPs have a consumption of resources below 50%, confirming that CCPs are resilient to the losses from the market stress scenario, before accounting for any additional losses due to concentrated positions and wrong-way risk.

56. Six common clearing member groups were selected among the top-2 defaulters at more than one CCP, with one at three CCPs. Furthermore, only two of these groups were also amongst the top interconnected defaulters for the other (December) date indicating that the relevant selection is not only sensitive to the shocks but also to the reference date. Again, no identification of a pair of members whose default would lead to systemic implications involving multiple CCPs under the considered scenario.

Cover-2 All CCPs for March 2023



	ATHX	BME	CCPA	ECAG	ECC	ENXC	CBOE	ICEEU	KDPW	KELER	LCHSA	LCHUK	NASDAQ	OMI	SKDD
Stress Loss after PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with PoA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss covered with other CCP-level Resources	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stress Loss above Margin covered with DF, SiTG and other DF-level Resources	-	12	-	1,924	52	-	-	80	-	-	-	0	15	-	-

FIGURE 5: COVER-2 GROUPS FOR ALL CCPS – DATE: MARCH 2023

57. When looking at the single combination of clearing member groups that would cause the highest resources consumption across CCPs for the March date (Figure 5), the results focus on one specific CCP, with limited impact across the system of CCPs. The resulting consumption of prefunded resources and overall consumption of resources across CCPs does not raise any concerns. We note that by prioritizing maximization of losses above required margin in absolute terms, the Cover-2 selection naturally leans towards combinations that are most impactful for the largest CCPs.

58. Overall, when considering the Cover-2 assessment against market risk losses and before accounting for additional losses from concentration and wrong way risk, the CCPs have shown individual resilience to the ESRB market stress scenario across the two dates. Furthermore, no additional systemic concerns from losses across CCPs have been identified.

3.2.2 Cover-2 per CCP with concentration and WWR for March 2023

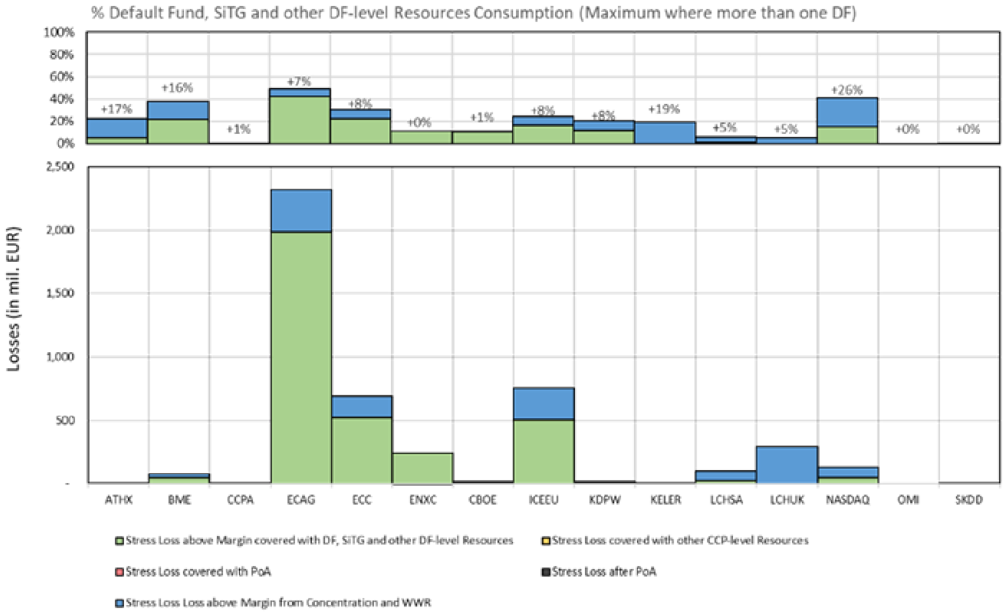


FIGURE 6: COVER-2 GROUPS PER CCP WITH CONCENTRATION & WWR – DATE: MARCH 2023

59. When adding estimates of market liquidation costs from concentrated positions and wrong way risk on top of the market stress scenario losses, a general increase in the consumption of prefunded resources across CCPs is observed (Figure 6), which is the expected behaviour. However, the results across CCPs continue to be positive, with all CCPs having a consumption of prefunded resources below the 50% mark, an indication of general resilience across CCPs towards the stress scenario and the additional modelled costs from liquidating portfolios after a default.

60. For most CCPs, this observed increase is driven by the additional concentration costs. Only for one CCP the additional wrong way risk costs are both significant and comparable to the estimated concentration costs. The wrong way risk costs primarily originate from cleared positions in covered bonds and equities where the relevant reference entity (issuer) would be part of the same corporate group with one of the defaulting clearing members.

61. The addition of the concentration and wrong-way risk impact in the considered scenarios did not raise any systemically relevant concerns. However, it should be noted that this impact was added to the profit and losses calculated from the baseline market stress scenario. Therefore, there may be cases where this additional cost, though significant, would be added to clearing accounts that would experience limited losses or even profits from the given market scenario, muting the final impact from these additional risks. The CCPs should have dedicated risk management measures to prudently mitigate these risks. The potential impact from increased concentration, independently from the market scenario, is assessed in the concentration component section of this stress test report.

62. Overall, CCPs continue showing individual resilience when also considering the impact from market liquidation costs from concentrated positions as well as wrong way risk from cleared positions and collateral, further strengthening the confidence on the overall resilience of the system of CCPs.

3.2.3 Sensitivity test analysis.

63. When assessing the effect of changing the severity of risk factor shocks for both dates of the Cover-2 assessment of market scenario losses, no breaches of prefunded resources were identified when scaling by x1.2 and x1.5, with breaches only appearing when using a factor of x2. These results provide a positive assurance that CCPs have a strong margin of safety with respect to the shocks produced by the baseline ESRB market stress scenario, being able to withstand significant increases in severity before observing any breach of prefunded resources.

64. When assessing the effect of changing the severity of risk factor shocks for the Cover-2 assessment with concentration and wrong-way risk, the first breach appears when using a x1.5 scaling factor. This highlights the importance of considering costs from market liquidation costs and wrong-way risk. Nevertheless, the distance from the baseline stress shocks to the x1.5 scaled shocks provides comfort about the resilience of CCPs, given these shocks go significantly beyond the common market stress scenario shocks and in particular what was considered as extreme but plausible for the purpose of this exercise.

3.2.4 Reverse stress test analysis

65. In the reverse stress test analysis, the resilience of the system of CCPs is assessed by further stressing the underlying assumptions along three dimensions: (i) the number of defaulting clearing member groups (the same across all CCPs), (ii) the severity of market stress shocks, and (iii) the severity of market liquidation (concentration) costs.

66. While exploring the different combinations, the analysis goes intentionally beyond what is considered as plausible for the purpose of this exercise. The idea is to capture the sensitivity of the results to the considered stress scenarios and understand how the results are affected by changing the underlying assumptions. After all, although the baseline scenario is carefully modelled to simulate extreme market conditions, it is still subject to uncertainties and limitations, as is the case with all modelling procedures.

67. The aggregate (across all CCPs) amount of losses (in bn EUR) exceeding the required prefunded resources are presented below (Figure 7).

		Loss above Required Prefunded Resources (bil. EUR)				
		Number of Groups Defaulting				
		1	2	3	4	5
Shocks x 0.70	no conc	-	-	-	-	-
	conc x 0.70	-	-	-	-	-
	conc x 1.00	-	-	-	-	-
	conc x 1.20	-	-	-	-	-
	conc x 1.50	-	-	-	-	-
	conc x 2.00	-	-	-	-	-
Shocks x 1.00	no conc	-	-	-	-	-
	conc x 0.70	-	-	-	-	-
	conc x 1.00	-	Baseline	-	-	-
	conc x 1.20	-	-	-	-	-
	conc x 1.50	-	-	-	-	-
	conc x 2.00	-	-	-	-	-
Shocks x 1.20	no conc	-	-	-	-	0.4
	conc x 0.70	-	-	-	0.1	0.7
	conc x 1.00	-	-	-	0.2	0.8
	conc x 1.20	-	-	-	0.2	0.8
	conc x 1.50	-	-	-	0.3	0.9
	conc x 2.00	-	-	0.1	0.7	1.2
Shocks x 1.50	no conc	-	-	0.9	2.3	3.3
	conc x 0.70	-	0.1	1.3	2.7	4.2
	conc x 1.00	-	0.4	1.7	3.2	4.6
	conc x 1.20	-	0.5	1.9	3.5	4.9
	conc x 1.50	-	0.8	2.3	4.1	5.7
	conc x 2.00	-	1.2	3.0	5.2	7.2
Shocks x 2.00	no conc	1.0	3.8	7.1	10.3	13.5
	conc x 0.70	1.2	4.8	8.7	12.6	16.8
	conc x 1.00	1.2	5.6	9.7	14.0	19.3
	conc x 1.20	1.3	6.1	10.4	15.5	21.2
	conc x 1.50	1.3	6.8	11.8	18.3	24.2
	conc x 2.00	1.5	8.0	15.4	23.1	29.3

FIGURE 7: REVERSE STRESS TEST – DATE: MARCH 2023

68. Overall, it is observed that the main drivers of stress for CCPs are the losses from market moves (risk factor shocks). Using the baseline market stress shocks, there are no breaches independently of the number of groups defaulting or the severity of the modelled market liquidation costs.

69. Under the cover-2 assumption (the same two member groups defaulting at all CCPs), the first breaches only appear when market shocks are scaled up by 50% and concentrated costs are added. When assuming a higher number of member defaults, there are shortfalls already when market stress shocks are scaled-up by 20%.

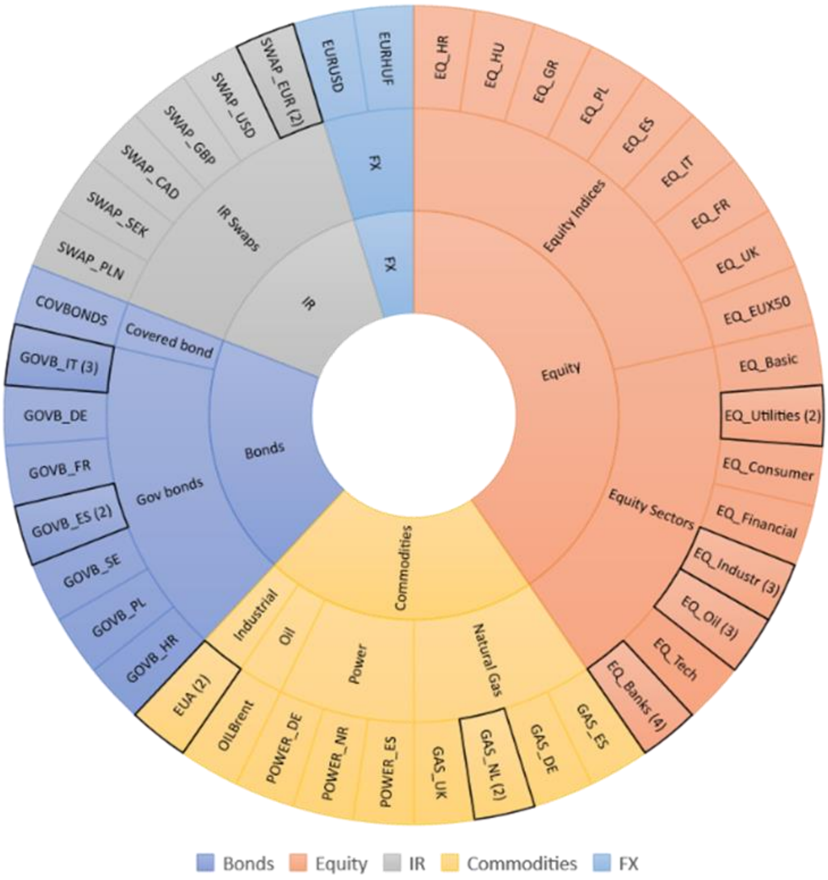
70. Market liquidation costs from concentrated positions increase the size of breaches, however the main driver of losses is the severity of assumed market stress shocks. Incremental increases in market risk shocks severity are more impactful than increases in the number of defaulting groups or in the severity of the assumptions underlying the market liquidation costs. Stressed market liquidation costs stemming from concentrated positions prove to have a significant impact but are absorbed for baseline market stress scenarios, also by the buffer

created due to the currently increased margin resources (see Analysis of Resources in 7.2). Continuous diligence is warranted for CCPs and supervisors on the calibration of resources meant to mitigate risks from such highly concentrated positions.

71. Overall, the results of the sensitivity and reverse stress test analyses confirm the resilience of CCPs and indicate that the results don't materially change when applying small changes to the parameters; losses of prefunded resources only appear when the parameters are substantially changed by increasing beyond the levels of the baseline stress scenario.

3.2.5 Cover-2 assessment with additional scenarios

72. As a first step for the identification and construction of the relevant additional market stress scenarios, an analysis is performed to identify which are the top risk factors for each CCP in terms of risk weighted exposure. The following graph provides an overview of the top risk factors selected across all CCPs, also indicating where a risk factor was amongst the top risk factors for more than one CCP.



(Number of CCPs for which this is a key risk factor, where > 1)

FIGURE 8: OVERVIEW OF TOP RISK FACTORS IDENTIFIED ACROSS CCPS

73. This analysis indicates that there is overall a limited overlap of top risk factors among CCPs, with most risk factors being amongst the top risk factors for only one CCP. In most of the cases, each CCP seems to have its own top risk factors indicating a reduced probability of shocks in one of those risk factors triggering pressure on multiple CCPs at the same time. There are, however, important exceptions, where two or more CCPs are significantly exposed to the same

top risk factors. For these cases, extreme shocks on these risk factors could potentially trigger system-wide events. Such risk factors with potential systemic implications are EUR interest rate swaps, two energy-related commodities (TTF natural gas and European Union Allowances, EUA), some equity sectors (banks, oil, industrials, utilities) and government bonds.

74. This highlights the importance of complementing the analysis with additional scenarios that can create stress in the most relevant risk factors of each CCP. The results for the cover-2 assessment with additional scenarios are presented in an aggregated manner, reflecting through a box plot, the distribution of the maximum percentage default fund consumption across all CCPs for each scenario, split by type of scenario (historical and scaled-up / inverse / sampled hypothetical).

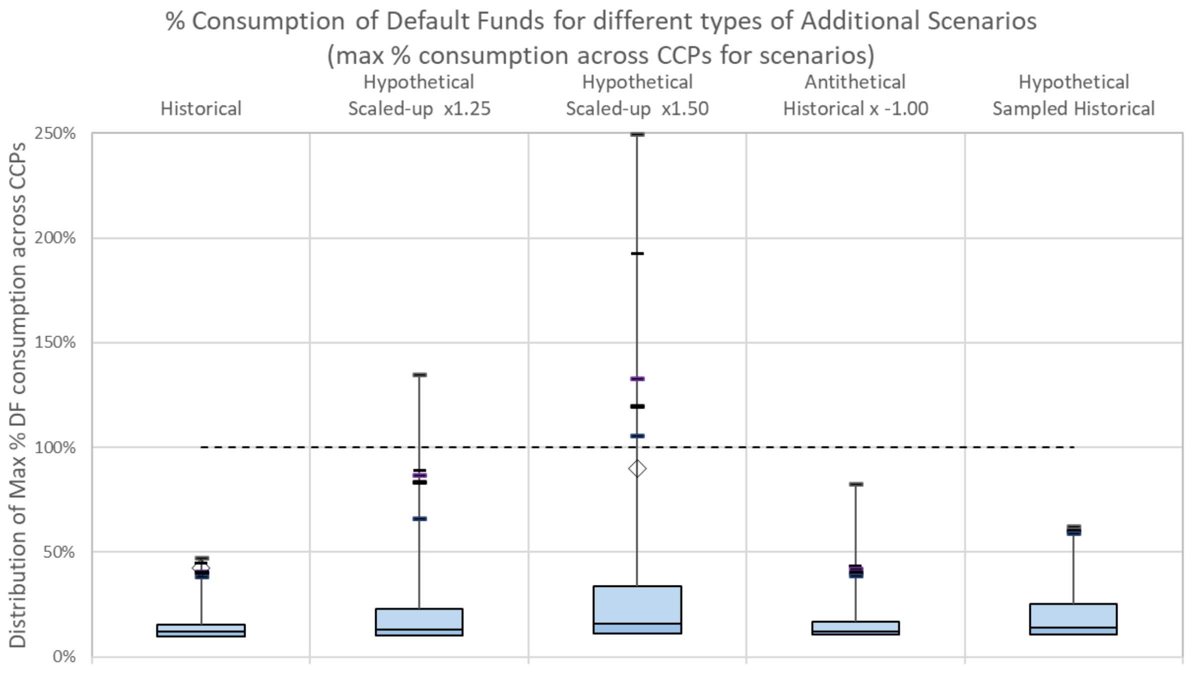


FIGURE 9: COVER-2 ASSESSMENT WITH ADDITIONAL SCENARIOS – DATE: MARCH 2023

75. In Figure 9, there are five box plots reflecting the distribution of the maximum percentage default fund consumption across all CCPs for each type of scenario (e.g. the first box shows the distribution of results for all historical scenarios tested and for all CCPs in scope). For each box plot, the lower side of the rectangle indicates the 25% quantile of the results distribution, and the upper side of the rectangle indicates the 75% quantile of the results distribution, with the horizontal line inside the rectangle indicating the median value. The top 5 highest consumptions are indicated with 5 black marks across the vertical line on top of the blue boxes. Additionally, in the historical and hypothetical scaled-up x1.5 scenarios, there is a white diamond indicating the maximum consumption produced for any CCP by the ESRB scenario and scaled x1.5 ESRB scenario respectively.

76. The results indicate that no CCP would breach the 100% mark of default fund contribution for the selected historical scenarios, providing further confidence that CCPs are resilient to a broad set of extreme but plausible scenarios. A very limited number of shortfalls would appear when shocks are scaled up beyond observed historical moves. In particular, there would be a shortfall under one scenario and one CCP when historical stress shocks are further increased by 25% and there would be shortfalls under six scenarios and three CCPs when historical stress shocks

are further increased by 50%. It is also important to note that none of these impactful hypothetical scaled-up scenarios would affect more than one CCP at the same time, confirming that there is overall limited overlap in terms of significant exposures to similar products / risk factors. These results have not been reconciled with CCPs. Nevertheless, ESMA plans to follow-up, in cooperation with relevant supervisors, with CCPs that exhibited a hypothetical shortfall under one of those scenarios to confirm modelled assumptions, plausibility of calculated results, and assess the need of remedial actions.

77. The results complement the core market stress test with an exploratory analysis of the impact of additional historical and hypothetical scenarios. The inverse and sampled hypothetical scenarios provide insights on how resilient CCPs are to opposite direction movements and shocks modelling correlation breaks with respect to historical relationships. The distribution of the default fund consumptions under the inverse hypothetical scenarios is very similar to the one of the historical scenarios. On the other hand, the distribution under the sampled hypothetical scenarios is more skewed towards higher consumptions, showing higher median and quartile values. Overall, the results are again positive, with no breach observed across the tested scenarios. These results indicate that CCPs are resilient to stress shocks of magnitudes observed in historical data paired with the tested correlation breaks.

78. However, a number of important limitations should be highlighted. Concentration and wrong way risk costs have not been considered for this analysis. Moreover, not all possible scenarios and co-movements are explored as it is not possible to cover all possible combinations for all CCPs. The range of scenarios explored is restricted by the granularity of the considered risk factors. The identification of relevant theoretical scenarios is based on the positions reported for one day, different positions would give rise to different scenarios being identified as relevant. One needs to also be careful when interpreting the results. On the one hand when anchoring the plausibility assessment on only what has happened in the past, and on the other hand assuming that what has happened in the past is still plausible at current market conditions. This is why the results are presented in the form of a sensitivity analysis. Finally, the accuracy of the results using the theoretical scenarios is restricted by using first-order sensitivities and using position data with reduced granularity compared to the data used internally by CCPs. In this sense, the results will not have the same level of accuracy as those computed through full revaluation and full product specifications by CCPs for the common stress scenario.

3.3 Conclusions

79. Overall, the results across the different tests indicate a resilient system of CCPs. These findings are supported by the exhibited sufficiency of prefunded resources to withstand the shocks of the baseline ESRB market stress scenario across dates, taking also into account additional costs from market liquidation costs from concentrated positions and wrong-way risk. Nevertheless, it should be noted that the observed high level of margin collateral that was available during the reference period has strengthened the resilience of CCPs and may have benefited their performance in some tests of this exercise. Findings could be reversed in the future in case of more benign market conditions.

80. Where scenarios assumed the default of the same 2 groups for all CCPs system-wide, most CCPs did not experience a significant stress. This indicates that while CCPs are highly interconnected, the exercise did not highlight any pairs of groups that are at the same time and under the common tested scenario highly impactful at multiple CCPs. The analysis of top risk factors across CCPs has highlighted limited overlap of top risk factors among CCPs, with most risk factors being amongst the top risk factors for only one CCP. Nevertheless, a selected group

of risk factors is amongst the top risk factors for more than one CCP, hence potentially deserving specific attention.

81. Overall, the results using additional scenarios also confirm that CCPs are resilient against an extended set of market and correlation breakdown shocks based on some of the most severe historical market stress events. Only for a few hypothetical scenarios and where shocks were scaled up beyond historically observed levels, some CCPs would have experienced theoretical breaches. None of these impactful hypothetical scaled-up scenarios would affect more than one CCP at the same time, confirming that there is overall limited overlap in terms of significant exposures to similar products / risk factors. These results have not been reconciled with CCPs. Nevertheless, ESMA plans to follow-up, in cooperation with relevant supervisors, with CCPs that exhibited a hypothetical shortfall under one of those scenarios to confirm modelled assumptions, plausibility of calculated results, and assess the need of remedial actions.

82. Sensitivity analysis and reverse stress testing has shown that substantial additional stress is needed to breach CCPs resources, which strengthens the confidence in the resilience of CCPs.

4 Concentration risk analysis

4.1 Objectives and overview of methodology

83. The objective of the concentration risk analysis is to assess the potential liquidation costs associated with clearing member positions that are large relative to market capacity. Liquidating these positions in a short time frame after the member's default might generate an adverse price impact on top of exogenous market moves. The cost due to this additional market impact needs to be factored in beyond the losses caused by the market moves as modelled in the credit risk analysis.

84. The positions in scope for the analysis cover securities (equities and bonds) as well as derivatives (equity, interest rate, inflation, FX, bond, credit, commodity, freight and emission allowance). A limited number of positions were excluded from the analysis as not deemed material[7].

Overview of the Methodology

85. The estimation of liquidation costs is based on reports provided by CCPs which detail clearing member positions in aggregation buckets defined according to a specified taxonomy for each asset class[8]. For each member's positions in each bucket, a relative position size was calculated as a ratio of the position to the respective market capacity as defined by the average daily volume or notional amount. If the position size is above a specified threshold, the position is defined as concentrated. The market impact for the concentrated positions is then calculated first at bucket level, by charging to the position a unit liquidation cost that is determined as a function of the position size. The market impact at member level is the sum of those for the bucket-level concentrated positions.

86. The functions mapping position sizes to unit liquidation costs are specific for each asset class. The functions were calibrated by ESMA aggregating submissions provided by the different CCPs as part of the original data request. The aggregation was based on the average of the CCP submissions, weighted by the size of each CCP's positions in the respective asset class, subject to data quality checks. A scaling factor was applied in some cases to correct for potential model risk in the process[9].

87. The source for average daily volumes or notional amounts was the systematic internaliser data published by ESMA, when this was available, and subject to data quality checks. In other cases, the reference volume was set using the CCP's own submitted data, which reflect the markets the CCP can readily access and for which it has in place the operational arrangements to readily execute transactions. In the limited number of cases where CCPs were not able to provide volume information, ESMA populated this based on indicators for comparable securities.

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[7] These were mainly dividend and volatility derivatives, forward-starting repos, and a small number of securities or structured products.

[8] For securities, the buckets are defined by the ISIN. Single-stock equity derivatives were aggregated with equity positions based on the underlying ISIN. For equity index, FX, bond, credit and FX derivatives, the buckets are defined by the underlying. For commodity, freight and EUA, the buckets are defined by the underlying commodity, settlement type and currency, and maturity. For interest rate and inflation derivatives, the buckets are identified by currency and maturity.

[9] For more details on the aggregation methodology, and a selection of unit liquidation cost functions for the most material asset classes, see Sections 8.6 and 8.7 in the Annex.

Key Assumptions for the Concentration risk analysis

88. Due to the relatively low frequency of events of large market liquidation, and the difficulty in separating liquidation costs from general market moves even when these events do occur, the observability of liquidation costs is limited, both in terms of their magnitude and their structure. For this reason, the methodology makes various assumptions in modelling these costs, with the main ones listed in the following. Please refer to the model risk section (4.3) for tests designed to highlight the materiality of these assumptions.

89. The methodology models the liquidation of the defaulter's positions with a bottom-up approach, adding up costs calculated separately per bucket, rather than attempting to model the costs resulting from the application of the CCP's default management procedure. This might follow different approaches such as auctioning macro-hedged portfolios and include additional steps, leading to larger or smaller costs overall.

90. The methodology relies on one particular taxonomy of specified buckets within each asset class. Different taxonomies or granularities for positions and/or liquidation costs might produce a different result.

91. Liquidation costs are estimated on the basis of the combination of cash positions and delta positions only for derivatives, ignoring costs deriving from option vega and other sensitivities, including any higher-order product risks.

92. Clearing positions and all the non-cash collateral of the defaulting clearing member are assumed to be liquidated at the same time, factoring in any interactions between the two.

93. The methodology assumes that all clearing member positions are liquidated at the same time, including house and client accounts. This is equivalent to no porting and can lead to larger or smaller costs compared to alternative porting assumptions.

94. Clearing members that are part of the same group are assumed to default simultaneously, and therefore the liquidation cost is calculated for the combined position of all the relevant member portfolios. The cost is then apportioned back to the different clearing members and their client / house accounts.

95. The methodology assumes a specific functional form for unit liquidation costs, with explicit values provided for standard liquidation sizes between 25% and 200% or 500% (depending on the asset class) of the average daily volume or notional amount, and piecewise linear interpolation in between. For position sizes smaller than 25%, liquidation cost is assumed to be zero, and for positions sizes greater than 200% or 500% unit liquidation costs are extrapolated as flat.

96. Finally, the aggregation of CCPs' submissions into a common unit liquidation cost function is in itself a model with its assumptions and potential model risk. For more detail, refer to the Annex 8.7.

4.2 Results

97. The main objective of the concentration risk analysis is to assess the adequacy of CCPs' resources in covering the cost of liquidating concentrated positions. In order to do so, the exercise computed the total market impact from concentration as the sum of clearing member-level figures calculated according to the methodology detailed above. This was then compared with the concentration add-ons reported by the CCPs.

98. Adding up the market impact for positions of all clearing members is not a meaningful measure of the potential market impact faced by CCPs in any specific situation, since the individual figures relate to separate events, that is, the default of clearing members, that are not likely to occur simultaneously. However, the sum of the market impact measures the overall resources that the CCP collected to cover liquidation costs resulting from concentrated positions.

99. The adequacy analysis was conducted at different levels of aggregation. As a first overview, the analysis considers the system-wide distribution of add-ons collected by all CCPs per asset class, and the corresponding distribution of the market impact of concentration risk across all asset classes for all CCPs.

100. The adequacy analysis then continues by comparing market impact and add-on at CCP level, and finally at asset class level separately per CCP.

4.2.1 System-wide concentration add-ons and market impact

101. Figure 10 shows the aggregated system-wide concentration add-ons collected by all CCPs and the aggregated system-wide market impact calculated by ESMA, broken down per asset class on a consistent basis. Interest rate derivatives account for the largest share of concentration add-ons and market impact at around 41bn EUR and 33bn EUR in total respectively. Note that the concentration add-ons more than cover the market impact for this asset class. The second largest share of add-ons and market impact is for bonds, with the add-ons at 16bn EUR again greater than the aggregated market impact at 11bn EUR. For the next asset classes the situation diverges, with stocks and equity derivatives coming third in terms of add-ons at 9bn EUR and significantly lower market impact at 4bn EUR, while for commodity derivatives the add-on of 6bn EUR is smaller than the 9bn EUR market impact.

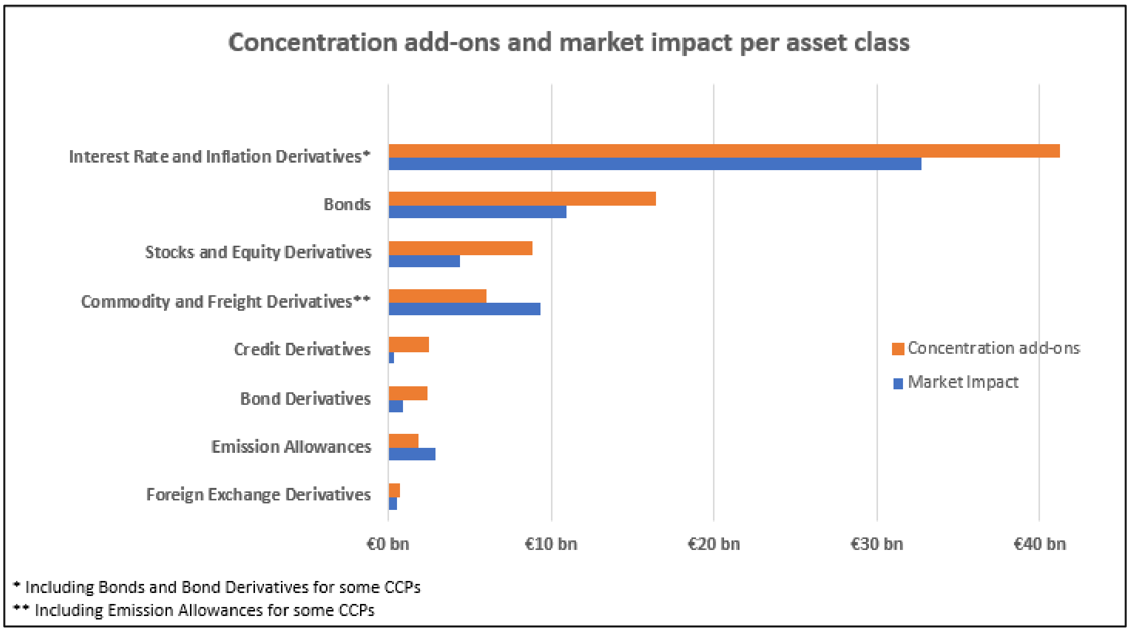

FIGURE 10: CONCENTRATION ADD-ONS VS MARKET IMPACT PER ASSET CLASS IN BN EUR EQ.

102. When examining the breakdown of the concentration add-ons at individual CCPs (Figure 11), it can be seen that for many asset classes, one CCP accounts for the majority of the concentration add-on collected across the market. This is the case for interest rate derivatives and foreign exchange derivatives with LCHUK as the dominant CCP, bonds with LCHSA, commodity derivatives and emission allowances with ICEEU and bond derivatives with ECAG. For stocks and equity derivatives, and credit derivatives, the distribution of add-ons is not dominated by a single CCP. The distribution of market impact shows a similar pattern.

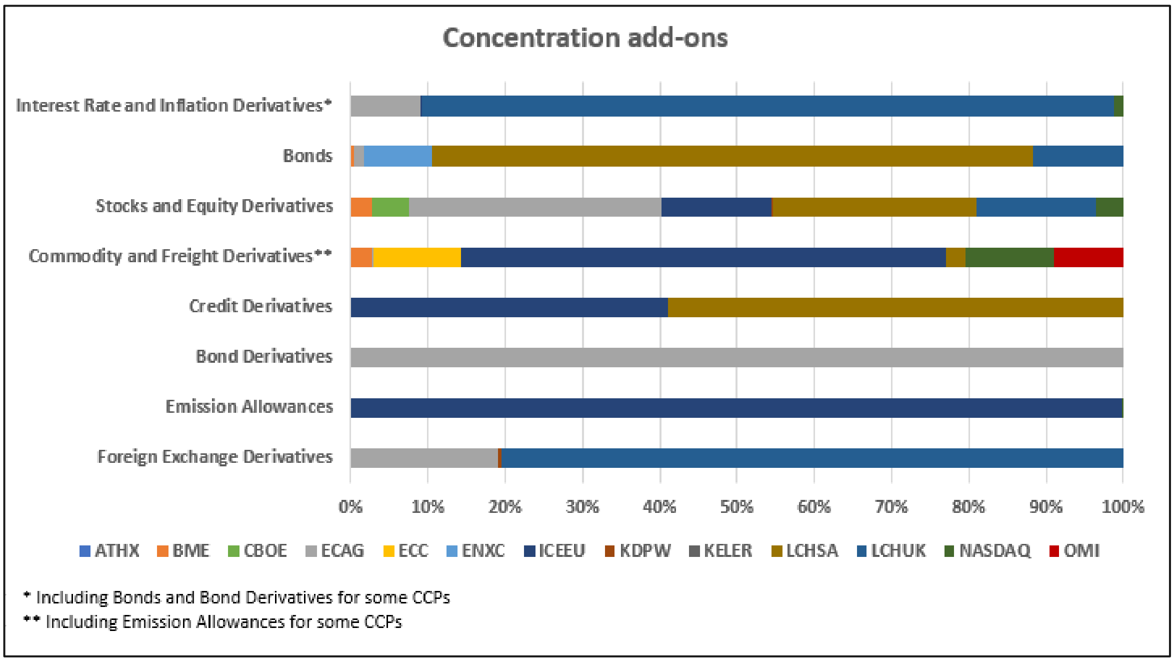

FIGURE 11: CONCENTRATION ADD-ONS PER ASSET CLASS AND CCP IN BN EUR EQ.

4.2.2 CCP-level coverage

103. Depending on the CCP, the aggregated concentration add-on at CCP level across asset classes is greater or smaller than the total estimated market impact. Figure 12 presents the result of the comparison, in three separate groups defined by order of magnitude of the add-on and market impact, and with the CCPs ordered by market impact within each group.

104. The CCP-level concentration add-on is greater than the market impact for LCHUK, LCHSA, NASDAQ, BME, CBOE, OMI, KDPW and ATHX. It is smaller for ECAG, ICEEU, ECC, ENXC, KELER, CCPA. In particular, KELER, CCPA and SKDD have not reported collecting concentration add-ons, therefore for these CCP any market impact is by definition in excess of the add-on.

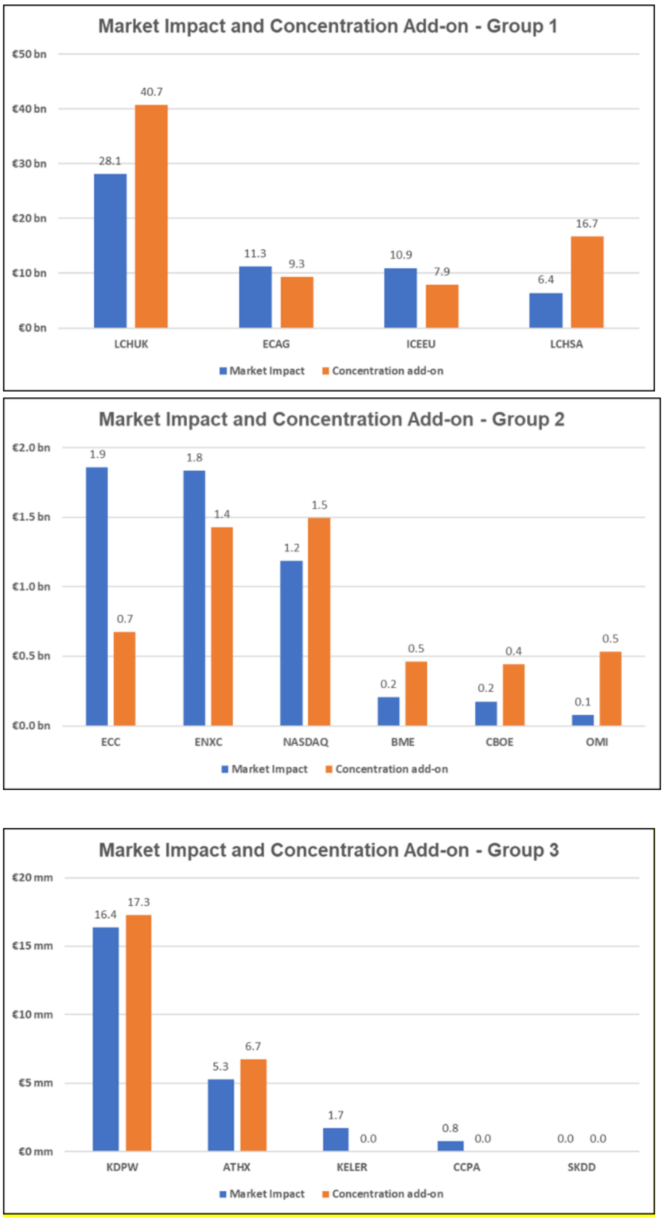

FIGURE 12: CONCENTRATION ADD-ONS VS MARKET IMPACT PER CCP IN BN EUR EQ.

4.2.3 Asset class-level coverage

105. For most asset classes, the results indicate significant variability in the coverage of modelled market impact with concentration add-ons, with the modelled market impact exceeding the add-on for some CCPs and falling below it for others.

106. This section presents the comparison for the most material asset classes. The modelled market impact and concentration add-ons are presented as normalised by the initial margin required by the CCP for that asset class. This highlights the magnitude of concentration risk in relation to market risk, and it allows for comparisons across positions that may be very different in absolute size. However, it is important to keep in mind that normalised figures that appear comparable in these charts may in fact have vastly different scale and impact in financial terms. The focus on individual asset classes can increase the relative importance of the model assumptions listed earlier, if these act in a systematic direction on certain subsets of positions.

107. For interest rate and inflation derivatives, Figure 13 shows that the add-on is greater than the modelled market impact at BME and LCHUK, and smaller at ECAG, ICEEU, KDPW, and NASDAQ. In absolute terms, the largest of these gaps are at ECAG[†] for 2bn EUR and NASDAQ for 191mn EUR respectively. Note that the figures for NASDAQ include the CCP's positions in bonds and bond derivatives.

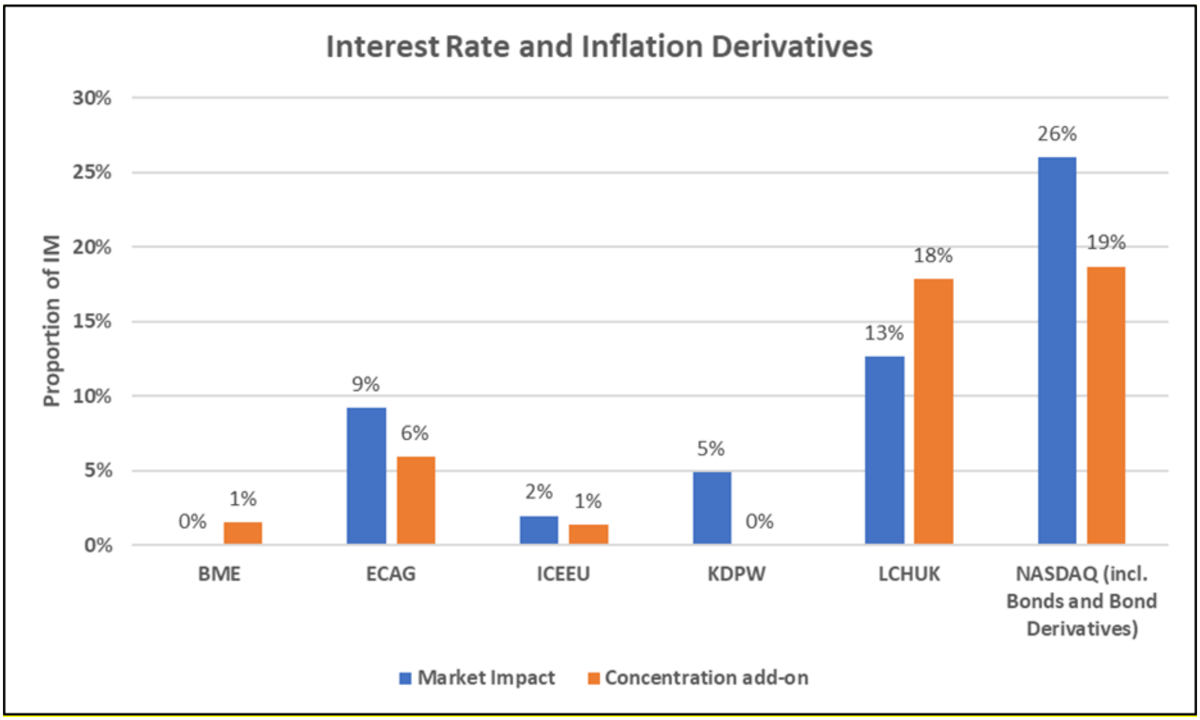

FIGURE 13: CONCENTRATION ADD-ONS VS MARKET IMPACT PER CCP FOR INTEREST RATE AND INFLATION DERIV.

108. For bonds, Figure 14 again shows variability across CCPs, with the add-on covering the modelled market impact at BME, KDPW, LCHSA and LCHUK, and shortfalls of different magnitude at ATHX, CBOE, ECAG, ENXC, KELER and SKDD. The largest of these gaps in absolute terms are for ECAG for 1.9bn EUR and ENXC for 350m EUR. The shortfall noted at

† Corrected on 10 July 2024

CBOE appears very large in relative terms, but it is modest at 36mn EUR in absolute size. The figure results from the treatment of ETCs. Unusually across CCPs, for CBOE these account for the near-entirety of the CCP's bond positions, and are handled conservatively by the market impact methodology. The relative size of the shortfall may have been exacerbated further by the approach used by CBOE to identify initial margin for bonds in portfolios containing a greater variety of products.

109. For CCPA, ECC and ICEEU, a market impact was recorded for the liquidation of bond collateral. However, ECC and ICEEU do not clear bonds, while CCPA does so only to a minimal extent. For this reason, the CCPs do not have a dedicated concentration add-on, nor an asset-class level initial margin to scale the figures against. The resulting gap was 106mn EUR for ICEEU, 27mn EUR for ECC and only 9k EUR for CCPA.

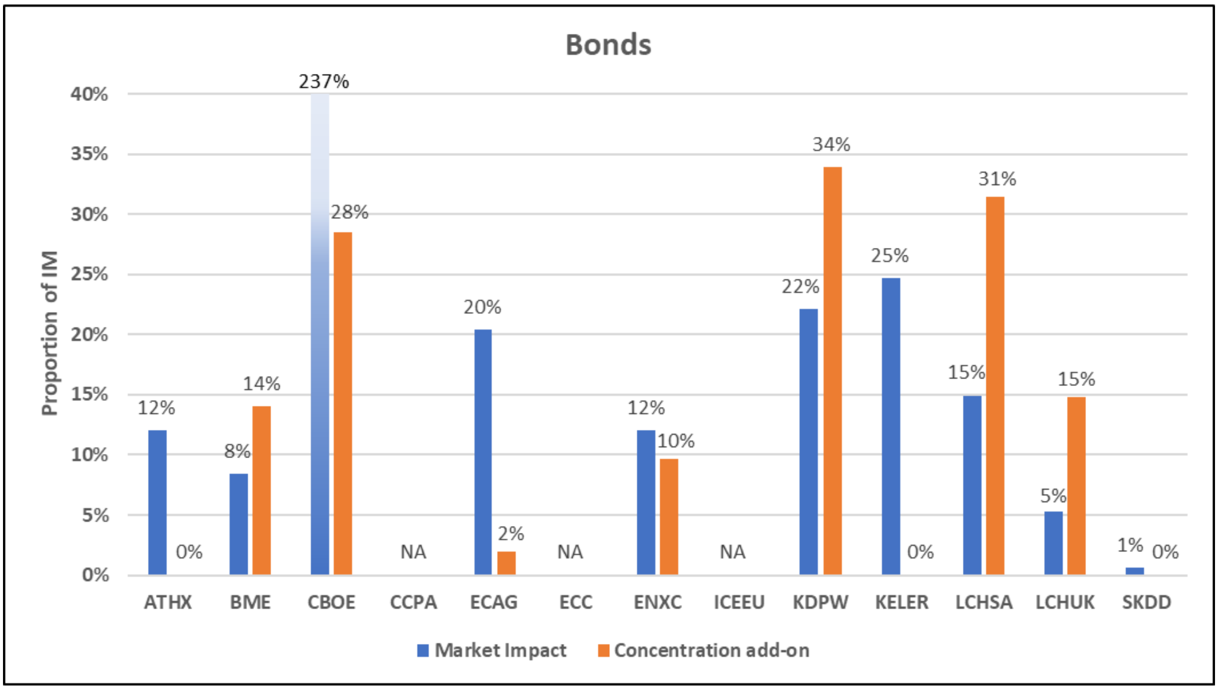

FIGURE 14: CONCENTRATION ADD-ONS VS MARKET IMPACT PER CCP FOR BONDS

110. For equity and equity derivatives (Figure 15), all the CCPs that charge a specific add-on for this asset class were able to cover the modelled market impact. The large difference observed for LCHSA is due to methodological differences, particularly the inclusion in the CCP add-on of a component considering potential settlement fails. By contrast, CCPA, ENXC and KELER do not charge an add-on for this asset class, therefore the market impact by definition generated a shortfall. The largest of these shortfalls was for ENXC at 57m EUR, while for CCPA and KELER the figures were 759k EUR and 639k EUR respectively.

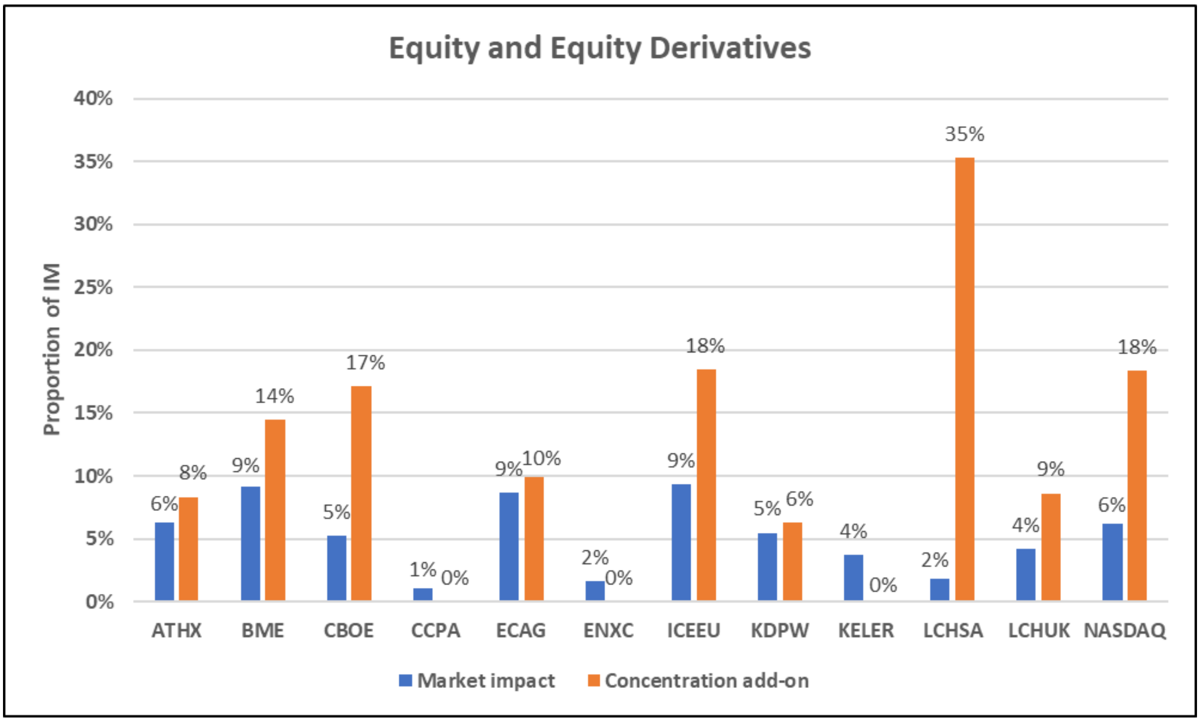

FIGURE 15: CONCENTRATION ADD-ONS VS MARKET IMPACT PER CCP FOR STOCKS AND EQUITY DERIVATIVES

111. For commodity, emission and freight derivatives (Figure 16), the picture is once again mixed, with concentration add-ons covering the modelled market impact for BME, ECAG, LCHSA, NASDAQ and OMI, and significant shortfalls at ICEEU† and ECC†† for 4.4bn EUR and 1.2bn EUR respectively. For both these CCPs, energy products make up the bulk of the clearing positions and of the shortfall in this asset class, although at ICEEU there is also a significant contribution from emissions. ATHX, KELER and ENXC do not charge a concentration add-on for this asset class, but the modelled market impact was modest at 81k EUR for ATHX and zero for KELER and ENXC.

† Corrected on 10 July 2024
†† Corrected on 10 July 2024

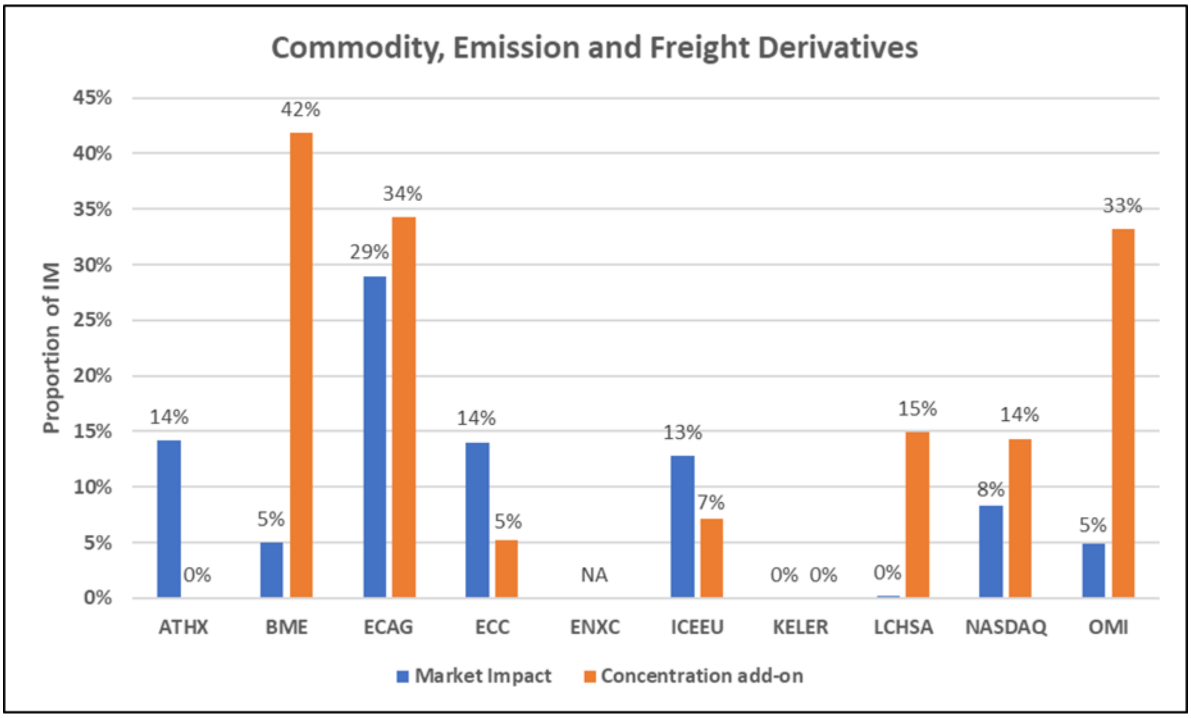

Figure 16: Concentration add-ons vs market impact per CCP for Commodity, Emission and Freight Derivatives

112.In concluding the adequacy analysis, it is worth pointing out that aside from the limitations already highlighted with respect to the methodology for calculating market impacts, comparisons at this level of aggregation may not capture the variability of concentration add-ons in relation to market impact at clearing member level. Even where the concentration charge was deemed adequate to cover the modelled market impact at CCP or asset class level, shortfalls may still exist for individual clearing members. In the case of the members' default, these shortfalls could become relevant irrespective of the add-on adequacy at aggregate level. This is assessed in the credit stress test (3.2.2) in the assessments where the concentration market impact is incorporated. The results have not raised any concerns in this respect. A related consideration is that CCPs may not charge concentration add-ons for clearing members considered at particularly low risk of default, such as government debt management agencies. Where this is the case, the market impact calculated for these clearing members will not be covered by an add-on. This may contribute to some of the shortfalls noted in this section.

4.3 Model risk

113.The following charts present the results of sensitivity testing for some of the modelling assumptions used in the calculation of market impact. These are obtained by comparing the modelled market impact calculated with the baseline model versus an alternative calculation where the assumptions have been modified.

Specification of the unit liquidation cost function

114.Several of the assumptions concern the analytic expression of the unit liquidation cost function. Two of these are to do with the treatment of position sizes outside the range for which the function explicitly provides a value, that is [25%, 200%] or [25%, 500%] depending on the asset class.

115. For positions smaller than 25%, the baseline model assigns no liquidation cost. To test the materiality of this choice, Figure 17 presents the effect on the modelled market impact of two alternative calculations, where the unit liquidation costs were extrapolated linearly down to 20% and 10%. The effect is very modest in relative or absolute terms, and frequently both, for most CCPs. Note that the result of this test may have been dampened by the requirement for CCPs to not report bonds and equity positions below certain thresholds. In any case, it is reasonable to expect that different assumptions on the treatment of small positions would only have limited impact on the modelled market impact of concentration.

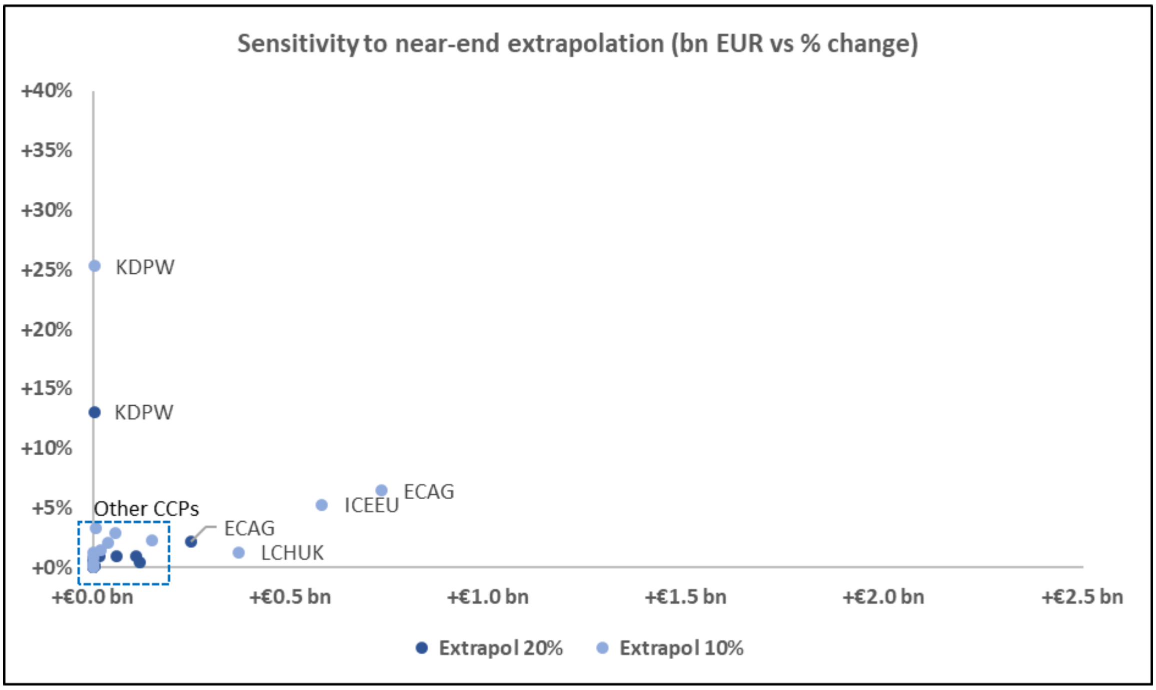

FIGURE 17: SENSITIVITY TO NEAR-END EXTRAPOLATION PER CCP IN ABSOLUTE AND RELATIVE AMOUNTS

116. A second model choice is to extrapolate the unit liquidation costs beyond 200% or 500% (depending on the asset class) on a flat basis. To test the materiality of this choice, Figure 18 presents the effect on the modelled market impact of two alternative calculations, where the unit liquidation costs were extrapolated linearly, first up to 250% or 600%, and then up to 300% or 700%. The effect is significantly more material for many CCPs, with meaningful differences across CCPs in the relative size of the effect. For example, the relative size of the effect for LCHSA is close to three times that for LCHUK, leading to a not dissimilar absolute impact. Naturally, other modelling choices are also possible for far-end extrapolation. Unlike for the case of near-end (<25%) extrapolation, these modelling choices apply to large positions and could generate a range of results significantly beyond that observed in the test.

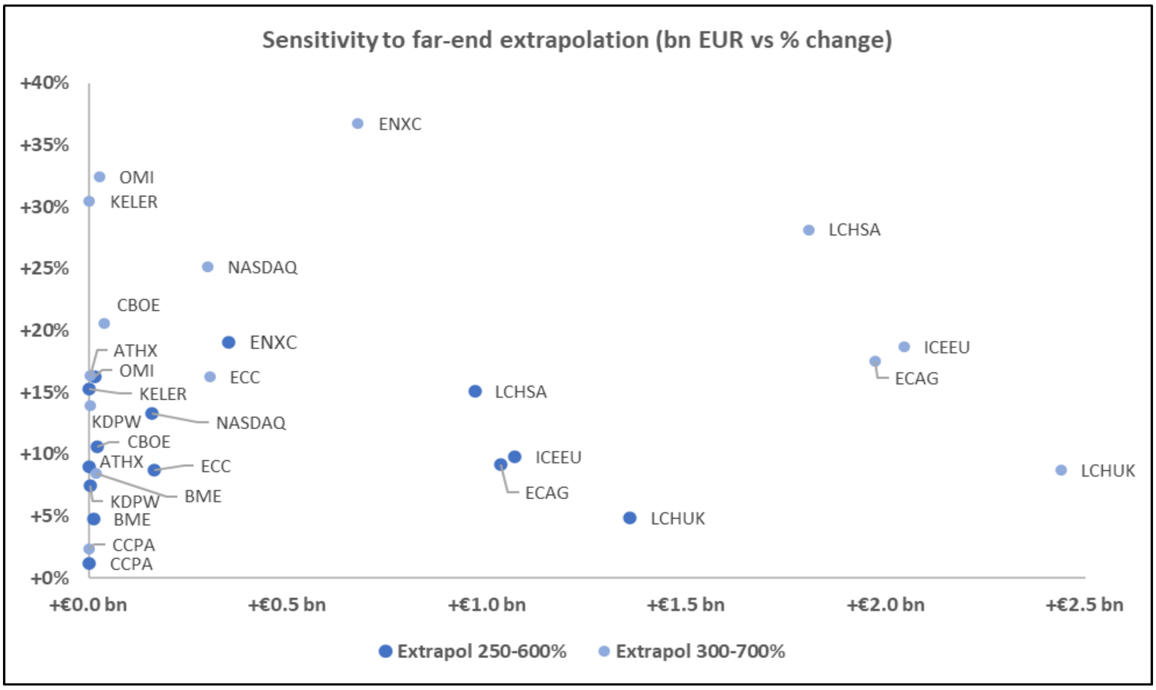

FIGURE 18: SENSITIVITY TO FAR-END EXTRAPOLATION PER CCP IN ABSOLUTE AND RELATIVE AMOUNTS

117. In a further sensitivity test, the average daily volumes and notional amounts (market capacity) were scaled down by 20%. This can be seen as a test on the value of these data points themselves, since they are not immune from estimation error, but it is also equivalent to translating the pillar points of the liquidation cost functions, for example assigning the baseline liquidation cost for a position size of 100% to a position size of 80%. The results of this test are presented in Figure 19. The sensitivity to this assumption is material in absolute terms for some CCPs. This is often driven by the size of the baseline market impact, although there is also some variability across CCPs in the relative size of the impact.

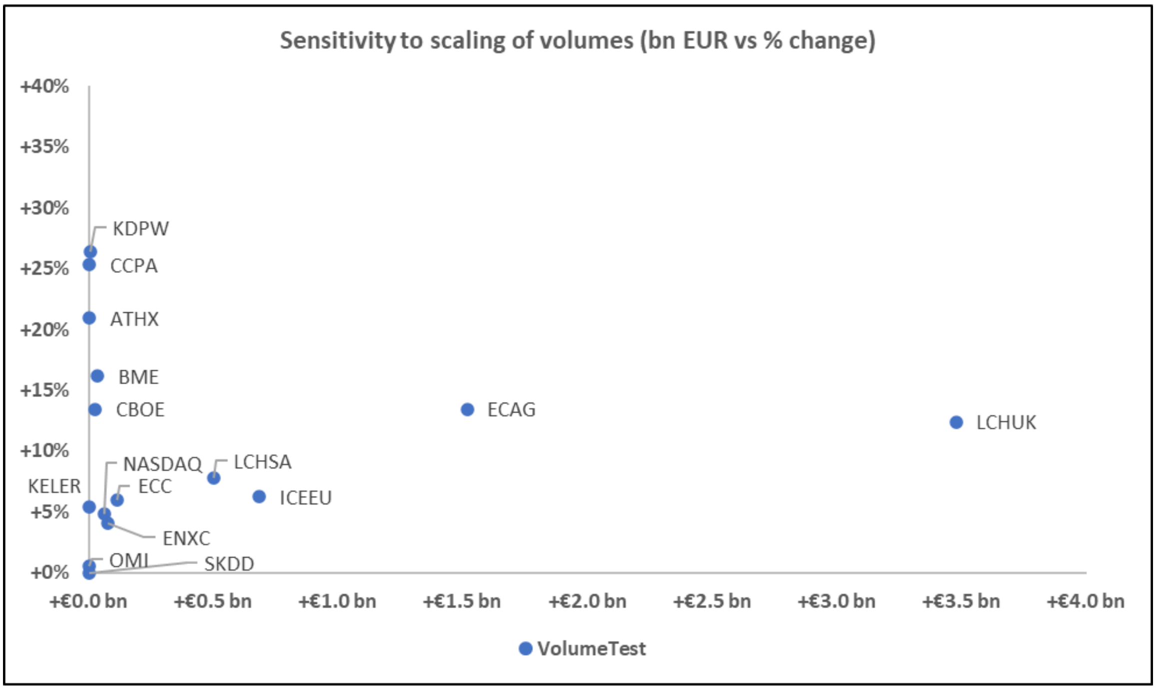

FIGURE 19: SENSITIVITY TO SCALING OF VOLUMES PER CCP IN ABSOLUTE AND RELATIVE AMOUNTS

118.Finally, a further model test investigated the effect of using an alternative formulation for the unit liquidation cost function, based on a different (non-linear) and independently calibrated analytical expression. The function was developed in an ECB working paper[10] and calibrated for a number of individual securities. A description of the model is included in Annex 8.8. The results in the below table (figures in bn EUR) show that this alternative approach would be more conservative than the baseline model. Note that the overlap between the two models in terms of securities is partial, and it includes a systematic component in that the alternative model coverage is focused on European securities.

Asset Class	**Market impact (ESMA model)**	**Market impact (alternative model)**
Bonds	4.27	9.89
Equity	0.73	0.88

Offsetting assumptions

119.A second set of assumptions concerns the modelling of liquidation costs for portfolios of correlated products. The baseline model market impact is calculated adding up the liquidation costs calculated separately per product bucket, where the definition of buckets is rather granular, particularly for some asset classes such as commodity. By contrast, the default

[10] Fukker, G., Kaijser, M., Mingarelli, L. and Sydow, M., Contagion from market price impact: a price-at-risk perspective, ECB Working Paper no 2692, Aug 2022

management policies of CCPs frequently involve the packaging of positions into portfolios, and the hedging of such portfolios on a global basis rather than bucket by bucket, before progressing to an auction. This allows for a degree of offsetting across positions in the liquidation phase.

120.The materiality of these assumptions in the baseline model was assessed using as a test case energy products, which make up the largest sub-asset class of commodity. The product buckets were relaxed in three incremental stages. In the first stage, the separation by settlement type and denomination currency was removed. In the second stage, the separation by maturity bucket was also removed. In the third stage, the buckets were widened further by grouping together underlyings in broad product segments[11], assuming that the different underlyings in each segment can act as a perfect hedge for one another. At each stage the market impact for energy products was recalculated with the new wider bucket definition, that is, allowing offsetting across a gradually wider range of positions, and compared against the baseline market impact for energy products.

121.The results reported in Figure 20 indicate that these assumptions can have a very material effect for CCPs with complex and diverse portfolios. For both ECC and ICEEU, the significant shortfalls observed in the concentration add-on compared to the baseline market impact reduce sharply as greater offsets are permitted, with the modelled market impact ultimately falling well below the CCP concentration add-on. For the remaining CCPs, the effect is much less pronounced. In any case, the starting point for these CCPs is a concentration add-on already well in excess of the market impact resulting from the baseline model. The difference in observations for the two groups of CCPs is directly correlated with the breadth of the respective product offerings and the typical complexity of members portfolios. These provide more scope for offsetting benefits.

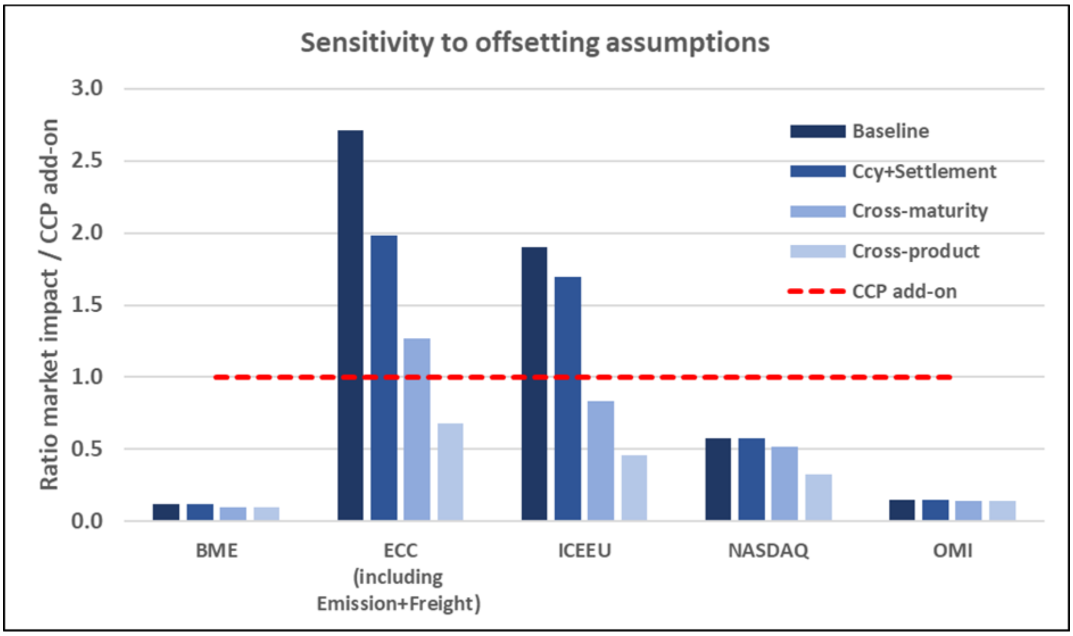

FIGURE 20: SENSITIVITY TO OFFSETTING ASSUMPTIONS ON ENERGY DERIVATIVES, PER CCP

122.It should be stressed that the sequence of models resulting from this approach was only considered for the purpose of assessing the materiality of different offsetting assumptions,

[11] Product segments defined as European Gas, US Gas, WTI, Brent, Gasoil, European Power, US Power.

rather than as alternative models in their own right. While it is reasonable to consider a degree of offsetting across the buckets of the baseline model, this is unlikely to fully eliminate the risk. A well-specified model would need to factor in the potential limitations of this approach and the resulting residual risk, rather than treat different positions as fully fungible. This is increasingly relevant as the bucket definition broadens during the process. Particularly in the last stage, the assumption that different underlyings can be substituted for one another ignores the potentially large risk of idiosyncratic moves in events of market disruption.

123. Nevertheless, the test clearly highlights offsetting assumptions as a major determinant of concentration charge requirements for CCPs with diverse portfolios. The results are likely to extend beyond the commodity asset class that was used here as a test case.

Impact of non-cash collateral

124. The baseline model assumes simultaneous liquidation of clearing positions and non-cash collateral for any defaulting clearing member. In reality, collateral may be liquidated only in part, or not at all. The inclusion of collateral liquidation costs is also a methodology change relative to previous iterations of the ESMA CCP stress test exercise. For this reason, a sensitivity test was run to isolate the additional contribution of collateral liquidation to the baseline market impact calculated on clearing positions only in the same asset class. The test was conducted separately for bond and equity collateral and clearing positions.

125. For bond collateral, the results in Figure 21 indicate a material impact in absolute terms for some CCPs, with the largest contributions as 366mn EUR for ECAG, 336mn EUR for LCHUK, 106mn EUR for ICEEU and 83mn EUR for LCHSA. In relative terms, these amounts are of limited materiality for LCHSA and ECAG, but for LCHUK the consideration of bond collateral causes the market impact calculated on bond clearing positions to approximately double. For ICEEU and ECC, a relative impact cannot be calculated since the CCPs have no bond clearing positions.

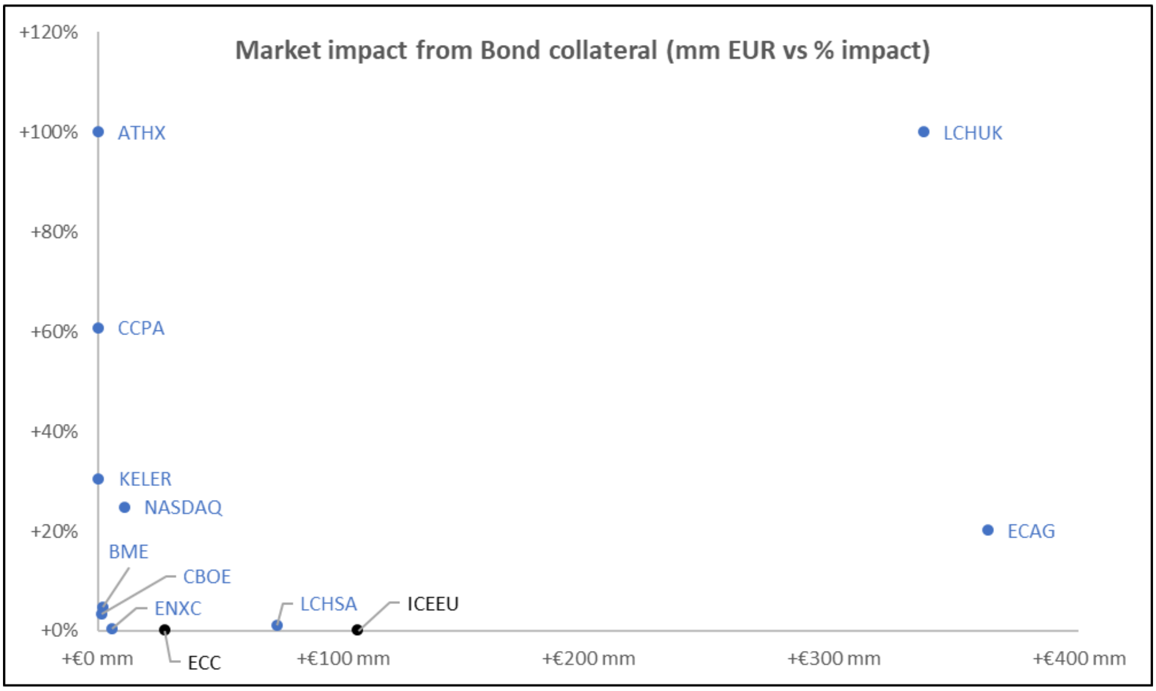

FIGURE 21: MARKET IMPACT FROM BOND COLLATERAL PER CCP

126. For equity collateral, the results in Figure 22 indicate a very limited materiality both in absolute and relative terms for ATHX and BME, the only two CCPs which accept this type of collateral to a meaningful extent.

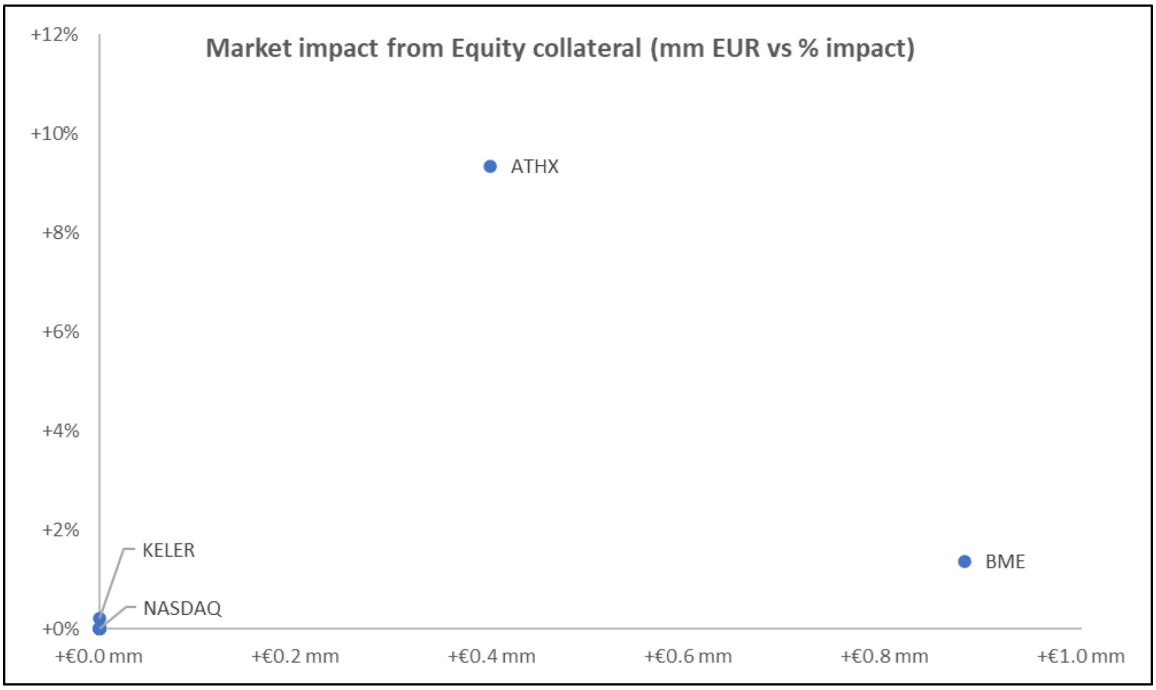

FIGURE 22: MARKET IMPACT FROM EQUITY COLLATERAL PER CCP

4.4 Conclusions

127. The analysis shows that concentrated positions have the potential for generating significant liquidation costs for CCPs. The risk is not uniformly distributed across the system but is especially relevant at one or a small cluster of CCPs dominating each asset class.

128. The adequacy of CCPs' concentration add-ons versus the modelled market impact presents a mixed picture, with some CCPs charging add-ons well in excess of the model's estimates and others significantly below. At CCP level, the largest shortfalls observed were 3bn EUR for ICEEU, 2bn EUR for ECAG, 1.2bn EUR for ECC and 0.4bn for ENXC. Significant variability was also observed at asset class level, sometimes with contrasting results for the same CCP in different asset classes.

129. Most CCPs charge dedicated margin add-ons for concentration. However, CCPA, KELER and SKDD do not, although KELER relies on a monitoring system to require additional collateral in case of elevated concentration. Other CCPs, while charging concentration add-ons at CCP level, do not do that for all the asset classes where the risk exists.

130. Model risk plays an important role in estimations of concentration risk, since the models used for this purpose typically place significant reliance on assumptions and choices, due to the limited observability of liquidation costs for large positions. This is likely to be a factor behind the variability noted earlier in concentration add-on levels across CCPs and asset classes.

131. The analysis has identified three potential sources of significant model risk in concentration models: the treatment of highly concentrated positions that account for large multiples of the

assumed market capacity, the accuracy of the market capacity estimate (e.g. average daily volume or notional amount) itself, and the modelling of offsetting across different positions during the liquidation phase. The last of these in particular is likely to be a root factor behind the shortfalls noted for ICEEU and ECC earlier. Both of these originate in commodity portfolios with large sensitivity to this aspect of the model.

132. These observations suggest that CCPs should strive to carefully calibrate, support and document model choices and parameter calibration for concentration risk models. Where this is challenging due to limited transparency, ESMA encourages CCPs to take a cautious approach while they continue to refine their models and collect empirical observations.

5 Liquidity Stress Test

5.1 Objectives and overview of methodology

133. The liquidity stress test assesses the resilience of CCPs to market wide and idiosyncratic liquidity stress events, i.e., whether the CCPs' available liquid resources are sufficient to cover the liquidity requirements that would be experienced under these events. The liquidity stress test also examines the resilience of the clearing landscape to system-wide stress events, such as the default of stakeholders having multiple connections with different CCPs, and includes an assessment of liquidity needs stemming from interoperable CCPs, thus capturing systemic dimensions of liquidity risk. It also assesses the impact of CCPs' investments on their liquidity positions.

134. The analysis in the liquidity stress test component is organised into 4 sub-components. First CCPs' liquidity resilience is assessed in EUR equivalent and per currency for each CCP. Then the systemic impact of the top 2 market participants is evaluated across all 16 CCPs. Reverse Stress Testing has been introduced in this exercise to identify liquidity breaking points. Finally, liquidity needs arising from interoperability links are measured for the first time.

Overview of Methodology

135. The applied methodology and computed scenarios can be summarised as follows (Figure 23):

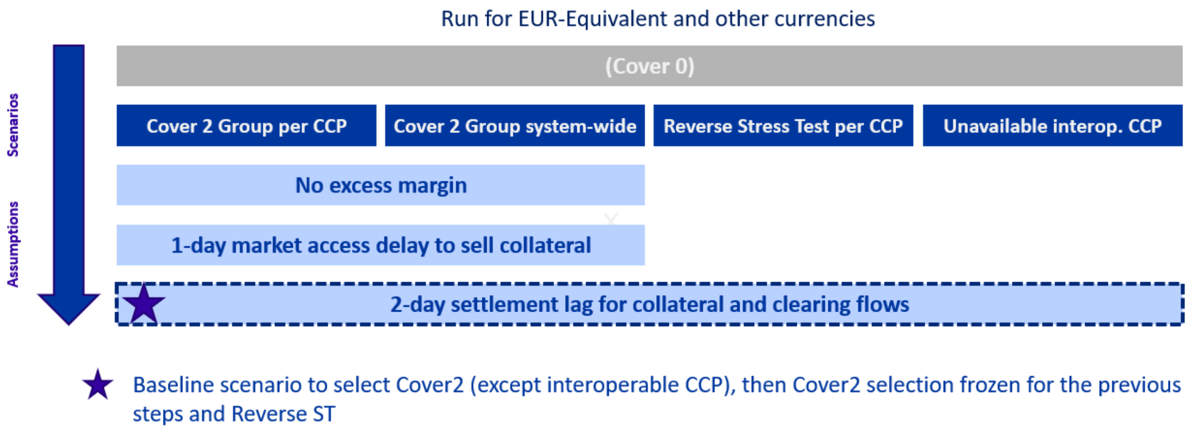

FIGURE 23: OVERVIEW OF LIQUIDITY RUNS

136. Liquidity stress test scenarios combine the impact of the ESRB market stress scenario with the default or unavailability of market participants in all their capacities (clearing members, issuers, custodians, payments banks or repo counterparties) measuring the impact on CCP's resources, tools and flows over a period of one week.

137. Various liquidity assumptions are then made, covering both extreme but plausible market conditions and limits on the liquidity tools available to the CCPs. These assumptions are run incrementally:

- Removal of excess collateral: this models the conservative view that in times of stress the members might reduce as much as possible their liquidity exposure to the CCP in order to maximise their own liquidity balance;

- Market access delay of one day for any asset sale performed by the CCP when monetising collateral (including the use of non-defaulting members' collateral for liquidity purposes to the extent allowed);

- A settlement lag of 2 days for asset selloffs.

138. In this exercise four scenarios are tested, using ESRB market stress scenario to impact both liquidity flows and resources:

- Cover 2 group per CCP: the 2 groups of market participants that impact the most the financial resources of the CCP are assumed to be in default.

- Cover 2 group system-wide: the 2 groups of market participants that impact the most the financial resources of all CCPs are assumed to be in default,

- Reverse stress test per CCP: stressed flows are increased using a set of multipliers (x1.20 x1.5 then x2),

- Unavailable interoperable CCP: the top liquidity need is assessed for each interoperability link.

139. To ensure comparability of results and reduce computational requirements, it was decided to run the selection of defaulting groups only once for each of the first two scenarios (Cover 2 per CCP and system-wide), by maximising the exposure when all liquidity assumptions are applied (the "baseline scenario"), then to compute all steps backward given the selection of defaulting groups. For both the reverse stress test and the scenario assuming the unavailability of relevant interoperable CCPs, only the baseline scenario was computed (i.e. including the three above-mentioned liquidity assumptions) instead of all steps as per Cover 2 cases.

140. The selection of the top two stakeholders defaulting in all their capacities (clearing member, liquidity provider, etc.) is based on the worst impact on liquid resources aggregated over all currencies given the defaulting entities, and not on the worst impact in terms of liquidity result. Therefore, selected entities are not necessarily the worst ones in terms of liquidity for each currency, and in exceptional circumstances this indicator may not capture the worst entities in terms of liquidity results by construction.

141. Subsequently, a liquidity mismatch analysis per CCP (or across CCPs) under the different scenarios over the next seven days is performed. All projected cash in- and outflows, linked to clearing and investment activities for the predefined time horizon, are aggregated per time bucket and the available counterbalancing liquid resources in each currency are assessed, also considering the allowed usage reported by CCPs and the investments of cash resources made by CCPs (mainly in reverse repos and bonds)[12].

142. A final assessment is made on the relative contribution of the different tools at CCPs' disposal to fill the liquidity mismatch. This leads to a liquidity profile showing a daily excess or a shortfall of resources at CCP level and the final liquidity result is defined as the worst daily amount (See Annex 8.10 for an example, that also shows for the baseline scenario the split between the

[12] Allowed usage refers to resources used at CCP or default fund level, or not accessible unless default, because segregated at clearing member or account level. See Annex 8.9

usage of central bank facilities as liquidity tool and liquid resources including cash and assets received / investments). Only material shortfalls (i.e., above 1 million per currency) are reported.

Key Assumptions

143.To limit computational complexity and promote understandability of results, the algorithm is selecting the worst groups under baseline scenario for Cover 2 per CCP and Cover 2 system-wide in EUR-Equivalent.

144.It is assumed that Central Securities Depositories (CSD), central banks and issuers of government fixed income securities are not defaulting. Similarly, the default of an interoperable CCP is not considered, only its temporary unavailability.

145.Intra-day liquidity and the number of settlement cycles per day was not modelled as ESMA focused on end of day positions (intraday scheduled and unscheduled variation margin calls are not modelled for instance). Actual liquidity needs may differ from the modelled liquidity needs based on the individual CCPs default management rule and procedures, including because of hedging transactions or optimisation of intraday cash use. Finally, changes in initial margin requirements of non-defaulting CMs during the liquidity assessment horizon are not accounted for.

146.Assets received by CCPs could potentially be used as additional collateral for liquidity tools. The current modelling does not fully capture this case which is a conservative assumption. On the other hand, where assets of a non-defaulting entity were assumed to be sold to generate cash, they would eventually need to be returned to this entity following default management.

5.2 Results

5.2.1 Cover 2 per CCP liquidity risk assessment

147.Under the Cover-2 per CCP scenario, the two entities selected are those whose simultaneous default would create the highest consumption of liquid resources.

Overall results in EUR-equivalent

148.For this computation, all currencies are aggregated using the shocked FX rates that result from the market stress scenario. It is implicitly assumed that all FX trading is possible and without limitations nor material transaction costs.

149.The first chart (Figure 24) presents the liquidity results in absolute terms (billions EUR on the vertical axis). The second chart (Figure 24) presents again the results but rescaled in relative terms to make it more readable as the sizes of the CCPs are heterogeneous. In each of the charts, the amounts for each CCP, from left to right show:

- The overall liquidity position before assuming any default (Cover 0);
- The position when the 2 groups are in default (Cover 2 Group);

- The effect of the introduction of the 3 liquidity assumptions, in this order: removal of excess collateral, market access delay and settlement lag.

150. A possibly counter-intuitive result is observed: in some cases, the liquidity position is better when two member groups are in default than when there is no default. The explanation is to be found in the availability of collateral. When a member defaults, its assets become available at CCP level. So, when a member with losses less than collateral is defaulting, if its collateral was accessible only at member level, the overall effect is an increase of liquid resources greater than the consumption of liquidity due to the default.

151. Overall, CCPs appear to be resilient under this scenario, since they all have liquidity resources left, even after introducing the three liquidity assumptions. Three types of CCPs can be identified based on the impact of each assumption on their liquidity results. First, some CCPs collect a significant amount of excess or prefunded margins which plays an important role on their liquidity score when considering the first assumption (removing excess collateral). Then CCPs having a material share of non-cash collateral are more sensitive to market access delay for selling securities. Finally, CCPs mainly clearing cash products are mostly impacted by the settlement lag assumption.

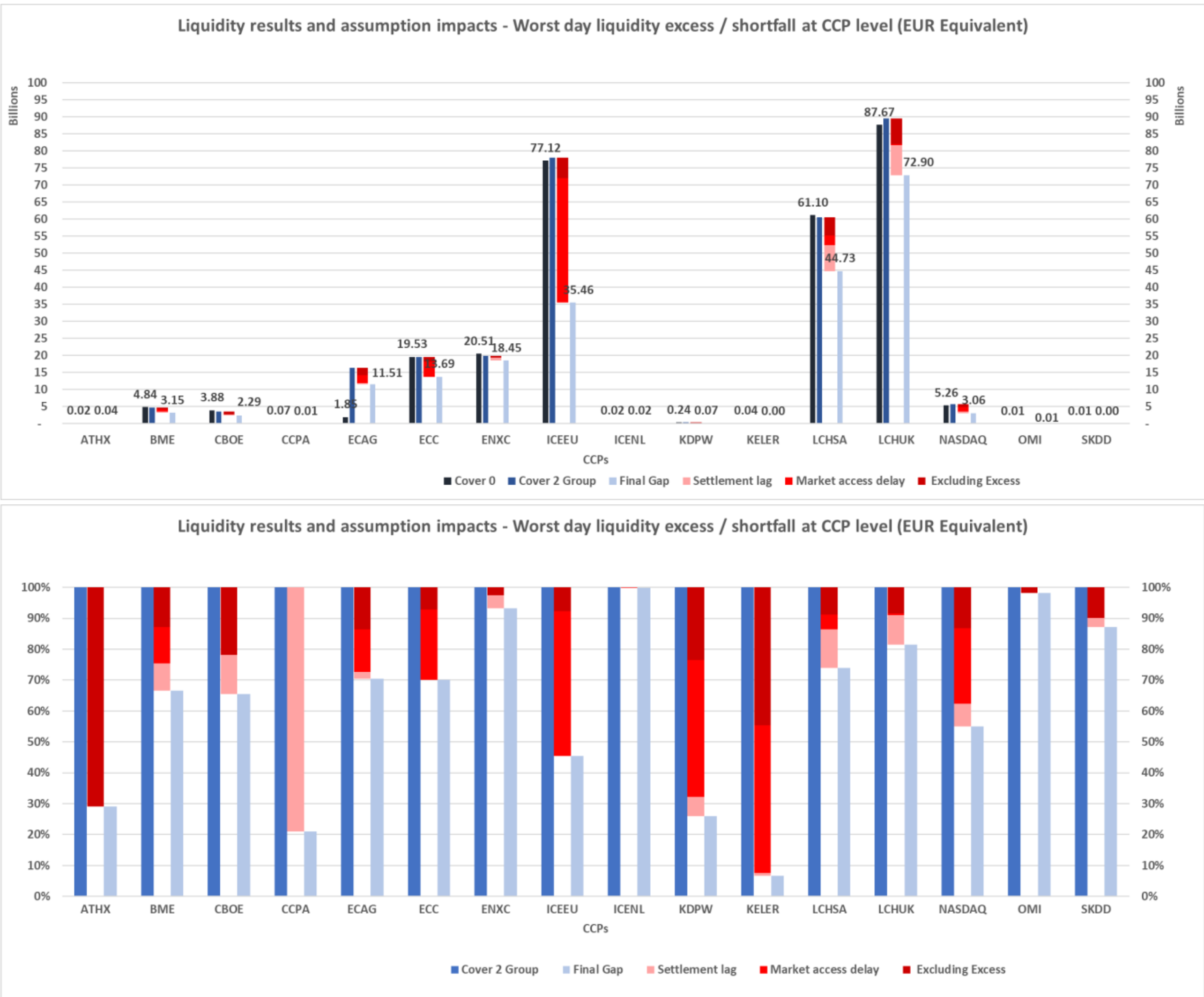

FIGURE 24: LIQUIDITY RESULTS OF COVER 2 PER CCP SCENARIO IN EUR EQUIVALENT

Overall results in EUR, GBP and USD

152. For the three major currencies (EUR, GBP, USD), the collective results of the Cover-2 per CCP scenario are displayed in the following figures. The same methodology as for the EUR-equivalent is used. The reported liquidity tools are also considered to swap potential liquidity excess from one currency to another with identified liquidity needs. These tools include multicurrency committed credit lines, securities financing transactions and swaps.

153. In Figure 25, results show no liquidity gaps to report for EUR.

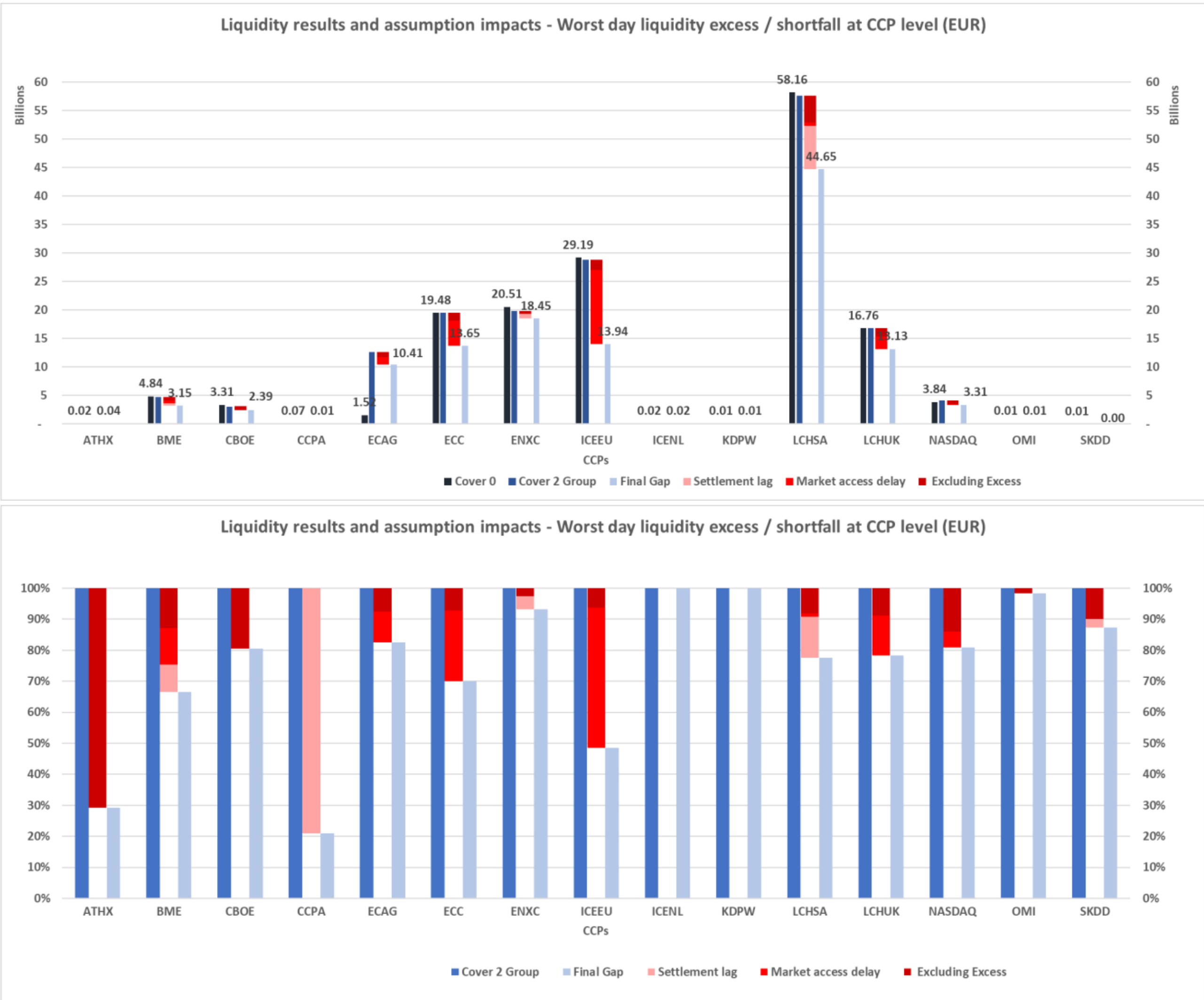

FIGURE 25: LIQUIDITY RESULTS OF COVER 2 PER CCP SCENARIO IN EUR

154. A focus on GBP shows that, as expected, the main stakeholders are the two UK CCPs (Figure 26). Again, all CCPs proved to be resilient in that currency. LCHSA's score can be explained by the fact that the CCP has non-cash collateral in GBP, yet no liquidity requirement in that currency, hence a balanced score of 0 when assuming market access delay to sell these assets.

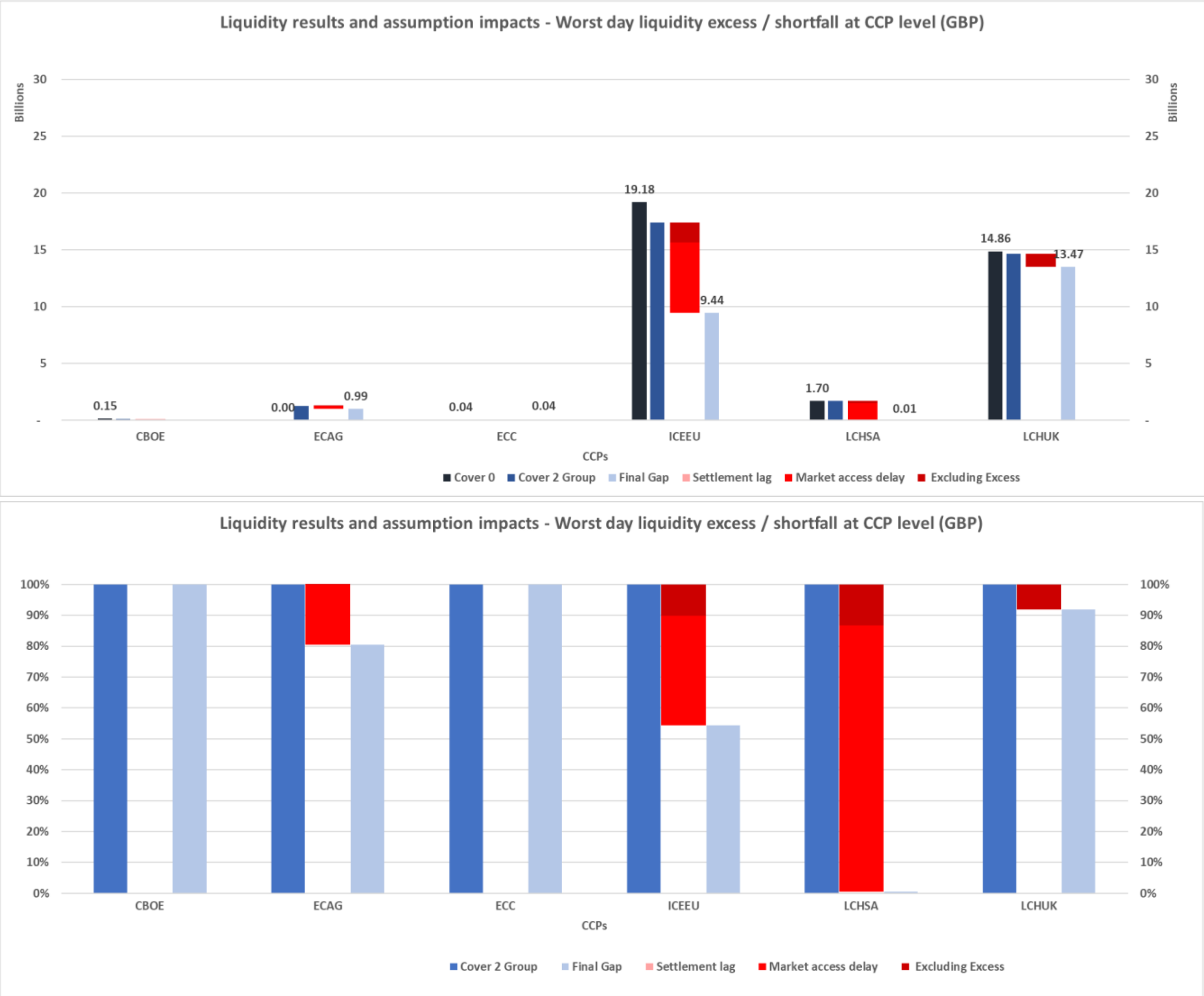

FIGURE 26: LIQUIDITY RESULTS OF COVER 2 PER CCP SCENARIO IN GBP

155. Six CCPs are exposed to USD currency (Figure 27), the main ones being ICEEU and LCHUK. Again, all CCPs had sufficient liquid resources to cover for their requirements in that currency.

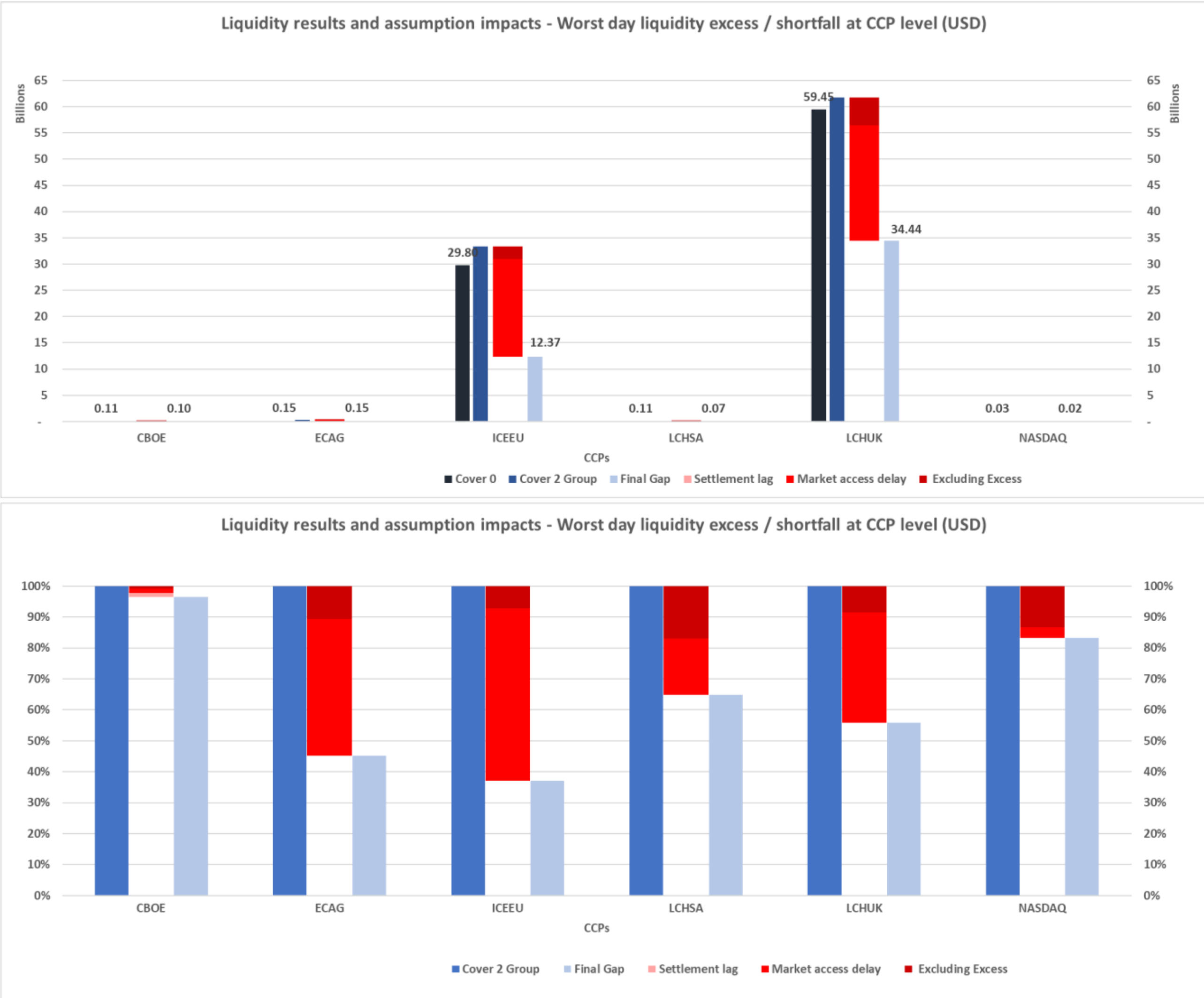

FIGURE 27: LIQUIDITY RESULTS OF COVER 2 PER CCP SCENARIO IN USD

Overall results in other currencies

156. Identified shortfalls per CCP for other currencies under the baseline scenario have been summarised in the table below. Where a shortfall in one currency is shown, it shall only be interpreted as a need to enter uncommitted FX tools that the CCP may have previously negotiated, or trade a certain amount on the FX market.

157. To further investigate the latter point, each shortfall has been compared with the average daily turnovers per currency reported in the latest BIS report.[13] The results indicate that CCPs would not be expected to have any issues trading these amounts in the spot market to cover potential shortfalls.

[13] BIS report on OTC foreign exchange turnover in April 2022 https://www.bis.org/statistics/rpfx22_fx.htm

	CURRENCY	CCP	Highest liquidity need in local currency in Mn	Highest liquidity need in Mn USD Equivalent	Average spot daily turnover in Mn USD*	Total average daily turnover in Mn USD*
3rd country	CAD	ICEEU	- 34	- 22	128,000	466,000
	CHF	ECAG	- 453	- 443	88,000	390,000
	CHF	ICEEU	- 9	- 9	88,000	390,000
	JPY	LCHUK	- 12,016	- 79	439,000	1,253,000
	HKD	LCHUK	- 1,869	- 214	45,000	194,000
	ZAR	LCHUK	- 165	- 8	22,000	73,000
EU	CZK	LCHUK	- 924	- 36	NA	29,000
	HUF	LCHUK	- 29,944	- 72	NA	26,000
	PLN	LCHUK	- 535	- 109	15,000	54,000

FIGURE 28: IDENTIFIED SHORTFALLS FOR OTHER CURRENCIES UNDER COVER 2 PER CCP SCENARIO

5.2.2 Cover 2 system-wide liquidity risk assessment

158. The same methodology is applied to the system-wide Cover-2 scenario. Under this scenario, the two groups are selected at the system-wide level, therefore for a given CCP these may not be the most impactful defaulting entities. Consequently, the results are less impactful for each CCP and no gaps have been identified.

159. Similar to the results of the credit component, one can conclude that although CCPs are highly interconnected, results do not highlight any pair of groups that is at the same time and under the common tested scenario highly impactful at several CCPs.

5.2.3 Reverse stress test

160. Using as a starting point the baseline scenario, the stressed flows have been multiplied by 1.2, 1.5 and 2 to assess the impact of increased activity and/or risk factor shocks on liquidity results and identify liquidity breaking points.

161. The reverse stress test does not aim at assessing the resilience of single CCPs, hence results have been anonymised and presented as the % impact on liquidity results.

162. Results show that the system is overall resilient as only two CCPs are experiencing a small theoretical liquidity shortfall and only when the stressed flows are doubled (step x2). As expected, results are decreasing linearly in most of the cases. Three broad categories of CCPs can been identified, which define their liquidity risk profile:

- CCPs mainly clearing cash products, for which larger stressed settlement flows have a significant impact on their liquidity profile,
- CCPs clearing mainly or only derivatives with a muted impact mainly stemming from increased stressed variation margin. Settlement flows are limited as most of these products are financially settled and/or mature later than cash products.
- CCPs with a diversified product mix that stand in the middle and could experience a moderate impact.

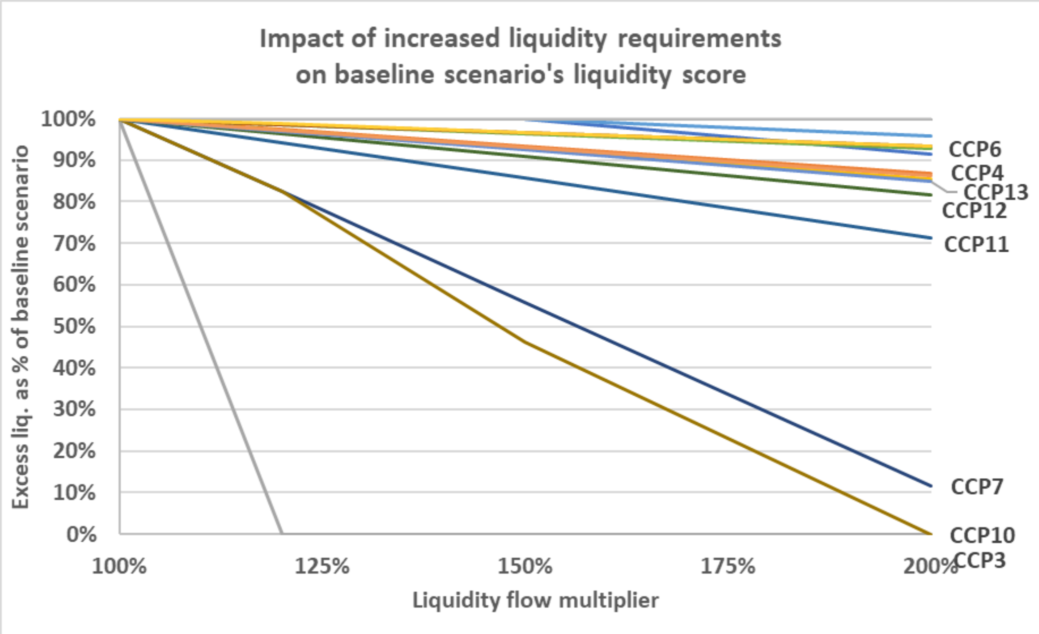

Figure 29: Impact of increased flows on Cover 2 baseline scenario's liquidity results

5.2.4 Liquidity needs from interoperable CCPs

163. Interoperable CCPs are linked CCPs that allow for the cross-system execution of transactions, i.e. where clearing members of one CCP can trade with members of another CCP. CCPs typically cover resulting exposures towards the other interoperable CCP(s) by asking 'additional initial margins' from their clearing members. Existing interoperability links in Europe mainly involve cash products which are demanding in terms of liquidity, due to large settlement flows, and therefore worth being evaluated.

164. Each interoperability link has been assessed from both ends, assuming the temporary unavailability of each interoperable CCP and considering the magnitude of stressed flows stemming from products being cleared on both sides (e.g. in a case where CCP1 has to pay cash to CCP2 versus stocks, what would be the liquidity impact for CCP2 if cash payments stemming from CCP1 were delayed and what would be the liquidity impact for CCP1 if stocks' deliveries from CCP2 were postponed). Since some links are not always directional, the liquidity impact stemming from theoretical opposite flows was also assessed. It should finally be noted that this dual assessment did not apply to links involving SIX x-clear AG (SIX) as SIX falls out of the scope of this exercise.

165. The top liquidity impact for each link has been displayed in the following figure for the CCPs in scope (LCHUK, CBOE, LCH SA and ENXC). Liquidity needs for each interoperability link under the contemplated baseline scenario appear manageable for all considered CCPs given their reported liquid resources.

166. The following interoperable arrangements are considered to compare liquidity needs stemming from unavailable interoperable CCPs versus liquid resources under a no-default baseline scenario:

- CBOE's top liquidity impact stems from LCH UK and amounts to 2.1bn EUR Equivalent, whereas the CCP has more than 3bn EUR Equivalent liquid resources,
- LCHUK's highest liquidity impact stems from SIX for a total of 2.6bn EUR Equivalent, to be covered by 77bn EUR Equivalent of liquid resources at CCP level.
- LCHSA and ENXC show respectively 53bn EUR Eq and 20bn EUR Eq of liquid resources, to be compared with a maximum liquidity impact of 2.6bn EUR Eq.

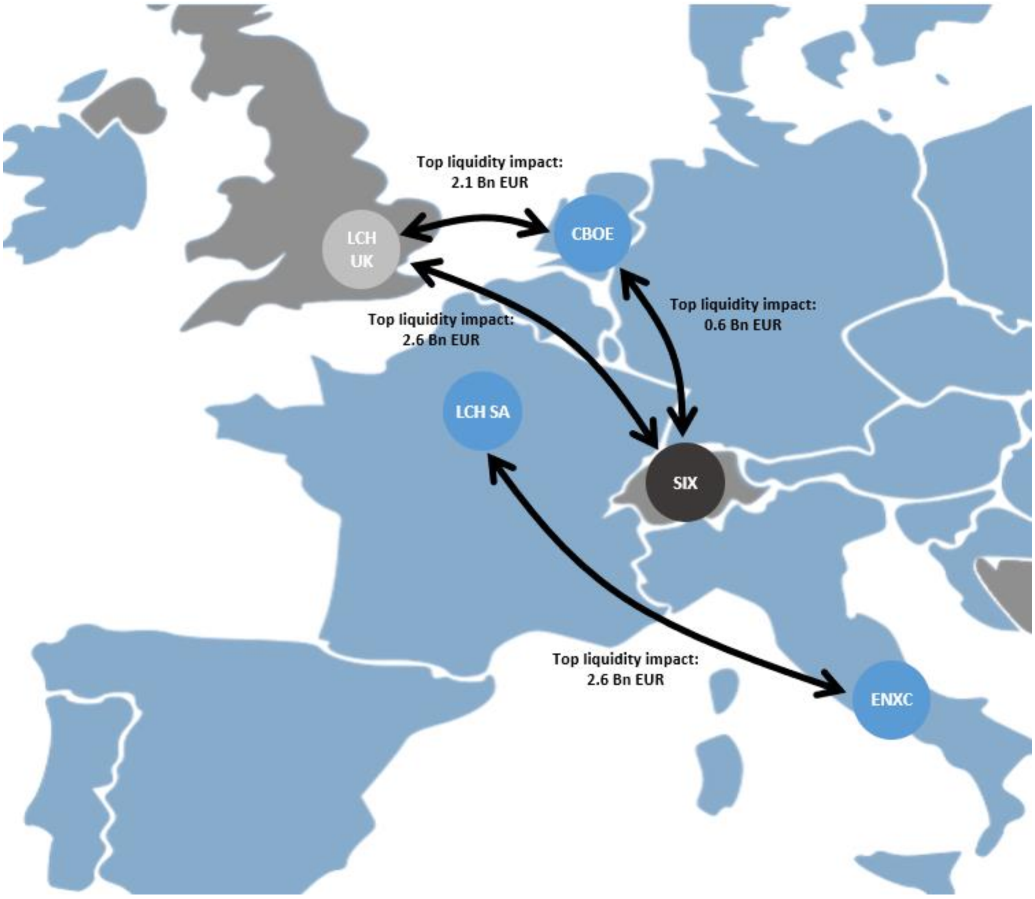

FIGURE 30: OVERVIEW OF TOP LIQUIDITY IMPACT PER INTEROPERABILITY LINK IN BN EUR EQUIVALENT

5.3 Conclusions

167. Liquidity risk profiles of CCPs are mainly influenced by two aspects:

- Types of cleared products, where in particular the settlement flows of cash products are significant in terms of potential liquidity needs compared to variation margins stemming from cleared derivatives;
- Collected resources and investment activity (e.g. the share of collected non-cash collateral, maturity of reverse repos impact the availability of resources).

168.Overall, CCPs proved to be resilient from a liquidity perspective under the baseline market stress scenario and simultaneous Cover-2 defaults.

169.Each CCP maintains a positive liquidity balance at an aggregate currency level and in the major currencies (EUR, GBP, USD) when assuming no access to FX markets.

170.Only a few CCPs need access to the FX market to cover specific needs in other currencies, however the observed amounts are not material compared to the overall size of the FX market.

171.The system also proved to be resilient under the assumed Reverse Stress Test scenario as only two CCPs are experiencing a small theoretical liquidity shortfall when stressed flows are doubled. It should however be noted that a sudden increase of volumes that goes beyond the considered reverse stress test could lead to a reduced resilience, which may occur for securities in periods of crisis.

172.The impact of interoperable CCPs' unavailability is large but seems manageable given their reported liquidity resources.

6 Climate risk analysis

173. The climate risk analysis should be seen as a new exercise to explore climate risks and their potential impact on CCPs from four different angles. This analysis differs from a regular stress test since it does not aim at providing any quantitative impact, in terms of margin or consumption of financial resources but to gain an understanding and raise awareness on climate risks and potential associated vulnerabilities. This analysis is still at an early stage of development and is expected to improve with a potential increased availability of adequate and reliable data.

6.1 Objectives and overview of methodology

174. The scope of this climate risk analysis covers four sub-components: (i) the impact of transition risk on the CCPs' business models, (ii) the impact of transition risk on the collateral that CCPs hold, (iii) the impact of physical risk on CCPs' operations, and (iv) the impact of climate related events on market risk. Accordingly, not all possible climate risk transmission channels have been taken into account and the methodological choices and outcomes should be considered in light of this selective approach. The analysis consists of a bottom-up exercise where participating CCPs submitted data subject to a common methodology. In order to ensure consistency and quality of outcomes, ESMA carried out a thorough reconciliation process with the CCPs.

6.1.1 Business model

175. The first sub-component looks at the impact of the transition to a low carbon economy on the business models of the CCPs. Under a short-term disorderly transition, that would translate into a sudden shock to the value of relevant portfolios, CCPs are expected to swiftly react by adjusting margins collected from clearing members and clients, or, in case of default of a clearing member, by activating the default waterfall irrespective of the cause of such default. Defaults and own investment risks aside, CCPs should not be affected by the market price of the contracts they clear. Under a long-term transition scenario nevertheless, CCPs' business models could be impacted if the contracts they are clearing are phased out. Conversely, some products were singled out in this analysis due to their pro-transition characteristics. This is notably the case for the EUA derivatives.

176. To evaluate the potential impact of climate risks on CCPs' business models, this sub-section leverages on a methodology established by the EU's Joint Research Centre (JRC)[14] using Transition Exposure Coefficients (TECs). Such TECs represent the average sensitivity to transition risk, on a scale from 0 (nil) to 1[15] and are allocated per activity as classified by Eurostat under the statistical classification of economic activities in the European Community (NACE[16] codes)[17]. On that basis, highly impacted sectors could be isolated. To adapt the methodology to this analysis, a number of methodological choices have been applied, as described in the Annex (8.20).

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[14] See Alessi & Battison, 2021, 'Two sides of the same coin: Green Taxonomy alignment versus transition risk in financial portfolios'.
[15] For example, certain activities such as the extraction of fossil fuels are deemed to be very strongly exposed to the Transition and receive a value of 1.00 for their TEC. For other activities, there is no exposure to the Transition and the value is 0.00. Industries moderately exposed to the Transition receive a value between 0 and 1.
[16] NACE is the acronym from the French 'Nomenclature statistique des activités économiques dans la communauté Européenne'.
[17] See https://ec.europa.eu/eurostat/web/nace

177.To evaluate the severity of the potential exposure to transition risk of CCPs' business models - *usually covering various product ranges* - cleared asset classes are split pro-rata using the initial margin[18] collected by the CCP for each class. Those asset classes are then further split pro-rata using the volumes of the contracts to be mapped to individual risk factors, as these were defined under the ESRB market stress scenario. Finally, the risk factors are allocated to NACE codes to retrieve the relevant TEC. To keep this analysis manageable at operational level, CCPs' exposures to transition risk are classified into four types: (i) asset class with a direct exposure to the transition[19], (ii) asset class with an indirect exposure to the transition[20], (iii) asset class with no exposure to the transition[21], and (iv) asset class benefitting from the transition, such as the emission allowance derivatives. The results of this analysis are presented by CCP and per type of exposure. No aggregation is performed between asset classes having direct or indirect exposures, due to their different nature[22].

6.1.2 Collateral replacement

178.The second sub-component analyses the potential impact of the transition to a low carbon economy on collateral required by CCPs from their clearing members. Under a short or long-term transition, that would translate into a shock to the value or availability/liquidity of collateral, CCPs are expected to swiftly react by (i) requiring their clearing participants to post additional eligible cash or securities, and/or (ii) increasing haircuts or removing securities from eligible collateral should their quality and liquidity be deemed insufficient.

179.To gauge the materiality of the potential impact of transition risk on collateral, this subsection leverages on the same methodology as described in Section 6.1.1 using TECs linked to the NACE of the issuer of the instrument at stake. Such TECs aim at measuring the average sensitivity of the value of collateral instruments to transition risk. On that basis, collateral highly exposed to transition risk could be isolated[23]. The mapping to TECs is further described in Annex (8.4).

6.1.3 Physical risk

180.CCPs are, to varying degrees, exposed to the materialisation of acute physical risks, that could result in (i) physical disruption to the operations of the CCPs, their counterparties, or their service providers, and/or (ii) increased volatility impacting certain markets, such as energy. To keep the analysis manageable at operational level, also considering availability and reliability of data, these two events are considered separately.

181.This part of the climate stress test focuses on the physical disruption to operations. In order to develop a view of the sensitivities of the clearing ecosystem to potential operational disruptions caused by acute physical risks, ESMA collaborated with the ECB and leveraged on its extensive

[18] Where a CCP uses cross-margining over two asset classes, the stress test instructions specified how to split the margins by requiring the CCP to compute the gross margins and allocate the portfolio margin pro-rata the gross margins of the asset classes which are margined together.
[19] An asset class has a direct exposure to the Transition where the underlying product of the cleared contract is itself directly exposed. This regroups all commodities, spot electricity markets, freight derivatives, and energy derivatives.
[20] An asset class has an indirect exposure to the Transition where the contract references securities issued by a company possibly involved in products and services that are exposed to the Transition. This encompasses equities, equity derivatives and credit default swaps.
[21] This encompasses FX, government bonds and repos, inflation and interest rate products.
[22] Asset classes with direct exposures are expected to be gradually phased out, while security issuers triggering indirect exposures could adjust their business models based on a green transition plan.
[23] In our analysis, cash and government securities are deemed to be immune to the Transition, and this analysis will focus on equities and corporate bonds

data and analytics for the assessment of physical risks[24]. Those provide a risk score from 0 to 5 (the highest being 5[25]) factoring the location[26] and each type of risk, encompassing landslides, subsidence, river floods, and windstorm, allowing to compute the risks associated to a specific location, excluding non-EU locations. The addresses of the CCPs and their top-10 clearing members (by initial margin) are used to determine the risk scores and examine the types of physical risks to which the locations could be exposed.

182. ESMA acknowledges that the methodology and data for CCPs and their clearing members are still at an early stage of development. The data and methodological elements which are used in this context were initially built to assess the risks on a large and diversified pool of physical assets (real estate). Therefore, the results should not be over-interpreted, due to the following limitations: (i) the data used was initially meant to assess physical risk for wide regions based on a large sample of entities while this analysis considers one address at a time, and (ii) existing remediation measures such as back-up sites, remotely located IT servers, or the possibility of remote working from ad hoc locations were not considered. Hence, such analysis should be considered as a yardstick for further analysis. Nonetheless, these data provide a risk score associated to each location for each type of risk considered, allowing the identification of prevalent risks. In this context, the CCPs or their clearing members are not necessarily exposed to those risks but rather their addresses are in a zone where real estate assets are exposed to these risks.

183. Annex (8.3) provides more details on the scoring and types of risks considered.

6.1.4 Climate Market risk scenarios

184. This analysis discusses the climate risk stress-testing capabilities of sampled CCPs by seeking information on any climate stress test scenarios that CCPs already use. Specifically, it explores the awareness and progress CCPs have already made for the development of climate-relevant scenarios and provides insight into the types of scenarios used for this purpose. The information is presented in an aggregated manner to avoid disclosing the details of the stress scenarios applied per individual CCP.

6.2 Results

6.2.1 Business risk

185. A majority of asset classes could be exposed to transition risk. However, the largest share of asset classes, split by initial margin and representing 61% thereof, are attributable to sectors that are deemed not or immaterially exposed to transition risk[27]. Asset classes exposed, either directly or indirectly, to transition risk account for a lower but still significant share of initial margin (36% thereof, with 21% directly exposed), confirming the potentially non-negligeable impact of transition risk for the CCPs at aggregate level.

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[24] See the most recent ESCB's Methodological report/statistical paper on Climate change-related indicators and Technical annex published in April 2024. However, the data used in this report are based on earlier publication and underlying data Methodological report published on January 2023.: https://www.ecb.europa.eu/pub/pdf/scpsps/ecb.sps48~e3fd21dd5a.en.pdf

[25] The geocoding procedure relies on a database of locational information to convert a given address into latitude and longitude coordinates. Since the accuracy of the assignment can vary, the resulting coordinates were checked and enhanced to minimize the distance between the assigned and the actual location of the address on the map.

[26] The data provided by the ECB include the geocoding of 10 million locations exclusively in Europe.

[27] The largest asset class by initial margin relates to interest rate derivatives. FX derivatives, government bonds and repos, inflation derivatives, along with interest rate derivatives are attributable to sectors immaterially exposed to transition risk.

186. The clearing of certain asset classes was singled out as 'benefitting' from the transition[28]. These are mostly emission allowances derivatives, and to a lesser extent due to limited volumes energy contracts referencing energy of certified 'green' origin. The relative share of direct and indirect exposures to transition risk differs per CCP on the basis of their business model, from the near absence of exposures subject to such risk to a clearing business concentrated on assets directly exposed to such risk.

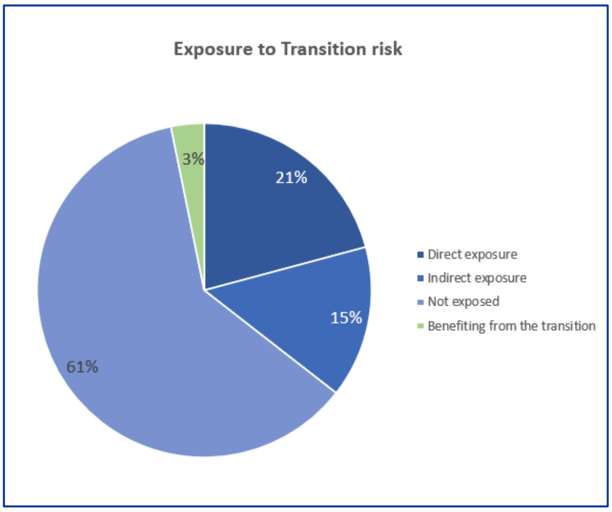

FIGURE 31: PROPORTION OF ASSET CLASSES EXPOSED TO TRANSITION RISK (BY INITIAL MARGIN)

Focus on cleared asset classes directly exposed to transition risk

187. Asset classes cleared by the sampled CCPs that are directly exposed to transition risk represent 21% of CCPs' portfolio at aggregate level. At individual level, as displayed in Figure 32, some CCPs dispose of significant direct exposures to transition risk in their portfolio (CCP2, CCP3, CCP5, CCP8, CCP11, CCP14 and CCP15). The severity of direct exposures to such risk is put into perspective on the basis of the TEC applying within the concerned cleared instruments. CCPs massively clearing instruments subject to high TEC values, particularly energy, metal, or commodity derivatives are expected to be more severely exposed to the Transition. By contrast, some commodities have a nil TEC value, such as agricultural commodities.

[28] An asset class 'benefitting from the Transition' hereby means an asset class whose characteristics allow to take advantage of opportunities arising during the Transition. Usually, such asset classes are expected to take a less severe impact of transition risk by preventing or reducing the emission of GhG.

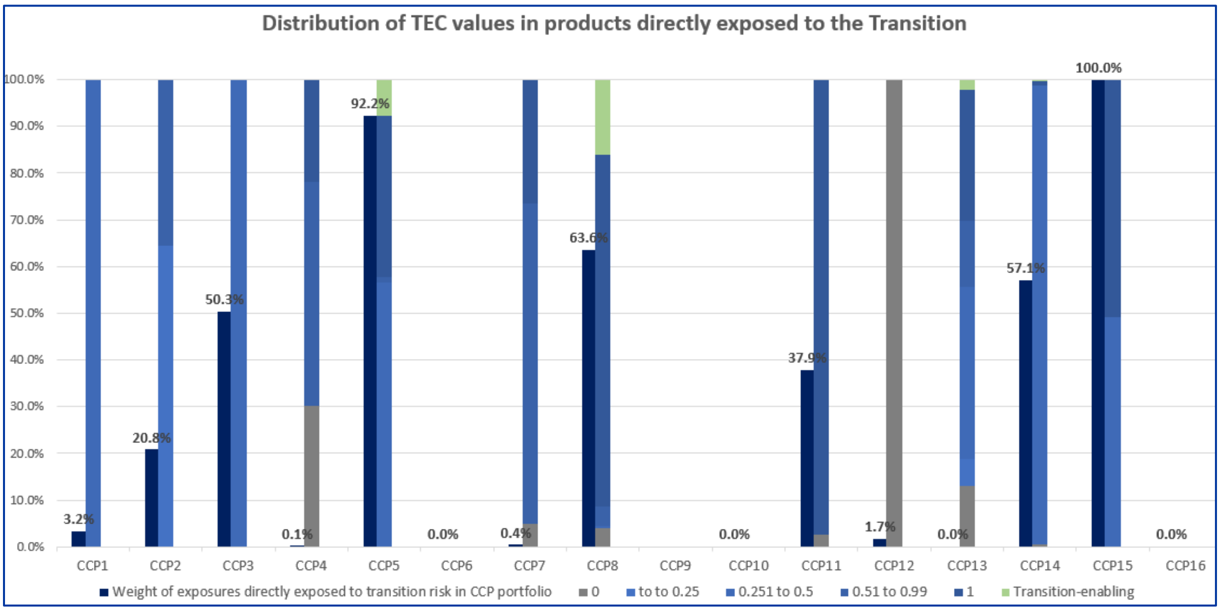

FIGURE 32: DISTRIBUTION OF TEC VALUES OF INSTRUMENTS DIRECTLY EXPOSED TO TRANSITION RISK

188. Hence, only four CCPs conduct businesses that could be significantly exposed to transition risks (CCP5, CCP8, CCP11 and CCP15), mostly due to the clearing of commodity and energy derivatives. Among these four, two CCPs (CCP8 and CCP11) present higher levels of concentration of their clearing business in instruments with a TEC value of 1. Such CCPs may, in the long run and under the assumption of no business adjustments, experience a stronger impact of transition risk.

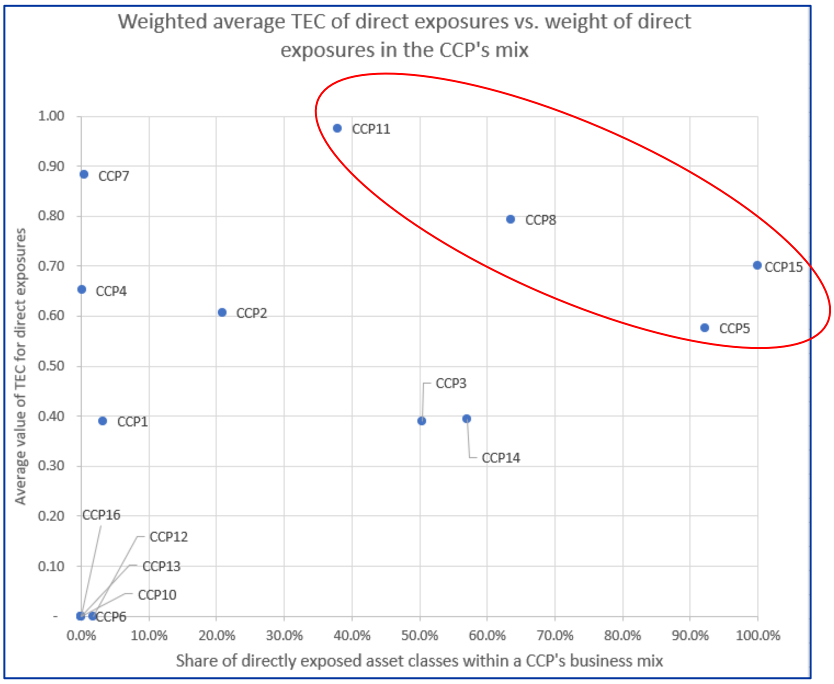

FIGURE 33: SEVERITY OF THE DIRECT EXPOSURE TOWARDS TRANSITION RISK PER CCP

Focus on cleared asset classes indirectly exposed to the Transition

189. Asset classes cleared by the sampled CCPs that are indirectly exposed to transition risk represent 15% of CCPs' portfolio at aggregate level. At individual level, while nearly all sampled CCPs are clearing indirectly exposed instruments, the severity of exposure to transition risk is put into perspective on the basis of the TEC applying to the concerned instruments. As displayed on Figure 34, the largest share of cleared instruments is attributable to sectors with relatively low exposure to transition risk. Such low exposure is explained by the predominance of large-index equity or credit derivatives and of large amount of securities issued by companies in sectors which are mapped to a nil TEC value, such as financials.

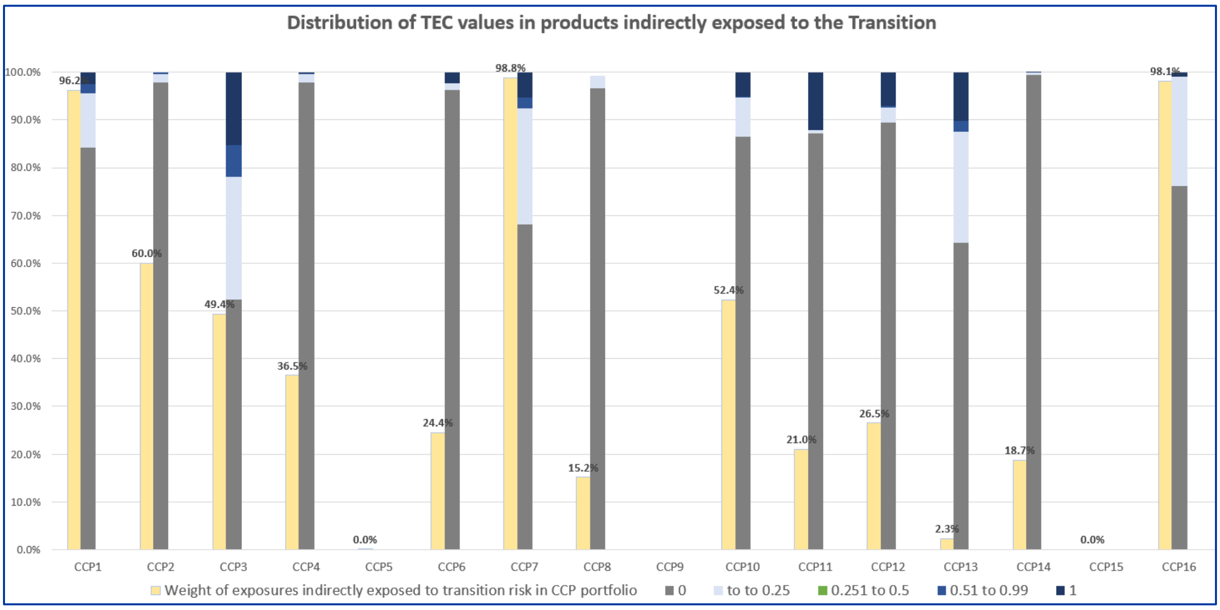

Figure 34: Distribution of TEC values relative to instruments directly exposed to transition risk

6.2.2 Collateral replacement

190. At aggregate level, as displayed in Figure 35, approximately 93% of the collateral held by CCPs is composed of cash and government securities. Those instruments are deemed immaterially exposed to transition risk. Only 1.3% (9.8bn EUR) of total collateral held by CCPs consists in equities (0.4%) and corporate bonds (0.9%), which are potentially indirectly exposed to transition risk.

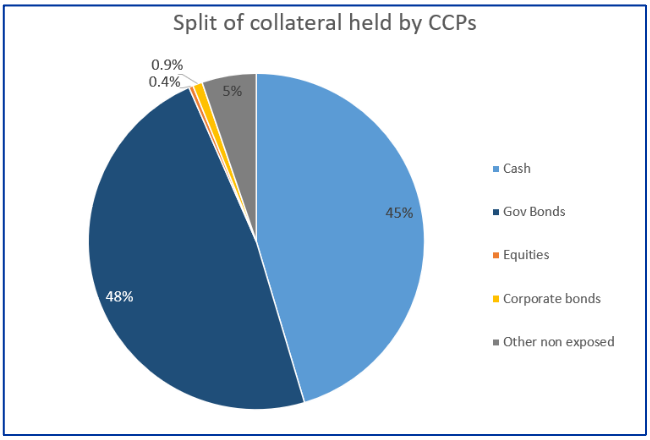

FIGURE 35: TYPES OF COLLATERAL HELD BY SAMPLED CCPS

AT INDIVIDUAL LEVEL, AS DISPLAYED IN

191. Figure 36, there is no overreliance on equities nor on corporate bonds in the collateral mix of the CCPs. The largest concentration of securities accepted as collateral are within CCP1 (11.4% equities), CCP2 (4.9% equities), and CCP4 (combining 1.7% in equities plus 4.3% in corporate bonds).

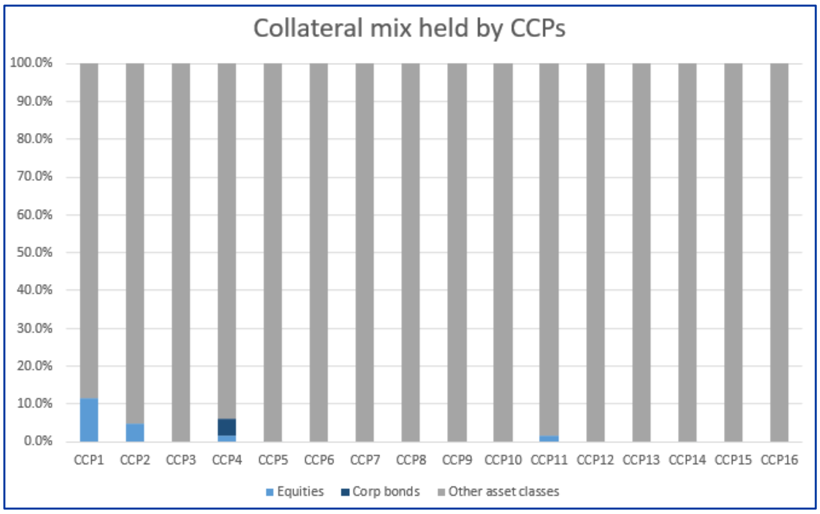

FIGURE 36: TYPES OF COLLATERAL HELD BY CCPS

192. The severity of the exposure of the equities and corporate bonds held as collateral by CCPs to transition risk is put into perspective on the basis of the TEC associated to their issuer. As displayed in Figure 37, the majority of such collateral gather into TEC values below 0.25 with hence limited indirect exposure to such risk. Furthermore, a large share of the corporate bonds is issued by companies in the financial sector and hold a nil TEC value. Hence, such collateral is even less exposed to transition risk than equities.

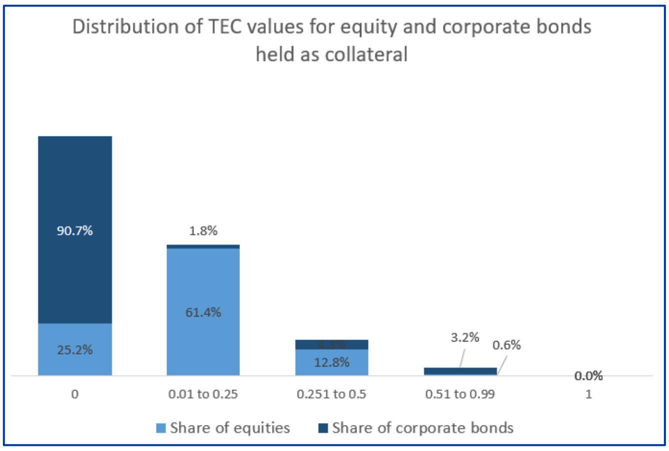

FIGURE 37: EXPOSURE TO TRANSITION RISK OF EQUITIES AND CORPORATE BONDS HELD AS COLLATERAL BY SAMPLED CCPS

193. Overall, the transition is unlikely to cause a significant need for additional collateral or for substitution of collateral from the clearing participants of the CCPs in the foreseeable future.

6.2.3 Physical risk

194. For the CCPs and their top 10 clearing members, the analysis considered the headquarter address linked to the LEI and used the risk scores provided by the ECB to assess the overall level of risk of the 99 locations in which these headquarters are located. The number of locations considers the overlap in the membership of different CCPs, while the locations with the highest number of selected clearing members illustrate a concentrated local market. This is subject to the limitations listed in Section 6.1.3 of this report.

195. Various risks were considered, encompassing landslides, subsidence, floods, and windstorms. Further information on those risks is available in Annex 8.3. No critical vulnerabilities to those risks were identified on the sampled locations. Solely subsidence risk, while considered immaterial for approximately half of the sampled locations, is flagged of medium importance for the other half. The risk scores however do not consider any structural mitigants vis-à-vis the buildings, such as deeper underpinnings or any other measures such as back-up locations or remote working possibilities.

196. Since this analysis has been limited to the locations of few counterparties, it may not cover all interlinkages between physical risks and CCPs but should be viewed as a yardstick for further assessments, possibly enlarging the considered locations where the CCP and its clearing members operate, as well as considering the locations of other participants in the clearing system.

6.2.4 Climate Market risk scenarios

197. ESMA collected information on the types of climate-related stress scenarios, if any, used by CCPs. The analysis at aggregate level aims at assessing the level of awareness and the progress that CCPs have already made in developing such scenarios, while maintaining data confidentiality.

Prevalence and characteristics of climate-related stress-test scenarios

198. CCPs have gradually started to integrate climate risk into their stress testing framework: out of sixteen sampled CCPs, nine reported running at least one climate scenario with few of those CCPs running more (only one CCP has developed more than ten scenarios). Approximately half of these CCPs developed historical scenarios while the remaining focused on hypothetical scenarios. One CCP developed, at that stage, both types of scenarios. Nevertheless, as displayed in Figure 38, the use of such scenarios differs with a minority using those for the sizing of the default fund. Scenarios are also used in the context of reverse stress testing or for only for risk identification purposes.

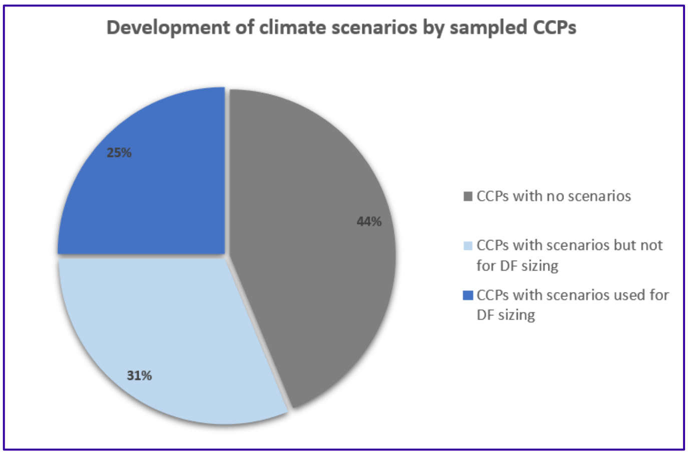

FIGURE 38: OVERVIEW OF CLIMATE SCENARIOS DEVELOPED BY SAMPLED CCP

199. As displayed in Figure 39, CCPs clearing commodities and energy derivatives are more prone to develop climate scenarios, respective to their higher risk level (please refer to subsection 6.2.1 on business risk). In approximately 60% of the cases, such scenarios do not cover exclusively commodities and energy derivatives but extend to other types of instruments. However, not all CCPs with such business model have yet developed specific scenarios. Among the four CCPs (CCP5, CCP8, CCP11, and CCP15) whose product mix is most exposed in the long run[29] in line with the conclusions of subsection 6.2.1, due to the clearing of commodities and energy products, two CCPs did not report having climate-related scenarios.

[29] This assumption is valid under the assumptions of (i) transition risk materialising and (ii) no business adjustment in the long run.

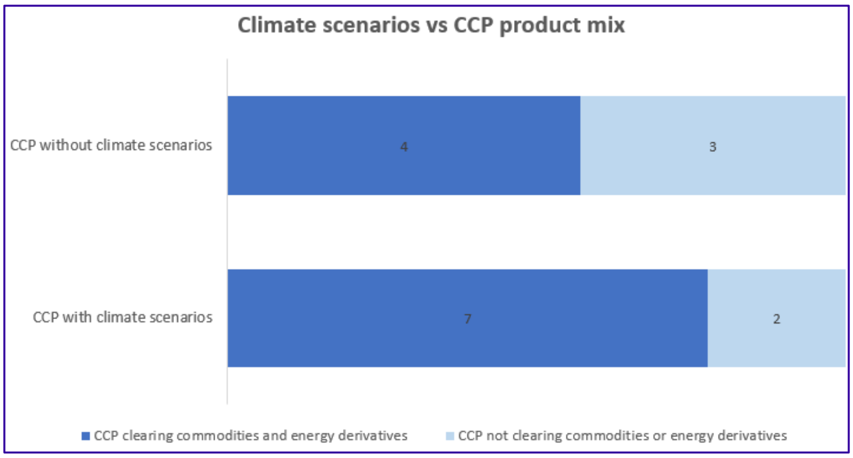

FIGURE 39: PREVALENCE OF CLIMATE SCENARIOS CONSIDERING CCPS' PRODUCTS MIX

Types of risk factors stress in climate stress scenarios

200. As expected, and as displayed in Figure 40, the scenarios are more likely to include shocks for instruments with high TEC value, such as energy and freight derivatives (with a TEC value of 1). Equities and equity derivatives are shocked usually across industries. Nevertheless, in one case, solely equities related to sectors with direct exposure towards climate risk (industrials and oil sectors) were shocked in relevant scenarios.

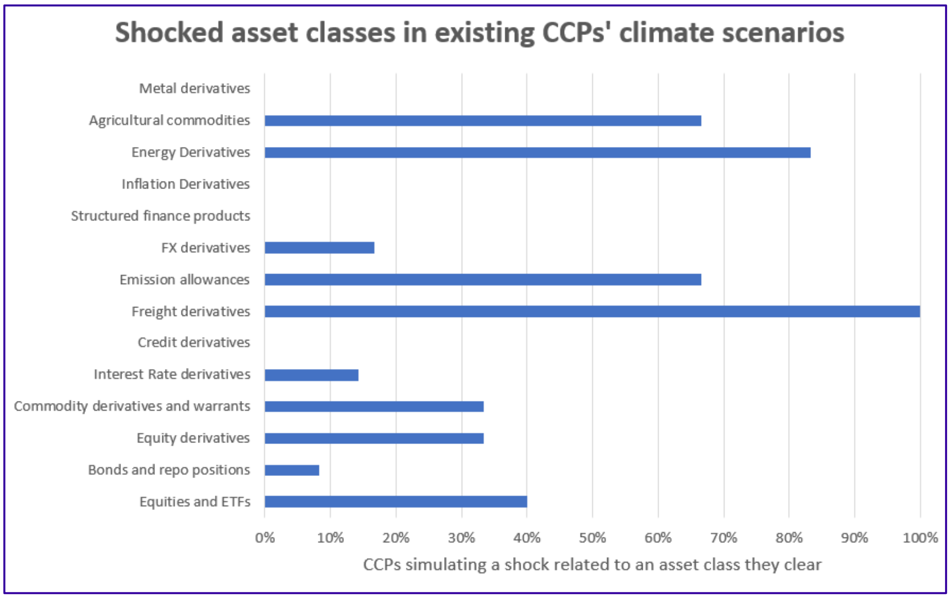

FIGURE 40: EXISTING SHOCKS AT CCPS PER ASSET CLASS

201. Energy markets are mapped to geography-specific risk factors, with contracts relating to specific delivery points. Hence, CCPs' climate scenarios could simulate a generic move in the price of energies or simulate a disruption to the energy market in a specific geographical zone. Figure 41 displays the severity and dispersion of the shocks used by each relevant CCP to power and gas derivatives.

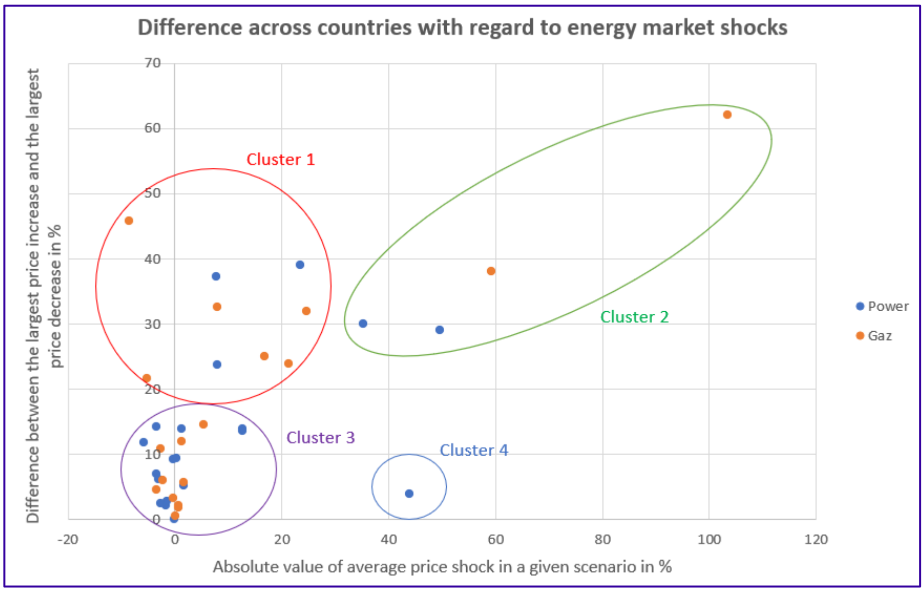

FIGURE 41: CCPS' VARIETY OF SHOCKS TO POWER AND GAS DERIVATIVES

Note: in the Y-axis, where no price increases are simulated, the value results from the difference between the largest and the lowest price decrease.

202. As a result, the shocks applied by the relevant CCPs could be divided into four clusters. Cluster 1 consist of shocks with a contained average energy price move but with important dispersion between the locations of the contract, hence shocking contracts differently depending on their geographical features. These scenarios should generate stress test losses for portfolios with "basis" positions (e.g., long on a commodity contract at a specific location while short on a same-commodity contract but in another location). Cluster 2 encompasses shocks with large average energy price moves and large dispersion across locations. Such features concern nevertheless a limited number of shocks applied by CCPs. The majority of shocks applied by CCPs, within Cluster 3, displays an average price move of limited severity and low dispersion across locations. Finally, the shock within Cluster 4 simulates a large average price move with a fairly limited dispersion across locations. Such a shock is expected to generate larger stress test losses for directional portfolios.

203. The shocks on commodities and energies used by CCPs in their climate scenarios are compared to those modelled under the ESRB market stress scenario, as a yardstick to evaluate their severity. This assessment could be performed solely for the risk factors commonly shocked by the ESRB and the CCPs.

204. On average, only a limited number of CCP shocks have a similar severity or are more severe than the shocks modelled under the ESRB market stress scenario. Nevertheless, for most risk factors, the maximum price shocks applied by CCPs are larger than the corresponding ESRB market stress scenario shocks.

6.3 Conclusions

205. The climate stress test aims at gaining an understanding of CCPs' exposure to climate risks and their level of awareness of their potential vulnerabilities and resilience towards such risks. Climate risks could impact CCPs along various lines, depending on their business and operating models.

206. First, potential risks arising from climate change could impact CCPs' business models. While these risks are not material at aggregate level in the short-to-medium run, due to the CCPs' overall diversified product mixes, at individual level and in the longer run, one point of attention concerns CCPs whose business model heavily depends on the clearing of assets directly exposed to transition risk. Four CCPs would fall in this category with a significant portion of their activity linked to commodity and energy contracts. For those CCPs, adequate strategies, governance, and level of risk management should be ensured to identify, monitor and mitigate such exposure to transition risk.

207. Secondly, potential risks arising from climate change could impact the prices of assets over time. In such case, a CCP may be obliged to take measures with regard to the collateral it requires from its clearing participants. However, the impact of transition risk on most of the collateral currently posted is deemed immaterial. Hence, no material changes in the collateral mix, mostly composed of cash and government bonds, is expected.

208. Thirdly, climate change risk could have direct implications on operational risk level. Subject to the important limitations of this analysis, acute physical risks although anticipated to become more likely and/or more severe as a result of climate change, are however not expected to result in major issues on the basis of the headquarters' locations of the CCPs and clearing members.

209. Fourthly, many CCPs have developed climate market stress test scenarios capturing the potential impact of acute physical risks on assets' prices. The maturity of the scenarios is correlated to the product mix cleared by the CCPs, with CCPs clearing commodities, energy and freight derivatives being first in line. Nevertheless, among the four CCPs whose product mix is directly and significantly exposed to climate risk, two did not report having climate market stress test scenarios. ESMA is encouraging CCPs to consider whether acute physical risk could negatively impact the value of the instruments they clear, and to complement the scenarios used to size prefunded resources with adequate market stress scenarios designed to capture and monitor these risks.

210. Finally, the scope of this climate stress test was limited to a selection of climate risk transmission channels. Accordingly, all interlinkages between CCP and climate risks may not be covered. Nevertheless, the outcomes of this analysis should be understood as a yardstick for further action with regard to climate risks' monitoring.

7 Ecosystem analysis

7.1 Overview and Objectives

211. Recent crises illustrate that CCPs are exposed to risks with root causes beyond its exposures to clearing members in extreme but plausible market circumstances, for example, risks related to concentrated positions of clients. On their turn, CCPs may impact the resilience of their clearing members, clients, and markets, for example, through abrupt margin calls during times of high prices and market volatility. Analysis of the central clearing ecosystem analysis is complementary to the core components of ESMA's CCP stress tests and enhances this work by considering the clearing system as a whole, providing insights into its structure and evolution, while also exploring specific areas with potential spill-over effects to the broader financial system.

212. For this purpose, the ecosystem analysis includes four exploratory studies.

- **Analysis of CCPs' and CMs' resources:** The data submitted by CCPs is used to analyse the size of the industry, its evolution through time and identify developments and trends.

- **Large clients analysis**: Network topology analysis is used in order to enhance the understanding of the clearing ecosystem and identify the systemic relevance of large clients for selected asset classes.

- **Analysis of variation margin flows:** The analysis uses data submitted by CCPs on Variation Margin to estimate the potential liquidity impact of CCP margin calls on clearing members and their clients.

- **Analysis of CCPs' investments**: The investment activity of CCPs is analysed with a focus on reverse repos and market risk stemming from bond portfolios, providing insights in the role of CCPs in repo markets.

7.2 Analysis of CCPs and CMs Resources

213. The CCPs included in the scope of the exercise reported data on the required and available financial resources used to run the stress test. The analysis presented in this section focuses in particular on the evolution and distribution of resources through time in an effort to identify changes or potential trends.

214. The total amount of financial resources comprising the default waterfalls of CCPs has increased significantly compared to the previous stress exercises. The amount corresponding to each tranche of the default waterfall across all CCPs in scope of this exercise can be seen in Figure 42 reported in bn EUR equivalent and in % share.

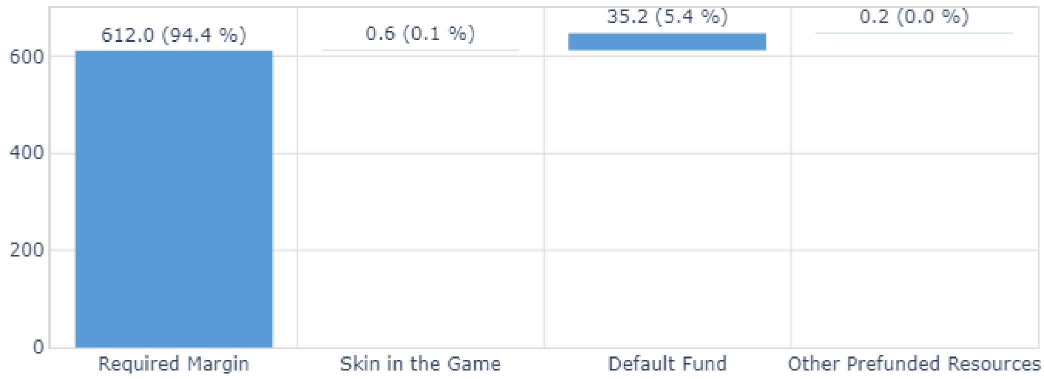

FIGURE 42: DEFAULT WATERFALL (IN BN EUR EQUIVALENT) - ALL CCPS

215. The total amount of required margin increased significantly, from 392bn EUR in March 2021 to 612bn EUR in March 2023 (+56%), causing the share of required margin in the waterfalls to increase to 94%. The stress events and resulting episodes of volatility surge experienced in the recent years have translated into higher margin requirements, contributing further to the systemic importance of the central clearing system as a whole.

216. The amount of default fund contributions shows an increase as well, although to a lesser extent from 31bn EUR to 35bn EUR (15% increase). Due to the sharp increase of required margin, the share of default fund contributions dropped by nearly 2 percentage point to 5.4% in the current stress test exercise. The overall decreased share of default funds in the CCPs' waterfall indicates a reduced level of risk mutualisation in the central clearing system and strengthened the 'defaulter pays' principle.

217. The breakdown of resources per CCP is reported in the Annex (8.5). No significant change was observed in terms of required vs excess margin with CCPs clearing cash securities showing a higher share of excess as exposures can change significant from one day to the other and members prefer to over-collateralise. Moreover, in terms of different asset types, approximately half of the collateral is provided in cash and half in government bonds with smaller CCPs having generally a higher share of cash. Although one could identify different practices and risk management techniques being implemented by different CCPs, the purpose of presenting this data is not to benchmark individual CCPs. Different CCPs clear different products with distinct characteristics. The size of resources alone cannot indicate the effectiveness of the CCP's risk mitigation arrangements. The resilience of CCPs to adverse market developments is assessed using the core stress results.

218. The increase in margin has not significantly impacted the concentration of clearing members providing these resources. Figure 43 shows the distribution of required margin across clearing member groups (blue bars) and their corresponding cumulative share of the required margin on aggregate (line charts). The top nine (9) clearing member groups provided each more than 20bn EUR required margin, which accounts on aggregate for 59% of the total required margin. Notably, the largest clearing member group was required to provide in total 58bn EUR to CCPs in scope of the exercise through multiple different legal entities being clearing members at those CCPs. This accounts for approximately 9% of the total required margin across all CCPs.

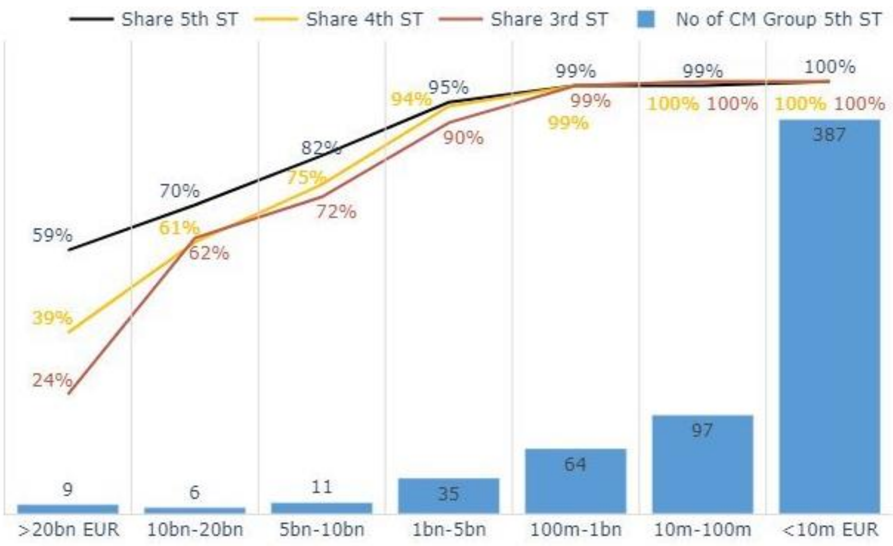

FIGURE 43: CLEARING MEMBER GROUPS – DISTRIBUTION OF REQUIRED MARGIN SHARE

219. More clearing member groups were required to provide very large margin amounts (i.e. more than 20bn EUR) compared to the previous stress test exercise. However, as it can be seen in Figure 44, focusing on the share of the top groups instead of the absolute amounts, the share of the 5 largest clearing member groups is only marginally higher and remains rather stable at around 40%. This indicates that there is no further notable increase in the concentration of resources provided by the top clearing member groups, but rather a more generalized increase of margin for all clearing members.

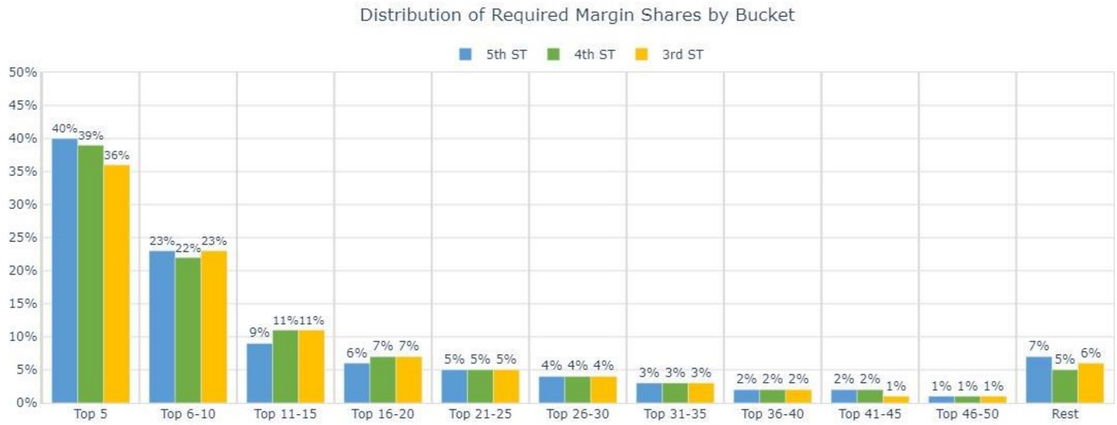

FIGURE 44: DISTRIBUTION OF REQUIRED MARGIN SHARES BY BUCKET

7.3 Large clients' analysis

220. The primary goal of this analysis is to identify potentially riskier clients that could be marked as "systemic", being those entities that hold large exposures with respect to the market size of the considered derivative asset class. Such entities may clear using multiple clearing members or ultimately across multiple CCPs. Looking only at the position held at each clearing member, in one or multiple omnibus or even segregated clearing accounts, could therefore underestimate the total concentration risk. The analysis does not attempt to stress the relevant exposures or

estimate the quantitative impact. The proposed framework can however help to enhance the understanding of the clearing ecosystem with a focus on possible spillover and contagion effects within derivative markets.

221. The analysis starts by reconstructing for specific asset classes a network view of the clearing ecosystem comprising CCPs, clearing members, and clients. The considered asset classes are equity derivatives, energy commodity derivatives (power, gas) and European Union emission allowances derivatives. The approach leverages on network topology techniques to evaluate the systemic relevance of large clients. The results are based on the analysis of derivative exposures reported from EU counterparties to Trade Repositories under the EMIR reporting obligation. The novelty of the analysis is that it sheds light into the dynamics of the client-clearing space, for which clients' details are not always available to other counterparties, for example the CCPs, hence attempting to improve the overall understanding on potential risks.

222. Starting from granular EMIR data, multiple data cleaning steps are applied to ensure de-duplication of reporting and to reconstruct the full trade chain composed of clients, clearing members and CCPs[30]. It must be noted that data limitations could persist due to EMIR data imperfect quality, however, data inconsistencies are fixed to the extent possible to reach a sufficient level of data quality. Finally, benchmarking the results for each derivative asset class against data reported for the purpose of this stress test exercise is also performed as a consistency check.

223. Drawing from the network topology, a numerical score measuring the importance of each entity in the client-clearing ecosystem is estimated by computing the nodes' eigenvector centrality[31]. The eigenvector centrality is an algorithm that measures the transitivity influence of nodes in the network, meaning that relationships originating from high-scoring nodes are given a higher weight. In addition, the eigenvector centrality also weights each edge between nodes by the size of their net exposure. This metric is therefore regarded to be appropriate to measure the "systemic relevance" of clients. However, it is good to highlight that in the network charts presented in the next subsections, the size of each node, based on its eigenvector centrality score, will reflect a combination of its net exposures and its number of connections.

Results

224. The client-clearing ecosystem of the four analysed derivatives markets exhibits a core-periphery structure, with clearing members and CCPs representing the dense, cohesive core of the network and clients the sparse, less-connected periphery[32]. There is typically a small number of clearing members playing a dominant role in their respective markets. One exemption is the equity derivatives market where various large clearing members exist with comparable size.

225. The share of the client clearing segment relatively to the total market size is estimated in terms of absolute net notional outstanding. Intuitively, the net notional exposure could be seen as an indicator of risk.

Figure 45 presents this estimation for each asset class:

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[30] While considering only client-clearing exposures (i.e. those trades between clients and clearing members for which the identification of the CCP where the trade is novated is possible) positions in house accounts are excluded from the sample.
[31] In network topology each entity part of a network is called a node, while each connection between nodes is an edge.
[32] Borgatti et Al., (1999), Models of core/periphery structures

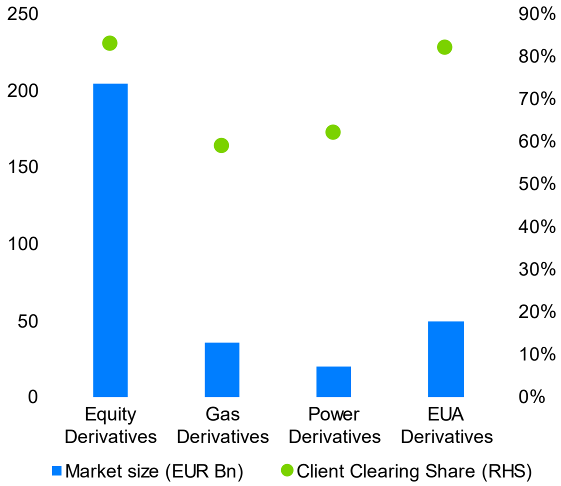


FIGURE 45: MARKET SIZE AND CLIENT CLEARING SHARE

Derivative Asset Class	*Equity*	*Natural Gas*	*Power*	*EU Emission Allowances*
Number of individual clients	33037	302	328	287

FIGURE 46: NUMBER OF INDIVIDUAL CLIENTS CLEARING PER ASSET CLASS

226. Figure 46 shows that the share of the client clearing segment varies across asset classes. equity derivatives and EUA derivatives are the ones with the largest client-clearing share, with more than 80% of the total clearing activity resulting from clients' accounts. The larger client segment for those two markets likely stems from the fact that clients' positions in those asset classes are more directional. The lower client activity in gas and power markets, on the other hand, can be attributed to two factors. Firstly, it is likely that non-EU clients trading with non-EU clearing members play a prominent role in these markets (that also include non-EU gas and power cleared contracts) and such entities are exempted from the reporting obligation in EMIR and therefore absent from our sample. Secondly, a significant portion of positions originates from house accounts of clearing members, which were excluded from this sample. Furthermore, equity derivatives have the largest number of individual clients, while for commodity derivatives we observe that in many cases the same clients are normally active in both energy (gas and power) and EUA derivatives, as also demonstrated from the similar count of entities in those classes (Figure 46). The difference in the number of clients might also reflect different market structures. Gas, power and EUA are likely more traditional markets, where few dealer-brokers provide liquidity to clients, whereas in equity there is a higher client participation via electronic trading platforms.

227. Next, an analysis of concentration for the Top 1 and Top 5 entities is conducted for each asset class, considering both long and short positions. Figure 47 summarises the results.

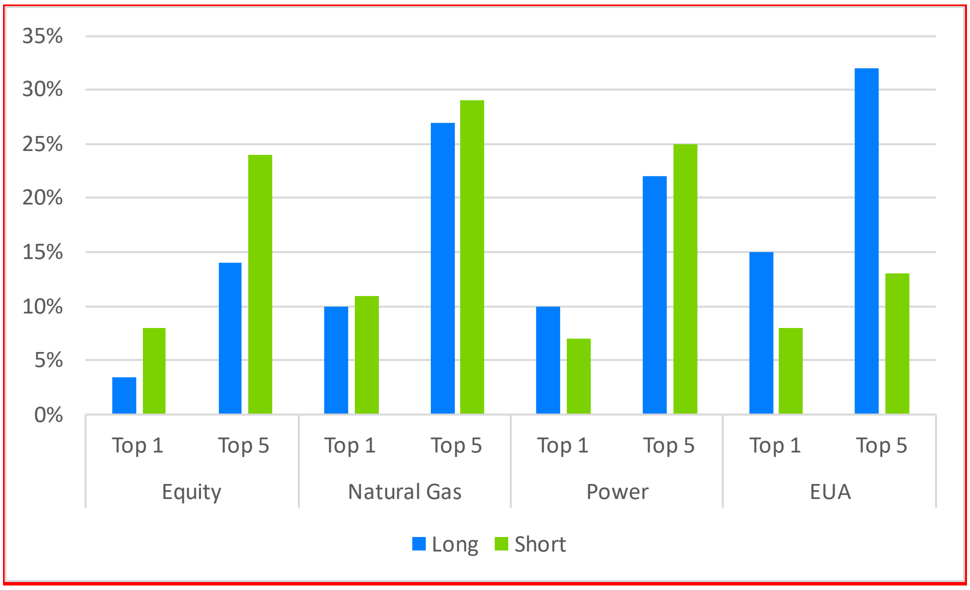


FIGURE 47: LONG AND SHORT TOP CLIENTS CONCENTRATION PER ASSET CLASS

228. More generally, the short side is more concentrated than the long side with the exception of EUA, where compliance entities are forced to buy allowances to compensate for their emissions and large banks act as liquidity providers in the market, therefore showing lower client activity on the sell side. On the long side, energy commodities and allowances are more concentrated than equity derivatives. This is also justified from the significantly lower number of entities active in such markets, as the number of clients in equities is circa 100 times bigger than the other classes. For EUA derivatives we observe the largest concentration on the long side, with the Top 5 entities accounting for 1/3 of total positions. In Natural gas there is a similar concentration for the long and the short side. Concerning the equity derivative market, whereas not very concentrated on the long side, the Top 5 short entities account for ¼ of the total market size.

229. Finally, in the next sub-sections, each derivative asset class is analysed individually, the network visualization for each market is presented and the results are discussed.

Equity Derivatives Analysis

230. A network visualization of the client-clearing ecosystem for equity derivatives is presented in the chart below (Figure 48). Each circle represents an individual node which is labelled as client, CM, or CCP. The size of each circle is proportional to the value of its eigenvector centrality, while the arrow between two nodes indicates that an exposure exists between the two entities. The size of each circle (node) does not only reflect the size of the relevant exposure but is a combination of its exposure and the number and size of all connected nodes. So, the fact that one node is larger than another does not necessarily mean that it has a larger net exposure. The size of a node alone cannot be used to derive the amount of its exposures but is used in the context of this analysis to assess its centrality in the network.

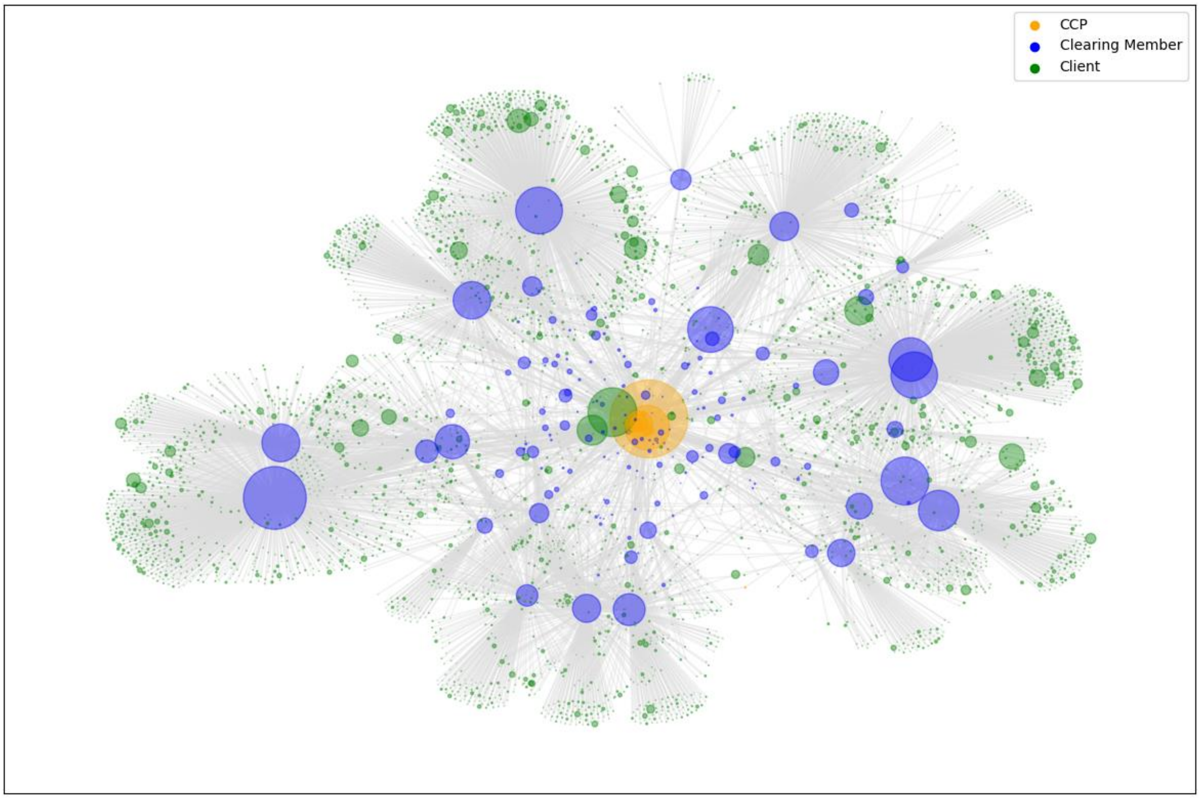


FIGURE 48: NETWORK FOR EQUITY DERIVATIVES

231. In equity derivatives we see a quite prominent core-periphery structure. The clearing activity is concentrated in few CCPs, that occupy the centre of the chart. One CCP has a significantly larger centrality score, since the majority of cleared positions are novated to this CCP.

232. The clients' ecosystem is quite heterogeneous in terms of centrality scores, with the exemption of a few clients that stand out as a result of both their relatively large exposures and their high number of connections with multiple clearing members. In adverse market conditions, such large and well-connected clients could potentially pose a higher "systemic" risk than peripheral, and less connected clients. More generally, we observe a pattern of clients being active in more than one CCP, while also having connections with multiple clearing members, likely reflecting the wide range of available equity derivative products traded in different trading venues – a key feature of this market.

233. The size distribution of clearing members exhibits a clear distinction between large and small entities. Most clearing members are small due to their limited number of connections. Interestingly, while there is no single dominant clearing member in this asset class, there is a consistent presence of larger clearing members with comparable sizes. This suggests a more competitive market structure, with less reliance on few dominant players—a stark contrast between the equity derivatives market and other markets that will be presented in following sections.

Gas Market Analysis

234. The network structure of the gas derivatives market is illustrated in Figure 49.

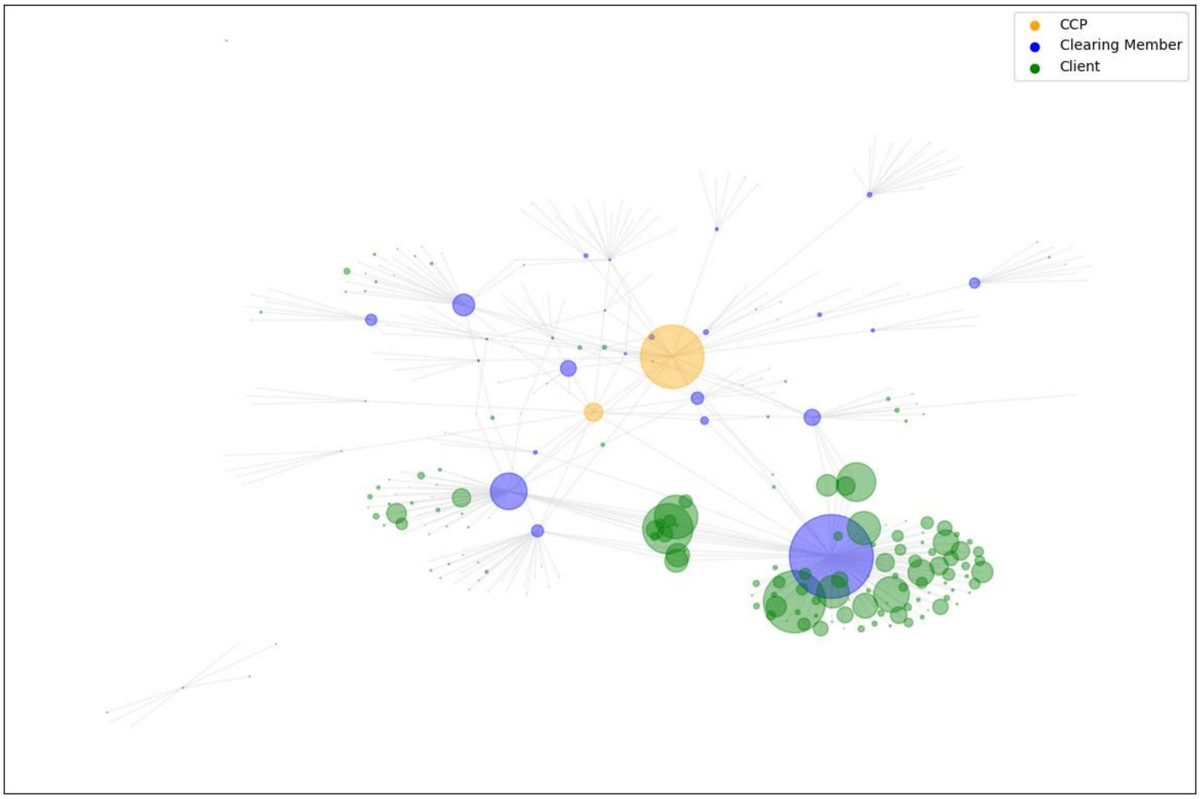


FIGURE 49: NETWORK FOR GAS DERIVATIVES

235. In this market, the exposures are mainly concentrated in two CCPs. Among CCPs, one stands out with a significantly higher centrality score. This distinction arises from its extensive connections to a larger number of clearing members. Additionally, the positions cleared by this CCP predominantly originate from some very large clearing members.

236. In this market, one clearing member exhibits a clear dominance. Many large clients trade exclusively with this entity, posing what could be a "systemic" dependence of the market on the provided clearing services.

237. Some large clients have relationships with multiple clearing members, and they also novate in both the two main CCPs. Cases are also observed where the same client trades with two different clearing members but clears at the same CCP.

Power Derivatives Analysis

238. The third network presented is for power derivatives.

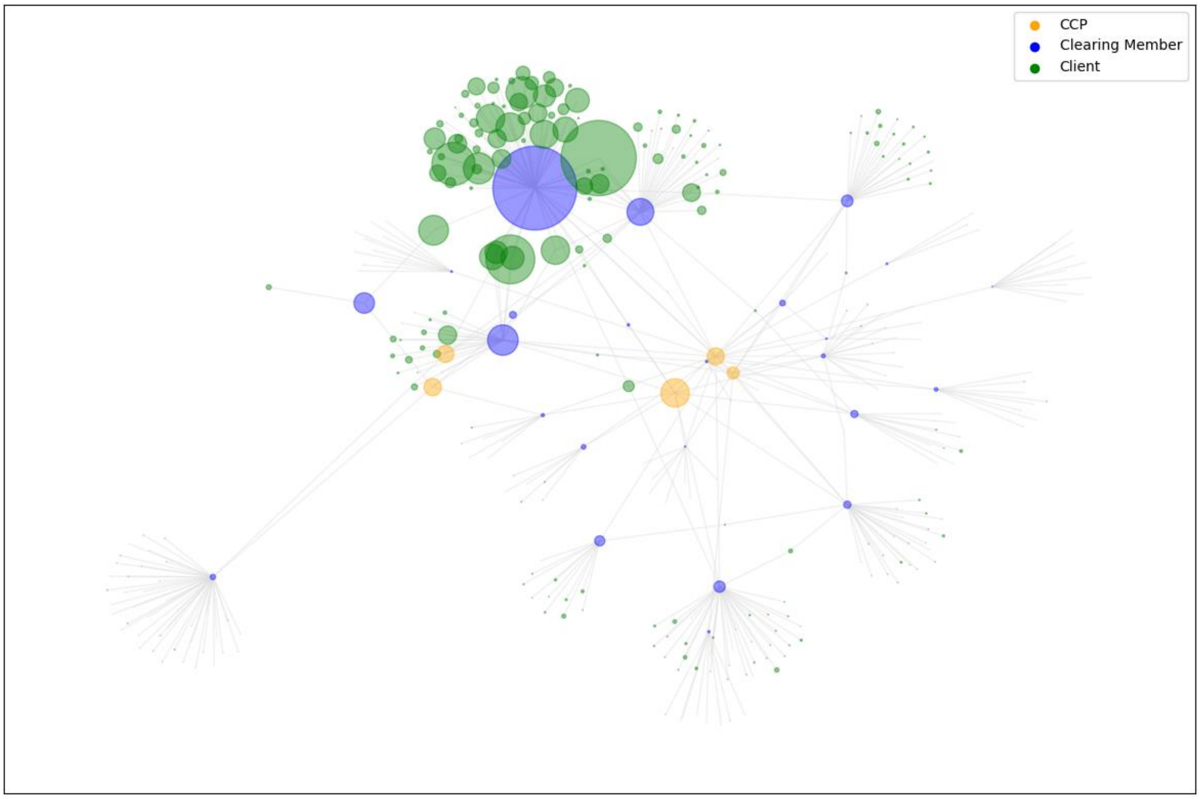


FIGURE 50: NETWORK FOR POWER DERIVATIVES

239. In power derivatives we see multiple CCPs having a similar centrality score, although one has relatively higher score than the others, since it attracts most of the position from the largest clearing member.

In terms of clearing members, also in this asset class there is one entity that appears to dominate the market, given its large number of clients and their large exposures. It is indeed also strongly connected to some of the most "systemic" clients, represented from the largest green circles. Such clients are very central in the network, in some cases also showing directional exposures with two of the largest clearing members while clearing in two different CCPs. However, the relatively big size of individual clients in the network reflects the fact that despite there are some large clients that are associated to more than one clearing member, specific clients have a relatively higher net exposure compared to the rest, marking them as of "systemic" importance. On the other hand, most of the medium-sized clients clear only with one clearing member.

EUA Derivatives

240.The last subsection addresses the EUA derivatives network.

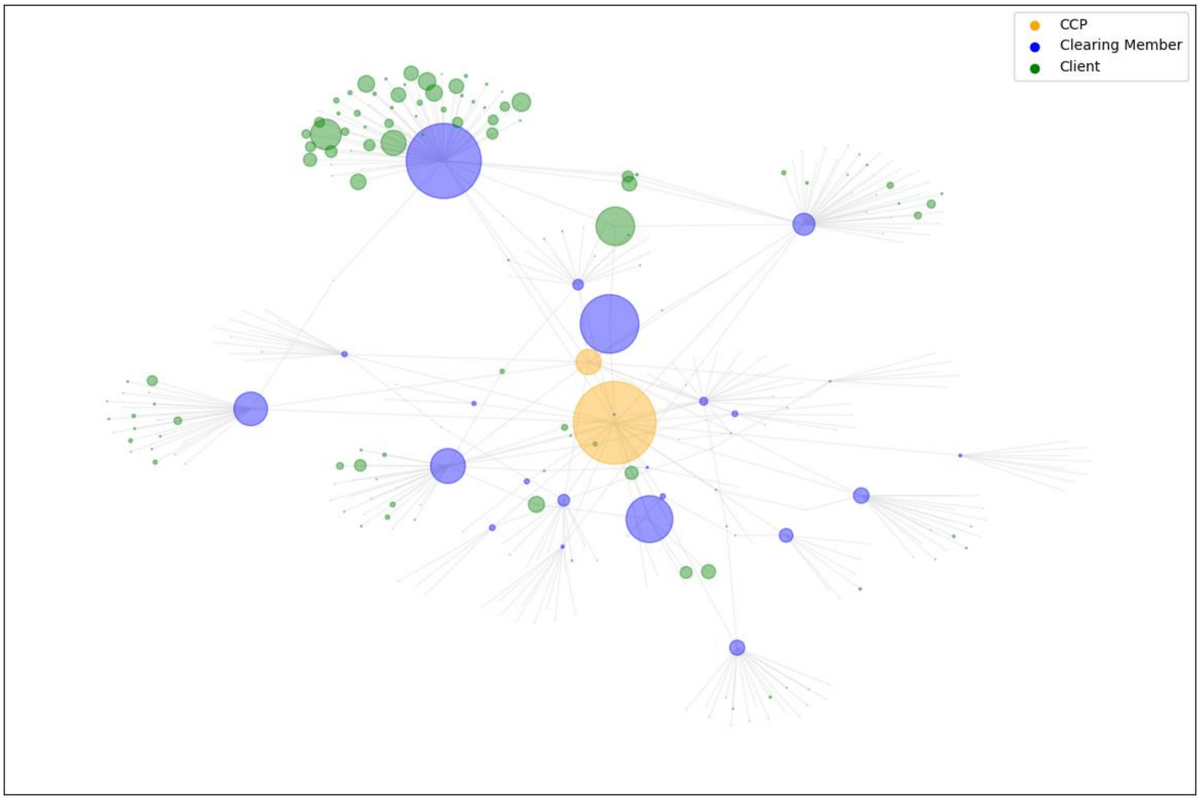


FIGURE 51: NETWORK FOR EUA DERIVATIVES

241.The EUA derivatives clearing activity is concentrated in only two CCPs, one based in the EU and the other based in a third country. One of them is relatively more central than the other, showing a bigger clearing activity.

242.The centrality score of the clients is overall homogenous, with only few larger entities. In general, clients trade only with one clearing member each, but it's not uncommon to observe entities having multiple clearing relationships. The latter is observed for cases of more important "systemic" clients, also active in both CCPs and trading with multiple different CMs.

243.On the clearing members side, three entities appear to be the most central in the network, with one of them having a bigger number of connections compared to the others. Many of the other clearing members are connected to smaller clients, making them less central in the network.

Final Remarks

244.The presented analysis while being exploratory and not strictly aiming to stress exposures leaving room for further development in future iterations, already provides insights into the client-clearing ecosystem and potential implications for possible contagion and spill-over effects, potentially impacting EU financial stability. It highlights the different functioning of more traditional derivative markets (e.g., commodities) compared to dynamic ones (e.g., equity). It helps to better understand the characteristics and behaviour of participants in cleared derivative markets, allowing to also evaluate concentration and market dominance, noting higher reliance on a few entities, including clients and clearing members, in specific markets potentially impacting resilience in periods of stress.

However, it is also important to acknowledge the limitations to this analysis. First, the scope of this analysis is limited as the reporting obligations under EMIR only apply to EU counterparties. Therefore, our focus is on cleared trades involving at least one counterparty based in the EU. Consequently, activities originating from clients and clearing members both being based outside the EU — despite being novated at EU CCPs — are not included in this study. Also, the outcomes of this study may be subject to data quality issues, such as misreporting. Nevertheless, regular exercises like this contribute to ongoing data quality monitoring, enabling to continuously enhance the level of detail in TR reports.

7.4 Stressed variation margins

245. In times of stress, when market volatility surges, margin requirements typically increase in line with the design of CCP risk models. As this may put a strain on market participants to meet these margin calls, sometimes leading to systemic risks, further analysis into margin contagion paths is warranted.

246. Data submitted by CCPs on variation margin that would need to be exchanged under the market stress scenario of the 5th stress test exercise was used to estimate the potential liquidity impact on clearing members and their clients in the EU clearing system. The sum of the gross stressed variation margin flows per CCP, also split between house and client accounts, are shown in Figure 52[33].

247. The figure shows that three CCPs would account for most of the stressed flows, namely LCHUK (46%), ECAG (24%) and ICEEU (23%).

248. In terms of currencies, and at a system-wide level, close to 89% of reported variation margin flows would need to be exchanged in the top three currencies, i.e. EUR (50%), GBP (15%) or USD (24%). Across CCPs, the share of variation margin flows in these different currencies varies considerably. Variation margin calls at ECAG are predominantly in EUR, while those at LCHUK and ICEEU see also large calls in USD and GBP.

249. The chart also illustrates the significance of client clearing activity at each CCP, with client flows greater than house flows in particular for ICEEU and ECAG. The data also shows that client clearing is concentrated in a few CCPs that also offer clearing in multiple currencies.

[33] Sum of inflows and outflows per account

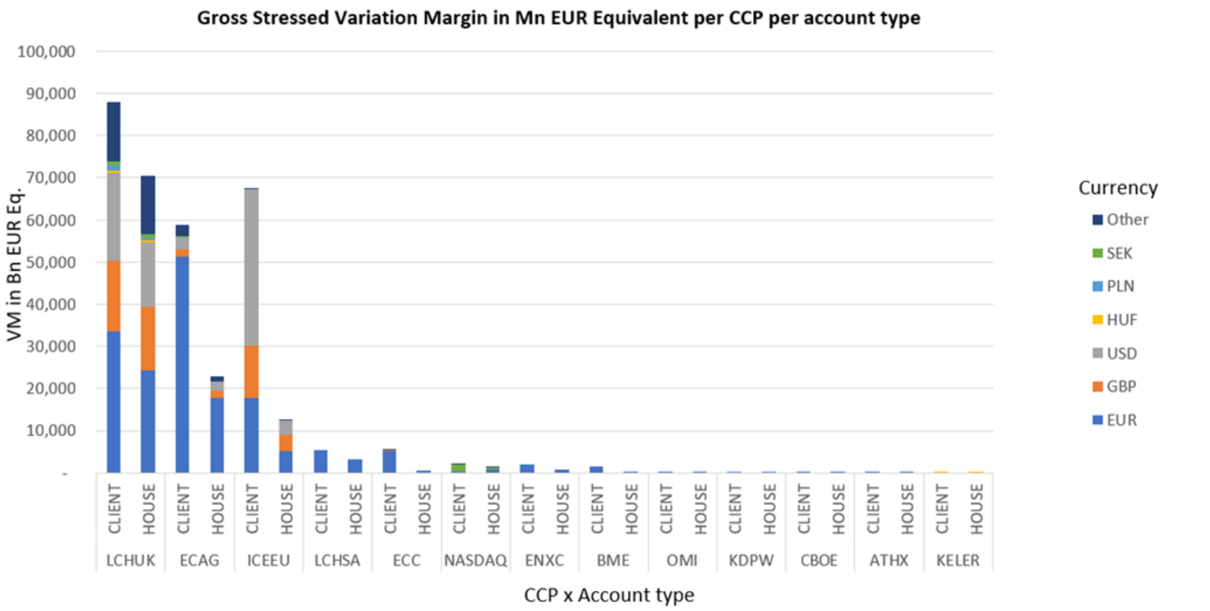


FIGURE 52: GROSS VARIATION MARGIN PAYMENTS PER CURRENCY BY CCP AND ACCOUNT TYPE

250. Figure 53 illustrates the breakdown per CCP and account type in relative terms for all currencies. Analysing the composition of variation margins at CCP level, eight CCPs see flows in one currency only. Beyond the three top currencies, other currencies that account for a large share or even the entirety of stressed variation margin flows at individual CCPs are SEK, PLN and HUF.

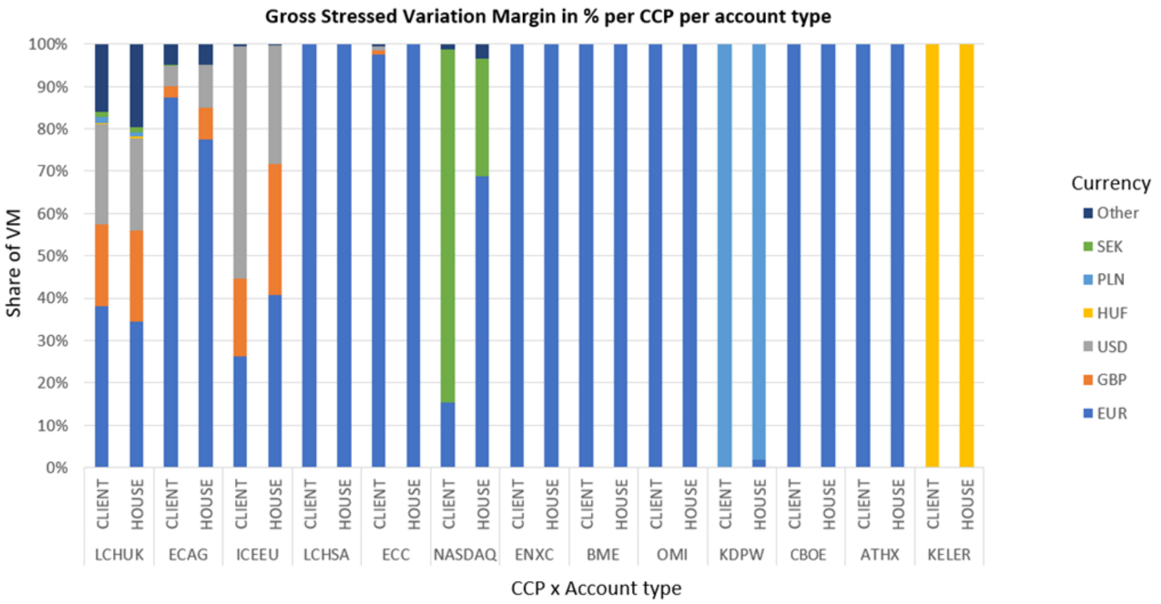


Figure 53: Shares of Gross Variation Margin payments per currency by CCP and account type

251. The below chart (Figure 54) shows the gross and net variation margin calls for the ten clearing member groups that face the greatest absolute calls in the considered market stress scenario.

252. The client account variation margin flows seem to net to a large extent between inflows and outflows. Taken together with the house variation margin flows, the net flows for most of the clearing members are rather balanced. The most notable exception is one clearing member with an outflow of around 10bn EUR equivalent. However, although it was not analysed as part of the work, the selected clearing member groups are large financial institutions, and it would be expected that the net reported flows are well below their hiqh-quality liquidity asset (HQLA) holdings[34].

253. Still, as clearing members need to service all payments to the CCP on behalf of their clients, which are responsible for most of the gross flows, the net flows underestimate their liquidity total requirements. For instance, at least in some markets, end of day VM calls are due by clients a few hours after the CMs have delivered themselves the margin due to the CCP.

[34] Based on publicly available data.

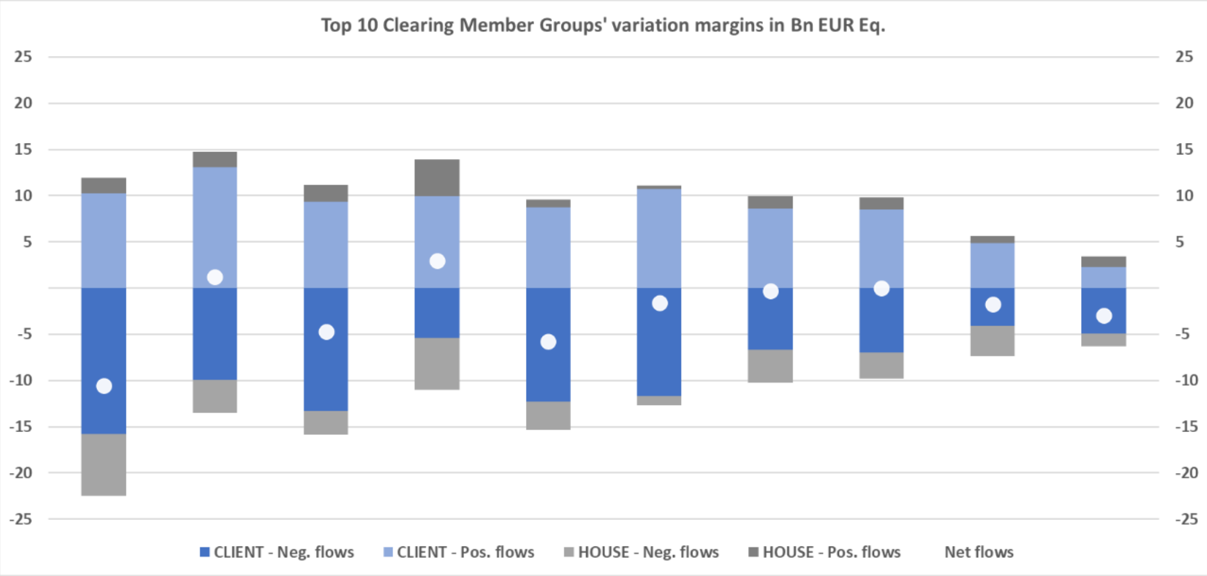


FIGURE 54: TOP 10 CLEARING MEMBER GROUPS IN TERMS OF ABSOLUTE VARIATION MARGINS IN BN EUR EQ.

254. The stressed variation margin flows split by clearing member groups' sector and region are presented in the following table. As expected, clearing members from the financial sector cover most of the gross stressed variation margin flows. The data provided didn't allow to extend this analysis to estimate the share of stressed variation margin flows impacting specific types of clients, such as clients that are not financial institutions.

Flows by CM Group's sector and region in Bn EUR Eq.	Sum of Pos. flows	Sum of Neg. flows
Financial institution	**169.6**	**- 167.8**
EU	**79.1**	**- 60.4**
NON-EU	**90.6**	**- 107.4**
GB	38.8	- 56.8
US	38.3	- 34.7
Other	13.4	- 15.8
Sovereign or public finance	**0.3**	**- 0.8**
EU	**0.0**	**- 0.8**
NON-EU	**0.3**	**-**
GB	0.3	-
Other	-	-
Non-financial / Other	**2.1**	**- 3.1**
EU	**0.5**	**- 0.5**
NON-EU	**1.6**	**- 2.6**
GB	0.0	- 0.0
US	1.2	- 2.4
Other	0.3	- 0.2
Grand Total	**172**	**- 172**

TABLE 1: STRESSED VARIATION MARGINS PER TYPE OF CLEARING MEMBER AND REGION IN BN EUR EQUIVALENT

255. Non-defaulting clearing members affected by the failure of payment banks[35] are assumed to be unable to make payments to CCPs on the day of default. The main results already assume that defaulting entities default in all their capacities, including as payment banks. The maximum payment bank net flows are large but represent a limited share of available liquid resources, with main stressed variation margin flows in EUR, GBP, USD and AUD.

	EUR	GBP	USD	CHF	AUD	CAD
ICEEU	5.3	3.6	4.7	.1		
LCHUK	1.8	1.8	1.5	.3	1.1	.5
ECAG	1.3		.2	.4		
NASDAQ	.3					
BME	.2					
OMI	.2					
ENXC	.5					

TABLE 2: MAXIMUM PAYMENT BANK NET FLOW IN ABSOLUTE VALUE PER CCP AND CURRENCY (MATERIAL AMOUNTS ONLY, REPORTED IN BN)

[35] Banks providing cash settlement services to CCPs and clearing members.

Conclusion

256.This analysis is a first step in assessing the impact of variation margin calls on the clearing ecosystem. It confirms that variation margin calls, which CCPs need to mitigate the risks related to uncovered exposures, have a significant impact on clearing members under the market stress scenario of this exercise. Overall, findings indicate that the net largest liquidity demands fall on the largest financial groups and appears manageable given their available liquid resources, although the net flows underestimate their liquidity requirements. Likewise, findings also show that, in case of the failure of payment banks, the liquid resources available to CCPs should allow them to withstand missed variation margin flows.

257.Under stressed conditions, CCPs would impact to a large extent financial institutions both of EU and non-EU origin (especially the United Kingdom and USA). A significant amount of stressed variation margin requirements may then be passed to clients, which may worsen the liquidity context.

7.5 Investment risk (Bonds & reverse repos)

258.The risk profile of the CCPs is impacted by their investment activities as these activities can result in market exposures and potentially losses. From this year, ESMA models the investment activity impact directly, allowing a better understanding of the risks.

259.The main focus of the investment risk analysis has been bond investments market risk and potential exposure to reverse repo collateral which is received by CCPs securing cash overnight. Bond and repo markets are systemically important markets, given their relevance for, among others, government debt issuance, collateralization of exposures, and as a monetary policy transmission channel. This analysis intends to provide a few insights in the role of CCPs in these markets as investor and counterparty for uncleared reverse repos.

Market risk for bonds

260.This initial analysis only covers the market risk of the bond investment portfolio, without considering the potential loss allocation, capital impact or profit sharing.

261.It should be noted that investments leave the currency composition of the resources mostly unchanged, without any material incremental FX risk.

262.Weighted average maturities remain all below 1.5 years, with an average of 0.7 years. The weighted average duration is even much lower, with a large CCP having most of its investments in floating rate notes, and below 3 months for most CCPs. Only 2 CCPs have longer average duration (of 0.9 and 1.49 years).

263.The limited market risk of CCP bond investments has been further checked by computing Value at Risk and Expected Shortfall metrics with different liquidation periods and confidence intervals[36]. The code was developed in collaboration with IMF staff, and using the same time series of historical data for relevant risk factors as in the additional analyses of the credit component. The metrics are consistent with reported durations, confirming that bond investment risk seems limited.

[36] Similarly to a typical initial margin computation

Reverse repo investments

264. Article 45(2) of Commission Delegated Regulation (EU) No 153/2013 provides that where cash is deposited other than with a central bank, and is maintained overnight, then not less than 95% of such cash must be deposited through arrangements that ensure the collateralisation of the cash with highly liquid financial instruments, for example, through repo transactions. CCPs participate to 20% of repo lending/borrowing according to ESMA's SFT report[37]. However, these figures include both CCPs' exposures in their role as intermediaries and their cash reinvestment activity.

265. As part of those reinvestment activities, large cash balances of 164.7bn EUR equivalent were reported by CCPs for the purpose of this exercise as secured via uncleared reverse repos, mostly securing USD (47%), EUR (34%) and GBP (17%) cash. However, those balances constitute only a small share of the 4.5 tn EUR of the whole bilateral repo principal amounts reported in September 2023[37].

CURRENCY	CASH LEG(mn)	CASH LEG EUR (mn)
USD	83,024	78,155
EUR	56,604	56,604
GBP	24,823	28,373
CHF	849	861
PLN	2,135	454
SEK	1,823	163
NOK	441	39
HUF	10,544	27
DKK	190	26

TABLE 3: REVERSE REPOS OF CCPS PER CURRENCY

266. A repurchase agreement or "repo" is effectively a collateralized loan, usually a short-term financing arrangement, where securities are exchanged for cash at a predetermined rate (repo rate).

267. A repo transaction can be classified as either 'generic' or 'specific', and this classification is based on the collateral taker's ability to request a determined instrument in exchange for cash. When the collateral provider can choose the security among a range of instruments satisfying predefined criteria (e.g. collateral baskets), the repo is termed 'generic' ('GC' repo). Typically, these repos involve a third party in charge of collateral selection and management, such as a third-party agent or the presence of a CCP (e.g. GC financing facilities), even though this is not always the case.

268. On the other hand, when the collateral taker requests a specific instrument to be delivered as collateral, the repo is termed 'specific'.

[37] See ESMA (2024), EU Securities Financing Transactions markets 2024, April, ESMA50-524821-3147.

269.Approximately 90% of EUR and GBP cash is secured by CCPs with generic reverse repos. In contrast, USD (58%) and CHF (47%) rely less on generic repos. Market-wide, generic collateral represents only 18% of bilateral principal amounts in September 2023[37].

Type	Pool of securities	Specific Collateral
USD	58.28%	41.72%
EUR	91.64%	8.36%
GBP	90.32%	9.68%
CHF	47.02%	52.98%
PLN	0.00%	100.00%
SEK	0.00%	100.00%
NOK	0.00%	100.00%
HUF	0.00%	100.00%
DKK	0.00%	100.00%
Grand Total	74.95%	25.05%

TABLE 4: REVERSE REPOS OF CCPS PER CURRENCY AND COLLATERAL TYPE

270.On the stress date, cash was largely secured with collateral of the same currency for EUR and GBP (94% and 87% respectively), but only for 75% of USD cash.

271.Further to the FX risk, the reported collateral varies widely in risk profile.

272.For instance, GBP collateral comprises more inflation-linked gilts than conventional gilts, with maturities up to 50 years. A EUR government bond with 94 years maturity has also been used as collateral.

273.Haircuts applied to the reverse repos are small overall, in general below 2%, and don't appear to be sensitive to the market risk of the collateral. It should be noted that low or zero haircuts on sovereign bonds are also common in uncleared repos, where zero haircut trades accounted for 70% of government bond collateral.

274.The same bonds could attract much higher haircuts when used as margin collateral: for example, depending on maturity, index-linked gilts have haircuts of between 1.45% and 31.5% in one large CCP.

275.The low level of haircuts for collateral in reverse repos securing cash could expose the CCP to market risk exposure in case of default of reverse repo counterparties.

276.There could also be repercussions for the ecosystem, as in case of liquidity stress event, counterparties could face further funding needs and costs for the collateral currently used for CCPs reverse repos.

Conclusion

277.The market risk taken by CCPs through their bond investment appears low considering an average duration below 3 months for most CCPs, invested amounts and limited FX risk.

278. As part of their cash reinvestment activity, CCPs invest large cash balances in reverse repos, which still constitutes a relatively small share of the whole bilateral repo market. However, observed low haircuts and varied market risk profiles of the collateral could create potential vulnerabilities for both CCPs and counterparties during a liquidity stress event, and this may lead to an uncovered exposure.

8 Annexes

8.1 Annex 1 - CCPs in scope

no	CCP	CCP code
1	Athens Exchange Clearing House	ATHX
2	BME Clearing	BME
3	Cboe Clear Europe NV	CBOE
4	CCP Austria Abwicklungsstelle für Börsengeschäfte GmbH	CCPA
5	Eurex Clearing AG	ECAG
6	Euronext Clearing / Cassa di Compensazione e Garanzia S.p.A.	ENXC
7	European Commodity Clearing	ECC
8	ICE Clear Europe	ICEEU
9	ICE Clear Netherlands B.V.	ICENL
10	KDPW_CCP	KDPW
11	Keler CCP	KELER
12	LCH.Clearnet Ltd	LCHUK
13	LCH.Clearnet SA	LCHSA
14	Nasdaq OMX Clearing AB	NASDAQ
15	OMIClear – C.C., S.A.	OMI
16	SKDD-CCP Smart Clear d.d	SKDD

TABLE 5: LIST OF CCPS IN SCOPE

8.2 Annex 2 - Climate risk – Business model risk

The EU Joint Research Centre's (JRC) methodology, using Transition Exposure Coefficients (TEC), is leveraged upon to evaluate the potential impact of climate risks on CCPs' business model. Such TECs are allocated per activity as classified by Eurostat under NACE codes. For the purpose of allocating the clearing activities of a CCP, the following methodological choices were applied:

For the clearing of commodities or derivatives referencing a commodity: since the NACE classification distinguishes between economic activities (extraction, transport…) and not resources, the code and hence the TEC allocated to the extraction or production of the commodity was retained as the most relevant. If the Transition results in the phasing-out of a commodity, clearing volumes are likely to evolve with the production/consumption of the underlying commodity.

For the clearing of electricity, there are different NACE codes depending on the origin of the electricity (in particular for renewable energies). However, contracts do not distinguish on the means of production but focus on the delivery location. The possibility to compute a weighted average TEC for the electricity in each country was rejected as (i) it can be argued that the demand for electric power is unlikely to be elastic and (ii) markets are interconnected allowing for a degree of substitution between the means of production. Therefore, the retained TEC is the average TEC across the energy market.

For activities with no TEC, primarily in financial industries: by analogy with the sectors allocated to a nil TEC value, such industries are considered not directly affected by the Transition and were assigned a nil TEC value.

For activities not listed in the JRC's tables but that are deemed to enable the Transition: to avoid creating negative values for TECs[38], such activities are allocated a nil TEC value and are singled out in the analysis.

For activities that are considered not being directly impacted by climate risks: asset classes such as FX, government bonds, and interest rate swaps are deemed not relevant in the sense that they are not expected to be directly impacted by the Transition.

For activities that do not perfectly match with NACE codes: Equities, CDS and corporate bonds are also analysed. Here, the reported risk factors are mapped to the most relevant NACE codes at the most aggregated level. Data availability and granularity increased the difficulty to allocate to the relevant codes: some CCPs reported that corporate bonds and repos were part of the same set of activities, with hence no available breakdown. In such cases, these corporate bonds were excluded from the analysis of indirect exposures. Moreover, some CCPs reported products such as ETN which are cleared alongside and cross-margined with equity products, while referencing a commodity as underlying risk factor. These products were

[38] The JRC's work also proposes an analysis of portfolios with Transition Alignment Coefficients (TACs). However, our approach is a single materiality approach and moreover the analysis we perform is on assessing the risk to the CCPs. Therefore, we did not wish to use the TACs for our work.

excluded from the analysis of direct exposures. Finally, national, or EU-wide indexes were allocated a nil TEC. Considering the size of the stock and CDS markets, cross-industry indices are assumed to be independent from the Transition, in other words, if some industries are penalised by the Transition, it is implicitly assumed that other activities will take their place.

8.3 Annex 3 - Climate risk – Physical risks

Focus on the European Central Bank's methodology

To evaluate the sensitivities of the clearing ecosystem to potential operational disruptions caused by acute physical risks, ESMA collaborated with the ECB that defined risk score factoring the types of physical risk and locations. Those are defined in the table below.

Hazard	Source	Return Period	Resolution	Measure	Definition
Coastal Flooding	JRC	10, 50, 100, 200, 500 years	100x100m	Water heights (m)	Water raises due to coastal flooding. Estimates based on modelled extreme events intensities (water heights) for return periods of 10, 50, 100, 200, 500 years.
River Flooding	JRC	10, 20, 50, 100, 200, 500 years	100x100m	Water heights (m)	Water raises due to river flooding. Estimates based on the extreme events intensities (water heights) simulated in the reference period 1990–2013 for return periods of 10, 20, 50, 100, 200, 500 years.
Windstorms	ECB's calculation, based on Copernicus	5, 10, 50, 100, 500 years	NUTS3 areas	Wind speed (m/s)	Windstorm data with wind speeds >10 m/s. Estimates based on the extreme events intensities (gust speed) simulated for 1979–2021 for return periods of 5,10, 50, 100, 500 years.
Landslides	JRC	2, 5,10, 20, 50, 200, 500	200x200m	Score indicator	Indicator combining the physical characteristics of the terrain with the daily maximum precipitation in that area. The resulting landslide hazard provides an estimate of the predisposition to landslide of an area for, 5 classes: 1-low to 5-very high
Subsidence	JRC	.	100x100m	Score indicator	Subsidence susceptibility layer at European level (susceptibility based on soils' clay content): 1 - Coarse (18% < clay and > 65% sand) 2 - Medium (18% < clay < 35% and >= 15% sand, or 18% < clay and 15% < sand < 65%) 3 - Medium fine (< 35% clay and < 15% sand) 4 - Fine (35% < clay < 60%) 5 - Very fine (clay > 60 %) The soils with fine texture and clay content are at risk (5 classes: 1-low to 5-very high)

TABLE 6: DEFINITION OF RISK SCORES PER TYPE OF RISK

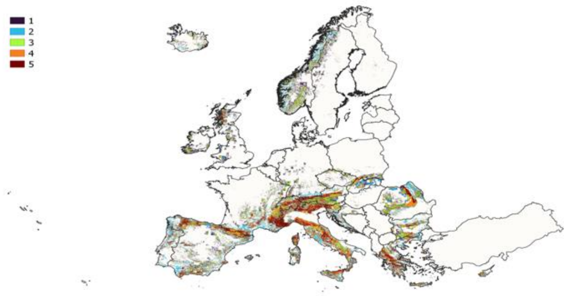
In addition to the risks listed above, the ECB provided data for risks such as water stress and wildfires. However, due to the urban location of the assets considered, these risks are deemed immaterial and hence omitted from this analysis.

Assessment of the potential impact of physical risk on CCPs' operation: main outcomes

This analysis focuses on 99 locations, covering CCPs and their top clearing members. The number of locations considers the overlap in the membership of different CCPs, while the locations with the highest number of selected clearing members illustrate a concentrated local market. Each type of risk is scored factoring such locations.

Landslides:

The risk of landslides is defined as the risk of gravitational movement of a mass of rock, earth, or debris down a slope, endangering assets settled on the risky locations. Landslide risk in Europe is depicted in Figure 55. The sensitivity to such risk is heterogeneous across the European Union. Nevertheless, for the majority of the 99 sampled locations, this risk is considered immaterial.



Risk Score	Number of locations concerned
0	94
1	5
above 1	0

FIGURE 55: MAPPING OF THE RISK OF LANDSLIDE WITH A RETURN PERIOD OF 500 YEARS IN EUROPE AND ASSOCIATED SCORES OF SAMPLED LOCATIONS

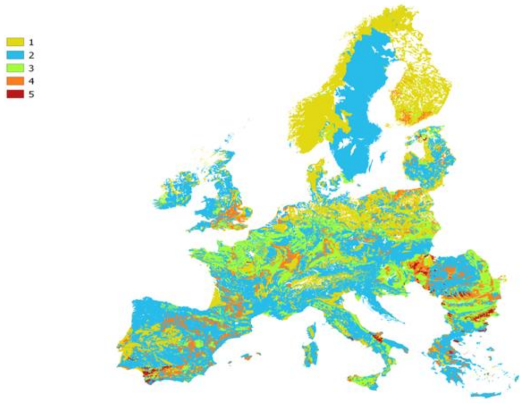
Note: 1 – very low; 2 – low; 3 – moderate; 4 – high; 5 – very high. A score set at 0 means the absence of landslide risk.

Source: DRMKC RDH (JRC), see https://esdac.jrc.ec.europa.eu/themes/landslides

Subsidence:

The risk of subsidence is defined as the risk of damage to real estate properties due to the variations on the humidity of the ground. The severity of this risk is therefore a function of the composition of the ground, as depicted in Figure 56. The sensitivity to such risk is heterogeneous across Europe and can differ within a few kilometers, hence presenting variations in risk levels within an area.

While this risk is considered immaterial for approximately half of the sampled locations, the risk is of medium importance for the other half. Nevertheless, such scores do not consider any structural mitigants relative to the building, such as deeper underpinnings, or any other mitigation measures, such as back-up locations or remote working possibilities.



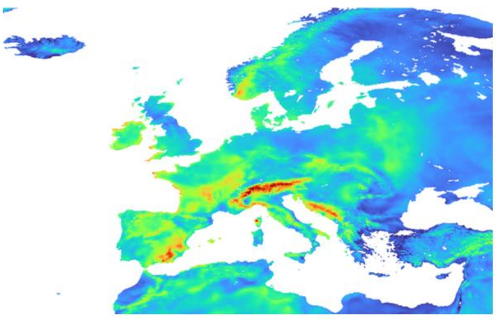
Risk Score	Number of locations concerned
0	54
1	7
2	36
3	2
4	0
5	0

FIGURE 56: MAPPING OF SUBSIDENCE RISK/SOIL TYPES IN EUROPE AND ASSOCIATED RISK SCORES FOR SAMPLED LOCATIONS

Note: 1 - Coarse (18% < clay and > 65% sand) 2 – Medium (18% < clay < 35% and >= 15% sand, or 18% < clay and 15% < sand < 65%) 3 – Medium fine (< 35% clay and < 15% sand) 4 – Fine (35% < clay < 60%) 5 - Very fine (clay > 60 %). A score set at 0 means the absence of subsidence risk.
Source: DRMKC RDH (JRC), European Central Bank analysis.

Windstorms:

Windstorm risk is defined as the risk of damage to infrastructure and property caused by extreme weather condition with very strong wind, heavy rain, and often thunder and lightning. The sensitivity to such risk is heterogeneous across Europe, with higher risk in mountainous regions and smaller coastal areas, as depicted in Figure 57.



Risk Score	Number of locations concerned
0	88
1	11
2 to 5	0

Note: wind speed highest in red
Source: Copernicus WISC (see https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-european-wind-storm-synthetic-events?tab=overview), European Central Bank analysis

FIGURE 57: FOOTPRINT OF A STORM AND ASSOCIATED SCORES PER LOCATION IN EUROPE

Windstorm risk is deemed immaterial for the majority of sampled locations, notably due to financial centers typically not settling in coastal or mountainous locations.

Flood:

Flood risk is defined as the risk of damage to infrastructures and properties due to water raise. This analysis distinguishes between river and coastal flood risks. Coastal flood risk is deemed immaterial for the sampled locations.

River flooding has historically been and remains a major source of physical risk in Europe. Nevertheless, despite a number of major urban centers historically being located near a river, such risk is deemed immaterial for the sampled locations, with the exception of one which is the location of a clearing member. Nevertheless, such scores do not consider any of this clearing member's mitigation measures that could be implemented in case of flood.

Risk Score	Number of locations concerned
0	96
1	2
2	0
3	0
4	1
5	0

8.4 Annex 4 – Climate risk – NACE codes and TEC for collateral analysis

Leveraging on the JRC's methodology while completing the values for the industries not in scope of their paper, the analysis established the following mapping to evaluate the impact of climate risks.

Level 1 NACE code	TEC	TEC value provided by the JRC	Description
A	0.0%	Y	agriculture, forestry, and fishing
B	90.1%	Y	mining and quarrying
C	22.9%	Y	manufacturing
D	34.6%	Y	electricity, gas, steam, and air conditioning supply
E	0.0%	Y	water supply; sewerage, waste management and remediation activities
F	13.4%	Y	construction
G	1.8%	Y	wholesale and retail trade; repair of motor vehicles and motorcycles
H	93.3%	Y	transportation and storage
I	0.0%	N	accommodation and food service activities
J	0.0%	Y	information and communication
K	0.0%	N	financial and insurance activities
L	70.0%	Y	real estate activities
M	0.0%	Y	professional, scientific, and technical activities
N	25.9%	Y	administrative and support service activities
O	0.0%	N	public administration and defence; compulsory social security
Q	0.0%	N	human health and social work activities
R	0%	N	arts, entertainment, and recreation
U	0%	N	activities of extraterritorial organisations and bodies

TABLE 7: MAPPING OF NACE CODES AND TEC

8.5 Annex 5 - Analysis of resources

In this annex the remaining graphs of the analysis of resources are presented.

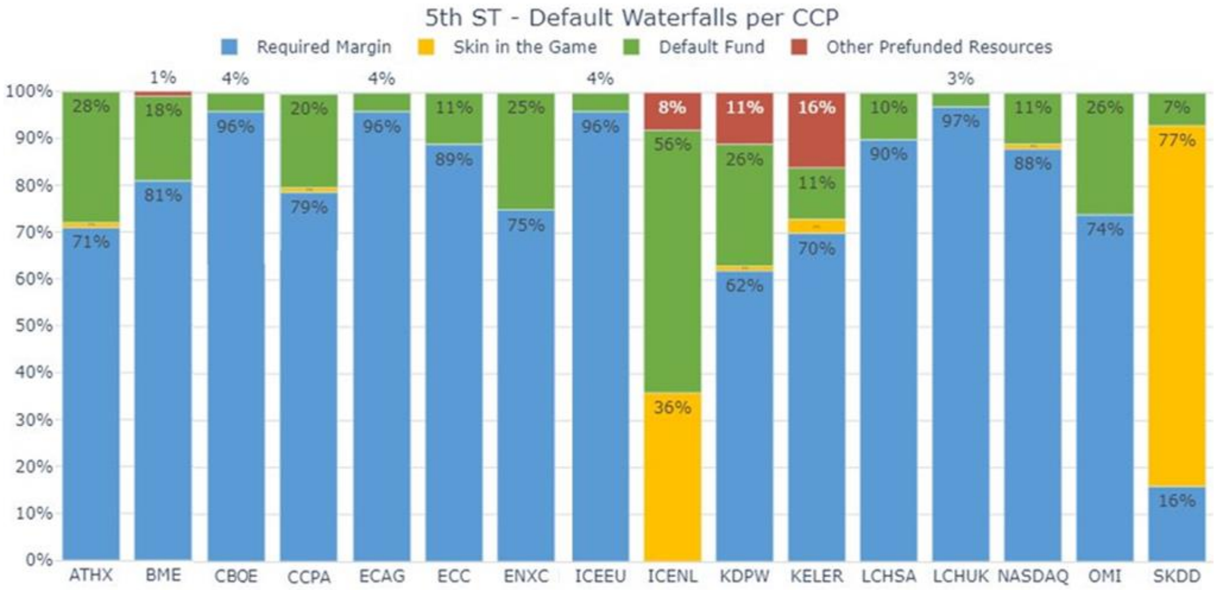


FIGURE 58: DEFAULT WATERFALL PER CCP – MARCH 2023

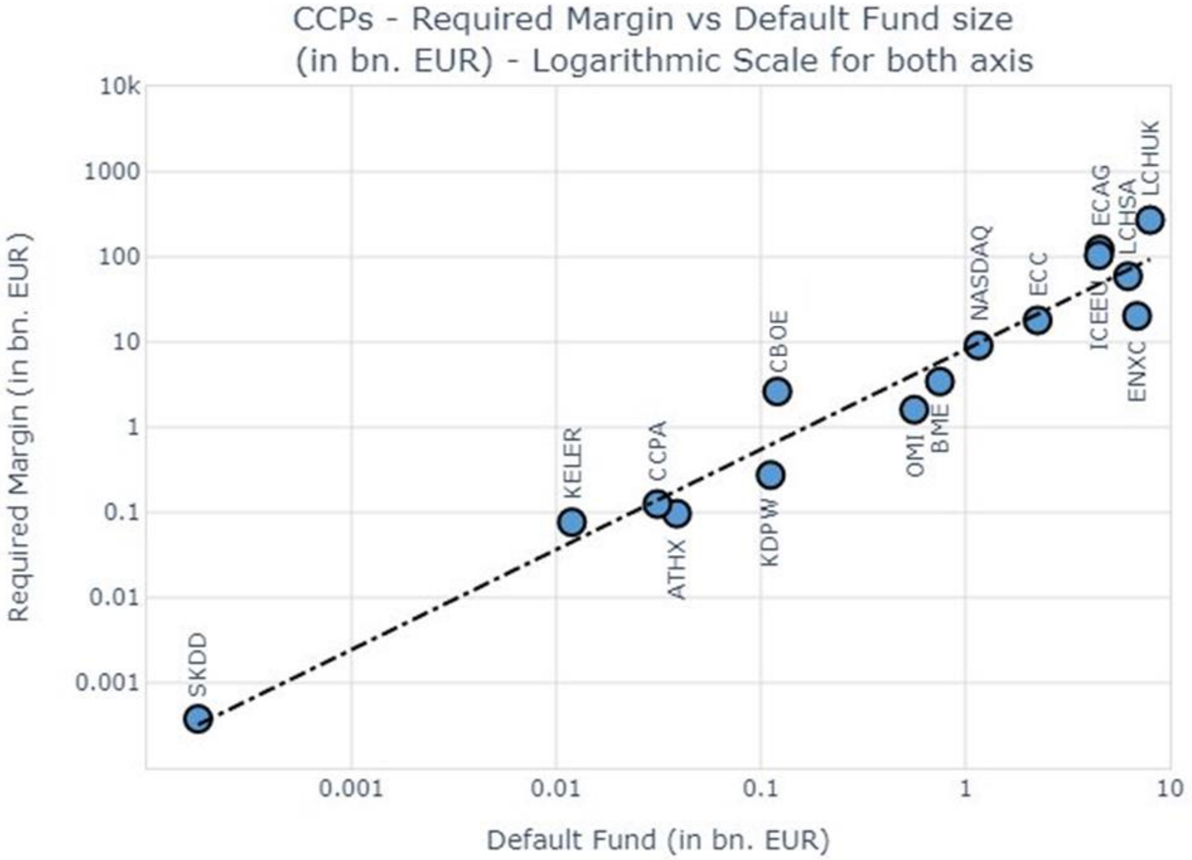


FIGURE 59: REQUIRED MARGIN VS DEFAULT FUND PER CCP – MARCH 2023

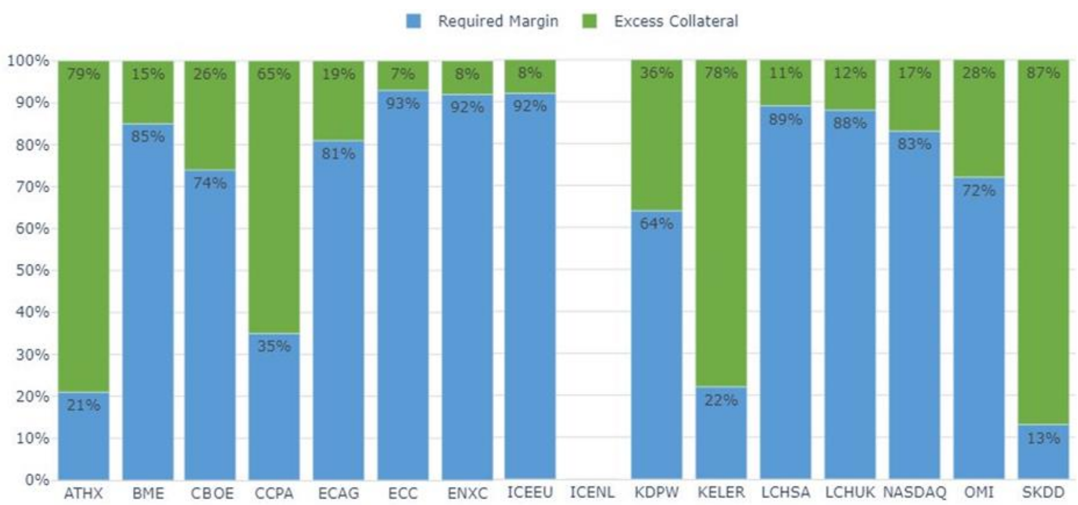


FIGURE 60: SHARE OF REQUIRED MARGIN VS EXCESS MARGIN PER CCP – MARCH 2023

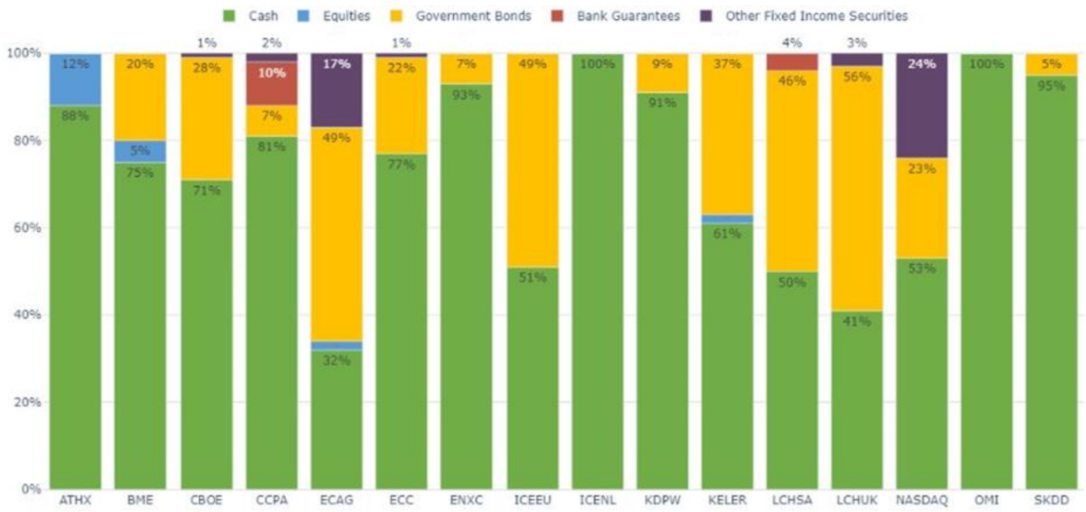


FIGURE 61: ASSET TYPE OF PROVIDED COLLATERAL PER CCP – MARCH 2023

8.6 Annex 6 – Concentration Risk, derivation of the unit liquidation costs

The unit liquidation cost functions were derived by aggregating CCP's submissions that were received as part of the data request. As a general principle, the aggregation of the submissions was carried out with a weighted average approach, with weights equal to the size of each CCP's gross positions in the relevant asset class, and subject to data quality controls. The controls led to the occasional exclusion of submissions that were identified as outliers.

The determination of the submissions by CCPs is in itself a non-trivial exercise. In many cases, CCPs' concentration add-on models do not incorporate a native definition of unit liquidation costs, for example where they rely on scaling up core initial margin. In these cases, the CCPs were instructed to reverse engineer their submissions so that they would recover the results of the concentration add-on model. However, this may not always be possible, or only on an approximate basis.

Besides, the unit liquidation costs in the ESMA stress test model are defined with a specific granularity, aligned with the taxonomy followed in the reporting of positions and the calculation of market impact. CCP concentration add-on models may not recognise this particular taxonomy, and they might treat differently two types of positions considered equivalent in the ESMA stress test. In this case the CCP would not be able to provide a submission representative of its model.

Finally, all the considerations noted in Section 4.1 regarding the functional form of the liquidation costs, interpolation, extrapolation, and choice of volumes also have the potential for interfering with the calculation of unit liquidation costs by the CCP.

These sources of model risk in the definition of unit liquidation costs are likely to be a factor in the wide dispersion observed for CCP submissions for some asset classes, and could be particularly material where the submissions were more limited in number.

In order to compensate for this risk, ESMA adjusted the weighted averages of CCP submissions by a scaling factor. The scaling factor was set in the range between 1 and 2 based on two criteria: the riskiness of the asset class, determined by the relevance for that asset class of the considerations above, and the degree of concentration observed in clearing positions across CCPs, as measured by the HHI index.

The scaling factors are reported below. HHI levels defined as 'Very High', 'High' and 'Medium' are those in excess of 7000, between 3000 and 7000, and below 3000 respectively.

HHI	Commodity Derivatives	Equity, Equity Derivatives	Bonds	FX Derivatives	Interest Rate, Inflation, Bond Derivatives
Very High	2	1.5	1.5	1.25	1
High	1.5	1.25	1.25	1	1
Medium	1	1	1	1	1

TABLE 8: CONCENTRATION - HHI PER ASSET CLASS

8.7 Annex 7 – Concentration Risk, unit liquidation costs

This section presents a selection of unit liquidation costs for the most material asset classes. The costs are expressed in bps of the position's Value or PV01 field, depending on the asset class, and as defined in the Instructions provided to CCPs. The costs are different for different position sizes.

As discussed in Section 4.1, costs are interpolated with a piecewise linear approach for intermediate position sizes between those in the table, and they are extrapolated with a flat approach beyond the largest position size in the table. For positions below 25%, the baseline model assigns zero liquidation cost.

Asset Class	Sub-Asset Class	25%	50%	100%	200%
Stocks	Small cap	123	167	494	1000
Stocks	Mid cap	67	100	413	889
Stocks	Big cap	84	136	329	645
Equity Derivatives	Stock index futures/forwards	100	136	221	404
Commodity Derivatives	Electricity futures/forwards	119	174	259	393
Commodity Derivatives	Energy commodity futures/forwards	132	192	280	412
Freight Derivatives	Freight derivatives	113	160	227	321
Emission Allowances	European Union Allowances (EUA)	119	174	259	393
Bond Derivatives	Short term	6	13	25	51
Bond Derivatives	Medium term	12	23	47	93
Bond Derivatives	Long term	22	44	88	175
Bond Derivatives	Ultra long term	92	184	367	734
FX Derivatives	Developed	15	26	45	89
FX Derivatives	Emerging	18	28	55	92

Table 9: Unit liquidation costs, main table, in bps

Sub-Asset Class	Rating	Maturity bucket	25%	50%	100%	200%
Sovereign Bond	Investment grade	Less than 1 year	7	14	26	51
Sovereign Bond	Investment grade	Between 1 - 5 years	8	15	30	61
Sovereign Bond	Investment grade	More than 5 years	14	29	56	108
Other Public Bond	Investment grade	Less than 1 year	3	6	10	18
Other Public Bond	Investment grade	Between 1 - 5 years	6	12	24	46
Other Public Bond	Investment grade	More than 5 years	17	36	69	131
Covered Bond	Investment grade	Less than 1 year	7	7	7	8
Covered Bond	Investment grade	Between 1 - 5 years	7	8	8	9
Covered Bond	Investment grade	More than 5 years	8	9	11	14
Corporate Bond	Investment grade	Less than 1 year	18	30	55	110
Corporate Bond	Investment grade	Between 1 - 5 years	17	29	54	107
Corporate Bond	Investment grade	More than 5 years	17	28	53	106
ETC	Investment grade	Less than 1 year	830	1586	1630	3143
ETC	Investment grade	Between 1 - 5 years	830	1586	1630	3143
ETC	Investment grade	More than 5 years	830	1586	1630	3143

Table 10: Unit liquidation costs for Bonds, in bps

Currency	Maturity Point	25%	50%	100%	200%	500%
EUR	2Y	0.9	1.5	2.7	5	12
EUR	5Y	1	1.7	3.1	5.8	14.1
EUR	10Y	1	1.7	3	5.7	13.8
EUR	30Y	1.9	2.5	3.9	6.5	14.6
USD	2Y	1	1.5	2.6	4.8	11.3
USD	5Y	0.9	1.5	2.7	5.1	12.2
USD	10Y	1	1.6	2.9	5.4	12.8
USD	30Y	1.6	2.3	3.7	6.6	15.1
GBP	2Y	2.7	3.8	6	10.4	23.7
GBP	5Y	3.3	4.5	6.8	11.4	25.1
GBP	10Y	2.8	4	6.2	10.6	24
GBP	30Y	5.7	7.1	9.9	15.5	32.2
CHF	2Y	2.4	3.1	4.7	7.9	17.4
CHF	5Y	2	2.9	4.6	8.1	18.6
CHF	10Y	2.2	3.2	5.1	9	20.8
CHF	30Y	3.5	5.1	8.1	14.3	32.6
JPY	2Y	1	1.5	2.3	3.9	8.8
JPY	5Y	1.3	1.8	2.5	4.2	9.5
JPY	10Y	1.3	2	3	5.2	11.5
JPY	30Y	2	3.3	5	7.3	14.8

Table 11: Unit liquidation costs for Interest Rate Derivatives, in bps

8.8 Annex 8 – Concentration Risk, Alternative model for liquidation costs

In order to benchmark the liquidation costs calculated by the baseline model, in Section 4.3 these were compared against liquidation costs derived by an alternative model. In this model, developed in an ECB working paper[39], the sale of a quantity S_i of security i generates a cost expressed with the following analytical expression as a proportion of the value of i:

$$B_i(1 - \exp\left(-\lambda_i S_i / B_i\right)).$$

In this expression λ_i is a parameter controlling the reactivity of the market impact, and B_i is the boundary parameter, representing the maximum proportion that the liquidation cost can attain in the limit for a very large liquidation. These parameters have been calibrated for a large number of securities by the authors of the study, at a range of different probabilistic levels. The benchmarking exercise considered the calibration in the 5% tail as the one closest to the situation of interest in the ESMA stress test.

[39] Fukker, G., Kaijser, M., Mingarelli, L. and Sydow, M., Contagion from market price impact: a price-at-risk perspective, ECB Working Paper no 2692, Aug 2022

8.9 Annex 9 – Liquidity stress test – scope of liquid resources per CCP

The below Figure details the scope of liquidity resources reported per CCP. This has a major impact on liquidity results as resources segregated at account or clearing member level are only available in case of default.

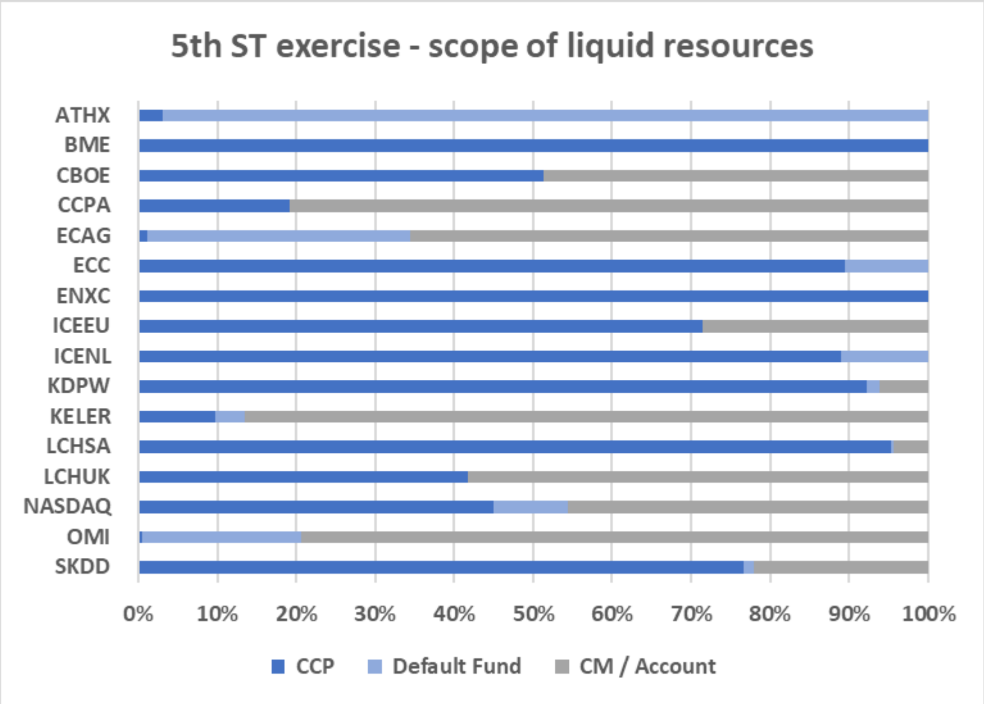


FIGURE 62: ALLOWED USAGE OF LIQUID RESOURCES PER CCP

8.10 Annex 10 – Liquidity stress test – example of liquidity risk profile for one CCP

The following Figure illustrates the liquidity profile of a CCP for the following scenarios and assumptions:

- Cover 0 (no default),
- Cover 2 without additional assumption,
- Cover 2 excluding excess margin,
- Cover 2 excluding excess margin and assuming a market access delay of 1 day to sell non-cash collateral,
- Cover 2 excluding excess margin, assuming a market access delay of 1 day and a settlement lag of 2 days to sell securities.

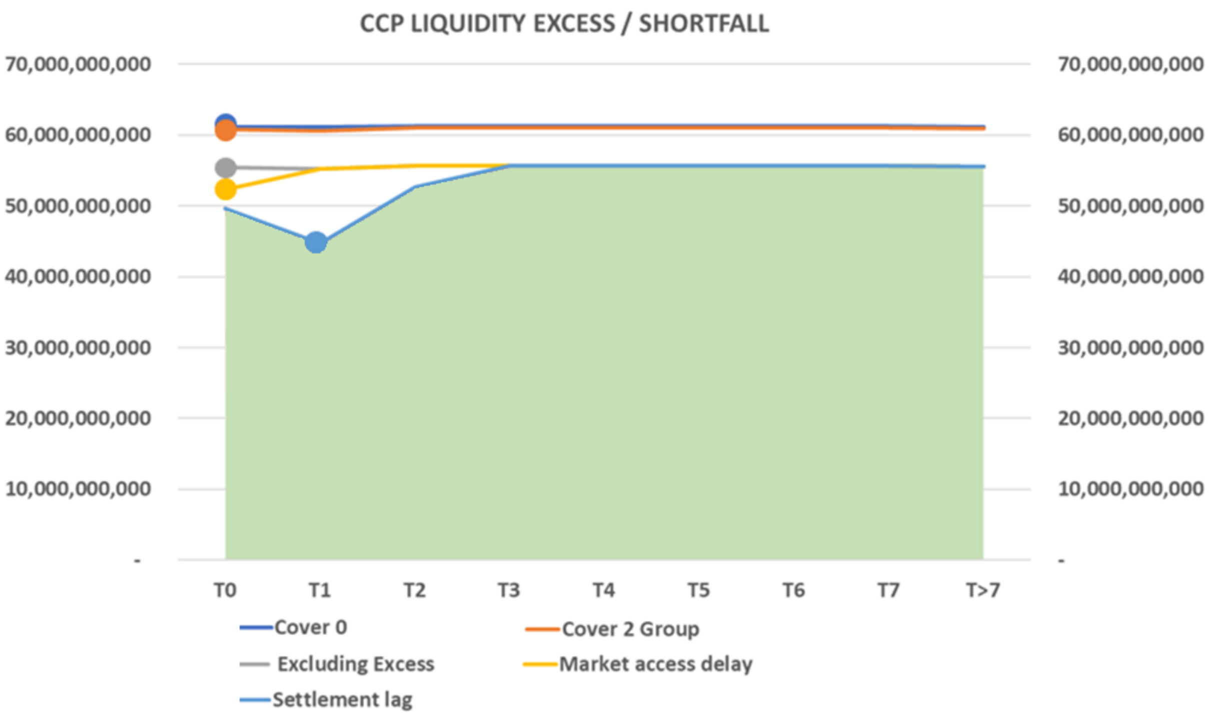


FIGURE 63: EXAMPLE OF CCP LIQUIDITY RISK PROFILE