An Empirical Analysis of Initial Margin and the SA-CCR

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I. Introduction

The question of setting bank capital requirements for the counterparty credit risk of OTC derivatives has a long history. As far back as the first Basel Accord of 1988 we can find a recognizable statement of the issue:[2]

> *"A majority of G-10 supervisory authorities are of the view that the best way to assess the credit risk on these items is to ask banks to calculate the current replacement cost by marketing contracts to market, thus capturing the current exposure without any need for estimation, and then adding a factor (the 'Add-On') to reflect the potential future exposure over the remaining life of the contract."*

The Current Exposure Method

The first Basel Accord introduced a method of calculating capital requirements following this broad outline, called the current exposure method (CEM). The CEM was modified in 1994 by the recognition of netting[3], but remains in use to this day. Its main features are: [4]

- The capitalization of an "exposure at default" (EAD) amount, defined as current exposure plus an estimate of potential future exposure (PFE), minus the adjusted value of collateral.
- For each contract, a baseline exposure amount called the "Add-On" is calculated as a fixed percentage of notional, adjusted by maturity and underlying asset class (e.g. interest rates, FX, etc.).
- The gross Add-On for a portfolio is the sum of Add-Ons across contracts in the netting set.
- The "net-to-gross ratio" (NGR) is defined as the ratio of net replacement cost to gross replacement cost.
- The PFE is then 40% of the gross Add-On plus 60% of the gross Add-On multiplied by the NGR.

Given the CEM's introduction in the early days of OTC derivatives markets and its simplistic design, it is hardly surprising that questions should arise concerning its design and calibration. In 2014 the Basel Committee summarized the main issues:[5]

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[2] See Basel Committee on Banking Supervision, *International convergence of capital measurement and capital standards*, BCBS 4a, 1988.

[3] See Basel Committee on Banking Supervision, *Basel Capital Accord: the treatment of the credit risk associated with certain off-balance-sheet items*, BCBS12a, 1994. Further modifications were subsequently introduced to expand the range of PFE Add-Ons and to modify the net-to-gross ratio: see section VII, Annex IV of the second Basel accord.

[4] See Basel Committee on Banking Supervision, *Treatment of potential exposure for off-balance sheet items*, BCBS 18, 1995.

[5] See Basel Committee on Banking Supervision, *The non-internal model method for capitalising counterparty credit risk exposures*, BCBS 254, 2013.

- The CEM "does not differentiate between margined and unmargined transactions";
- The CEM's "supervisory Add-On factors do not sufficiently capture the level of volatilities as observed over the recent stress periods"; and
- "The recognition of hedging and netting benefits," defined by the CEM's NGR, "is too simplistic and does not reflect economically meaningful relationships between the derivative positions".

The Standardized Approach to Counterparty Credit Risk

At the same time that these deficiencies were highlighted, the Basel Committee presented a new approach for calculating capital requirements for counterparty credit risk, called the Standardized Approach for Counterparty Credit Risk (SA-CCR). The SA-CCR was intended to address a desire by the Basel Committee to design an approach that:[6]

- "Is suitable for a wide variety of derivatives transactions (margined and unmargined, as well as bilateral and cleared), which is comparatively simple and easy to implement";
- "Addresses known deficiencies" of the prior approaches to capitalizing counterparty credit risk;
- "Draws on prudential approaches already available in the Basel framework";
- "Minimizes discretion used by national authorities and banks while helping both national authorities and banks to better understand banks' risk profiles relating to derivatives exposures"; and
- "Improves significantly the risk sensitivity of the capital framework without creating undue complexity".

The SA-CCR was finalized in 2014 but, at the time of writing, has not yet been implemented in some national bank capital regulations, notably that of the United States. The approach has been subsequently adopted in additional areas of international banking regulation. In particular, the Basel Committee made use of the SA-CCR in three additional areas:

i) The leverage ratio framework, where a modified version of the SA-CCR is used to determine the leverage ratio exposure measure for OTC derivatives;[7]
ii) The framework for Global Systemically Important Banks (G-SIBs),[8] where the SA-CCR is used in the size metric; and
iii) The framework for capitalizing bank exposures to derivatives clearinghouses,[9] where the SA-CCR is used to measure the adequacy of margin levels.

The SA-CCR's original use was as a tractable, relatively simplistic method for calculating capital in the risk weighted framework. Larger and more sophisticated banks would typically use an alternative approach known as the internal models method (IMM). However, no such choice is available in the leverage or G-SIB frameworks, where all market participants must use the SA-CCR. Moreover, the modelled capital outputs under Basel III are subject to an overall output floor based on the standardized approach, so even in the risk-weighted framework for the most sophisticated banks the SA-CCR has a central importance.

[6] *Op. cit.*
[7] See Basel Committee on Banking Supervision, *Basel III: Finalising post-crisis reforms*, BCBS 424, 2017, which builds up the earlier *Basel III leverage ratio framework and disclosure requirements*, BCBS 270, 2014.
[8] See Basel Committee on Banking Supervision, *The G-SIB assessment methodology - score calculation*, BCBS 296, 2014.
[9] See Basel Committee on Banking Supervision, *Capital requirements for bank exposures to central counterparties*, BCBS 282, 2014.

Margin and Exposure on OTC Derivatives Portfolios

Derivatives clearing organizations (DCOs) that act as central counterparty between market participants are now a ubiquitous feature of the OTC derivatives industry. DCOs provide clearing and settlement services, mitigating counterparty credit risk through collateralization and portfolio liquidation after member default. A DCO protects itself against member exposures by means of initial margin and guaranty fund contributions. Variation margin payments are also exchanged to settle daily changes in portfolio value. The DCO initial margin models estimate potential portfolio loss at a given confidence level, corresponding to a quantile of a parametric or historically simulated portfolio value distribution. These margin requirements are guided by international standards set out in the CPMI-IOSCO principles for financial market infrastructures (PFMI).[10] The models are also subject to high levels of due diligence by the DCOs as well as substantial supervisory review by respective national regulators, including the CFTC.

In the below analysis, exposure is defined as $\mathbf{E}(\max\{0,V\})$, where (V) is a collateralized or uncollateralized portfolio value. The exposure thus represents the unpaid portfolio value owed from the defaulted counterparty. Initial margin should substantially offset this exposure calculation. Under simplified theoretical conditions, a margin model that targets 99% coverage of expected loss would reduce exposure to the expectation taken in the 1% tail. The precise reduction in exposure will ultimately depend on the portfolio profit-and-loss distribution and the initial margin methodology used by the DCO. The interaction of margin and exposure under the SA-CCR will be more formally explored in the following sections.

Paper Outline and Related Work

Given the diversity of uses for which the SA-CCR is applied, it is vital that the features and performance of the approach are well-understood, and that it is indeed fit for the multiple areas of applicability. After introducing the design of the SA-CCR, we examine its calculation of counterparty credit risk for cleared derivatives portfolios. Specifically, we compare its performance against a benchmark exposure calculation based on the initial margin models used by two DCOs. A comparison of the SA-CCR calculation against the exposure implied by the initial margin amount will illustrate the relative level of collateral offset provided by the framework. Over 7,000 real client-cleared interest rate swap portfolios are used for the comparison, giving valuable insight into the range of possible outcomes.

The rest of the paper is structured as follows: Section II outlines the SA-CCR methodology for interest rate swaps, while Section III provides further analysis of the multiplier function that determines the level of expected exposure offset from initial margin. The results from cleared portfolios are presented in Section IV, and Section V concludes.

Other work in this area includes studies by market participants such as ISDA (2017) and FIA (2016) on the transition from CEM to the SA-CCR. Albuquerque et al. (2017) provides estimates of the reduction in exposure due to initial margin for different portfolios, as well as a comparison of the CEM and the SA-CCR. Andersen, Pykhtin, and Sokol have produced two papers (2016 & 2017) that analyze the counterparty credit risk reduction available from margin that deepen the analysis of its properties.[11]

[10] See CPMI-IOSCO, *Resilience of central counterparties (CCPs): Further guidance on the PFMI,* CPMI 163, 2017
[11] See L. Andersen, M. Pykhtin, A. Sokol, *Does initial margin eliminate counterparty credit risk?*, 2017 and ibid., *Rethinking the Margin Period of Risk*, 2016.

II. The SA-CCR for OTC Derivatives Portfolios

This section reviews how the SA-CCR estimates exposure for portfolios within a given netting set.[12]

1. Exposure at Default

The SA-CCR exposure at default depends on the sum of replacement cost (*RC*), representing current portfolio value, and potential future exposure (*PFE*), representing future changes in value over the exposure period. This sum is scaled by a parameter α that accounts for uncertainty in exposure potentially caused by interim contract cash flows. The parameter α is set equal to 1.4, which yields:[13]

$$EAD = \alpha(RC + PFE) = 1.4 \times (RC + PFE)$$

2. Replacement Cost

The replacement cost represents the largest current portfolio exposure that would not trigger a variation margin call, taking into account the mechanics of collateral exchanges in the relevant credit support agreements. This reflects the current portfolio value (V_0), the collateral collected by the bank (*C*), and the terms of the credit support agreement that governs trading between the counterparties.

For a bilateral margin agreement, the replacement cost will either be the positive portfolio value in excess of held collateral, or any uncollected mark-to-market payments below the amount that triggers a variation margin call. The latter is specified using the minimum transfer amount (*MTA*) and threshold amount (*TH*) from the credit support agreement. Any unpaid increases in value below these combined thresholds will be offset by the net independent collateral amount (*NICA*) upon counterparty default. Thus the SA-CCR *RC* calculation accounts for both under-collateralization and any unpaid mark-to-market cash flows owed by the defaulter:

$$RC = \max\{0, \mathrm{V}_0 - \mathrm{C}, MTA + TH - NICA\}$$

In most centrally cleared settings there is daily exchange of variation margin equal to the mark to market portfolio value, so ($V_0 = \mathrm{VM}$). There are also a zero threshold and zero minimum transfer amounts for the settlement payments. As a result, the *RC* will also be zero. Note that the net independent collateral amount corresponds to initial margin:[14]

$$RC_{\text{cleared}} = \max\{0, V_0 - VM - IM, 0 + 0 - IM\} = 0$$

3. Potential Future Exposure

The SA-CCR potential future exposure component (*PFE*) estimates the adverse (positive) change in portfolio value over a predefined time horizon. The SA-CCR must be flexible enough to measure future exposure for both margined and unmargined transactions over their correspondent horizons. Therefore the framework first estimates uncollateralized exposure assuming zero mark-to-market (called the "aggregate Add-On" component), and then scales this by a multiplier function $m(*)$ that allows for the recognition of collateral and non-zero portfolio value:

$$PFE = m(*) \times AddOn^{Aggregate}$$

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[12] For a fuller discussion, see BCBS, *Foundations of the standardized approach for measuring counterparty credit risk*, Working Paper No. 26. 2014 (revised 2017). The case of margined, net portfolios is relevant for the vast majority of large OTC derivatives portfolios.

[13] See E. Canabarro, E. Picoult, T. Wilde, *Analysing Counterparty Risk*, 2003 where they find $\alpha = 1.2$. Based on this, SA-CCR sets α to the conservative value of 1.4.

[14] For simplicity we assume no time lag between VM exchange and counterparty default. See Andersen, Pykhtin, and Sokol (2017) for an analysis of these issues.

4. The Add-On

The Add-On component represents an estimate of uncollateralized exposure through the exposure period (t). The SA-CCR approximates portfolio exposure with weighted notional sums across individual contracts, rather than using a parametric or historically simulated portfolio value distribution to calculate the expectation outright: $\mathbf{E}(\max\{0, V\})$. This notional-based approach provides tractability and ease-of-use, but might also be inconsistent with underlying risk factor characteristics. The summation methodology varies across the asset classes that constitute a given netting set (i.e. credit, FX, equity, etc.). The empirical results below are conducted on interest rate swap portfolio data, so the relevant calculations for interest rate derivatives will be briefly summarized:

i) A supervisory duration factor is applied to adjust position-level notional (converted to domestic currency) depending on the maturity of the contract:

$$SD_i = \frac{\exp(-0.05S_i) - \exp(-0.05E_i)}{0.05}$$

Where (S_i) and (E_i) are the start and end dates of the contract.

ii) A maturity factor is applied to reflect the length of exposure period over which the defaulted portfolio is exposed to changes in value. For unmargined transactions, it is set to the minimum of one year and instrument maturity. For margined transactions, it depends on whether or not the portfolio is cleared. The margin period of risk ($MPOR_i$) here is defined as:

   a. Five business days for centrally cleared derivative transactions subject to daily margin agreements that clearing members have with their clients;
   b. Ten business days for uncleared derivative transactions subject to daily margin agreements;
   c. Twenty business days for uncleared netting sets consisting of over 5,000 transactions.

$$MF_i^{\text{margined}} = \frac{3}{2}\sqrt{\frac{MPOR_i}{1Y}}$$

The duration and MPOR adjusted notional for the ith trade is then given by multiplying the notional, the supervisory duration and the maturity factor:

$$\text{Notional}_i \times SD_i \times \frac{3}{2}\sqrt{\frac{MPOR\_i}{1Y}}$$

iii) The Add-On for interest rate derivatives must capture the risk of imperfect correlation across rate tenors. To address this risk, the SA-CCR divides interest rate derivative positions into maturity categories (or "buckets") based on their end date (E). The three buckets are:

- Less than one year (denoted k = 1);
- Between one and five years (k = 2);
- More than five years (k = 3).

The net effective notional (D_k) for each bucket k is calculated as the sum of the adjusted notionals for each trade i in the bucket, multiplied by the supervisory delta factor (δ_i) to reflect directionality:

$$D_k = \sum_{i \in bucket\ k} \text{Notional}_i \times SD_i \times \frac{3}{2}\sqrt{\frac{\text{MPOR}}{1Y}} \times \delta_i$$

Where δ is 1 for long swap positions (receive floating rate) and -1 for short positions (pay floating rate).

iv) A partial offset across maturity buckets within the same currency is allowed under a variance-covariance sum. The correlation parameters across buckets are set to 0.7 for adjacent buckets and 0.3 for buckets 1 and 3. The effective notional for currency *j* is then:

$$\mathrm{D}_j = \sqrt{D_1^2 + D_2^2 + D_3^2 + 1.4\, D_1 D_2 + 1.4\, D_2 D_3 + 0.6\, D_1 D_3}$$

v) The currency-level net effective notionals are multiplied by 0.5% to obtain the Add-On for each currency:

$$\mathrm{AddOn}_j = 0.005 * \mathrm{D}_j$$

vi) The Add-On for a portfolio of interest rate swaps is the sum of the Add-Ons for each currency in the portfolio:

$$\mathrm{AddOn}^{\mathrm{Aggregate}} = \sum_j \mathrm{AddOn}_j$$

Several design decisions in the SA-CCR Add-On calculation are worth noting:

- There is no risk offset across different currencies.
- There is complete offset of net notional within a given maturity bucket on a duration-adjusted basis. For example, the exposure of a thirty-year swap can be perfectly offset with a six-year swap that references the same floating rate.
- In contrast, the offset across different maturity buckets is relatively conservative. For example, the best four-year swap hedge against a ten-year position only reduces exposure by about 30%.

5. The Multiplier Function

The SA-CCR multiplier function $m(*)$ adjusts the Add-On for the presence of collateral in excess of current portfolio value. The multiplier function uses the ratio of excess collateral to aggregate Add-On as its input $((\mathrm{V} - \mathrm{C})/\mathrm{AddOn})$, reflecting the relative level of collateralization compared to the SA-CCR estimate of exposure. The output of the multiplier applied to the Add-On will be referred to as “residual exposure” in the following analysis, since it represents the amount of potential future exposure that remains after collateral offset. A floor of 5% is employed to ensure that even highly overcollateralized portfolios $(\mathrm{V} - \mathrm{C} \gg \mathrm{AddOn})$ receive some level of residual exposure:

$$m = \min\left\{1, Floor + (1 - Floor) \times \exp\left(\frac{V - C}{2 \times (1 - Floor) \times \mathrm{AddOn}}\right)\right\}$$

In the context of centrally cleared derivatives, variation margin again cancels current portfolio value $(\mathrm{V}_0 = \mathrm{VM})$, as in the replacement cost calculation. The term $(\mathrm{V} - \mathrm{C})$ reduces to amount of initial margin collected by the DCO, and the multiplier becomes a function of $(\mathrm{IM}/\mathrm{AddOn})$. Figure One shows the multiplier at various ratios of initial margin to Add-On, representing the residual exposure or risk reduction as a function of collateral:

$$m = \min\left\{1, 0.05 + 0.95 \times \exp\left(\frac{-\mathrm{IM}}{2 \times 0.95 \times \mathrm{AddOn}}\right)\right\}$$

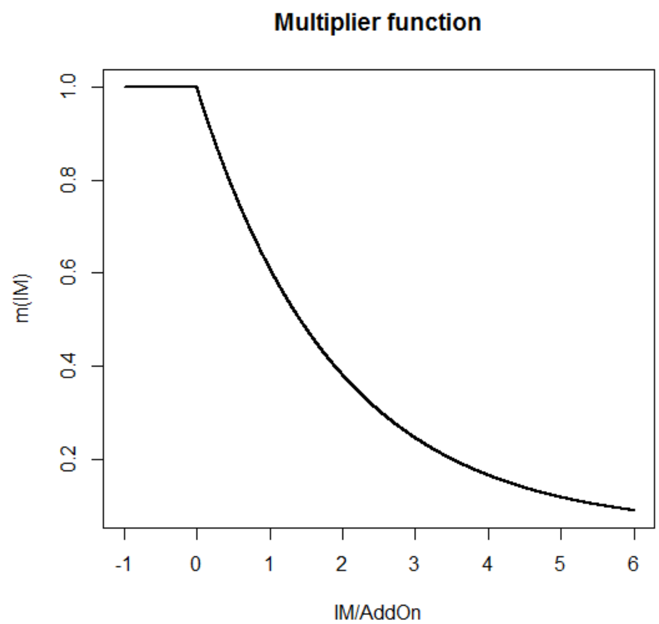

Figure One – The SA-CCR multiplier function

6. Derivation of the Multiplier

The multiplier function is derived from an analysis of exposure with and without initial margin, assuming a Gaussian portfolio distribution.[15] The expected exposure with no collateral can be calculated as the expectation taken over the positive half of the portfolio value distribution through period (*t*), representing unrealized mark-to-market gains owed from the defaulted counterparty:

$$EE_{\mathrm{IM}=0} = \mathbf{E}(\max\{0, V_t\})$$

In the presence of collateral, the amount is subtracted off from the expected increase in portfolio value, since the non-defaulted counterparty may use it to offset any gains. The centrally cleared case has initial margin subtracted from portfolio value at time (*t*):

$$EE_{\mathrm{IM}} = \mathbf{E}(\max\{0, V_t - IM\})$$

The "model" multiplier function uses the Gaussian assumption to reduce these two expectation equations to analytic closed form:

$$EE_{\mathrm{IM}=0} = \mathbf{E}(\max\{0, V_t\}) = \sigma\sqrt{t}\phi(0)$$

$$EE_{\mathrm{IM}} = \mathbf{E}(\max\{0, V_t - IM\}) = -IM\,\Phi\left(\frac{-IM}{\sigma\sqrt{t}}\right) + \sigma\sqrt{t}\phi\left(\frac{-IM}{\sigma\sqrt{t}}\right)$$

Where Φ is the Gaussian cumulative distribution function and ϕ is the probability distribution function. Using the previous equation, we obtain an analytic form for the residual exposure as a function of initial margin (IM), represented as the ratio of collateralized to uncollateralized exposure:

[15] See BCBS, *Foundations of the standardized approach for measuring counterparty credit risk*, Working Paper No. 26. 2014 (revised 2017).

$$m(*) = \frac{EE_{\mathrm{IM}}}{EE_{\mathrm{IM}=0}} = \frac{-IM\,\Phi\left(\frac{-IM}{\sigma\sqrt{t}}\right) + \sigma\sqrt{t}\phi\left(\frac{-IM}{\sigma\sqrt{t}}\right)}{\sigma\sqrt{t}\phi(0)}$$

Figure Two provides a visual depiction of the above equations. The first panel shows the distribution of future portfolio value over exposure period, taken as the standard Gaussian distribution with mean zero and variance one. The expected exposure with no collateral is calculated as the expected value taken over the positive half of the distribution, shown in the second panel. Assuming initial margin set to 99% value-at-risk, the amount of collateral may be obtained using the inverse Gaussian cdf ($\Phi^{-1}(0.99) = 2.326$). The third panel illustrates this quantile used for the margin risk measure. The expected exposure with collateral can then be calculated as taking the expectation over the 1% tail beyond the initial margin value, shown in the fourth panel:

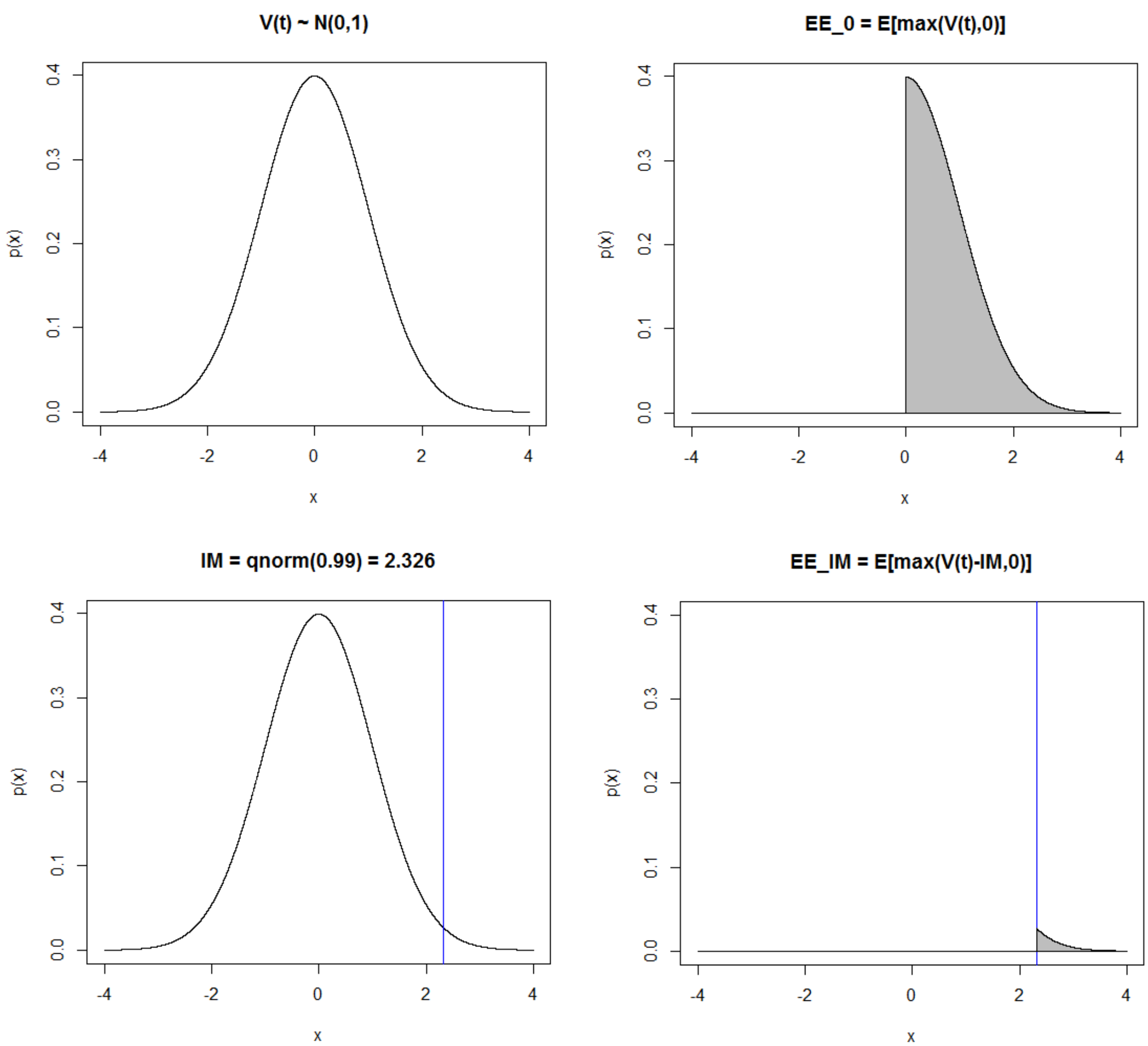

Figure Two – An illustration of the residual exposure with 99% value-at-risk

Note that the SA-CCR Add-On approximates the same uncollateralized, zero mark-to-market expected exposure ($EE_{\text{IM}=0}$) derived from the above portfolio distribution. The Add-On can then be substituted in place of uncollateralized expected exposure, which gives residual exposure as a function of the input ratio (IM/AddOn). The baseline "model" multiplier derived from the Gaussian distribution and the SA-CCR exponential function are shown below, for reference:

$$m_{\text{model}}(*) = -\frac{\text{IM}}{\text{AddOn}}\Phi\left(\phi(0)\frac{-\text{IM}}{\text{AddOn}}\right) + \frac{\phi\left(\phi(0)\frac{-\text{IM}}{\text{AddOn}}\right)}{\phi(0)}$$

$$m_{\text{SACCR}}(*) = \min\left\{1, 0.05 + 0.95 \times \exp\left(\frac{-\text{IM}}{2 \times 0.95 \times \text{AddOn}}\right)\right\}$$

The underlying assumption of Gaussian returns is unlikely to hold, since observable financial time series exhibit fatter tails and more extreme potential gains and losses. The SA-CCR floored exponential form was selected as a more conservative alternative that always produces a higher residual exposure than the model multiplier. The function matches the first derivative of the model multiplier at zero, so that both functions converge at the minimum input ratio. Figure Three illustrates the two multiplier functions side-by-side. The SA-CCR multiplier decays at a slower rate than the Gaussian-derived expression, with the difference becoming more pronounced at higher ratios of initial margin to Add-On:

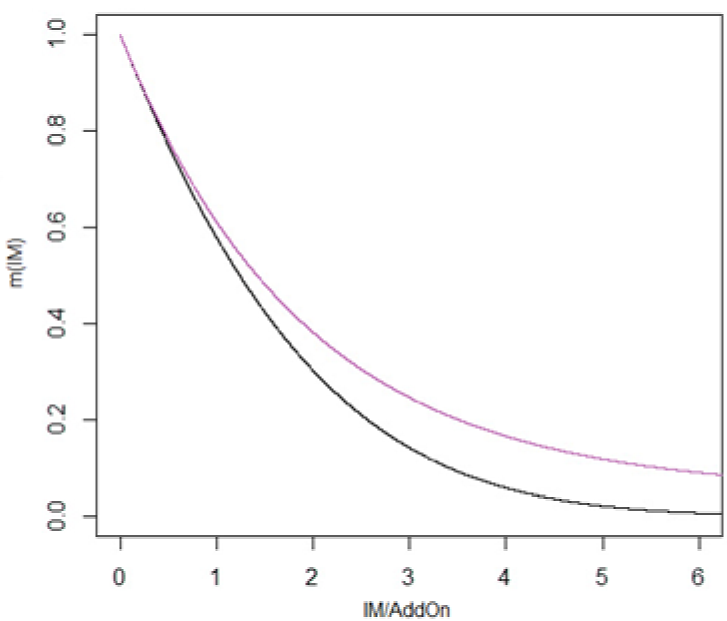

Figure Three – The residual exposure after IM assuming a Gaussian portfolio value distribution (in black) and the SA-CCR multiplier function (in purple)

III. Analysis of the Multiplier Function

1. Heavy-tailed Portfolio Distribution

In order to better understand the SA-CCR exponential multiplier function, the residual exposure will be directly evaluated without the assumption of normality. A heavy-tailed distribution increases both the quantile-based measurement of initial margin as well as exposure, resulting in a higher residual exposure after collateral offset. The Student-t distribution will be taken as a common reference point, with the degrees-of-freedom parameter controlling the heaviness of the tails. The residual exposure function loses its convenient closed form, and therefore must be computed numerically from the Student-t pdf (φ) and cdf (Φ):

$$\frac{EE_{\mathrm{IM}}}{EE_{\mathrm{IM}=0}} = \frac{-IM\left(1-\Phi(IM)\right)+\int_{IM}^{\infty} x\varphi(x)\mathrm{d}x}{\int_{0}^{\infty} x\varphi(x)\mathrm{d}x}$$

As the portfolio return distribution tails become heavier, the expected exposure with collateral (EE_{IM}) becomes proportionally larger relative to the expected exposure without collateral ($EE_{\mathrm{IM}=0}$). This results in a higher residual exposure, as Figure Four illustrates. The SA-CCR floored exponential function roughly corresponds to a Student-t distribution with three degrees of freedom. However, even when the tail has substantial mass beyond the 99% quantile, the residual exposure remains below the SA-CCR floor of 5% as can be seen in Figure Five. This minimum value therefore constrains the results to significant degree.

Degrees of Freedom	IM using 99% VaR	$EE_{\mathrm{IM}=0}$	Input ratio: $\mathrm{IM}/EE_{\mathrm{IM}=0}$	EE_{IM}	Residual exposure: $\frac{EE_{\mathrm{IM}}}{EE_{\mathrm{IM}=0}}$
3	4.541	0.551	8.24	0.025	4.47%
4	3.747	0.500	7.49	0.015	2.95%
5	3.365	0.475	7.09	0.011	2.29%
10	2.764	0.432	6.39	0.006	1.39%
100	2.364	0.402	5.88	0.004	0.89%

Figure Four – The ratio of initial margin to uncollateralized expected exposure for four different heavy-tailed distributions

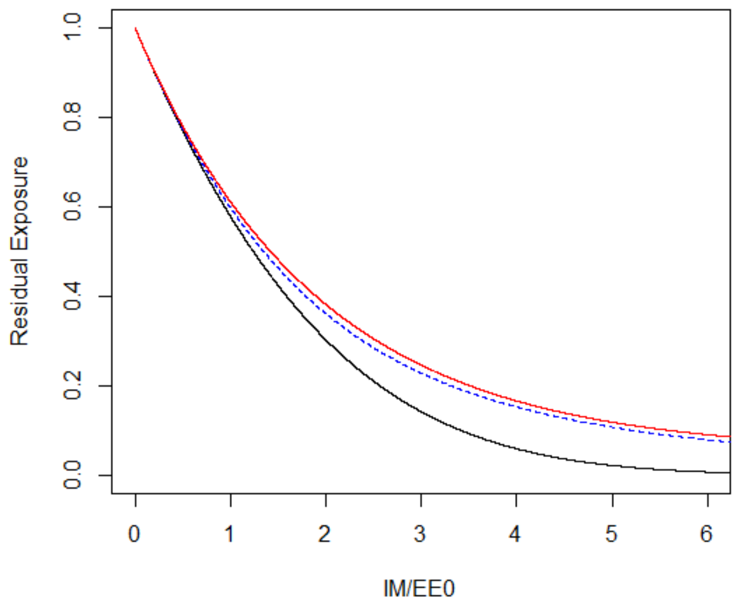

Figure Five – The residual exposure under Gaussian distribution (solid black) and Student-t distribution (df=3) (dashed blue) compared to the SA-CCR multiplier (solid red)

2. Clearinghouse Risk Measure

In the context of margined and cleared derivative portfolios, the SA-CCR multiplier function has a central importance, as it sets the risk reduction from collateral and the resulting level of exposure. The input to this function is the ratio of initial margin to the SA-CCR Add-On (IM/AddOn), meaning that the relative size of margin compared to the weighted notional sums described above will determine the residual exposure.

Major U.S. DCOs that clear interest rate swaps typically calibrate initial margin to a confidence interval at or above 99% (the regulatory minimum for OTC derivatives). Historical simulation models are commonly used to forecast the loss distribution, and the initial margin may either be set at the value-at-risk (i.e. a quantile estimate) or at the expected shortfall (i.e. an average of the tail above the chosen quantile).[16] Given a particular quantile and risk measure, the residual exposure equation may be expressed in closed form as a function of quantile, assuming a Gaussian portfolio distribution.

Figure Six shows both the input ratio ($IM/EE_{IM=0}$) and residual exposure from four different risk measure and quantile combinations. The margin-to-exposure ratios increase as the confidence interval increases, which results in a lower residual exposure when run through the SA-CCR multiplier function. These ratio and residual exposure values will benchmark the below empirical analysis, since they represent the expected risk offset from a given margin methodology under the baseline Gaussian assumption.

[16] See Pedro Gurrola-Perez and David Murphy, *Filtered historical simulation Value-at-Risk models and their competitors,* Bank of England Working Paper No. 525, 2015 for a further description of these models.

Initial margin methodology	$IM/EE_{IM=0}$	SA-CCR residual exposure
99% VaR	5.83	9.41%
99.5% VaR	6.46	8.18%
99% ES	6.68	7.82%
99.5% ES	7.25	7.09%

Figure Six – The ratio of initial margin to uncollateralized expected exposure and residual exposure for four risk measures

IV. Results

This section presents the results from cleared swap portfolios using DCO initial margin and SA-CCR exposure calculations. The analysis was conducted on client-cleared interest rate swap portfolios at two U.S. clearinghouses. The position data was taken from a single date in March 2018 and consists of 7,501 client accounts from 46 unique clearing members. The portfolios are diverse in composition and size, ranging from a single swap contract to hundreds of positions across many currencies.

1. Methodology

The previous section explained how the SA-CCR applies to cleared derivatives portfolios in the presence of initial margin. There are two quantities of interest: (1) the "input ratio" of IM to the SA-CCR Add-On (IM/AddOn), and (2) the residual exposure obtained from this ratio via the multiplier function.

Figure Six above provides guidance for how to analyze the relative performance of the SA-CCR's exposure estimates, given the risk measure and quantile used to set margin. For example, with a 99% value-at-risk the input ratio should be 5.83, and the residual exposure should be 9.41%, assuming a Gaussian portfolio distribution. However, the SA-CCR Add-On only approximates the uncollateralized expected exposure term ($EE_{IM=0}$) from Figure Six. The weighted notional sums are computed entirely separately from the parametric or historically simulated loss distribution used in the margin model methodology. This disconnect suggests that the residual exposure for these cleared portfolios will not be as fixed as shown in the above table. Instead, the ratio and residual exposure will vary based on how differently the two methodologies assess the risk of a given portfolio. A significantly high or low ratio would induce a residual exposure that doesn't necessarily reflect the underlying portfolio distribution or the quantile-based risk measure that determines margin. For example, a ratio of one would result in a more conservative residual exposure of 61%, while a ratio of ten would result in a comparatively aggressive residual exposure of 5.50%.

The following subsections outline the analysis performed on client-cleared IRS portfolios. First, the SA-CCR Add-On is generated for each portfolio in the dataset. This allows the input ratio (IM/AddOn) and the residual exposure to then be computed. Client-level margins are reported at the segregated account level and scaled down, if necessary, to reflect a five-day exposure period.[17] Separate results are presented for each of the two clearinghouses, as each has a distinct margin methodology and therefore a distinct implied ratio and residual exposure value.

[17] For extra conservativeness due to liquidation concerns, certain DCOs set client margin at a longer MPOR than the regulatory requirement of five days.

2. Ratio Distribution

Figure Seven shows the distribution of the (IM/AddOn) ratio for the client portfolios at each DCO. 95% of the ratios are below their respective implied values. This indicates a higher-than-anticipated exposure estimate compared to an assumed Gaussian distribution.[18] The ratios demonstrate a high degree of dispersion around the implied value, ranging from a minimum of 0.000046 to a maximum of 279 (with larger values truncated for presentation).

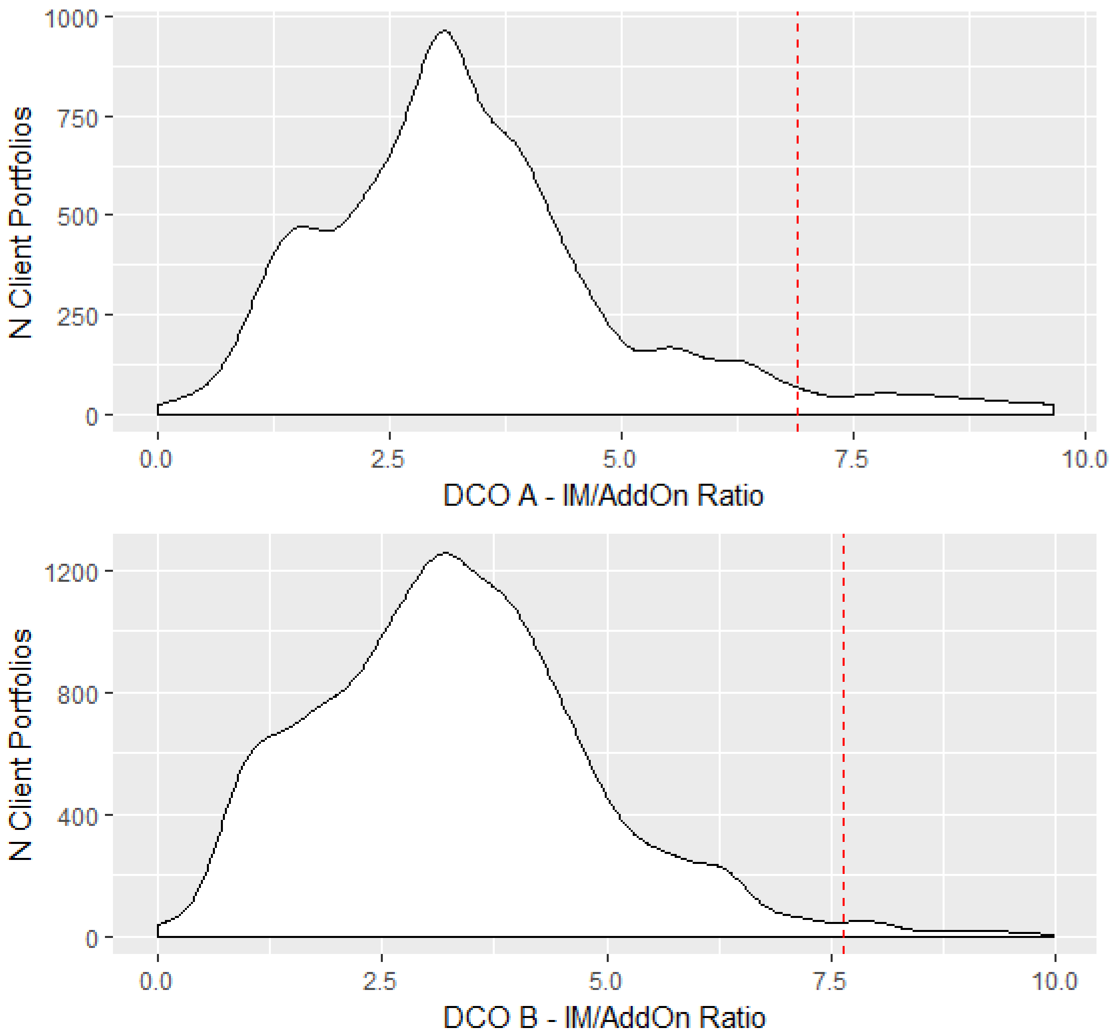

Figure Seven – The distribution of the ratio (IM/AddOn) for IRS portfolios cleared at DCOs A and B

[18] Note that a heavy-tailed distribution actually implies a higher ratio than the Gaussian-calibrated values used for comparison, so the results would not materially change in terms of number of portfolios below the implied value. Moreover, the multiplier function already adjusts the input ratio to account for heavy tails.

3. Residual Exposure Distribution

The ratios found above lead to widely variable outcomes in terms of residual portfolio exposure. Figure Eight illustrates this fact and Figure Nine reports descriptive statistics for these distributions.

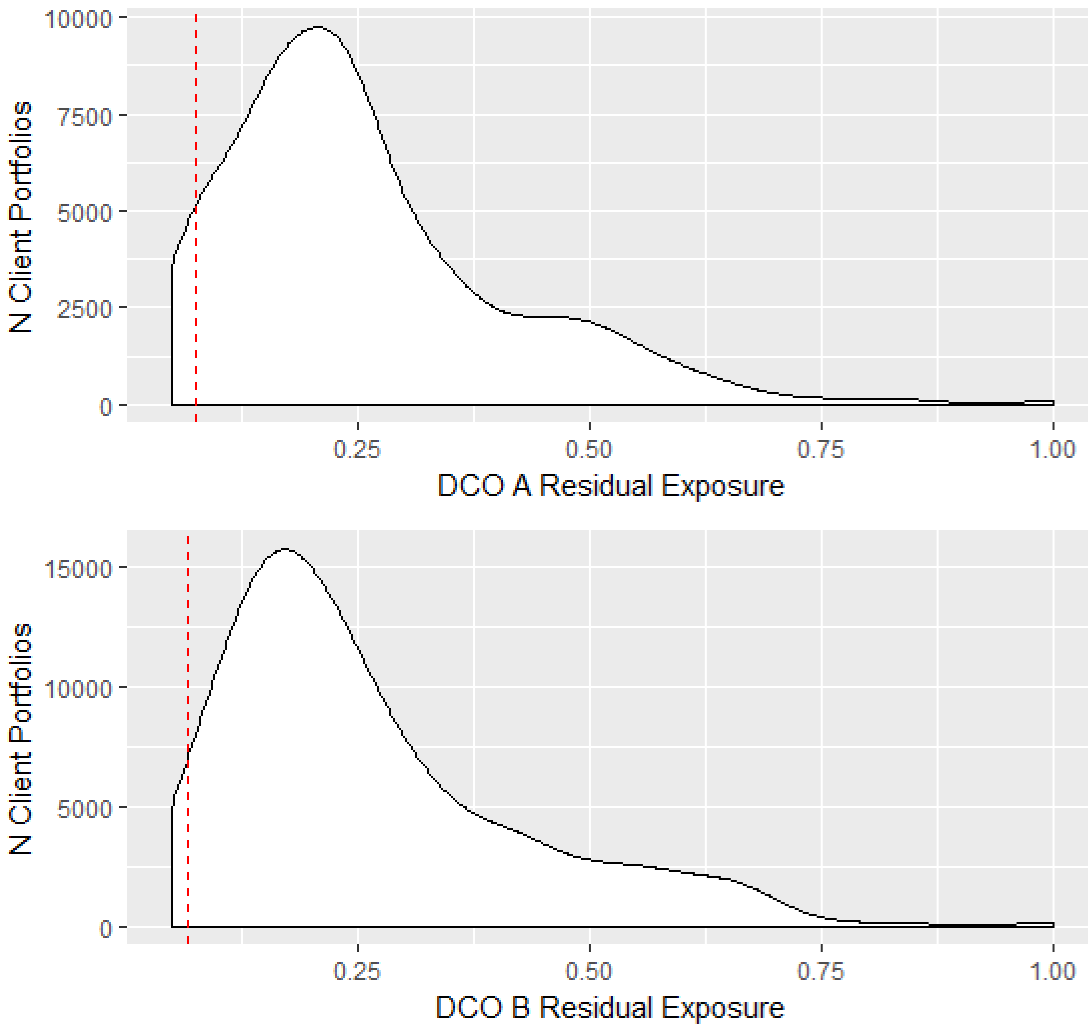

Figure Eight – The distribution of residual exposure for IRS portfolios cleared at DCOs A and B

	DCO A	DCO B
Minimum	5.00%	5.00%
25th Percentile	15.47%	14.96%
Mean	**25.84%**	**26.51%**
75th Percentile	32.64%	33.74%
Maximum	99.99%	99.94%

Figure Nine – Descriptive statistics for the residual exposure distributions

On average across the two clearinghouses, 26% of exposure remains after IM according to SA-CCR. The low margin-to-exposure ratios produce a relatively high residual exposure. Even a very heavy-tailed portfolio distribution would exhibit less than 10% exposure after initial margin offset, as illustrated in Figure Six above. It is clear that the conservatism of SA-CCR is not fully justified by a heavy-tailed portfolio distribution assumption.

4. The Empirical Quantile Targeted by the SA-CCR

The relatively high average level of residual exposure may be better conceptualized by shifting initial margin to a quantile that leaves the same amount of exposure, viz. 26%. This entails solving the residual exposure function for the quantile, with the output fixed. We assume a Student-t (df=3) portfolio return distribution, as this approximately matches the SA-CCR exponential multiplier function. Figure Ten below shows that a 26% residual exposure corresponds to an 89% value-at-risk as calibrated to the Student-t (df=3). The risk measure quantile used by DCOs A and B is marked by the red dashed line. On average, the SA-CCR treats the 99.7% value-at-risk or expected shortfall used by the DCOs as only collateralizing the 89% quantile of loss.

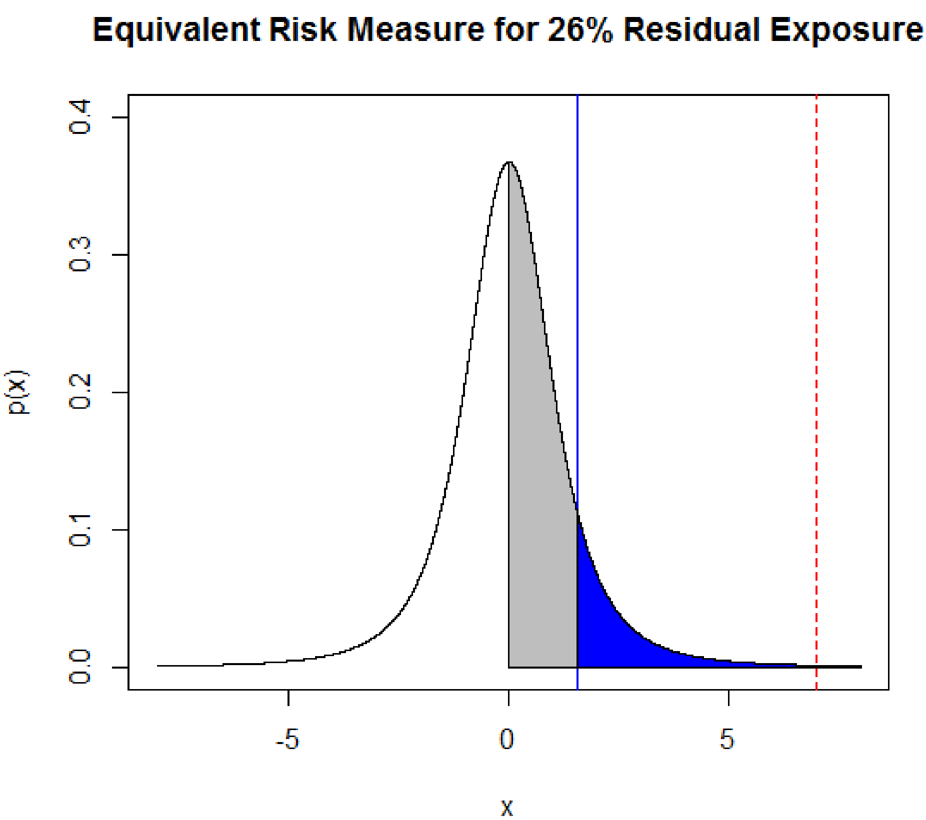

Figure Ten – An illustration of DCO targeted IM (at 99.7%, dotted red line), and the quantile SA-CCR on average gives credit for (89%, solid blue line).

5. Portfolios with High Residual Exposure

The residual exposure depends on the (IM/AddOn) ratio, and as a result, shows the same wide variability, from a minimum at the 5% floor to a maximum of 99.99%. The SA-CCR calculations can produce outcomes at either extreme, depending on the high-level portfolio characteristics. A brief study of these extreme cases will give insight into instances where the SA-CCR deviates significantly from the initial margin model, thus providing either a very conservative or very generous offset.

In our sample, the IRS portfolios with a low ratio value, i.e. IM ≪ AddOn, are generally made up of two broad risk profiles. Either they consist of a single short-dated position or they are large, multi-currency portfolios. For short-dated swap instruments, the relative sizing of the Add-On component over margin may be explained by the duration adjustment in the SA-CCR. Prior to summation, position-level notionals are multiplied by the supervisory duration factor that weights the notional amount by tenor, as discussed in Section II.4.i above. This adjustment reflects the increased risk of long-dated swaps compared to short-dated instruments. However, it is calibrated rather differently than the increase of initial margin with maturity due to changes in the forecasted loss distribution. Figure Eleven below illustrates this, showing the IM/AddOn ratio and the residual exposure on USD Libor swaps, with initial margin generated by DCO A's model as a function of maturity.

	Receiver		Payer	
Tenor	IM/AddOn	Residual exposure	IM/AddOn	Residual exposure
2W	0.0002	99.99%	0.0002	99.99%
1M	0.0028	99.94%	0.0011	99.94%
2M	0.0057	99.93%	0.0014	99.93%
3M	0.01	99.81%	0.0038	99.81%
6M	1.82	53.31%	1.28	53.31%
1Y	1.62	51.46%	1.36	51.46%
2Y	2.81	34.86%	2.20	34.86%
3Y	3.36	32.97%	2.32	32.97%
5Y	3.56	29.17%	2.60	29.17%
10Y	3.76	25.37%	2.93	25.37%
20Y	3.27	22.01%	3.27	22.01%
30Y	3.12	21.26%	3.35	21.26%

Figure Eleven – DCO initial margin for various USD Libor swaps

It can be seen that shorter-dated IRS exhibit a much lower (IM/AddOn) ratio and a much higher residual exposure than longer-dated ones. This is due to the methodological differences between the two models. The DCO A margin model uses historical risk factor movements and revalues each instrument to generate a portfolio loss quantile. For short-dated instruments the potential change in value is small, which results in a lower initial margin figure. The SA-CCR, on the other hand, scales notional amount by a fixed, tenor-specific adjustment that apparently exceeds the true price sensitivity for shorter-dated positions. The case of very short-dated swaps on the three month Libor is particularly extreme. Swaps with less than three months residual maturity have the last payment fixed and are only exposed to changes in discount factors. The SA-CCR does not recognize this effect, resulting in a relatively high level of residual exposure.

For large multi-currency portfolios, the higher residual exposures can be explained by the lack of cross-currency offsets in the SA-CCR notional sums as discussed in Section II.4.vi. The SA-CCR prevents any degree of risk reduction from offsetting positions across highly correlated currencies, whereas DCO A's margin methodology accounts for cross-currency diversification by computing loss at the portfolio level. The more currencies there are in the portfolio, the more pronounced the effect, as Figure Twelve illustrates.

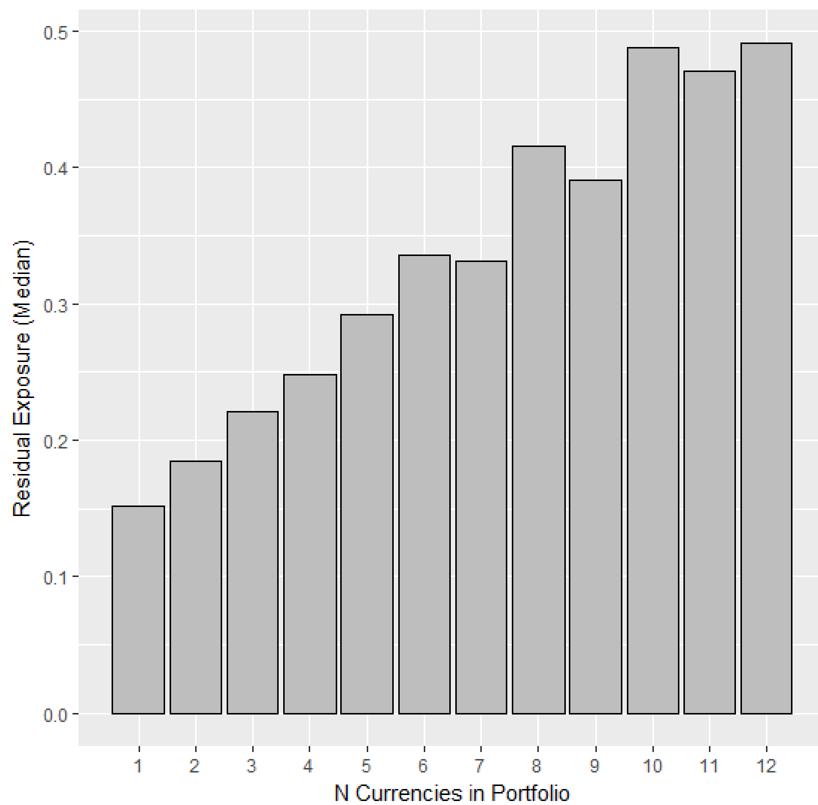

Figure Twelve – Residual exposure as a function of the number of currencies in the portfolio

It is more difficult to isolate the effect of cross-currency diversification on the margin-to-exposure ratio, since these portfolios are by construction large and complex. The three examples of Figure Thirteen below represent simplified cases compared to actual client portfolios. In each sample portfolio a Euro-denominated swap is paired with a different currency. Note that the SA-CCR produces the same Add-On across the three portfolios, since the tenor and notional values are fixed across currencies. For a currency that has historically low correlation with the Euro, such as the Mexican Peso (MXN), the residual exposure after margin offset is relatively low. Japanese Yen curve movements are somewhat better associated with those of the Euro, so the required initial margin decreases and residual exposure increases. Finally, with a highly correlated curve pair such as EUR/NOK and thus a more pronounced diversification effect, the initial margin charged by DCO A further decreases relative to the SA-CCR exposure estimate, producing an even higher residual exposure.

Portfolio A				
Currency	Notional (USD)	Tenor	IM/AddOn	Residual exposure
EUR	-$1,000,000	10Y	2.09	**36.57%**
MXN	$1,000,000	10Y		

Portfolio B				
Currency	Notional (USD)	Tenor	IM/AddOn	Residual exposure
EUR	-$1,000,000	10Y	1.48	**48.55%**
JPY	$1,000,000	10Y		

Portfolio C				
Currency	Notional (USD)	Tenor	IM/AddOn	Residual exposure
EUR	-$1,000,000	10Y	1.06	**59.27%**
NOK	$1,000,000	10Y		

Figure Thirteen – Residual exposure for cross-currency hedge portfolios

6. Portfolios with Low Residual Exposure

IRS portfolios that exhibit a high ratio value, i.e. IM ≫ AddOn, are generally smaller portfolios made up of offsetting positions at closely separated tenors. A simple example would be a receiver/payer combination staggered by one year in maturity, within the same SA-CCR maturity bucket. The three portfolios in Figure Fourteen are illustrative of the decline in exposure for offsetting USD Libor swaps. DCO A's margin model generates a portfolio value distribution that accounts for cash flows from both contracts, reflecting the slight gap in instrument maturity and the incremental risk of the longer-dated swap. The SA-CCR, on the other hand, gives a low estimate of portfolio exposure as the duration-adjusted notional sums are netted towards zero.

Portfolio A			
Notional	Tenor	IM/AddOn	Residual exposure
$1,000,000	5Y	3.28	**21.95%**
-$1,000,000	6Y		

Portfolio B			
Notional	Tenor	IM/AddOn	Residual exposure
$1,100,000	6Y	13.34	**5.08%**
-$1,000,000	7Y		

Portfolio C			
Notional	Tenor	IM/AddOn	Residual exposure
$1,330,000	7Y	374.71	**5.00%**
-$1,000,000	10Y		

Figure Fourteen – Residual exposure for two offsetting swaps in the same currency and same maturity bucket

V. Discussion

The analysis presented above provides evidence of a substantial dispersion in counterparty credit risk estimates between the SA-CCR and the initial margin models of two major U.S. DCOs. The SA-CCR expected exposure is sometimes lower than initial margin suggests it should be, but more often it is considerably higher. To summarize the main results across all the 7,501 portfolios studied:

- 95% of client portfolios receive a higher residual exposure than the value implied by on the SA-CCR assumptions, and are thus considered undercollateralized by SA-CCR.
- The average residual exposure of 26% effectively treats the clearinghouse 99.7% value-at-risk or expected shortfall measure as if it were an 89% value-at-risk.
- Residual exposures range from 5% to nearly 100%, with a discernible pattern across portfolio types. Short-dated and multi-currency portfolios receive a high level of residual exposure in SA-CCR, and tenor-offset portfolios receive a much lower level.

There are several prudential reasons why the SA-CCR might aim to intentionally overestimate expected exposure relative to initial margin. The framework was designed specifically to provide a measure of exposure that is robust in stressed market conditions. In contrast, initial margin methodologies are typically dependent on past data to calibrate model parameters or to simulate the forecasted loss distribution. A sudden, historically unanticipated shift in market risk factor relationships might lead to a much larger loss beyond margin than the implied exposure amount, although DCO backtesting indicates that margin breaches have been historically a very rare event. A conservative risk estimate in a standardized approach such as SA-CCR can thus account for unprecedented market conditions or any inherent model risk. There is a balance to be struck in such approaches between complexity and risk coverage that could be defined at the outset of model design.

Nevertheless, the results presented show that the SA-CCR is not just on average conservative, but much more conservative for cross-currency portfolios, and much less so for portfolios where the net risk within each SA-CCR maturity bucket is small. This wide variability of outcomes induces an incentive that favors certain types of portfolios. Clearing members already offer optimization services to their clients on the basis of reducing capital requirements under the CEM; under SA-CCR, the capital charge for an interest rate swaps portfolio can be zeroed out on a duration-adjusted basis within maturity buckets.

Together these results suggest that a re-examination of the calibration of SA-CCR might be justified with a view to reducing its variability. This is particularly the case as SA-CCR is now being used outside the original design space through its adoption in the leverage ratio. In these cases the relatively more conservative treatment of large, diversified multi-currency portfolios could be particularly problematic. A more consistent outcome in terms of residual exposure might be achieved by addressing the interaction of margin and uncollateralized exposure.

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