

**Finance and Economics Discussion Series  
Divisions of Research & Statistics and Monetary Affairs  
Federal Reserve Board, Washington, D.C.**

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**2018-082**

Please cite this paper as:

Anderson, Edward, Fernando Cerezetti, and Mark Manning (2018). "Supervisory Stress Testing For CCPs: A Macro-Prudential, Two-Tier Approach," Finance and Economics Discussion Series 2018-082. Washington: Board of Governors of the Federal Reserve System, <https://doi.org/10.17016/FEDS.2018.082>.

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# SUPERVISORY STRESS TESTING FOR CCPs: A MACRO-PRUDENTIAL, TWO-TIER APPROACH

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## Abstract

Stress testing has become an increasingly important mechanism to support a variety of financial stability objectives. Stress tests can be used to test the individual resilience of a single entity or to assess the system-wide vulnerabilities of a network. This article examines the role of supervisory stress testing of central counterparties (CCPs), which has emerged in recent years. A key message is that crucial differences in CCPs' role, risk profile and financial structure, when compared to banks, are likely to require significant adaptation in the design of supervisory stress tests (SSTs). We examine how supervisory stress tests may be designed to complement CCPs' own daily stress tests, and argue that macro-prudential supervisory stress testing of CCPs is valuable for both authorities and market participants. The paper offers practical guidance on the implementation of the exercises and proposes some specific design principles that should allow authorities to extract more information from such tests. We propose a two-tier approach that meets the intended policy objectives, while balancing ambition and resource cost. The first tier encompasses more standardized tests that can be conducted frequently to assess the resilience of the clearing network over time. The second tier encompasses less frequent and more complex 'deep dive' assessments. The proposed approach should overcome operational and resource challenges, which to date, may have inhibited the widespread application of supervisory stress testing.

**JEL Classification:** G02, G23, G28

**Keywords:** Central Counterparties, Stress Testing, Financial Regulation, Macro-prudential Policy

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The views expressed in this paper are those of the authors and should not be interpreted as reflecting the views of the Federal Reserve Board or any other person associated with the Federal Reserve System, ICE Clear Europe, or the Financial Conduct Authority.

*Acknowledgements:* This paper has benefitted considerably from extensive discussions with Steve Greska and Jorge Cruz Lopez, as well as colleagues at the Bank of England, the Federal Reserve Board and the Federal Reserve Bank of Chicago, Arnaud Faure, Matt Gibson, Takahide Habuchi, Eszter Tanai, and members of the CPMI-IOSCO Sub-group on Supervisory Stress Testing of CCPs. Finally, we would like to thank panelists and participants at the second Symposium on OTC Derivatives, which was co-organised by the Federal Reserve Bank of Chicago and the People's Bank of China and took place in Shanghai in June 2018.

<sup>2</sup> Work on this paper began in the summer of 2017, when both Fernando Cerezetti and Mark Manning worked in the Financial Market Infrastructures Directorate at the Bank of England.

# 1 Introduction

Following the global financial crisis in 2008, central counterparties (CCPs) have assumed a more prominent role within the financial system. Official sector bodies and industry participants alike have an increasing interest in ensuring that CCPs promote stability in the markets they serve. As discussed in Cruz Lopez and Manning (2017), policymakers effectively use CCPs as an instrument to support the broader objective of financial stability.

To help achieve this objective, a raft of new regulations has been introduced to increase the individual financial and operational resilience of CCPs. The Dodd-Frank Act, EMIR, and the CPMI-IOSCO Principles for Financial Market Infrastructures (PFMI; CPMI-IOSCO, 2012) are examples of new standards that now apply for these entities.<sup>3</sup> The rationale behind this regulatory approach is that the network as a whole can be strengthened by enhancing the resilience of the key nodes within it. Recognizing that individual resilience alone may not adequately capture the breadth of potential stability risks, the PFMI also take a macro-prudential perspective at points. For instance, they require that in designing their governance, risk and operational frameworks, CCPs also take into account stability in the wider system in which they interact.

Across the financial system, stress testing has become an increasingly important mechanism to support a variety of objectives. Stress tests can be used to test the individual resilience of a single entity or to assess the system-wide vulnerabilities of a network. In particular, stress testing is one technique for gauging risks in a range of relevant adverse market conditions. In the CCP context, such exercises may be carried out either by the CCPs themselves, or by relevant supervisory authorities. This article examines the particular role of supervisory stress testing. Arguing that the added value of supervisory stress testing of CCPs is to take a macro-prudential perspective, we examine how supervisory stress tests may best be designed to complement CCPs' own daily stress tests of individual resilience.

A key message of the article is that crucial differences in CCPs' role, risk profile and financial structure are likely to require significant adaptation in the design of SSTs relative to the frameworks and tests applied to banks. Accordingly, in addition to offering practical guidance on the implementation of the exercises, the paper proposes some specific design principles that should allow the authorities to extract more information from the tests in support of a macro-prudential objective.

In particular, we propose a two-tier approach intended to meet the policy objective, while balancing ambition and resource cost. The proposed approach envisages, in the first tier, standardized tests that can be conducted frequently to assess the resilience of the clearing network over time. In the second tier, less frequent and more complex 'deep dives' may be carried out. After a one-time investment in data collection, automation and supporting governance arrangements, the proposed approach should overcome operational and resourcing challenges for both authorities and CCPs. We believe that, to date, these challenges have inhibited the widespread application of supervisory stress testing.

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<sup>3</sup> European Market Infrastructure Regulation, EMIR, is the common name for Regulation (EU) No 648/2012 of the European Parliament and Council, 4 July 2012, on OTC derivatives, central counterparties and trade repositories. Dodd-Frank Wall Street Reform and Consumer Protection Act, Dodd-Frank, represents the US Public Law n° 111-203, from 21 July 2010.

The remainder of the paper is organized as follows. Section 2 discusses the evolution of CCP stress testing, with a focus on emerging supervisory stress testing practices, and on the differences between bank and CCP supervisory stress tests. Section 3 introduces possible CCP supervisory stress testing objectives, and the desirability of macro-prudential objectives. Section 4 examines other desirable characteristics and key design parameters for macro-prudential CCP SSTs. Section 5 proposes a two-tier supervisory stress testing approach. The paper concludes with some final remarks on a future path for SST development.

## 2 Evolution of CCP stress testing

Stress testing is a forward-looking risk management tool designed to support risk identification, measurement and monitoring. It is not a new practice. For instance, stress testing of financial systems has been a key component of the IMF Financial Sector Assessment Program (FSAP) since it was launched in 1999. Similarly, Pillar 1 of the Basel II framework, published in 2004, requires that banks using the Internal Models Approach have in place a rigorous program of stress testing. However, it was the recent financial crisis that put stress testing of financial institutions under the spotlight. As IMF (2012) observes, “Stress testing, once an arcane subject, has become almost a household name.”

In the particular case of banks, BCBS (2017b) observes that stress testing – whether conducted by each individual institution or performed by the authorities – has undergone substantial enhancement since the crisis. In many respects, banks have set the benchmark for best practice.<sup>4</sup> Banks routinely use stress testing to inform risk management and strategic planning, increasingly integrating these tests into business-as-usual processes. Further, many jurisdictions now run large-scale supervisory stress testing exercises on at least an annual basis.

Generally following practices for banks, the evolution of stress testing has been similar in the CCP space. Stress testing has long been a core risk management tool for CCPs, informing their financial resource sizing decisions and their assessments of resource adequacy. Additionally, new international regulatory standards have placed extra focus on stress testing practices. Even though important enhancements have been made to CCPs’ internal stress tests in the past years, only recently have some authorities also begun to perform SSTs.

### 2.1 Towards supervisory stress testing of CCPs

When the international recommendations for CCPs were first developed in the early 2000s (CPSS-IOSCO 2004), CCPs were expected to run internal stress tests for credit on a monthly basis. The PFMI, published in 2012, raised the level of the minimum standards. In particular, the PFMI set a firm expectation that CCPs perform daily stress tests to assess the sufficiency of financial resources – for both credit and liquidity. CCPs are required to demonstrate sufficiency at all times, to a high degree of confidence, and under a wide range of potential stress scenarios. Moreover, these so-called ‘extreme but plausible’ scenarios should not be static, but are expected to evolve as market conditions change and new risks emerge.

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<sup>4</sup> IMF (2012) observes that much of the recent work on stress testing was related to implementing lessons learned from the 2007/08 financial crisis, when testing frameworks failed to perform as expected. Some examples discussed in the paper are: models had a narrow scope; shocks were not sufficiently severe; and key risk factors were missing.

In 2015, the Financial Stability Board (FSB) launched a CCP work plan with the objective of raising the bar further in the areas of CCP resilience, recovery and resolution (see FSB 2015 for details). By the time the core elements of the work plan were completed in mid-2017, CPMI-IOSCO had issued, among other things, more extensive guidance on CCPs' stress testing and margining practices (CPMI-IOSCO 2017). The guidance provided more granularity on how to develop extreme but plausible scenarios, including the sources of risk to be taken into consideration. It also encouraged CCPs to consider stressing intraday exposures, as well as end of day exposures, and to incorporate intraday price changes in their stress scenarios.

As another important outcome of the work plan, CPMI-IOSCO published a framework for supervisory stress testing of CCPs (CPMI-IOSCO 2018). The framework aims to complement the internal stress tests performed by CCPs, supporting authorities in their analysis of the macro-prudential risks that could eventuate should CCPs face common market shocks. Following the path taken in the banking sector, SSTs of CCPs had already emerged. Most notably, in accordance with legal provisions in EMIR, ESMA has performed two EU-wide supervisory stress testing exercises in recent years (ESMA 2016, 2018). Similarly, CFTC conducted a credit SST in 2016, covering four CCPs under its jurisdiction. And in October 2017, CFTC published the first liquidity risk-focused SST of CCPs (CFTC 2016, 2017).

## 2.2 Comparing bank and CCP stress testing objectives

Many of the design choices of these emerging CCP SSTs were similar to those taken in the more mature bank stress tests. For instance, as in banking sector exercises, the objective of ESMA's 2017 exercise was to "assess the resilience of CCPs to adverse market developments, [and] identify any potential shortcomings in the CCPs' resilience" (ESMA 2018, p9).<sup>5</sup> Other similarities include the typical near-annual frequency of tests, the lengthy end-to-end timeframe for running the tests (i.e., around a year from the time the initial test design is published to the time the results are released), the small number of scenarios used, and the selective disclosure of results, methodology and scenarios.

Drawing insights from similar tests in a related sector not only accelerates methodological developments, but also provides a benchmark for comparison. However, the applicability of banking sector design choices to the CCP context needs to be assessed carefully. Cox and Steigerwald (2017) and Manning and Hughes (2016) caution strongly against viewing CCP resilience and risk management through a bank lens. Three differences are particularly relevant to the design of SSTs:

- *Context.* Cox and Steigerwald emphasise the fundamental difference between banks' and CCPs' risk profiles. In the authors' words, "banks are risk-takers" while "CCPs are risk managers". One important implication of this distinction for stress test design is that a CCP's financial risk exposures only crystallise following the default of a clearing member or investment counterparty. For a scenario to be relevant, therefore, it must combine a market shock and a default.

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<sup>5</sup> The BCBS (2017b) states that the majority of stress tests performed by regulators focuses on informing institutions' solvency and liquidity assessments.

- *Scenarios and risk drivers.* CCPs provide clearing services for specific financial products and are exposed to sudden, fast-burn shocks (e.g., typically over a horizon of less than 10 days), often idiosyncratic to those products. To be informative, therefore, a scenario has to be relevant to the products cleared by the CCP. Accordingly, any given scenario is likely to be severe for only a subset of in-scope CCPs. By contrast, the larger bulk of banks' exposures derives from a common set of financial instruments inside the banking book.<sup>6</sup> Slow-burn, long-horizon, macroeconomic scenarios are therefore likely to be more relevant and more representative across the range of banks included in a test.
- *Interdependence with the network.* Given their role and purpose, CCPs sit at the heart of the networks they serve. The size and distribution of a CCP's risk exposures derive directly from the trading activities of its members. These activities may not be stable over time. Mutualised financial structures create a further layer of interdependence between CCPs and their members. And indirect links – often across borders – arise from members' activities in other markets and their participation in other FMIs.

These fundamental differences between banks and CCPs need to be taken into account both in setting the objectives of a supervisory stress testing program for CCPs and in the design of such tests, as explored in Sections 3 and 4, respectively.

### 3 Objectives of CCP supervisory stress testing

The most important decision the authorities must make when designing a CCP supervisory stress testing program is specifying what objective the program is trying to achieve. In other words, what specific question (or questions) is the program trying to answer? It is helpful to consider this as a regulatory design problem. As observed in OECD (2012), any regulatory intervention should adhere to accepted principles of good regulation. While each jurisdiction has developed its own principles and guidelines in this regard, all typically speak to the importance of ensuring that any intervention is designed effectively to meet its objective, and that its benefits outweigh the costs.<sup>7</sup>

These principles imply that the objective of any SST should meet the following criteria, discussed in more detail in the remainder of the section. The objective should:

- provide a net added benefit that justifies the intervention of the supervisory authorities; and
- be clear and transparent, and should be complementary to, rather than overlapping with, CCPs' own stress tests or other supervisory initiatives.

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<sup>6</sup> As discussed in Greenlaw et al. (2011), comparison of stress figures across banks not only is possible, but also necessary to deal with the opaque nature of the assets and the different techniques that entities use to value them.

<sup>7</sup> The OECD recommendations were among the first internationally relevant set of guidelines on regulatory policy and governance to be issued after the crisis. They were aimed at establishing well-functioning national regulatory frameworks that could improve the design, enforcement and review of regulations.

### 3.1 Two types of objectives – Macro-prudential vs micro-prudential

The different objectives that regulators could pursue with a CCP supervisory stress testing program can be classified into two categories: micro-prudential; and macro-prudential. For the purposes of this paper, micro-prudential objectives are defined as those primarily concerned with the resilience of individual CCPs, while macro-prudential objectives are concerned with the resilience of the system of CCPs and their participants as a whole. Both of these objectives serve a valuable but distinct purpose for regulators.

In thinking about this distinction, it is helpful to note that to support their clearing services for particular products, CCPs establish sophisticated risk frameworks that rely on collateralization of exposures up to a high degree of confidence and mutualization of residual financial risks with their members. Stress tests of individual resilience – whether supervisory, or carried out by the CCPs themselves – assess whether the financial resources available under these frameworks would be sufficient to deal with losses or liquidity shortfalls under a range of extreme but plausible scenarios. In these tests, the interactions of the CCPs with the external environment are exogenous. In macro-prudentially oriented stress tests, on the other hand, the externalities generated by CCPs' risk and operating frameworks are endogenous. This includes externalities arising from linkages and dependencies between CCPs and between CCPs and their members, other FMIs and service providers.

In particular, an individual CCP may bear only part of the cost of risk exposures generated by such linkages and dependencies. Or they may have incomplete information about such exposures, since they will typically only be able to observe and quantify their direct exposures. Interactions within a system may have amplifying effects for each entity in the network that may not be accounted for by each entity when assessing its individual resilience. A macro-prudentially oriented stress test captures information on such externalities and interdependencies, thereby taking a system-wide perspective on the collective response to a given stress. Macro-prudential stress tests complement micro-prudential tests of individual resilience by identifying and quantifying the additional risks and exposures, applying a consistent stress scenario to the system of CCPs.

Tables 1 and 2 below help to clarify the difference between micro-prudential and macro-prudential objectives by providing illustrative questions that a CCP supervisory stress testing program could attempt to answer. The SST program could focus on the risk that the CCP will incur financial losses (credit risk), or the risk that the CCP will not be able to meet its cash obligations on time in the relevant currency (liquidity risk), or both.

One important difference between micro-prudential and macro-prudential objectives is whether it is feasible for the test to result in pass/fail determinations or provide specific hurdle rates. Pass/fail metrics and hurdle rates are appropriate for micro-prudential objectives that are primarily focused on the resilience of individual CCPs. However, individual pass/fail metrics or hurdle rates are less appropriate for SSTs with macro-prudential objectives where the identification of vulnerabilities of the clearing network is the main driver of the exercises.

Table 1: *Illustrative micro-prudential CCP supervisory stress testing objectives*

Credit Risk	Liquidity Risk
Does the CCP have sufficient prefunded financial resources to withstand the default of one or two clearing members under stressed market conditions provided by the authorities?	Does the CCP have sufficient liquid resources to meet its liquidity needs upon the default of one or two clearing members under stressed market conditions provided by the authorities?
Does the CCP have sufficient assessment powers beyond prefunded financial resources to withstand the default of more than two clearing members under stressed market conditions provided by the authorities?	What is the impact on a CCP's ability to meet its liquidity demands if a liquidity provider fails to meet its obligations to the CCP?
What is the ranking of CCPs from most resilient to least resilient under the stress scenarios provided by the authorities?	What is the ranking of CCPs from most able to withstand a liquidity stress to least able to withstand a liquidity stress under scenarios provided by the authorities?

Table 2: *Illustrative macro-prudential CCP supervisory stress testing objectives*

Credit Risk	Liquidity Risk
What additional financial resources (assessments) would the CCPs collectively require from non-defaulting clearing members if a common shock was applied to all CCPs and would the non-defaulting clearing members have any problem meeting these assessments?	What is the total cash by currency that will be demanded simultaneously by the set of CCPs on common liquidity providers given a stress scenario provided by the authorities?
What set of clearing member defaults would exhaust the largest cumulative percentage of prefunded resources across all CCPs under plausible stressed market price scenarios?	Identify the cumulative size of the market transactions (repos, sales, etc.) by asset class (government bonds, agency bonds, equities, etc.) and timing (same day settlement, next day settlement, etc.) that the set of CCPs is relying upon to meet its liquidity needs under a common stress scenario provided by the authorities.
Which risk factor shocks or stress scenarios would be likely to generate the largest cumulative losses across all CCPs? What would be the dispersion of losses in such scenarios and what implications might this have for stress propagation?	Identify the common liquidity provider whose failure, in specified common stress scenarios and/or combined with specified member defaults, would cause the most stress on the set of CCPs cumulatively.

Similarly, micro-prudential SSTs – in theory - may allow the authorities to rank order the in-scope entities from most resilient to least resilient based on stress test outputs. Conversely, macro-prudential stress tests do not support the rank ordering of in-scope entities because, again, individual resilience is not the primary question.

Many authorities would describe the objectives of current bank SSTs as macro-prudential given their long term focus (for example, nine quarters), their use of macro-economic variables such as GDP and unemployment to describe the stress scenarios, and their application of common stress shocks to all banks. However, most bank supervisory stress testing programs focus on the individual resilience of the banks and are an important input into the determination of the capital that they are expected to hold. Since the tests apply common shocks, macro-prudential conclusions may be drawn across the in-scope banks, but applying the definition above, these tests would be considered micro-prudential at core. The design and objectives of these tests are therefore fundamentally different from those of the macro-prudential SSTs we propose for CCPs in the following sections.



### 3.2 The case for macro-prudential objectives for CCP supervisory stress testing

The internal stress testing performed by CCPs is undertaken with a focus on individual resilience and hence has a micro-prudential objective. For any given clearing service, a CCP is commonly exposed to a large number of market and product-specific risk factors. To assess the potential tail impact of these risk factors, a CCP runs at least daily stress tests that comprise many tailored risk factor shocks. Unless SSTs were similarly run daily and with a comprehensive set of scenarios, it is doubtful that they could add material value over CCPs' internal tests. As noted, recently elaborated regulatory expectations regarding CCPs' internal stress tests are already stringent (CPMI-IOSCO 2017). There is no reason to believe that in the future they will not keep pace with the evolution of the operating environment. While it is important that supervisors validate that CCPs' internal stress tests adequately capture the breadth of risks to individual resilience, and are able to instill confidence in CCP users and other stakeholders that this is indeed the case, this can probably be achieved more effectively by means other than SSTs. For instance, supervisors can examine closely the range of stress scenarios applied in CCPs' own internal stress tests and the modelling approach and calibration of such scenarios. They can also encourage the disclosure of scenarios and testing outcomes.

Furthermore, it is extremely difficult to meaningfully implement a SST program for CCPs with a micro-prudential objective and with the goal of establishing pass/fail metrics or rank ordering of CCPs. To conclude that one CCP is more resilient than another CCP would require that the authorities first have to establish that the shocks applied to each CCP's asset class are comparably stressful. Otherwise, authorities will not know whether the relative difference in CCP resilience is due to the difference in risk management standards of the CCPs or the difference in the shocks provided by the test. But since CCPs typically clear products in specific asset classes, with only limited overlap with other CCPs, this may not be possible. Note that this challenge is less pronounced in bank stress tests as large banks take risks in a more homogenous set of asset classes, while CCPs generally operate in mutually exclusive asset classes.

In contrast with internal exercises, the system-wide data and information required to answer the questions that stress tests with a macro-prudential objective would pose are not available to any individual CCPs. To perform a stress test with a macro-prudential objective would require coordination and the sharing of confidential information across multiple CCPs, which may only be feasible in a supervisory program. Recognizing that particular features of the financial network determine how stress transmits, FSB-IMF-BIS (2011) encourages authorities to develop dedicated tools for the analysis and management of macro-prudential risks.

Although authorities have started to develop tools to address some of these macro-prudential questions, there is substantial scope to better understand the implications of system-wide stress shocks. For example, multi-CCP fire drills, such as those implemented by the EU, UK, and US authorities, only gauge the industry's capacity to deal operationally with simultaneous stresses across CCPs, and in particular, common participants' capabilities to support multiple CCPs' default management processes.<sup>8</sup> From a more analytical perspective, BCBS, CPMI, FSB and IOSCO established a study group to analyze interdependencies between CCPs, major clearing members and financial service providers. However, to

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<sup>8</sup> See Bank of England (2018) for more details on the exercises.

date such work has been unable to quantify the impact of simultaneous stressed losses and liquidity shortfalls.<sup>9</sup>

In more specific terms, currently there is no existing regulatory tool other than a supervisory stress testing program that can meet the macro-prudential policy objective of identifying and measuring system-wide vulnerabilities across CCPs and their participants. For example, existing regulatory tools or analyses do not allow authorities to quantify the total cash by currency that would be demanded of common liquidity providers by a set of CCPs subject to a consistent stress scenario and the timing of those cash demands. Similarly, existing regulatory tools or analysis do not allow authorities to estimate the cumulative financial assessments that CCPs may call from common non-defaulting clearing members under a consistent stress scenario (see table 2 above for additional illustrative macro-prudential objectives). Given that stressed market conditions may impact multiple CCPs, and many CCPs have common clearing members and liquidity providers, a SST program with a macro-prudential objective would help authorities evaluate the collective robustness of the risk management frameworks that have been developed independently at CCPs with incomplete information on the risk frameworks of other CCPs. This type of information, as discussed in Goldstein and Sapra (2013), if properly disclosed, could promote market discipline by providing additional details relevant for the decision making process of market participants.

Finally, CCP supervisory stress testing programs focusing on macro-prudential objectives have been endorsed by international regulatory bodies such as CPMI-IOSCO. The CPMI-IOSCO framework for supervisory stress testing of CCPs (published in early 2018) positions these tests firmly in the macro-prudential context, envisaging system-wide tests that simultaneously stress multiple CCPs using a common scenario set. That is, the framework regards SSTs as an analytical tool to help authorities better understand the system-wide risks that could materialize if multiple CCPs were to face a common stress event. CPMI-IOSCO (2018) elaborates: “In particular, conducting a multi-CCP SST could help authorities better understand the scope and magnitude of the interdependencies between markets, CCPs and other entities such as participants, liquidity providers and custodians. For instance, a multi-CCP SST could be designed to analyze concentrations of exposures to common participants, common risk factors or common dependencies on particular liquidity providers or other service providers.” It is reasonable to argue that this macro-prudential objective could perhaps best be served by conducting system-wide SSTs, spanning CCPs, banks and other institution types. The design, data management and other capabilities to support such an extended scope have, however, not yet been developed. This may be part of the future evolution of supervisory stress testing.

For the reasons presented above, the authors recommend that supervisory stress testing programs of CCPs focus on clear macro-prudential objectives. This approach would complement the internal stress tests performed at CCPs, it would avoid being duplicative, and it would have a clear value-added benefit. As CPMI-IOSCO (2018) notes: “The macro-prudentially oriented SSTs contemplated under this framework

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<sup>9</sup> The group published its first report in July 2017, and its second report in August 2018. Please see FSB-CPMI-IOSCO-BCBS (2017, 2018) for more details. The 2018 report notes (p5) that “the analysis is not suited to support any conclusions related to the impact of entity default on the broader financial system or real economy or to demonstrate transmission of risks through CCPs.” This is precisely the gap that SSTs for CCPs would fill.

would neither supersede internal stress testing conducted by CCPs nor assess the resilience of individual CCPs” (page 2).

### 3.3 Systemic risk propagation in financial networks

FSB-IMF-BIS (2011) proposes that macro-prudential tools be designed to address the two dimensions of systemic risk: its evolution over time (i.e., the time dimension); and the distribution of risk in the financial system at a given point in time (i.e., the cross-sectional dimension). Financial markets are not static. They are continuously adapting to new technologies, demand pressures, and regulatory developments. Therefore, it is important to assess how exposures, concentrations and interlinkages change as markets evolve.

As discussed in BCBS (2017a), if stress testing exercises are to meaningfully support authorities’ macro-prudential assessments, they should be performed regularly. Any tool designed to support a macro-prudential policy should be capable not only of identifying systemic risks at a point in time, but also of measuring and monitoring those in response to developments in financial markets. Moreover, authorities should make sure stress tests are properly integrated into their supervisory and/or financial stability programs to be used along with other available analytical and/or policy instruments.

On the cross-sectional dimension, it has long been accepted that the architecture of the financial system plays a fundamental role in shaping systemic risk. Since the early models of contagion risk presented by Kiyotaki and Moore (1997), much has been written on the theme, especially following the 2007/2008 global crisis. However, while ‘big data’ modelling techniques have advanced considerably in the past decade, there remains an incomplete understanding of how stresses might amplify and transmit in different network configurations. There are also significant data limitations. Comprehensive network analysis relies on data inputs from many entities, often across borders. No single entity or authority has access to such data, without establishing a network of legal gateways for data exchange.

Nevertheless, there are important insights from the existing financial networks literature that are relevant to the design of macro-prudentially oriented SSTs. In particular:

- As observed by Haldane (2009) and Gai et al. (2011), financial systems may be robust-yet-fragile. Within a certain range of shocks, connectivity between institutions in the network contributes to risk sharing, helping the system to absorb shocks. However, beyond a certain ‘tipping point’, interconnectivity may fuel contagion, transmitting stress more widely through the system and threatening stability. Indeed, as demonstrated by Acemoglu et al. (2015), while a system naturally tends to equilibrium, a network will typically also have properties that, under certain conditions, could force it to depart from its stable state;
- Gai et al. (2011) identify some key determinants of network fragility and the conditions in which stress could be transmitted through the system. They observe for instance that institutions’ liquidity positions and activity in the interbank market are among the most important determinants. If an institution is both fragile and central to the network, even a small shock can have a magnified impact on the network. Battiston et al. (2015) go on to demonstrate that

network topology can also impact the effectiveness of the policy response. For the case of capital buffers, the authors observe that the policy response is likely to be more effective in a more tightly interconnected network.

As noted, internal tests performed by CCPs typically do not take into account the possibility of amplification effects arising from second (and third, fourth, etc.) interactions of the system. Even though CCPs' financial resources may be sized to withstand a first round of shocks, feedbacks from both inside and outside of the clearing network may challenge default management frameworks. Consideration of propagation mechanisms is therefore essential to the design an effective program. Accordingly, in pursuing a supervisory stress testing program with a macro-prudential objective, the authors recommend that a deeper understanding of how systemic risk can propagate in the financial system also be developed.

#### 4 Desirable characteristics of macro-prudential CCP SSTs

Having established a macro-prudential objective, to ensure that the regulatory intervention of a macro-prudential CCP supervisory stress testing adds value, it is important to design exercises in such a way that:

1. The key parameters of the exercise – CCP scope and frequency – are appropriately tailored to the macro-prudential objective;
2. Exercise findings and risk metrics are disclosed in such a way as to meet the information needs of stakeholders, including that they can be easily interpreted to support effective decision-making;
3. The resource cost of the exercise for both CCPs and authorities is managed;
4. The types of actions that the supervisory authorities may take after conducting the SST are clear.

The remainder of this section describes these desirable characteristics in more depth.

##### 4.1 Frequency and scope

The need to tackle appropriately the time series and cross-sectional dimensions of systemic risk, as discussed in Section 3, implies that macro-prudentially oriented SSTs should be run at a frequency commensurate with the true underlying data-generating processes. As is discussed below, this is likely to require that tests be run more frequently than has been the case to date, with a comprehensive set of risk factor scenarios, and that it should include as broad a scope of CCPs as possible.

The relevant sources of risk that define the dynamics of the network are positions and asset prices. The data-generating processes for these will differ across products, but will clearly not be stable through time. Rather, they will change as the size and profile of each institution's risk profile is modified; and as the nature and scale of each entity's financial market activity changes. Indeed, when stress scenarios are properly calibrated for extreme but plausible conditions, they tend to remain static for an extended period of time. The more frequent source of perturbations to potential losses or liquidity shortfalls is likely to be changes in member (or underlying customer) exposures. The value of supervisory stress testing would therefore be enhanced if it was conducted sufficiently frequently – and with sufficiently stable scenarios and methodology – that changing risk profiles could be tracked over time.

Given the features of financial networks, and the complex transmission mechanisms at play, there is a strong argument that tests with a macro-prudential orientation should be sufficiently broad in scope as to capture the most relevant interdependencies. A broad scope will reveal members' common participation across CCPs. It will also help to assess, for instance, the implications of dependencies on common service providers, and help to capture correlations between products cleared by different CCPs. This argues in favor of investing in the cooperative arrangements that could support cross-jurisdictional, multi-CCP stress tests. While SSTs aimed at ensuring the resilience of individual CCPs can be run on a small number of CCPs, the quality of the results of macro-prudential SSTs will be enhanced as the number of CCPs or the coverage of the network increases. In fact, given that the objective of macro-prudential SSTs is to assess the resilience of the entire system of CCPs, it may be difficult to draw meaningful conclusions from macro-prudential CCP SSTs that captures only a small part of the network. It is worth emphasizing however that, even if there is only one CCP (or few) in a given jurisdiction, supervisory stress testing of CCPs is still likely to be a policy-relevant exercise. A single domestically-focused CCP is still likely to be exposed to – or contribute to – macro-prudential risks that are transmitted across borders via market interlinkages and common membership. Therefore, inclusion of such a CCP in an exercise that also had linked CCPs and other linked entities within its scope would yield macro-prudential benefits.

While a macro-prudential SST can still add value with a relatively limited scenario set, the authorities could consider developing scenarios that collectively cover a wide range of risk factors. To do so would yield insights on the performance of the clearing network under a spectrum of market conditions, allowing the authorities to assess the sensitivity of the system to particular realizations of shocks. A range of statistics could be examined to inform the authorities of potential concentrations of exposure, or to identify potential central or vulnerable nodes in the system.

## 4.2 Disclosure and interpretation

Stress test results on their own may not always provide the full context about the vulnerabilities of the clearing network. Therefore, when running the exercises additional information could aid interpretation and give the results some context. This supplementary set of information may include not only relevant risk metrics, but also details of the methodological design of the tests, their parameterization, and operational details of their implementation. In defining the disclosure strategy for a testing program, careful consideration would also have to be given as to whether the results would be made available outside the group of authorities performing the tests. In particular, important differences and trade-offs between supervisory discipline and market discipline, informed by the disclosure of results, would need to be assessed.

## 4.3 Resource cost

Ultimately, the net value added of a SST will rest on its being able to deliver #1 and #2 above at an acceptable resource cost. The fact that the end-to-end timeframe for some tests carried out to date has extended well beyond a year would suggest that these tests have been highly operationally complex to run. Such complexity might not only result in a high resource cost, but may also undermine the value-added of the exercise due to the time lag between the effective date of the exercise and the publication

of findings. Indeed, perceived operational complexity and high resource costs would seem to be the main factors delaying the widespread implementation of SSTs. The proposal in Section 5 aims to address this.

#### 4.4 Regulatory responses to findings

In designing a supervisory stress testing program, it is crucial that there is clarity on the tools and levers available to the authorities in responding to the findings, labelled here as the ‘response set’. They should also have an ex ante defined strategy to guide selection from the response set for alternative potential test outcomes. Indeed, since the anticipated response strategy ultimately defines the added value of the test, every aspect of design – the scope of the exercise, the frequency, the scenarios to be considered and the metrics to be assessed – should flow from this.

In general terms, for SSTs with a macro-prudential orientation, regulatory responses could assume one of three main forms:

- *‘Running repairs’ on the regulatory framework for CCPs.* Every policy framework or regulatory regime should be reassessed from time to time to ensure that it remains fit for purpose as new information emerges, or as the risk and operating environment changes. Supervisory stress testing of CCPs can be an important source of such new information. If a test – or a series of tests – reveals gaps or vulnerabilities that are not adequately addressed by the existing regulatory framework, adjustments to the framework could be proposed. For instance, if the tests reveal that the profile of the network is such that amplification mechanisms are being exacerbated by the typical design of CCPs’ frameworks for mutualisation of losses, authorities could propose guidance, or even technical standards, on to how to more appropriately adjust the calibration of CCPs’ waterfall structures.
- *Focused response at specific institutions in the network.* A macro-prudential network view could reveal that wider network stability was vulnerable to a shock at one or more specific nodes in the network (under particular modelled stresses). These could be particular clearing members, service providers, or individual CCPs. Such a finding could, for instance, trigger a focused dialogue with the relevant supervisor(s) and subsequent targeted corrective action.
- *Focused macro-prudential response.* Where a stress test revealed an urgent systemic vulnerability in the clearing network – whether at the level of the CCPs, clearing members, clients or service providers – this could be elevated to the relevant macro-prudential authorities to consider the need for a system-wide macro-prudential response. The response could, for instance, be: cyclical and generalised to a particular community (e.g., countercyclical capital on banks); cyclical, but targeted (e.g., focused on activity or exposures in a specific market or sector); or structural (e.g., related to structural features of the system, such as legal, tax, accounting, data or infrastructure arrangements).

Equally, specific findings could simply trigger heightened monitoring in some specific areas. Potential sources of propagation, such as common dependence on particular service providers, or the long chains of sub-custodial relationships, could be the focus of a specific monitoring program. For instance, in such

cases, CCP authorities could propose some mechanism for coordinated cross-border monitoring of the evolution of exposures in the system.

## 5 Building a value-added SST framework

Building a value-added supervisory stress testing framework with the features described in Section 4 poses a number of challenges. In particular, there is an inherent trade-off between standardization and accuracy. On the one hand, reducing the complexity of exercises and standardizing data requests and data collection may be desirable from the perspective of both the authorities and the covered CCPs. It would simplify operational processes, lower resource costs and perhaps allow for more frequent tests that can better track the dynamics of the network. But increased standardization may come at the expense of failing to fully reflect the sources of risk to which each CCP is exposed and the specific risk frameworks, operational procedures, and rules under which each in-scope CCP operates, including how the CCP will respond in times of stress.

### 5.1 A two-tier approach

A supervisory stress testing program that adds value to authorities needs to navigate these trade-offs, ensuring that the benefits of the program outweigh the costs. To strike the right balance, we propose that authorities develop a two-tier approach:

- *Core assessments.* In the first tier, authorities would run macro-prudentially-oriented SSTs that are relatively simple to implement with a less complex test design. This would facilitate shorter testing cycles, with shorter time lags between the assessment date and the delivery of results. Such relatively simple exercises could be considered ‘core’ CCP SSTs, which could be conducted frequently to assess the resilience of the clearing network over time. Simpler and more standardised tests could be more readily supported by automated processes for data collection and analysis, substantially lowering the resource cost of exercises once an initial fixed investment had been made. Indeed, subject to the investment in such capabilities, there would be a low marginal cost to enhancing the value-added of core SSTs by increasing the frequency of tests (or the number of reference dates considered) in accordance with the data-generating processes, and expanding the coverage of both risk factors (e.g., captured by the scenario set) and the network (e.g., captured by the number or size of in-scope CCPs). The design of these tests seeks to identify an optimal point in the trade-off between standardisation and accuracy, recognising that a test can still add value from a macro-prudential perspective even if some simplifying assumptions have to be made about the sources of risk and CCPs’ response functions.
- *Deep-dive thematic assessments.* The core SSTs could be supplemented, as necessary, by less frequent and more tailored ‘deep-dive’ thematic assessments. Such exercises could investigate particular amplification channels of interest, perhaps focussing on specific macro-prudential risks or vulnerabilities identified by the core SSTs. The interlinkage between core and deep-dive assessments should, in fact, run in both directions. As much as the core assessment should inform the deep-dive analyses, insights from the deep-dive exercises could help shape and mature the design of the core tests. Since interdependencies are dynamic, changing through time, the specific

purposes and coverage of these tests could be quite flexible, adapting to current and evolving market conditions. Such exercises could also be used to develop experimental and coordinated assessments with authorities of other sectors, aiming at measuring the propagation effects that extend beyond the CCPs. Indeed, such deep-dive exercises could be the first step towards system-wide tests which, as noted, have not yet emerged. Leveraging CCPs' expertise would be essential for these tests, particularly since they could involve analysis of multiple risk sources. In fact, authorities could use these exercises to measure the resilience of the clearing network to particular stress scenarios of interest not captured under the core SSTs. They could also be used to test the capacity of the supervisory stress testing program to identify and measure new and emerging risks, such as non-default losses triggered by operational failures.

As discussed in Section 3, these two types of macro-prudentially focused supervisory stress testing exercises would be designed to complement CCPs' internal stress tests. Since the proposed core assessments would need to be run frequently to meet their objective, with the results available in a timely manner, there is an even greater need for the authorities to more carefully navigate the trade-off between resource costs and benefits for this tier of the program. Our particular focus in the remainder of the paper is therefore the practical design of these core, as opposed to deep-dive, assessments.

## 5.2 The core assessment

The theoretical principles discussed in the previous sections illuminate some of the key design elements of the proposed core assessments, organizing the discussion around scenario development, aggregation and reporting of risk metrics, and resourcing and data collection. For a high-level summary of the main design choices under each component – and how these compare with CCPs' internal exercises and the proposed deep-dive assessments – see Table 3, below.



Table 3: *Design choices for stress testing exercises*

Component\Exercise	CCP Internal Exercise	Core Assessment	Deep-dive Assessment
<b>Objective</b>	Micro-prudential	Macro-prudential	Macro-prudential
<b>Risk coverage</b>	Credit and Liquidity	Credit and Liquidity	Credit, Liquidity, and Operational
<b>Scenario development – Scenario set</b>	Extensive, complex	Potentially extensive, relatively static	Potentially extensive, bespoke
<b>Scenario development - Model complexity/ coverage of risk sources</b>	Potentially complex models for all risk sources	Focused on most important risk sources (i.e. mid-market price movements)	Potentially complex models for all risk sources
<b>Network coverage</b>	Single CCP	Potentially extensive	Potentially extensive
<b>Risk metrics</b>	Specified by CCP Consistent and standardized, tailored to individual resilience objective	Specified by authorities Consistent and standardized, tailored to macro-prudential objective	Specified by authorities Ad hoc, exercise-specific
<b>Disclosure and reporting</b>	Internal, regulatory reporting, specified external disclosures	Periodic external reporting, accessible to public and relevant stakeholders	Exercise-specific, technical
<b>Resourcing and data collection</b>	Calculations performed by CCP, bespoke internal processes	Calculations performed primarily by authorities Standardized templates, extensive raw data Leverage existing data exchange mechanisms Automated processes Cross-jurisdictional gateways	Calculations performed jointly by CCPs and authorities Bespoke data requests Leverage existing data exchange mechanisms, where possible Leverage automated processes, where possible Cross-jurisdictional gateways

## Scenario development

One of the most challenging and resource-intensive parts of a stress testing exercise is the calibration of risk factor shocks. As noted in Section 4.1, the set of scenarios considered will ideally cover a wide range of risk factors, so as to give authorities a sufficiently broad perspective on risks that may emanate from different market segments, or that may disproportionately impact particular nodes and then transmit stress through the system. Section 4.1 also observed that, for a given test objective, a value-added test design should be capable of capturing how risks transmit through the network and how the stability of the network evolves through time.

Given these observations, the authors propose that, for the core assessment, the authorities develop a scenario set that is relatively stable through time. This scenario set would ideally be extensive, but need not be complex.

- A stable scenario set can act as a useful benchmark, allowing the authorities to monitor the evolution and changing pattern of carefully selected risk metrics. When monitored over time, risk metrics derived from tests run on a stable scenario set should work as triggers, alerting supervisors to the need for further investigation when unexpected results are observed.
- To perform this function effectively, the scenario set for the core SSTs could be extensive in the risk factor dimension, but need not be complex in its methodological design. Scenarios could initially be sourced directly from past historical events, and, if needed, complemented with other relatively simple scenarios developed by the authorities, potentially guided by the methods already used by in-scope CCPs or the scenarios used in less frequent deep-dive thematic assessments.

One important characteristic of the set of scenarios is that each realization be considered plausible and be applied consistently across CCPs. This is especially important for stress tests with macro-prudential objectives where the goal is to evaluate the collective response of all the in-scope CCPs. As discussed in Murphy and Macdonald (2016) and Tompaidis (2018), authorities should carefully consider the relationships between asset classes and within asset classes to make sure those are indeed plausible. Narratives, or other framing parameters that describe the shocks applied in each stress scenario, can be useful to establish the plausibility of the resulting scenario and to quickly communicate the magnitude of the shocks. Both the core SSTs and the deep-dive thematic assessments could benefit from mechanisms to anchor the scenarios, but this may be more important for the deep-dive assessments that would use customized, bespoke scenarios generated from potentially complicated models. We envisage that the core SSTs, by contrast, would use relatively static scenarios with a particular focus on the most important risk factors.

To yield useful results in support of a macro-prudential objective, it is important that the same stress scenarios be applied to all in-scope CCPs. Only with common stress scenarios will it be possible to understand the collective impact of a stress event on all CCPs simultaneously. This means that the same clearing members should be chosen to default at every CCP and the same market price shocks should be applied to those defaulted clearing members' portfolios. This is in contrast to the micro-prudential stress scenarios run internally at CCPs that can use mutually exclusive stress scenarios and still be useful in addressing the micro-prudential objective. As noted in Section 3, one consequence of applying the same scenario to all CCPs is that it is unlikely that the chosen scenarios will be stressful at every CCP.

Given that CCPs are exposed to many different sources of risk, we would argue that authorities should sensibly balance the value added from developing sophisticated, complex models of the different sources of risk with the potential cost, time and model risk that this may entail. There may be diminishing marginal benefits to increasing the complexity of the models that are used to generate the risk source shocks – particularly from a macro-prudential perspective. It is therefore proposed that authorities focus their modeling efforts on the most important risk sources – i.e., those with the largest impact on losses and liquidity shortfalls and the most variability in their data-generating processes. Indeed, it may be sufficient to include only mid-market price changes on cleared positions and collateral. More complicated models of transaction costs, wrong-way risks, losses in the CCP's investments, etc. could be covered in the deep-

diverse assessments, as required. In summary, the scenarios used in the core SSTs should only be as complex as required to ensure that the scenarios are still considered plausible and the results of the SST remain useful.

Although authorities could use the above approach to design stress scenarios for credit and liquidity stress tests, two important differences should be emphasized. The first difference is that the stress scenarios developed for liquidity stress tests will need to include the path that the market prices take over the assumed liquidation period as opposed to the credit stress test scenarios that can simply provide the cumulative price change over the period. The second difference is the potential need to provide additional information regarding each CCP's ability to convert non-cash collateral into cash. For example, a liquidity stress test scenario may include assumptions, determined by authorities, regarding how quickly the CCPs can access the repo market, or a potential delay in the performance of a common liquidity provider.

### Network coverage

As noted, to maximize the benefit of the core tests, network coverage would be sufficiently extensive to capture the key channels for stress transmission. This will require that the test capture at least those CCPs that control the largest exposures and that themselves have the most extensive interlinkages with other nodes in the network (clearing members, custodians, liquidity providers, etc.). As noted above, there may be diminishing returns when including additional risk factors and risk sources. Similarly, there may be diminishing returns to the addition of CCPs once the largest part of the network is covered by the test.

Over the years, regulators internationally have established extensive cross-border cooperative arrangements to support their supervisory activities. Such arrangements and the legal information-sharing gateways that support them could be leveraged to run cross-authority SSTs, thereby enhancing the value-added of such tests by expanding their CCP scope. Furthermore, joint, standardized tests will reduce the burden on the covered CCPs (see *resourcing and data collection* below).

### Risk metrics

A critical part of the SST process is the aggregation of raw data into risk metrics to be analyzed, an argument carefully elaborated in CPMI-IOSCO (2018). Accordingly, to meet the objective of the core assessments, and deliver meaningful macro-prudential insights, authorities would need to develop specific risk metrics tailored to identifying and measuring macro-prudential risks.

Even for a single CCP, over a relatively short monitoring period, changes in member exposures may lead to significant changes in risk profile. It will be important to develop a consistent, standardized set of risk metrics to track how the stability of the system evolves over time. Two categories of risk metrics will be particularly important:

- *Size and distribution of cumulative losses and liquidity shortfalls.* This category of metrics would capture both the cumulative size of modelled losses and liquidity shortfalls, and how these are distributed across stress scenarios/risk factor shocks, and across defaulting clearing members and (potentially) their clients. Such metrics could also illuminate particular interdependencies between CCPs. Both the size and distribution dimensions are likely to be important from a macro-

prudential perspective. The cumulative size is relevant as a measure of the losses or liquidity demands that the system would need to absorb, informing flow-on analysis of the capacity of the system to do so. The distribution of losses or liquidity demands is also important, since evidence of concentrated exposures under particular stress scenarios could, for instance, help to identify central or potentially vulnerable nodes within the network that might act as important channels for stress transmission.

- *Financial resource access, composition and usage.* This category would capture the size and composition of the available financial resources that could be drawn upon in a stress scenario. For instance:
  - Such metrics could capture how losses would be allocated across different categories of prefunded resources provided by clearing members, or in extremis post-funded assessments on members. These metrics would inform analysis of the flow-on implications of potentially simultaneous draw-down of members' prefunded resources at multiple CCPs, or members' ability to meet post-funded assessments or calls for replenishment.
  - This category could also include metrics to examine the composition of resources, providing a granular breakdown by attributes such as resource provider (e.g., liquidity provider), collateral type (e.g., cash or non-cash), collateral issuer, custodian, credit quality, or liquidity profile. Such metrics would, for instance, assist in illuminating potential system-wide concentrations of dependence on/exposure to particular custodians, other FMIs, or liquidity providers, or concentrations in collateral holdings that could signal fire-sale risks.

### Disclosure and reporting

As previously observed, a value-added test must be informative for the user. Consistent and comprehensive disclosure of relevant risk metrics, as described above, is an important part of this. There are also a number of ways in which reporting can be enhanced to ensure that results are presented with appropriate context. For instance:

- *Informative and relevant metrics and well-chosen benchmarks.* Once a set of relevant risk metrics has been developed, as appropriate for the macro-prudential objectives of the SST, it is important that they be presented against well-chosen benchmarks to allow the user of the test results to interpret the results. Once a time series of data is available, history will provide one benchmark, but it is important that an effort be made ex ante to establish analytically the macro-prudential implications of different potential outcomes on each metric.
- *Assumptions.* It is also important to present any critical assumptions made, which could impact their interpretation. In a liquidity-focussed SST, in particular, a number of assumptions would need to be made, for instance around CCPs' response functions and the timing of access to particular liquidity sources. These can be critical to the interpretation of results.

## Resourcing and data collection

The two-tier approach aims at designing stress testing tools that can efficiently meet the stated objectives. Experience shows that crafting such a framework will entail an initially material fixed cost for authorities and other stakeholders involved in the test design and implementation. However, under the premise that CCP supervisory tests are in their early stages and here to stay, the extracted benefits of the development of a proper assessment framework could be exploited for longer periods of time.

When performing the SST exercises, CCPs and authorities commonly share the responsibilities. Under the proposed core approach, where more frequent assessments are expected with a potentially larger number of stress scenarios, careful consideration needs to be given as to how to allocate tasks. If the core SSTs are to be more frequent, there would be a case for the authorities to establish arrangements with the CCPs to collect highly granular data, using standardized templates, and to then assume responsibility for a larger fraction of the calculations. For instance, authorities would collect a large volume of high-variability data that are readily available to the CCPs – e.g., member and customer account-level position data; data on relevant risk factor returns; data on margin collateral and other financial resources held – and then perform all of the aggregation processes and calculation of profits/losses and surpluses/shortfalls across scenarios.

If the running cost of a supervisory stress testing program is to be sufficiently low and manageable, for both authorities and CCPs, it would be important for the authorities to invest in the capability to automate, as much as possible, not only their internal processes to generate stress scenarios and test results, but also data collection. Automation would both reduce the resource cost of implementing the core tests and reduce the potential for error in the generation of the results. As authorities consider ways to most efficiently execute the core SST exercises, they may wish to consider how many reference dates will be included in each SST. By including more than one reference date in each core SST, the authorities could potentially reduce the frequency of the core SSTs while still being able to analyze trends over time.

Over the past few years, many authorities have enhanced the flow of data from CCPs and developed in-house technical capabilities to design programs and applications to conduct more technical analyses. The deeper familiarity with the data derived from such programs and the analytical tools that have been developed could potentially be leveraged to support a supervisory stress testing program. And to both reduce the risks for authorities and ensure that the investment in a supervisory stress testing program delivers a high added value the authorities should consult widely with CCPs and market participants.

Furthermore, since authorities have established important cooperation networks in the context of regulatory colleges and other such initiatives<sup>10</sup>, there could be scope for knowledge-sharing and standardization of testing approaches – as well as expanding network coverage by bringing a larger number of jurisdictions within the scope of the test. And, as noted, running joint tests and standardizing test methodologies will further reduce the burden on the covered CCPs.

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<sup>10</sup> See CGFS (2012) and Avdjiev et al. (2015) for an account of how the BIS banking statistics have been used to support cross-jurisdictional financial stability studies in the case of banks.

It is important to recognize that the ability of the authorities to take on the larger part of the responsibility for calculations will depend upon the degree to which the test is standardized. As discussed above, a CCP's response to liquidity shortfalls is likely to be more dynamic and uncertain than its response to credit losses. Therefore, the ability of authorities to automate processes and assume the calculation burden will be more limited for liquidity stress tests than credit stress tests.

In particular, in contrast to the well-defined loss waterfalls that describe how CCPs will cover credit losses, CCPs have significant optionality in how they generate the cash necessary to meet their liquidity needs. Not only will CCPs have different ways of generating liquidity, CCPs may also change how they plan on meeting their liquidity needs based on the stress scenario provided by the authorities or by the assumed clearing member default. Therefore, unless standardized simplifying assumptions are made on CCPs' response functions, there could be reduced scope for the authorities to automate processes and assume the calculation burden. Authorities may use information gained in past deep-dive SSTs to help establish these necessary simplifying assumptions.

## 6 Final remarks

An important development since the global financial crisis has been the increasing focus on macro-prudential analysis (BCBS 2017b). Regular and appropriately targeted supervisory stress testing can be an integral element of the authorities' macro-prudential toolkit. Supervisory stress testing has only recently emerged in the CCP space, with two authorities publishing the results of their first exercises in 2016 and CPMI-IOSCO issuing guidance on a framework for such tests in 2018.

While this activity is in its infancy, it is surely here to stay. Now is therefore a good time to encourage careful consideration of how the value added of SSTs for CCPs can best be realized. In particular, the authors propose that authorities focus on SSTs with a macro-prudential objective and establish a two-tier approach in which authorities make an up-front investment in data collection infrastructure, establish robust legal gateways with authorities in other jurisdictions, and build their own data analysis capabilities to support the following:

- *First tier.* This would entail frequent 'core' SSTs, with a macro-prudential policy objective that does not duplicate CCPs' routine internal stress tests. Design parameters would be tailored to the role and risk profile of CCPs. Test scenarios would only be as complex as necessary to ensure plausibility of the scenarios, but would be stable and potentially extensive. Data would be collected at a granular and 'raw' level, where possible, based on standardised data collection templates, leaving the authorities to develop automated routines for running the tests and calculating a carefully selected set of risk metrics.
- *Second tier.* The second tier will involve complementary 'deep-dive' analyses potentially involving the more sophisticated modelling of scenarios and would potentially require more calculations to be performed by the CCPs.

The two-tier approach described in the paper aims to keep the resource cost of SSTs manageable. It may seem paradoxical to argue for lowering the resource costs of SSTs, while simultaneously encouraging more

frequent tests, a wider scope of covered CCPs, and a potentially extensive set of stress scenarios. However, the authors believe that after a one-off investment in data collection, test design and automated analytical processes, the marginal cost of running relatively simple, stable and core tests with targeted objectives will be low. And it will be far outweighed by the policy value-added of the tests. Less frequent, more complex tests could then be carried out, as appropriate, in the second tier.

It is acknowledged that analytical methodologies in this space continue to evolve. For instance, over time, it is likely that supervisory stress testing capabilities will be enhanced to monitor feedbacks and spillovers more effectively. Tests will also expand to capture non-default risks, and supervisory stress testing of banks, CCPs and other FMIs is likely to be integrated to inform a system-wide view. Such enhancements would be expected initially to be captured in second-tier exercises, with some elements eventually folded into the first-tier exercises once they could be automated.

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