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Staff Discussion Paper/Document d'analyse du personnel—2023-34

Last updated: December 29, 2023

Procyclicality in Central Counterparty Margin Models: A Conceptual Tool Kit and the Key Parameters

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DOI: https://doi.org/10.34989/sdp-2023-34 | **ISSN** 2369-9639

Acknowledgements

The author would like to thank Éric Chouinard, Radoslav Raykov, Peter Youngman and Maren Hansen for helpful comments. Hiru Rodrigo provided excellent research assistance.

Abstract

Central counterparty (CCP) initial margin models are procyclical by nature, and CCPs use anti-procyclicality (APC) tools to mitigate this. However, despite the widespread use of such tools, margin models of CCPs around the world reacted severely to the heightened volatility during the March 2020 market turmoil. This triggered a debate globally on the adequacy of APC tools. We offer potential explanations for why those tools were not sufficient. We highlight that, to effectively mitigate procyclicality, the focus should be on the key parameters for both the margin model and the APC tools. One widely adopted APC tool established by the European Market Infrastructure Regulation is the stress period. We show that, to mitigate procyclicality with this tool, the main focus should not be on the calibration of its stressed margin level, but rather on the weight used to add this to the margin model. Further, the stress period tool can be highly effective, but only when its weight parameter is calibrated adequately high. These insights are essential for regulators to provide effective guidance on margin procyclicality, and for CCPs to appropriately design and calibrate their margin systems and procyclicality frameworks. To further serve these needs, we provide a novel conceptual tool kit for regulators and CCPs. The tool kit allows them to see a margin system's performance in procyclicality as well as in other competing objectives—such as margin coverage and cost of collateral—all in one place and for any combination of calibrations of the key procyclicality parameters. This feature lets regulators set outcomes-based procyclicality targets achievable by CCP margin models and APC tools. Moreover, it helps regulators design prescriptive procyclicality guidance in line with these desired outcomes-based targets. CCPs can use the tool kit to determine the set of parameter calibrations that satisfy the required procyclicality targets and perform sufficiently well in the other competing objectives.

Topics: Coronavirus disease (COVID-19), Credit risk management, Financial institutions, Financial markets, Financial stability, Financial system regulation and policies

JEL codes: G, G0, G01, G2, G23, G28

Résumé

Les modèles de marge initiale des contreparties centrales sont de nature procyclique, et celles-ci ont recours à des outils pour atténuer la procyclicité. Mais, malgré l'utilisation généralisée de ces outils, les modèles de marge des contreparties centrales à travers le monde ont réagi durement à la montée de la volatilité pendant l'épisode de turbulence des marchés en mars 2020. S'en est suivi un débat mondial sur l'efficacité des outils anti-procyclicité. Dans cette étude, nous proposons des explications possibles au manque d'efficacité de ces outils. Nous soulignons que, pour réduire suffisamment la procyclicité, il faut mettre l'accent sur les paramètres clés tant du modèle de marge que des outils anti-procyclicité. La prise en compte des périodes de tensions est un outil anti-procyclicité largement adopté, qui a été établi en vertu du règlement sur l'infrastructure du marché européen. Nous montrons que, pour atténuer la procyclicité avec cet outil, il vaut mieux mettre la priorité sur la pondération des observations de situations de tensions dans le modèle de marge que sur l'étalonnage du niveau de risque de tensions. Cet outil peut se révéler très efficace, mais seulement si la pondération des périodes de tensions est à un niveau suffisamment élevé. Ces informations sont essentielles aux organismes de réglementation pour fournir des recommandations judicieuses concernant la procyclicité des marges, et aux contreparties centrales pour bien concevoir et étalonner leurs systèmes d'appel de marge et leurs cadres de procyclicité. Afin de mieux répondre à ces besoins, nous proposons une nouvelle boîte à outils conceptuelle à l'intention des organismes de réglementation et des contreparties centrales. Cette boîte à outils leur montre dans quelle mesure un système d'appel de marge permet de gérer la procyclicité et d'atteindre d'autres objectifs concurrents – comme assurer que la couverture procurée par les marges est adéquate et que le coût des garanties est acceptable – et cela à un seul et même endroit et pour toute combinaison d'étalonnages des principaux paramètres liés à la procyclicité. Elle aide les organismes de réglementation à fixer des cibles de procyclicité axées sur les résultats que les modèles de marge et les outils anti-procyclicité des contreparties centrales sont capables d'atteindre. Elle les aide également à formuler des recommandations prescriptives concernant la procyclicité conformes à ces cibles axées sur les résultats. Les contreparties centrales peuvent se servir de la boîte à outils pour déterminer l'ensemble des réglages des paramètres permettant d'atteindre les cibles de procyclicité imposées et d'obtenir des résultats satisfaisants à l'égard des autres objectifs concurrents.

Sujets : Maladie à coronavirus (COVID-19), Gestion du risque de crédit, Institutions financières, Marchés financiers, Stabilité financière, Réglementation et politiques relatives au système financier

Codes JEL : G, G0, G01, G2, G23, G28

Introduction

A central counterparty (CCP) is a financial market infrastructure that stands between buyers and sellers in financial transactions to centralize and reduce counterparty credit risk. In a bilaterally cleared market, each counterparty relies on the other to perform. The failure of one counterparty, say a large financial institution, would impact all its other counterparties. Furthermore, a lack of transparency about exposures to the failed financial institution would create uncertainty in the market about whether other financial institutions were affected. If severe enough, this uncertainty can disrupt the financial system, creating systemic risk. Yet, with central clearing, the CCP novates, or replaces, the contracts to become the buyer to every seller and the seller to every buyer for the transactions that it clears, so that each counterparty would be exposed only to that CCP. This has the potential to reduce both counterparty and systemic risk.

However, by design, a CCP concentrates all the counterparty risks into a single entity that would otherwise be decentralized in bilateral clearing. As a result, CCPs need highly robust risk management mechanisms to be in place. One of these mechanisms requires a CCP's participants to post initial margin (IM) collateral, which is kept by the CCP throughout the lifetime of the derivatives position. The IM collateral collected from a market participant is designed to cover potential losses in the value of that participant's position over an appropriate close-out period (such as two days), in the event that the participant defaults.

CCP initial margin models are procyclical by nature

In the context of CCP margin systems, procyclicality refers to "changes in risk-management requirements or practices that are positively correlated with market, business or credit cycle fluctuations and may cause or exacerbate financial instability."[1] In order to calculate the base IM collateral required from their participants, CCPs typically use margin models based on value-at-risk or expected shortfall.[2] As a result, when the underlying markets become more volatile, the required IM for the derivatives associated with these markets increases. Corresponding margin calls to post additional collateral can create liquidity challenges for CCP participants during periods of market stress and scarce liquidity. Therefore, CCP IM models are procyclical by nature.

Adequate margin coverage is the primary objective of the CCPs when calibrating their margin models. However, they also take margin procyclicality into account to mitigate the potential for excessive and destabilizing margin calls that would unduly amplify market turmoil during

[1] See Section 5.2.37 in the Committee on Payments and Market Infrastructures and International Organization of Securities Commissions (2017).

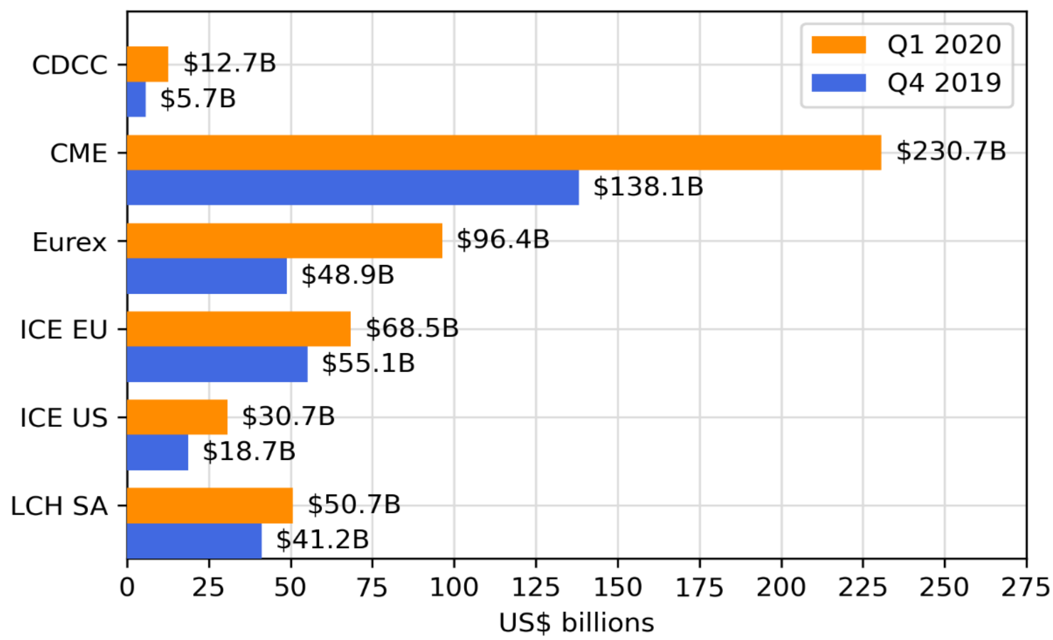
[2] CCPs often require margin add-ons for the risks not addressed by the base IM, such as liquidity risk, concentration risk and wrong-way risk. For the remainder of the paper, unless explicitly stated otherwise, we use "IM" or "margin" for simplicity to refer to "base IM" only.

volatile periods. To achieve this goal, CCPs commonly use supplementary anti-procyclicality (APC) tools, ranging from applying a floor within margin models to including stress observations in the lookback period of these models.[3, 4]

Anti-procyclicality tools in place proved not sufficiently effective during the March 2020 market turmoil

Chart 1 shows the unprecedented increase in total IM requirements from the end of the fourth quarter of 2019 to the end of the first quarter of 2020 at the Canadian Derivatives Clearing Corporation (CDCC).[5] It also shows the increases in total IM requirements at five prominent CCPs that have sizable exchange-traded derivatives (ETD) clearing services within their businesses.

Chart 1: **Quarter-end total initial margin requirements at central counterparties**



Note: Total initial margin requirements data are public quantitative disclosures presented for the Canadian Derivatives Clearing Corporation (CDCC), Chicago Mercantile Exchange (CME), Eurex, Intercontinental Exchange Europe (ICE EU), Intercontinental Exchange US (ICE US) and the London Clearing House SA (LCH SA).

Sources: CDCC, CME, Eurex, ICE EU, ICE US, LCH SA Last observation: first quarter of 2020

[3] Lookback period refers to the time horizon, typically historical, over which the observations are used as an input to the margin models to calculate IM requirements.

[4] See Table 4 in the Basel Committee on Banking Supervision (BCBS), Committee on Payments and Market Infrastructures (CPMI) and International Organization of Securities Commissions (IOSCO) (2022) for a list of commonly used APC tools among CCPs and their use for various cleared asset classes.

[5] CDCC is one of the major CCPs in Canada. It clears all derivatives traded on the Montreal Exchange, such as futures on equity indexes.

Note that, among various asset classes, the increase in total IM requirements during March 2020 was the largest for ETDs in absolute terms.[6] This was particularly the case for the derivatives written on equities and was mainly driven by heightened volatility on the global equity market, but more importantly by the severe reaction of the margin models to the increase in volatility.[7]

Approaches for avoiding excessive margin procyclicality vary. For example, the European Market Infrastructure Regulation (EMIR) guidance requires that CCPs operating in the European Union employ at least one of three prescribed APC margin measures[8]:

- inclusion of stress periods in the lookback period (assign to them at least 25% weight)
- application of a margin floor
- application of a margin buffer (scale up by at least 25% during periods of low volatility)

Currently, several CCPs in other jurisdictions also use these or similar APC tools; some were implemented before the March 2020 market turmoil, while others have been deployed as a corrective measure since then. Table 4 of the 2022 report by the Basel Committee on Banking Supervision (BCBS), Committee on Payments and Market Infrastructures (CPMI) and Board of the International Organization of Securities Commissions (IOSCO) tracks the CCPs that responded to the IOSCO Financial Stability Engagement Group's data survey with respect to their derivatives clearing service. The table shows that at least 95% of those CCPs reported having at least one of these three APC tools in place. CDCC, for instance, had the margin floor before March 2020, while it implemented the other two APC tools afterward.

Despite the widespread use of APC tools by CCPs, the IM requirements still exhibited steep increases during March 2020. These increases prompted regulators and participants of major CCPs to question the procyclicality performance of CCP IM models and triggered a debate among international standard-setters on the adequacy of the APC tools that CCPs were deploying at that time.[9]

In this paper, we shed light on the various factors that contributed to such sharp increases in IM requirements, and on possible explanations as to why the APC tools in place during the March 2020 market turmoil were not sufficiently effective. We approach this issue from a

[6] BCBS, CPMI and IOSCO (2022) state that, "The increase of required IM [from end-February to mid-March 2020] for CCPs clearing ETDs—which account [sic] for 46% of total required IM—was 62%. This accounted for roughly two-thirds of the total increase of required IM for all asset classes [ETD, OTC derivatives and cash products]."

[7] Increases in the open interest or the price of the derivatives could escalate IM requirements as well. However, these weren't the main drivers of the increases in IM requirements observed during March 2020, in particular of the exchange-traded equity derivatives. For the remainder of the paper, our focus is on the reaction of the margin models to the increase in volatility, as the main driver of the sharp increases in IM requirements.

[8] See the European Securities and Markets Authority (2018).

[9] See, for instance, Huang and Takáts (2020); the Futures Industry Association (2020); the European Securities and Markets Authority (2022); and BCBS, CPMI and IOSCO (2022). In response and mostly to defend their IM models, various prominent CCPs retrospectively self-reported the anti-procyclicality performance of their IM models for March 2020; see, for instance, Acuiti and Eurex (2020), London Clearing House (2022) and CME Group (2021).

regulator's perspective and point to some of the important aspects and design elements that could improve the effectiveness of regulatory guidance on margin procyclicality. To facilitate that, we also provide a conceptual tool kit for regulators. Because the APC tools established by EMIR have been widely adopted, including by CCPs outside of the European Union such as CDCC, our focus is around these tools and how the EMIR guidelines prescribe them. The tool kit and the insights we provide could also be used by CCPs to appropriately design and calibrate their margin systems (i.e., margin models and APC tools) and procyclicality frameworks.

Model

To mitigate procyclicality, the focus should be on the key parameters

The starting point for understanding why CCP IM requirements can increase steeply within a margin system during high market volatility is to analyze the margin model and APC tools constituting this margin system. In particular, the key parameters that drive the margin system's responsiveness to heightened volatility should be correctly determined. Only then can regulators provide effective guidance on margin procyclicality and CCPs appropriately design and calibrate their margin systems and procyclicality frameworks.

To illustrate, we take the case of CDCC's base margining model and APC tools used for its standard equity index futures (SXF – S&P/TSX 60 Index Standard Futures).[10] This model is based on a value-at-risk framework. CDCC's estimate for the volatility of the contract's returns as well as the predetermined and constant close-out period and confidence level values are the main components used to calculate the potential future exposure (PFE). PFE is expressed with the "margin interval" term in the model, that is, the maximum price fluctuation in percentages that the contract is expected to have over the close-out period (two days) and with the desired level of confidence (99.87%, normal distribution).[11]

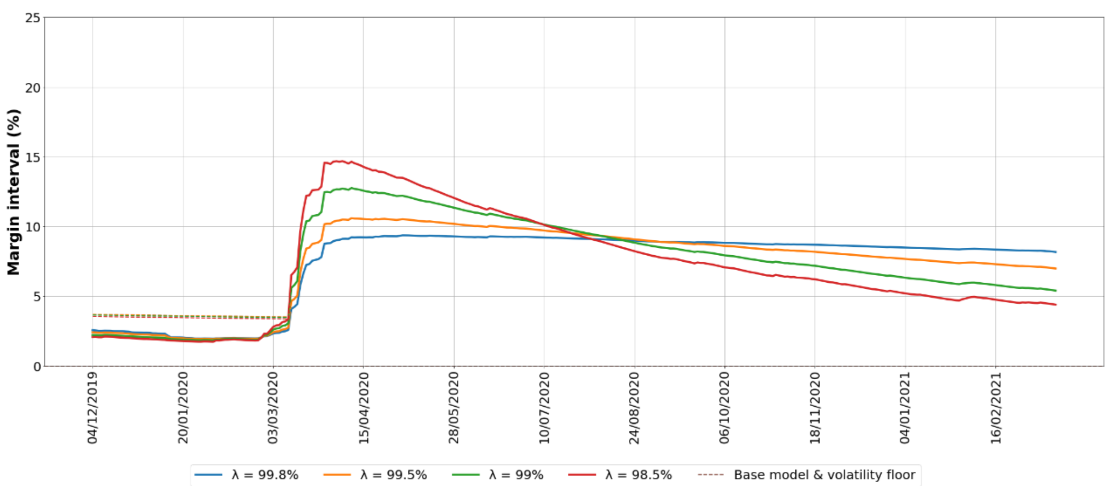
CDCC's volatility estimator uses an exponentially weighted moving average (EWMA) approach with the responsiveness/decay factor lambda (λ) equal to 0.99. And it has a lookback period of 260 days, meaning that for any calculation day, it uses the variation of the contract returns over the 260 days prior to that date. While averaging, each day's return variation is weighted with an exponentially decreasing term [$\lambda^{i-1} * (1 - \lambda) / (1 - \lambda^{260})$] for i = 1 to 260, with the most recent observation (i = 1) having the highest weight.

[10] See Appendix A for a comprehensive explanation of the technical details of the base margining model and APC tools used for SXF, particularly for how the IM requirement for a single SXF contract is calculated based on publicly available financial data. Note that these APC tools and base margining model are commonly used among CCPs clearing derivatives. Therefore, our findings throughout the paper are also applicable to other CCPs.

[11] To calculate the expected maximum price fluctuation in a dollar amount, which corresponds to the IM requirement for a single SXF contract, the margin interval is multiplied by the price of that contract along with a constant multiplier (contract size).

The averaging process within the EWMA methodology results in smoothing the sudden changes in the underlying return volatility while computing the volatility estimate. This means that if heightened volatility hits the underlying asset market, the margin interval increases, but less severely. It also means that when the markets are back to normal, the effect of the recent volatility episode doesn't vanish immediately, and the margin interval exhibits a slow decay rather than a sharp drop. These are illustrated in **Chart 2** (solid lines), which plots the margin interval calculated with the base margining model for SXF from December 2019 to March 2021. Note that the chart displays the margin interval for a range of hypothetical lambda values, while CDCC's actual lambda value during this period was equal to 0.99. From late February 2020 to May 2020, the underlying interest S&P/TSX 60 Index price, and therefore the SXF contract value, was unusually volatile. Accordingly, the EWMA-based volatility estimates for SXF, as represented by the margin interval values in Chart 2, increase from late February onward. But these increases are actually less severe compared with the changes in the underlying market volatility. Moreover, as the market gets back to normal from May 2020 onwards, the margin interval values exhibit a slow decay, at least until March 2021, as opposed to a steep drop.

Chart 2: Margin interval for equity index futures for varying lambda parameter values



Note: These margin interval values (solid lines) are calculated using the base model. The dotted lines represent the margin interval values calculated using the base model with the volatility floor anti-procyclicality tool. The period studied is from December 2019 to March 2021.

Source: Bank of Canada calculations Last observation: March 2021

The responsiveness/decay factor lambda is the major parameter determining the severity of the increases in margin interval, as well as the speed of the decay in it.[12] We see in Chart 2 that, depending on the value of lambda, the responsiveness of the margin interval values changes. The smaller (larger) it is, the larger (smaller) the total increase is but also the faster (slower) the subsequent decay is. In this paper, we characterize the procyclicality of a margin model through the magnitude of the maximum margin change it exhibits over a period of heightened market

[12] The lookback period length parameter also has an impact on these. However, its effect would be more noticeable on the speed of decay, and much less on the size of margin increases.

volatility.[13] And we use the maximum difference (i.e., large-call metric) in the margin interval to measure it. The short-term procyclicality measure refers to 2-day periods, and the long-term measure, 30-day periods.[14] Accordingly, the responsiveness/decay factor lambda is the key parameter of the base margining model in determining the level of procyclicality (for both the short and long terms). Therefore, to mitigate procyclicality the focus should be on this parameter of the base margining model as much as it should be on the choice and parameters of APC tools.

The volatility floor APC tool is not effective when its lookback period doesn't include a stress period

During the time period shown in Chart 2, CDCC mitigated the procyclicality inherent in its base margining model (lambda equal to 0.99) for SXF by applying a floor value to the calculated volatility estimates. We see that the volatility floor APC tool was binding for the period until March 2020; i.e., the floor values (dotted lines) were larger than the EWMA-based volatility estimates (solid lines) from December 2019 to March 2020. Note that the floor value on a given day is determined through simple averaging of the daily volatility estimates observed over the previous 10 years. Therefore, the floor value is expected to change very slowly over time. This APC tool effectively improves the procyclicality of the IM model by raising the estimate levels for pre-crisis period volatility. Due to how the tool is calibrated, though, the improvement it brings is not always expected to be sizable, especially if the lookback period doesn't include stress periods. This is the case for CDCC since, during the first quarter of 2020, the 10-year lookback period didn't include the 2008–09 global financial crisis. Consequently, with the application of this APC tool, we observe only about a 10% improvement, or decrease, in the 30-day large-call (long-term procyclicality) measure. Furthermore, we observe no improvements in the short-term procyclicality measure as the largest increase over 2 days comes from a period where the volatility floor is not effective.

The weight parameter of the stress period APC tool is one of the most important for procyclicality

In October 2021, CDCC introduced a second APC tool for SXF, commonly called stress period or stress VaR. In this approach, a stress period is included as an input to the IM model, and a stress risk (or stressed margin) component is calculated based on the volatility estimates from this period. A fixed weight, *w*, is then applied to the stress risk component, and a weight of *1-*

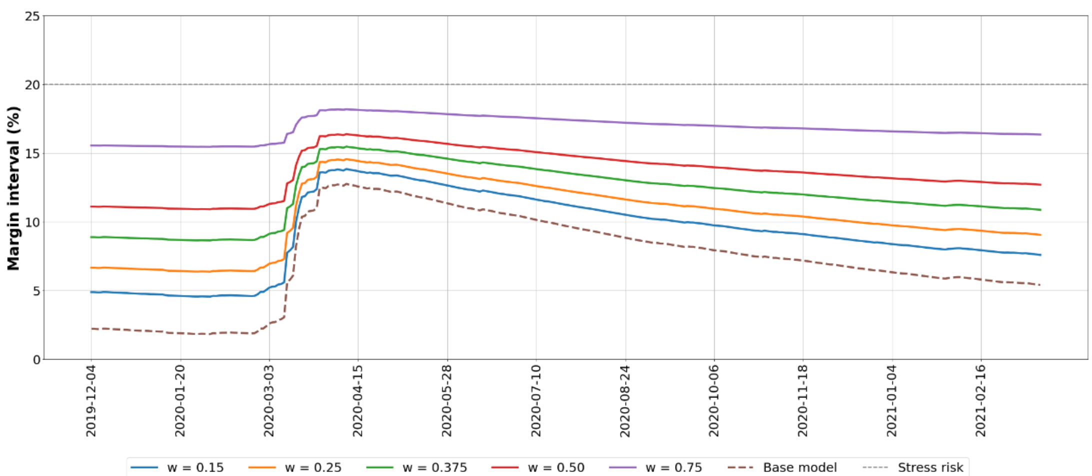
[13] Our focus in this paper is the margin procyclicality solely stemming from the reaction of a margin model to the changes in the underlying market volatility. Accordingly, in our analysis we exclude the impact of the underlying price changes on margin procyclicality. Therefore, for assessing margin procyclicality, the main object we analyze is margin interval rather than margin requirement.

[14] Notice that the large-call metric measures the margin (interval) changes in absolute terms (as difference) as opposed to relative terms (as ratio). We use the large-call metric since it more fairly represents the size of margin calls from, and therefore liquidity pressure felt on, CCP participants. Furthermore, in the paper, whenever we assess a modification in an IM model (e.g., due to application of an APC tool or change of a parameter value) we check the percentage change in the large-call measure.

w is applied to the EWMA-based historical risk component, in order to calculate the margin interval. At CDCC, the fixed level of the stress risk component was calculated using a stress period of minimum 260 days, and its weight parameter was set to 25%. This percentage weight is also the minimum value as required by the EMIR guidance.[15] Like CDCC, many non-European CCPs have chosen to implement this minimum required value.

Chart 3 plots the margin interval calculated for SXF (model lambda equal to 0.99) if CDCC had had the stress period APC tool in place from December 2019 to March 2021. The dashed line corresponds to the base model (i.e., the EWMA-based historical risk component with the volatility floor APC tool applied). This APC tool's weighted averaging procedure attenuates the values coming from the EWMA-based component (dashed line) by [*w*]% and shifts them upward by [*w**stress risk*]. Chart 3 shows this effect for varying weight parameter values, while the stress risk component's level is calculated as 20% based on a severe stress period and is typically higher than the EWMA-based component. In such a case, this APC tool effectively mitigates procyclicality by raising the margin interval levels of both the pre-crisis and the crisis periods, but the former by a larger amount.[16]

Chart 3: **Margin interval for equity index futures for varying weight parameter values**



Note: These margin interval values (solid lines) are calculated using the base model with the stress period anti-procyclicality tool. The level of stress risk (dotted line) is set to 20%. The dashed line represents the margin interval calculated using only the base model. The period studied is from December 2019 to March 2021.

Source: Bank of Canada calculations | Last observation: March 2021

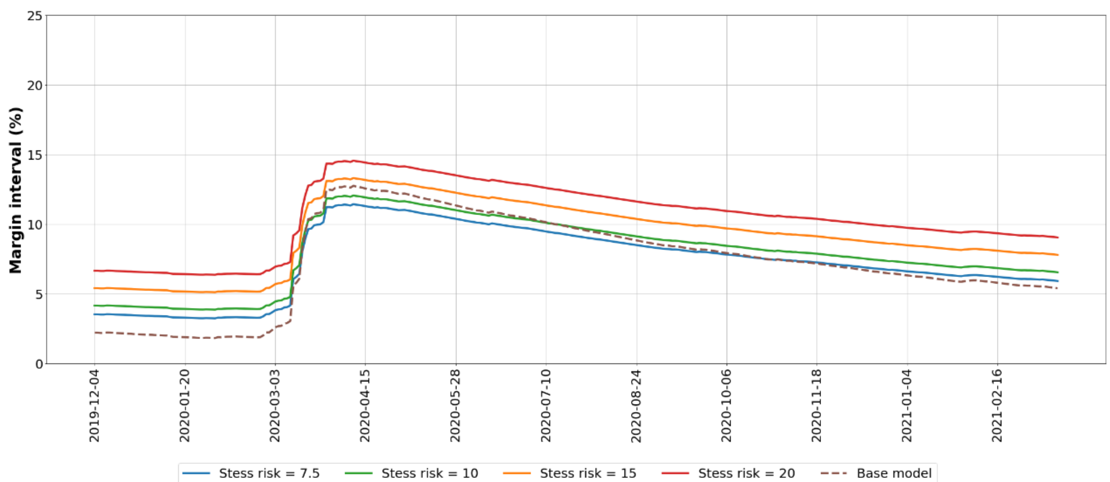
[15] See the European Securities and Markets Authority (2018).

[16] See Chart B-1 in Appendix B for a case where the prevailing market conditions get worse than the stress period used for calibrating the level of the stress risk component (10%). This APC tool's weighted averaging procedure is still the same even though the calibration value of its level is different; that is, it still attenuates the values coming from the EWMA-based component by [w]% and shifts them upward by [w*stress risk]. However, since in this case the EWMA-based component would surpass the level of the stress risk component (as in Chart B-1), the way this tool mitigates procyclicality is effectively by raising the margin interval levels during pre-crisis periods while dampening those during crisis periods.

We also see in Chart 3 that the larger the weight parameter, the higher the APC tool's procyclicality mitigation (for both the short and long terms). Indeed, the improvement or decrease in the large-call measure is precisely [*w*]%. Therefore, this tool can be highly effective against procyclicality, but only when the weight parameter is calibrated adequately high.

Chart 4 also plots the margin interval calculated for SXF (model lambda equal to 0.99) if CDCC had had the stress period APC tool in place from December 2019 to March 2021. However, this time it shows varying levels of the stress risk component, while the "weight" parameter is fixed at 25%. Again, the weighted averaging procedure of this APC tool attenuates the values coming from the EWMA-based component (dashed line) by [*w*]% and shifts them upward by [*w*stress risk*]. Consequently, for different stress risk component values, we obtain plots that all have the same shape (and large-call measures) but are shifted parallel to each other. This means that the calibration for the stress risk component's "level" doesn't have any effect on margin procyclicality (for both the short and long terms).

Chart 4: **Margin interval for equity index futures for varying stress risk levels**



Note: These margin interval values (solid lines) are calculated using the base model with the stress period anti-procyclicality tool. The weight parameter value is set to 25%. The dashed line represents the margin interval calculated using only the base model. The period studied is from December 2019 to March 2021.

Source: Bank of Canada calculations Last observation: March 2021

We conclude that, to mitigate procyclicality with the stress period APC tool, CCPs and regulators should focus on the weight parameter rather than the level of the stress risk component. As noted previously, many CCPs have set the weight parameter at the minimum value required by EMIR guidance (25%). This is one of the major factors why steep and large increases in IM requirements were still observed at prominent derivative-clearing CCPs during the March 2020 market turmoil, even though most of these CCPs had this APC tool in place at the time.[17] One way for regulators to deal with this in their margin procyclicality guidance is to

[17] This is because, when the weight parameter is set to 25%, the improvement or decrease in the long-term procyclicality (30-day large-call) measure is bound to 25%. Moreover, as explained in Appendix B, if the stress period

require CCPs to justify their calibration decisions for the key model parameters through a comprehensive and forward-looking analysis. This requirement is especially important if the CCP opts for the minimum value, either as proposed by EMIR guidance or because it has become common practice across the industry.

Tool kit

The tool kit we present in this section assists regulators to provide effective guidance on margin procyclicality as well as CCPs to appropriately design and calibrate their margin systems and procyclicality frameworks. The tool kit is essentially a table that one constructs for a specific margin system (i.e., margin model and APC tools) by focusing on its key parameters and following a holistic framework. Once constructed, the table is populated with the performance indicators corresponding to different calibration values of the key parameters. To illustrate, we present in **Table 1** the tool kit prepared for the base margining model and APC tools analyzed in the Model section.[18]

The framework we use for our tool kit assesses margin procyclicality performance within a trade-off structure. This approach is important since guidance on procyclicality and its key parameters based solely on procyclicality performance would fail. This is because the parameters that control procyclicality performance also have an impact on other aspects of the margin model, including margin coverage and participants' cost of collateral (for central clearing). For instance, it is straightforward to diminish margin model procyclicality by simply setting a constant margin requirement, fixed at all times. Meanwhile, to provide sufficient margin coverage in line with the requirements of the Committee on Payment and Settlement Systems (CPSS) and IOSCO's *Principles for Financial Market Infrastructures* (PFMI) (CPSS and IOSCO 2012), this constant level of margin requirement could be set very high. Such a model calibration would result in no margin procyclicality at all, even during extreme market volatility. However, such a setting would be unacceptably costly in terms of IM collateral required for central clearing, especially during non-stress periods.

Identification of trade-off dimensions

The trade-off dimensions we use are listed in the first column of our tool kit, as illustrated in Table 1. Note that there are various ways of selecting these high-level dimensions for a trade-off framework. Our choices are similar to others we observe in the literature. For another, slightly different, set of trade-off dimensions, see the European Securities and Markets Authority (2022). Furthermore, there are various ways of quantifying each of these dimensions.

is implemented in addition to another APC tool, such as volatility floor, its marginal improvement could even be considerably less.

[18] The regulators and CCPs could directly use the populated tool kit in Table 1 and the insights it delivers if the margin model and APC tools of their interest are similar. But more importantly, they could use the framework and approaches we follow to construct and populate their tool kits, tailored to their desired margin models and APC tools.

For instance, we use the maximum difference (i.e., large-call metric) in the margin (interval) to measure margin procyclicality. The short-term procyclicality measure refers to 2-day periods, and the long-term measure, 30-day periods.

Table 1: Performance indicators for different values of the key margin system parameters and trade-off dimensions

Trade-offs \ Parameters	Lambda			Stress risk weight			Stress risk level		Margin floor	
	High (0.995)	*Medium* (0.99)	*Low* (0.985)	*High* (0.50)	*Medium* (0.375)	*Low* (0.25)	*High* (20)	*Medium* (10)	*High* (6)	*Medium* (4)
Short-term procyclicality	+	~	–	+ +	+	~			~	~
Long-term procyclicality	+	~	–	+ +	+	~			+	~
				Stress risk level *H* / *M*	**Stress risk level** *H* / *M*	**Stress risk level** *H* / *M*				
Margin coverage *(During stress times)*	–	~	+	H: + / M: –	H: + / M: –	H: + / M: ~	+	–		
Cost of collateral *(During normal times)*	–	~	+	H: – – / M: –	H: – – / M: –	H: – / M: ~	– –	–	–	~

Note: The numbers in parentheses are the values for the parameters indicated above them. The signs in the cells are the performance indicators. The "~" sign either refers to the common parameter calibration, or it means no significant improvement or deterioration relative to this calibration is achieved for that parameter value. The "–" ("+") sign in a cell means that the choice of that parameter value results in a deterioration (improvement) in the performance of the trade-off dimension it corresponds to. The "– –" ("+ +") sign means that the deterioration (improvement) is beyond the feasible/practical (adequate) levels for the corresponding trade-off dimension. Accordingly, the "– –" signs are marked in red to avoid considering the corresponding parameter values. An empty cell means that the parameter doesn't affect the corresponding trade-off dimension per se.

Range of parameter values

The first row of Table 1 lists the key parameters in determining margin procyclicality of the base margining model as well as the important parameters or calibrations of the APC tools in use, as determined in the Model section. Before populating the tool kit with performance indicators, we first determine the range of parameter values that are feasible and practical regarding the trade-off dimensions.[19] We do so based on the findings of our sensitivity analysis in the Model section:

- Regarding the lambda parameter of the base margining model, we see in Chart 2 that, when it is equal to 0.998, the decay of the margin (interval) is too slow. Even one year after the March 2020 episode of heightened market volatility, the margins were more

[19] In the paper, unless explicitly stated otherwise, we refer to parameter calibration values as infeasible when the resulting margin model doesn't provide sufficient margin coverage to meet the PFMI requirements. And we refer to them as impractical when the participants' cost of collateral (for central clearing) is unacceptably high.

or less at the same level as they were during March 2020. Therefore, in our tool kit we consider only lambda values of less than 0.998. Note that it is common among CCPs, like CDCC, to have lambda equal to 0.99. That is why in our tool kit we have one value greater (0.995) and another one less (0.985) than this value.

- For the stress period APC tool's weight parameter, we consider three values within the range of [25%, 50%], as 25% is the minimum value required by the EMIR guidance. And we see in Chart 3 that even a 50% weight tends to generate impractically high margins during non-stress periods. As a result, there is no need to consider values beyond 50%.
- For the stress period APC tool's level calibration, which is calculated using a historical or hypothetical stress period, we consider the two following values: 10% and 20%. For the lower value, we choose 10% since a value such as 5% (or less) would be considered a margin (interval) level representing non-stress periods (see Chart 2). And for the upper value, we choose 20% as this is a high enough value, even larger than what CDCC and other CCPs experienced during March 2020, where for CDCC these reached around 12.5% (see Chart 2, green line). Notice that, in Table 1, for each weight parameter value, we specify whether it is assessed under the stress risk level calibration equal to 10% or 20%. This is because there is a close interaction between these two. To see this dependence, compare Chart 3 (level equal to 20%) and Chart B-1 (level equal to 10%): In Chart 3, the weight parameter at 50% already tends to generate impractically high margins during non-stress periods, while in Chart B-1, only a 75% weight parameter value does so.
- For the volatility floor calibration values, we consider 4% and 6%. As seen in Chart 2, CDCC's floor value just before March 2020 (in a non-stress period) was around this lower value (4%), which indeed was quite low in terms of its effectiveness as an APC tool. As noted previously, CDCC's volatility floor didn't include a stress episode, such as the global financial crisis, at that time in its 10-year lookback period. And we consider 6% as the higher value and an improvement to this. Indeed, Chart B-1 shows that a 4% calibration for the floor value would make this APC tool ineffective when implemented together with the stress period (for the weight parameter values considered in our tool kit), while a 6% for the floor value would have an effect on the margin (interval) during non-stress times.

Sensitivity analysis

Once we determine the range of parameter values that are feasible and practical regarding the trade-off dimensions, we next fill in the cells of the tool kit with performance indicators based on the findings of our sensitivity analysis in the Model section:

- The "~" sign either refers to a common (and therefore feasible and practical) parameter calibration, or it means no significant improvement or deterioration (relative to this calibration) for the parameter value chosen on the corresponding trade-off dimension.
- The "+" sign in a cell means that the choice of that parameter value results in an improvement in the performance of the trade-off dimension it corresponds to, while

the "–" sign means a deterioration. See **Box 1** for an example of populating the cells of the tool kit with the "+" and "–" signs, particularly for the table cells corresponding to the high lambda value.

- The "– –" ("+ +") sign means that the deterioration (improvement) is beyond the feasible or practical (adequate) levels for the corresponding trade-off dimension. Accordingly, we mark the "– –" signs in red to avoid considering these parameter values, especially if they indicate insufficient performance related to the cost of collateral or margin coverage dimensions.
- An empty cell means that the parameter doesn't affect the corresponding trade-off dimension per se. For instance, as we show in the Model section, the level calibration of the stress period APC tool doesn't affect margin procyclicality performance in either the short or the long term.

Box 1: Filling in the tool kit cells with performance indicators based on the sensitivity analysis findings

A high lambda value (0.995) calibration, compared with a medium value (0.99), improves both the long-term and the short-term procyclicality performances of the margin model. This is because, with a higher lambda value, the margin model reacts less severely to a change in the underlying market volatility. This is seen in Chart 2, where for lambda equal to 0.995 (orange line), the steep increase in the margins during the period of heightened market volatility is smaller than the increase observed for lambda equal to 0.99 (green line)—resulting in smaller 2-day and 30-day large-call measures, and therefore improved procyclicality performances. Meanwhile, the performance of the margin model worsens in margin coverage because lower margin levels exhibited for higher lambda values can result in more margin coverage breaches, especially during stress periods. Finally, for a higher lambda value, the performance of the margin model in the cost of required collateral is worse. Again, this is seen in Chart 2, especially after the high market volatility period is over, as the average margin level for lambda equal to 0.995 (orange line) is larger than that for lambda equal to 0.99 (green line).

Accordingly, we populate Table 1's cells corresponding to the high lambda value (0.995), with the "+" sign (improvement performance indicator) for the procyclicality dimensions and the "–" sign (deterioration performance indicator) for the margin coverage and cost of collateral dimensions.

The value of our tool kit is that it allows CCPs and regulators to see a margin system's performance in procyclicality—as well as in other competing objectives—all in one place and for any possible combination of values of the key parameters. This feature enables CCPs and regulators to compare the outcome of any chosen set of parameter values relative to another set and assess the resulting margin system performance differences in each trade-off dimension. To do so, one can process the table horizontally and add up, for each row, the "+" and "–" performance indicators in the cells corresponding to the set of parameter values of interest. See **Box 2** for an example of the tool kit comparing two such sets.

Box 2: Comparing the performance of two sets of parameter values using the tool kit

We compare a set of parameter values {lambda = 0.985, weight = 0.375, level = 10, floor = 6}, as highlighted in blue in Table 1, to a second set with the same parameter values but lambda set to 0.995 instead.

For the first set of values, the central counterparty (CCP) would achieve the following performance scores:[20]

- a neutral performance score for short-term procyclicality
- a (single) positive performance score for long-term procyclicality
- a neutral performance score for margin coverage
- a (single) negative performance score for cost of collateral

This is a desirable outcome in terms of effective procyclicality mitigation, adequate margin coverage—meeting the requirements of the *Principles for Financial Market Infrastructures* (CPSS and IOSCO 2012)—and acceptable level of cost of collateral (required for central clearing).

For the second set of values, the CCP would achieve the following performance scores:

- a double positive performance score for short-term procyclicality
- a triple positive performance score for long-term procyclicality
- a double negative performance score for margin coverage
- a triple negative performance score for cost of collateral

This is an undesirable, if not infeasible, outcome because of the inadequate margin coverage and impractical level of cost of collateral.

[20] Notice that the effects of the stress risk level calibrations on margin coverage and cost of collateral are already reflected under the stress risk weight parameter in Table 1. Therefore, while aggregating, we ignore the "–" signs under the stress risk level calibration (equal to 10%). This is also why these signs are illustrated with lighter colors in Table 1.

Notice that we populate our conceptual tool kit with coarse (less precise) performance indicators, i.e., reflecting only the sign and the rough magnitude [+, ++, − or − −] of the sensitivity analysis. And we do so relative to a common margin system parameter calibration, which exhibits a neutral performance score at all trade-off dimensions. Alternatively, the tool kit could be populated with numerical (more precise) performance indicators based on sensitivity analysis, and, further, the performance score for the reference (common) parameter calibration could be computed numerically. In that case, our tool kit would also allow regulators and CCPs to quantitatively and independently assess a margin system's performance for a chosen set of parameter values.

This capability would enable regulators to set outcomes-based procyclicality targets that are verified to be achievable by CCP margin models and APC tools. For that, the regulators could follow the procedure below:

- First, they would construct and populate our tool kit numerically based on a wide range of commonly used and potential CCP margin models and APC tools in their jurisdictions.
- They would then set provisional short-term and/or long-term procyclicality performance targets that are desired for their jurisdictions.[21]
- Next, they would determine the subset of all parameter value combinations that satisfy these provisional procyclicality targets. To do so, they would identify the combinations for which the horizontally aggregated values (or performance scores) for the procyclicality rows in the tool kit are within these targets; meanwhile, they would also ensure sufficient margin coverage and an acceptable cost of collateral performance.
- At this stage, the tool kit would assist regulators to verify their provisional targets and, if needed, to adjust them further. For instance, if regulators notice that the determined subset is too limited (and therefore that the regulatory procyclicality performance targets are too hard to attain by a wide range of CCP margin systems), then they would consider relaxing these overly ideal or restrictive targets to more plausible ones before imposing them on CCPs. Furthermore, regulators could consider setting custom-tailored procyclicality targets specific to different cleared asset classes. This would be especially needed if commonly used CCP margin systems for different asset classes exhibit quite diverse procyclicality performances, therefore making it difficult to design effective procyclicality guidance by just setting a single target for all.
- Once the targets are verified to be achievable by CCP margin models and APC tools, regulators would simply impose these short-term and long-term margin procyclicality performance targets on the CCPs in their jurisdictions. Note that it is then up to the CCPs which APC tools to implement and how to calibrate their margin system

[21] When deciding on these targets, the regulators would take into account the specifics of the CCPs in their jurisdictions as well as the level of procyclicality mitigation they desire in those jurisdictions.

parameters to meet these targets. But, as the targets are verified, regulators know that CCPs can achieve them—for instance, by implementing the APC tools and key procyclicality parameter calibrations they used in their tool kit analysis.

- Some regulators may prefer instead to provide prescriptive guidance—in line with the verified (outcomes-based) procyclicality targets.[22] In that case, the regulator would further need to identify the range of desirable values for each key procyclicality parameter in the tool kit—based on the subset of parameter value combinations that it previously determined as satisfying the targets. The regulator would then impose on CCPs the corresponding (prescriptive) restrictions for the key procyclicality parameter values as well as for the choice of APC tools.

The capabilities of our tool kit would also assist CCPs to appropriately design and calibrate their margin systems (i.e., margin model and APC tools) and procyclicality frameworks (including internal procyclicality targets). For these, CCPs could follow the procedure below:

- First, they would construct and populate our tool kit numerically for their specific (existing) margin models and APC tools. They could further include potential APC tools considered for implementation to assess their impact. While doing so, CCPs would also take into account any prescriptive procyclicality guidance provided by their regulators.
- They would further set provisional short-term and/or long-term procyclicality performance targets in line with their internal policies. Note that CCPs could consider setting custom-tailored procyclicality targets specific to different asset classes they clear.
- Next, they would determine the subset of all parameter value combinations that satisfy these provisional internal procyclicality targets as well as any regulatory procyclicality targets. To do so, they would identify the combinations for which the horizontally aggregated values (or performance scores) for the procyclicality rows in the tool kit are within these targets; meanwhile, they would also ensure sufficient margin coverage and an acceptable cost of collateral performance.
- At this stage, the tool kit would assist CCPs to verify their provisional internal procyclicality targets and, if needed, to adjust them further. For instance, if CCPs notice that the determined subset is too limited, then they could consider relaxing their internal targets. Note that if the subset remains too restricted after relaxing the internal

[22] For effective procyclicality mitigation, regulators should ideally provide outcomes-based guidance (i.e., guidance indicating the desired procyclicality performance targets for CCP margin systems). This is preferable to prescribing the ways CCPs should follow, hoping for these desired outcomes, such as indicating which specific APC tools to use and how to calibrate them. However, doing so is not a straightforward task—especially due to the lack of universal and effective ways of measuring and assessing margin procyclicality as well as the lack of widely accepted benchmarks for procyclicality targets. Accordingly, various regulators have chosen to design prescriptive procyclicality guidance, and several CCPs have followed such guidance. Notice that our tool kit can assist regulators to design effective prescriptive procyclicality guidance.

targets—likely due to the regulatory targets—then the CCPs may need to consider alternative APC tools and margin models for implementation.

- Once the CCPs verify their internal procyclicality targets and decide on which APC tools to implement, they would finalize calibrating their margin systems by optimally choosing the parameter values from the determined subset—based on the overall performances they would want from their margin systems at all (four) trade-off dimensions.

Conclusion

CCP initial margin models are procyclical by nature. Accordingly, CCPs use APC tools to mitigate the procyclicality inherent in their margin models. However, despite the widespread use of anti-procyclicality tools, during the March 2020 market turmoil we observed unprecedented increases in IM requirements at CCPs globally. The sharp increases were mainly driven by the severe reactions of the margin models to the heightened volatility. This prompted regulators and participants of major CCPs around the world to question the procyclicality performance of CCP margin models and triggered a debate among international standard-setters on the adequacy of the APC tools that CCPs were deploying at that time.

In the first part of this paper, we shed light on the various factors that contributed to such severe reactions of the margin models to heightened volatility, and on possible explanations as to why the APC tools in place at the time were not sufficiently effective. In particular, we highlight that to effectively mitigate procyclicality, the focus should be on the key parameters of the margin system (i.e., margin model and APC tools) in determining procyclicality. Only then can regulators provide effective guidance on margin procyclicality and CCPs appropriately design and calibrate their margin systems and procyclicality frameworks.

To further serve these needs, in the second part of this paper, we provide a novel conceptual tool kit for regulators and CCPs. The tool kit allows them to see a margin system's performance in procyclicality as well as in other competing objectives—such as margin coverage and cost of collateral—all in one place and for any possible combination of calibrations of the key procyclicality parameters. This feature enables regulators to set outcomes-based procyclicality targets that are verified to be achievable by CCP margin models and APC tools. Moreover, it assists regulators in designing prescriptive procyclicality guidance in line with these desired outcomes-based procyclicality targets. CCPs themselves can use the tool kit to determine the optimal parameter calibrations for their margin systems by choosing them from the set of parameter calibrations that satisfy the required procyclicality targets and also perform sufficiently well in the other competing objectives. Finally, the tool kit can improve the communication between regulators and CCPs. Regulators can use it to disclose and explain how their procyclicality guidance is designed. And CCPs can use it to justify how they select their APC tools and calibrate their margin systems to meet the regulatory and internal procyclicality targets.

Appendix A

Canadian Derivatives Clearing Corporation's initial margin methodology for equity index futures

The details of CDCC's base margining model and anti-procyclicality (APC) tools used for its standard equity index futures (SXF - S&P/TSX 60 Index Standard Futures) are described in detail within CDCC's Operations Manual (2023). For context in this paper, we summarize key parts of the manual below.

First, to calculate the initial margin (IM) requirements for SXF, CDCC's risk methodology is based on Price Scan Range (PSR), which is a component of the Standard Portfolio Analysis of Risk (SPAN) framework. The PSR amount corresponds to the margin requirement for holding one long/short position of the corresponding futures contract. It is calculated as:

$$PSR_t = MI_t \times Contract\ Size \times Price_t,$$

where $Price_t$ is the futures contract's value at time t, the $Contract\ Size$ is the multiplier constant applied onto the price (Can$200 for SXF) and MI_t is the margin interval for the contract at time t. The margin interval reflects the maximum price fluctuation (in percentage terms) that the contract is expected to have over the close-out period and with a predetermined confidence level. The margin interval at CDCC is calculated through a series of operations. It starts with calculating the historical risk component, which is based on a value-at-risk approach and obtained through:

$$Historical\ Risk_t = \alpha \times \sqrt{\text{MPOR}} \times \sigma_t,$$

where the margin period of risk (MPOR) is the close-out period (two days for SXF), α is equal to the number of standard deviations corresponding to the confidence level (three standard deviations for SXF, based on a 99.87% confidence level for normal distribution) and σ_t is the volatility estimator for the contract's future returns at time t. CDCC computes it using an exponentially weighted moving average (EWMA) approach, and the formula is given by:

$$\sigma_t = \sqrt{\frac{(1-\lambda)\sum_{i=1}^{260}\lambda^{i-1}(R_{t-i}-\bar{R})^2}{(1-\lambda^{260})}},$$

where R is the past daily returns of the futures prices, $\overline{R}$ is the mean return over the specified period of 260 days and λ is the responsiveness/decay factor (0.99 for SXF). The responsiveness factor has an important role in determining how fast the base margining model reacts to market price fluctuations; therefore, it is a key determinant for the degree of procyclicality in the model. The effect of using an EWMA approach is that the increase in margin requirements would be less steep than the increase in the underlying asset's volatility during market turmoil, and the decrease would be a smooth decay when the market volatility returns to more typical levels.

After the historical risk component is computed, CDCC applies its first APC tool, the stress period (or stress VaR), as follows:

$$MI_{t^*} = (1 - w) \times Historical\ Risk_t + w \times Stress\ Risk.$$

The level of the stress risk (or stressed margin) component is calculated through a simple value-at-risk approach, where the past daily returns come from a stress period (high market volatility). Therefore, the level of the stress risk component is typically larger than that of the historical risk component. The weight parameter w determines which weight to use to combine the two components, and it is an important determinant of the IM model procyclicality level. Note that the value of the stress risk component is static; that is, it remains constant over time at the level it is calibrated to based on some past stress period. However, the stress risk component could be recalibrated in the future, for example, after periods of severe market stress.

Finally, to complete the calculation of the margin interval, CDCC applies its second APC tool, the volatility floor.[23] The value of this floor is calculated based on the average of the daily and EWMA-based volatility estimators (σ_t) observed over the last 10 years:

$$MI_t = \max(MI_{t^*}, Volatility\ floor_t).$$

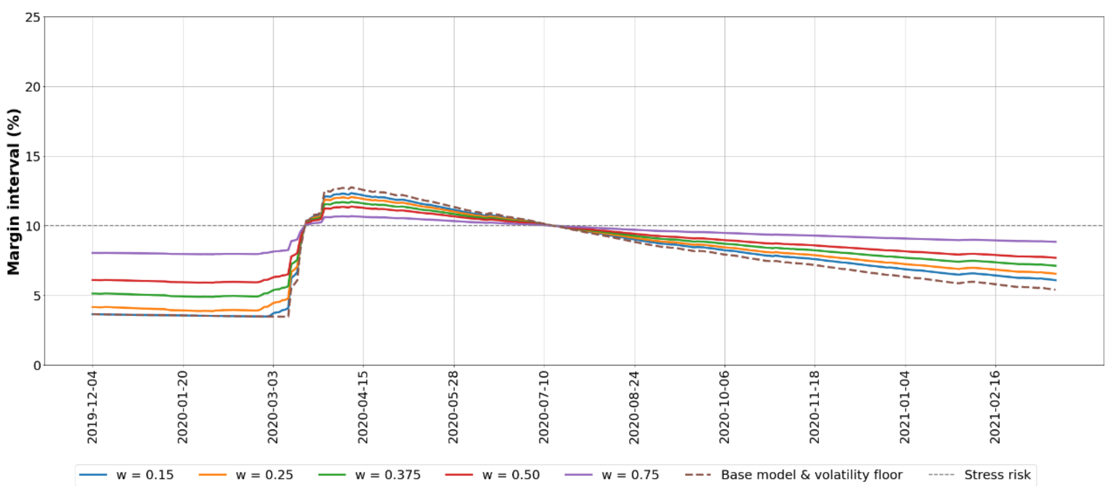
The volatility floor ensures that, especially during non-stress periods, the margin requirements are not lower than those that would be calculated using volatility estimates over the 10-year lookback period.

[23] Notice that while it is called volatility floor, it is effectively a margin (interval) floor.

Appendix B

Chart B-1 plots the margin interval calculated for SXF, S&P/TSX 60 Index Standard Futures, (model lambda equal to 0.99) if, additional to the volatility floor, CDCC had also had the stress period anti-procyclicality (APC) tool in place and the level of its stress risk component had been calculated as 10% from December 2019 to March 2021. The dashed line corresponds to the base model (i.e., the historical risk component based on the exponentially weighted moving average, or EWMA) supplemented with the volatility floor APC tool. The chart plots the margin interval for varying weight parameter values, while the level of the stress risk component is kept constant at 10%. Note that the level of the stress risk component is calculated based on a past stress period, but prevailing market conditions can get worse than this past stress episode. In this case, the EWMA-based component would surpass the level of the stress risk component (as in Chart B-1). In such cases, the stress period APC tool effectively mitigates procyclicality by raising the margin interval levels during pre-crisis periods while dampening those during crisis periods.[24]

Chart B-1: Margin interval for equity index futures for varying weight parameter values



Note: These margin interval values (solid lines) are calculated using the base model with the stress period and volatility floor anti-procyclicality tools. The level of stress risk (dotted line) is set to 10%. The dashed line represents the margin interval calculated using the base model only with the volatility floor APC tool. The period studied is from December 2019 to March 2021.

Source: Bank of Canada calculations Last observation: March 2021

When the weight parameter of the stress period APC tool is set to [w]%, the corresponding improvement or decrease in the long-term procyclicality (30-day large-call) measure is expected also to be [w]%. However, we see in Chart B-1 that the improvements brought by the

[24] Notice that, in Chart B-1, the stress period APC tool's weighted averaging procedure actually has the same impact on the EWMA-based component as it has in Chart 3; that is, attenuating the values coming from the EWMA-based component by [w]% and shifting them upward by [w*stress risk]. However, in Chart B-1 the procedure effectively results in the shrinkage of the dashed line toward the stress risk level calibration (10%) from both sides.

stress period APC tool to the 30-day large-call measures are only around 5% and 15% for weight parameter values equal to 15% and 25%, respectively.[25] This is because the volatility floor APC tool has already decreased the long-term procyclicality by around 10% by raising the margin interval levels during the pre-crisis period. Therefore, when the additional APC tool, stress period, is implemented, its marginal improvement is considerably less than [w]%.

[25] As seen in Chart B-1, the margin interval levels for weight parameter values equal to 15% and 25% during the pre-crisis period are barely above the volatility floor (dashed line). Furthermore, during the crisis period we see only slight decreases in the margin interval levels corresponding to these weight parameter values. These together explain the reasons behind the mentioned low improvement percentages.

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