A Framework in Search of an Optimal Margining Policy for Official Institutions: The Canadian Experience

by Tomo Nakashima, Mihai Cosma and Boran Plong

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Acknowledgements

Abstract

One of the main outcomes of the global financial crisis has been a series of new regulations imposed on the financial system and specifically on banks. As a result of the changing regulations, bank dealers introduced various "credit" and "liquidity" charges for uncollateralized over-the-counter (OTC) derivatives trades, governed by a one-way or asymmetric credit support annex (CSA), whereby only bank dealers are required to post collateral in favour of official institutions—sovereigns, central banks, government agencies, sovereign wealth funds and supranational institutions—such as the Government of Canada. These charges have sharply increased costs for the government, which, like other official institutions, has been an extensive user of OTC derivatives. In this paper, we propose a framework that official institutions can use to analyze the cost and risk trade-offs among potential margining policies, including moving to a more symmetric CSA versus the prevailing one-way CSAs. Our analysis indicates that, in the case of Canada, moving to a more symmetric CSA results in lower cost and risk for the government relative to the prevailing one-way CSA margining policy, due to the government's relatively lower funding cost. In fact, all margining policies tested dominate the prevailing one-way CSA prior to 2015. As a result, remaining under the one-way CSA and continuing to transact OTC derivatives is no longer the best policy given the charges levied against the government.

JEL classification: G32
Bank classification: Foreign reserves management; Financial markets

Résumé

La crise financière mondiale a notamment eu pour principale conséquence l'imposition d'une série de nouvelles règles destinées au système financier, en particulier aux banques. Ces règles ont amené les opérateurs bancaires à fixer divers frais de crédit et de liquidité pour les opérations non garanties sur produits dérivés de gré à gré, qui sont régies par une convention de nantissement asymétrique (ou unilatéral) appelée annexe de soutien au crédit. Selon cette annexe, seuls les opérateurs bancaires sont tenus de constituer des garanties en faveur d'institutions officielles (entités souveraines, banques centrales, organismes gouvernementaux, fonds souverains et institutions supranationales), telles que le gouvernement du Canada. Ces frais ont entraîné une forte augmentation des coûts pour l'État, qui, à l'instar d'autres institutions officielles, a souvent eu recours aux opérations sur dérivés de gré à gré. Dans ce document d'analyse, nous proposons un cadre que ces institutions peuvent employer pour effectuer un arbitrage entre les coûts et les risques associés aux différentes exigences de marges possibles, notamment les coûts et risques

découlant de l'abandon des conventions de nantissement unilatéral les plus courantes au profit d'un nantissement plus symétrique. Selon notre analyse, l'adoption par le gouvernement du Canada d'une annexe de soutien au crédit prévoyant des modalités de nantissement plus symétrique aboutit à des coûts et à des risques moindres par rapport aux conventions de nantissement unilatéral sur lesquelles repose la politique de marges actuelle. Et ce, en raison du coût de financement relativement moins élevé pour l'État. En fait, toutes les politiques de marges étudiées étaient, avant 2015, plus avantageuses que la convention de nantissement unilatéral qui a cours. Utiliser ce type d'annexe de soutien au crédit et continuer d'effectuer des opérations sur dérivés de gré à gré ne constituent donc plus la meilleure stratégie, au vu des frais imposés à l'État.

Classification JEL : G32
Classification de la Banque : Gestion des réserves de change; Marchés financiers

1   Introduction

Official institutions (e.g., sovereigns, central banks, government agencies, sovereign wealth funds and supranational institutions) are some of the largest users of over-the-counter (OTC)[1] derivatives. The credit support annex (CSA) provides one of the principal risk mitigants when transacting OTC derivatives, between official institutions (OIs) and their bank dealers. The CSA governs the collateral posting by each party, which is meant to mitigate counterparty risk stemming from the changing mark-to-market values of the OTC derivatives. Traditionally, OIs have had "asymmetric" credit support terms with bank dealers, effectively making them a one-way CSA: collateral, or a variation margin, is posted only by the bank dealer, and the OI does not have a reciprocal obligation unless its credit rating deteriorates substantially. Additionally, in cases where an OI does post the variation margin, it may do so without rehypothecation rights. Finally, these one-way CSAs may call for an "independent amount" or margin in favour of the OI, whereby the bank dealer posts additional collateral usually triggered by a credit rating downgrade below a certain threshold. These asymmetric practices mainly stem from the better credit rating that OIs traditionally have enjoyed over their bank counterparties.[2]

After the global financial crisis, to ensure that the liquidity and credit risks stemming from OTC derivatives were properly captured, regulators imposed new rules on bank dealers. The rules required them to set aside appropriate capital for their OTC derivatives exposure against an OI. The risks inherent when bank dealers are trading with an OI under a one-way CSA can be described in the event of a default by an OI: large losses would presumably be incurred, since the OI would not have any collateral posted to the bank dealers. As a result, new regulations imposed on bank dealers for transacting under one-way CSAs have led to various "credit" and "liquidity" costs. Bank dealers have ultimately passed these costs on to the OI. Given that there were over $1.6 trillion outstanding in OTC derivatives for Organisation for Economic Co-operation and Development (OECD) sovereigns,[3] mostly in interest rate derivatives and cross-currency swaps (CCS), and with the vast majority governed by one-way CSAs, it has become significantly more expensive for OIs to transact their OTC derivatives under their prevailing CSA. For example, in Canada, the USD 67 billion foreign reserves portfolio (as of 31 March 2015) is primarily funded by transacting OTC CCS where Canadian dollars funded by the Government of Canada (GoC) with CAD-denominated securities are swapped into foreign currencies.[4] CCS have allowed for a cost-effective means of raising funds for the foreign reserves. However, since the introduction of the aforementioned charges, the total charge for OTC derivatives is estimated to have increased by 10–15 basis points (bps) on a swap portfolio of about USD 50 billion.

The introduction of the credit and liquidity charges, together with the desire to improve counterparty credit risk protections, has prompted the GoC to undertake a review of the terms of the CSA with the aim of reducing the cost of transacting CCS while improving credit risk mitigants. Specifically, the exercise aims to understand whether, by moving to a more symmetric CSA (i.e., two-way CSA), the GoC could eliminate the charges—and in some instances potentially reduce their credit risk—for their CCS activity. Thus the analysis is carried out from the perspective of a very low-risk OI that is a relatively small player in the international OTC derivatives market.

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[1] For a full list of abbreviations used in this paper, please refer to Appendix A.1.

[2] In the recent European debt crisis, however, bank dealers renegotiated the terms of CSAs with certain sovereigns considered to present significant credit risk, in order to continue to transact those sovereigns' OTC derivatives.

[3] See OECD (2011).

[4] For details on how the GoC's foreign reserves are managed, see De León (2000–2001).

From a financial stability perspective, one-way CSAs, which OIs often have with their respective bank dealers, result in the buildup of large counterparty exposure with bank dealers. A default of an OI may cause those directly exposed bank dealers to default because of margining requirements, and those defaults in turn could potentially lead to the defaults of other bank dealers not directly exposed to the OI. A move to more symmetric CSAs consistent with margining requirements that are similar to those of centrally cleared trades would remove this counterparty exposure and promote a safer OTC derivatives market, thereby improving financial stability. Consideration of symmetric CSAs would be consistent with the G20's OTC derivatives reform commitments of 2009.[5]

We provide an analytical framework to analyze the trade-off between the cost and risk of choosing various margining policies. The framework identifies the four main costs to an OI given a particular CSA: (i) the cost of regulatory capital faced by the bank dealer, (ii) the cost of collateral funding for the bank dealer, (iii) the cost of collateral funding for the OI, and (iv) the cost of risk faced by the OI. The framework then seeks a CSA that minimizes the total costs while at the same time minimizing the cost of risk faced by the OI.

In the case of Canada, we show that the status quo (remaining under a one-way CSA, and continuing to transact the GoC's OTC derivatives) is dominated by more symmetric options, given the charges levied against the GoC and risk for the GoC. This is largely a result of Canada's lower cost of funding relative to bank dealers and thus there are savings to be obtained by moving to a more symmetrical CSA. Our analysis suggests that the optimal choice is between a scenario where no initial margin (IM) is posted from bank dealers and one where IM is posted to the GoC.[6]

The analysis can be adapted to various types of OIs that have a portfolio of OTC derivatives. They may find the proposed framework helpful when assessing which margining policy should be retained, based on costs and risks. Additionally, we report the results of the quantitative analysis conducted prior to entering into negotiations with bank dealers on the terms of the GoC's new two-way CSA announced in 2013.[7,8]

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[5] See https://g20.org/wp-content/uploads/2015/09/FSB---s-Ninth-Progress-Report-on-the-Implementation-of-OTC-Derivatives-Reforms.pdf.

[6] The optimal amount of IM depends on the tolerance for close-out risk that is mitigated by IM and the bank dealer funding cost. Even though our framework identifies the optimal amount of IM for each bank dealer, it may not be feasible for official institutions. Further, taking a uniform approach to all bank dealers may serve the purpose of not discriminating among bank dealers. We therefore postpone discussion of the IM decision for future work.

[7] See http://www.bankofcanada.ca/2013/12/discussions-changes-to-margining-policy-cross-currency-swaps/.

[8] As noted in Merkowsky and Wolfe (2015), Canada established two-way CSA agreements with several bank dealers in 2015 and is in the process of negotiating with the remaining one-way CSA dealers.

2   The cost estimate framework

A framework to search for an optimal margining policy for OIs first requires that the characteristics of distinctive margining policies be identified. In this analysis, the combinations of answers to three questions determine various distinctive margining policies. First, which counterparty posts the variation margin (VM)? Second, can the VM be rehypothecated?[9] Lastly, which counterparty posts initial margin (IM)? The combinations of answers to these three questions will identify distinctive margining policies that an OI may consider adopting. For example, typical market conventional CSAs will call for both counterparties to post a VM and allow the VM to be rehypothecated by both. Table 1 shows a subset[10] of margining policies that an OI may adopt depending on how the above three questions are answered.

Table 1: Characteristics of Various CSAs

	1	2	3	4	5	6	7
	Does Counterparty Post Variation Margin?						
Official institution	No	No	No	No	Yes	Yes	Yes
Bank dealer	No	Yes	Yes	Yes	Yes	Yes	Yes
	Is Rehypothecation of Variation Margin Permissible By the Counterparty?						
Official institution	No	No	No	No	No	Yes	Yes
Bank dealer	No	No	Yes	Yes	Yes	Yes	Yes
	Does Counterparty Post Initial Margin?						
Official institution	No	No	No	No	No	No	Yes
Bank dealer	No	No	No	Yes	Yes	Yes	Yes

Under the changing regulatory environment impacting bank dealers, the various margining policies in Table 1 may or may not warrant various "credit" or "liquidity" costs/charges. And the same margining policies also present various degrees of risk to the OI, mainly in the form of credit risk. The analytical framework must therefore account for the risks, costs, the total of the two and their trade-offs. In this framework, searching for an optimal margining policy is determined by four categories of costs: (i) the cost of regulatory capital faced by a bank dealer, (ii) the cost of collateral funding for the bank dealer, (iii) the cost of collateral funding for the OI, and (iv) the cost of risk faced by the OI. The framework can be summarized by the following equation:

Total cost to the OI[11] = cost of regulatory capital for the bank dealer + cost of collateral funding   (1)
by the bank dealer[12] + cost of collateral funding by the OI + cost of risk faced by the OI.

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[9] Rehypothecation is explained in detail in section 3.3.

[10] Depending on how each question is answered, many distinctive CSAs are possible. Out of 64 possible unique CSAs in this framework, Table 1 illustrates a few of the potential CSAs that an OI may consider adopting.

[11] The framework does not include any marginal costs stemming from the operational burden associated with more symmetric margining policies. For example, additional resources would likely be required for middle and back offices, as well as additional IT investment for an OI under a market standard two-way CSA. While non-immaterial, these costs would be small relative to the costs and risk mentioned above, and should be considered in the margining policies to retain.

[12] Currently, an OI with a one-way CSA would likely have this cost passed on, since no variation margin would be posted by the OI.
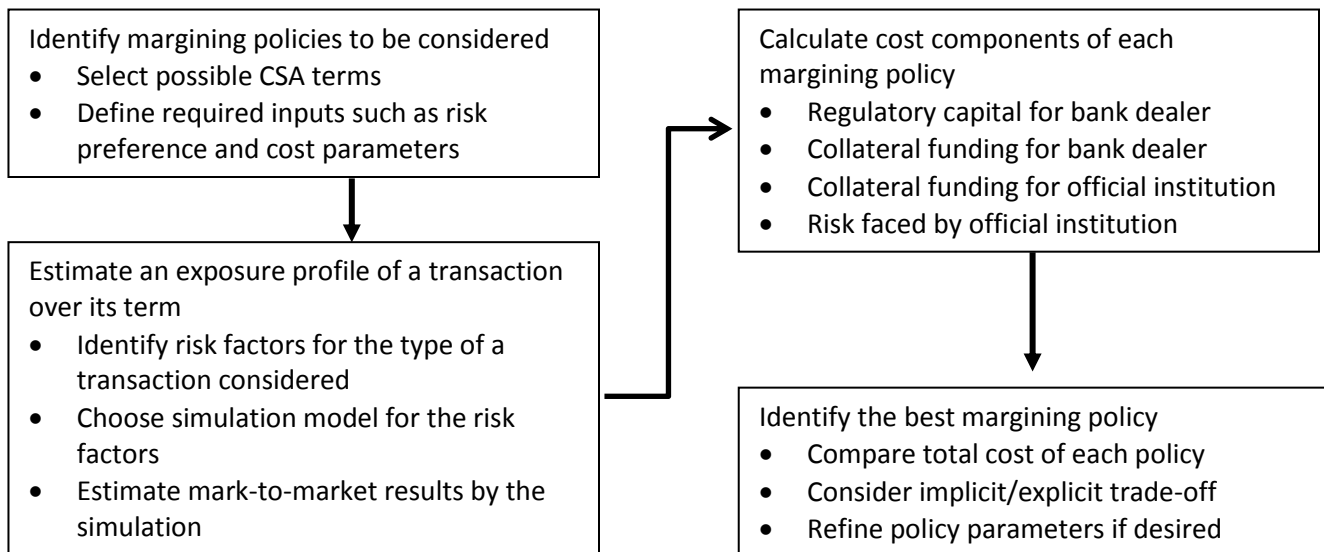
The framework amounts to a cost minimization exercise where we seek a margining policy that will minimize the total cost to the OI while at the same time minimizing the last variable in equation (1), the cost of risk faced by the OI.

In practice, a number of additional characteristics can be written into a CSA that may increase the total cost to an OI. These include non-negligible minimum transfer amounts, non-zero variation margin thresholds and types of collateral acceptable as a variation margin. However, for the purposes of this framework, we will consider only those shown in Table 1, since they tend to be the most contentious issues in CSAs between bank dealers and OIs given the current regulatory environment.

Under this framework, our assumption is that OIs are price takers, or that all costs incurred by the bank dealer as a result of the characteristics of a particular margining policy are passed on to the OI. Finally, the framework does not consider any potential financial stability effects as a result of increased demand for collateral postings by OIs.

The entire framework can be summarized in a series of steps illustrated in Figure 1. First, we identify potential CSA policies under consideration. Second, to get an exposure profile of transactions over its term, we generate a path of potential moves in variables affecting the mark-to-market (MTM) of a portfolio. Third, we calculate the four cost variables in equation (1) for each policy identified in the first step. Fourth, we identify the best policy by comparing the costs and trade-offs of considered CSA policies.

Figure 1: **Cost Estimate Framework**

3 Cost estimate framework: the Canadian experience

In the case of the GoC, several margining policy scenarios are tested. First, scenario 1-Way is a one-way CSA margining policy very similar to the policy in place for the GoC prior to 2015. The variation margin is only posted by bank dealers. The GoC only posts the variation margin when it falls below a certain credit rating threshold. Under this margining policy, the variation margin is only posted by bank dealers when the MTM of the portfolio breaches a non-zero threshold that is credit rating dependent. No IMs are exchanged. Second, scenario VM is a CSA whereby the variation margin is posted by both parties with zero thresholds. Rehypothecation rights are not granted for either party and an initial margin is not exchanged. Third, scenario VM-ReHyp is a CSA whereby the variation margin is posted by both parties with zero thresholds. In this case, rehypothecation rights are granted for both. Fourth, scenario VM-ReHyp-IM is a CSA whereby both parties post the variation margin with zero thresholds. Rehypothecation rights are again granted for both parties, but an initial margin amounting to 5.5%[13] of the notional of the CCS is posted by the bank dealer to the GoC with no rehypothecation rights. Finally, for scenarios VM, VM-ReHyp and VM-ReHyp-IM, we assume zero-zero variation margin thresholds with daily transfers. These scenarios are summarized in Table 2.

Table 2: Potential Canadian CSAs Tested

	1-Way	VM	VM-ReHyp	VM-ReHyp-IM
Does Counterparty Post Variation Margin?				
Government of Canada	No	Yes	Yes	Yes
Bank dealer	Yes	Yes	Yes	Yes
Is Rehypothecation of Variation Margin Permissible By the Counterparty?				
Government of Canada	No	No	Yes	Yes
Bank dealer	No	No	Yes	Yes
Does Counterparty Post Initial Margin?				
Government of Canada	No	No	No	No
Bank dealer	No	No	No	Yes

Future exposures derived from the mark-to-market of the OTC derivatives portfolio are generated by Monte Carlo simulations (see section 3.1) of interest rates and foreign exchange rates. Then, the exposures are used to estimate the up-front and running costs associated with the margining policies (outlined in Table 2) for both the GoC and bank dealers. These costs stem from the different characteristics of each potential margining policy. There are challenges in determining the methodology for calculating the costs by each bank dealer.[14] In this framework, we assume that each bank dealer is adhering to Basel II and III guidelines and sets aside regulatory capital accordingly. By doing so, we can measure the costs as set out in equation (1) using the Basel guidelines. The variables in equation (1) can then be divided into the subcomponents shown in Table 3, as specified in the Basel guidelines.

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[13] In section 3.5 we further discuss how we arrive at 5.5% of the notional as an appropriate IM amount to test.

[14] For example, one of the many challenges was making assumptions for bank dealer funding costs charged to the fixed-income treasury groups of bank dealers. This information is not readily publicly available and therefore assumptions were made based on market-observable rates.

Table 3: Total Costs to the Government of Canada

Costs	Description	Abbreviations
(1) Cost of regulatory capital for bank dealers	Credit value adjustment (expected credit loss) [explained in section 3.2.1] Capital cost (unexpected credit loss) [explained in section 3.2.2] • Counterparty credit risk (CCR) capital • Credit value adjustment (CVA) capital	$C_{\text{Regulatory Capital for Bank Dealers}}$
(2) Cost of collateral funding by the bank dealer	Variation margin [explained in section 3.3] Initial margin [explained in section 3.5]	$C_{\text{Collateral Funding for Bank Dealers}}$
(3) Cost of collateral funding for the Government of Canada	Variation margin [explained in section 3.3]	$C_{\text{Collateral Funding for GoC}}$
(4) Cost of risk faced by the Government of Canada	Credit value adjustment (expected credit loss) [explained in section 3.4.2] Capital cost (unexpected credit loss) [explained in section 3.4.3] • Counterparty credit risk (CCR) capital • Credit value adjustment (CVA) capital	$C_{\text{Risk Faced by GoC}}$

3.1 Simulation framework

For a given initial portfolio of cross-currency swaps (CCS), Monte Carlo simulations are used to determine alternative hypothetical exposures and collateral required for both counterparties separately. The simulation models must measure both risk factors that affect the mark-to-market of CCS: interest rates and foreign exchange (FX) rates. Several criteria are required to most effectively simulate the values of the portfolio of CCS; specifically, they must

- precisely match market-observable yield curves, forward rates
- match historical interest rate behaviour and volatilities
- not allow for negative interest rates[15]
- provide robust estimates over long simulation horizons

A Libor Market Model (Brace, Gatarek and Musiela 1997) is employed such that spot FX rates and interest rates are simulated simultaneously. FX rates are generated by short-term forward rates using a geometric Brownian motion model (Brace 2008). For interest rates, historical volatilities observed during the stress period of 15 September 2008 to 15 September 2009 are recalibrated to match implied volatilities (available from current market quotes on swaptions). Please refer to Appendix A.2 for further analysis.

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[15] This condition may become unnecessary in the near future to allow for negative interest rates, as observed recently.

3.2 Cost of regulatory capital for bank dealers

3.2.1 Credit value adjustment (expected credit loss)

When two counterparties enter into an OTC derivatives transaction, they take on mutual credit risk. This risk is mitigated by the posting of collateral, as agreed in the CSA between the two parties. Either party could be exposed to a loss if their counterparty defaults, in the amount of their exposure not covered by collateral. The simplest measure of this counterparty default risk is the credit value adjustment (CVA),[16] which is the product of a counterparty's expected positive exposure (EPE) and their probability of default, as measured by an appropriate credit spread over a risk-free rate.[17]

The CVA cost is reduced by a lower exposure threshold, which caps the amount of uncollateralized exposure, since collateral is posted above that threshold. In this analysis, scenarios VM, VM-ReHyp and VM-ReHyp-IM, as outlined in Table 2, have zero-zero thresholds with daily transfers. In these scenarios, outstanding exposure does not exist for either counterparty, whereas the 1-Way scenario has a significant CVA cost due to the non-zero threshold, in particular for bank dealers, since no variation margin is posted by the GoC given the "one-way" nature of the current CSA.

For collateralized CSAs (i.e., scenarios VM, VM-ReHyp and VM-ReHyp-IM), there is no uncollaterized exposure except for potential MTM changes during the close-out period. To calculate the required capital under those scenarios, we use the shortcut method[18] defined by Basel III for estimating effective EPE under the internal model method (BCBS 2010).

To calculate the expected credit loss, the following parameters are used for our sample case. For the GoC, a small default probability is assigned and its average loss-given-default rate is 45%. For scenarios VM, VM-ReHyp and VM-ReHyp-IM where a variation margin is posted, expected exposure is estimated using a close-out or margin period of risk of 10 days.

3.2.2 Capital cost estimate: counterparty credit risk and credit valuation adjustment capital

A counterparty that does not post a variation margin exposes its counterparty to default risk. Regulatory capital requirements dictate what capital needs to be set aside in case of losses caused by a counterparty's default. These requirements give rise to two additional costs: **counterparty credit risk (CCR) capital** and **CVA capital**.[19]

The cost for setting aside **CCR capital** for bank dealers is calculated based on the CCR capital amount and bank dealers' cost of capital (i.e., required return on capital in Table 4). For both the GoC and the bank dealers, CCR capital charges are calculated using the required returns on capital in Table 4. Since the required returns for bank dealers are not directly observable, they were conservatively estimated.[20] The required return for the GoC is

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[16] Expected credit loss, often referred to as a CVA, can be calculated as follows:

$$\text{EPE} \times \text{Credit Spread} = \text{CVA}(t) = \text{EEPE}(1-R)\sum_{j=1}^{m} \text{PD}(t_{j-1}, t_j) = \text{EEPE} \times (1-R) \times \text{PD}(0, t_m)$$

The expected loss is the product of the expected positive exposure (EPE), probability of default (PD) and 1 minus the recovery rate (R).

[17] A credit spread is commonly calculated from market-observed credit default swap spreads, and a proxy is used when no such instrument is actively traded.

[18] The add-on is calculated as E[max(ΔMtM, 0)], where E[…] is the expectation (i.e., the average over scenarios) and ΔMTM is the possible change of the mark-to-market value of the transactions during the close-out period.

[19] Not to be confused with CVA in section 3.2.1.

[20] Based on a survey of bank dealers conducted by the GoC.

assumed to be higher than those of their bank dealers given the GoC's risk-averse nature or its very low risk tolerance, and not as a result of its relative credit risk and/or a higher return required from its shareholders.

Table 4: Required Return on Capital Assumptions

	GoC	Low-cost bank dealer (LCD)	High-cost bank dealer (HCD)
Required return	25%	7%	14%

CCR capital captures the risk associated with OTC derivatives in a default situation. This risk stems from the potential future exposure during its "close-out period," the time after default required to enter into another similar position, assumed to be 10 days. The CCR capital is calculated by the advanced internal-rating-based approach (BCBS 2010).

Basel III (BCBS 2010) has introduced a new capital charge, called **CVA capital**. It adjusts the price of a derivative to incorporate changes in counterparty creditworthiness throughout the life of the transaction. According to Basel III,

> Banks will be subject to a capital charge for potential mark-to-market losses (i.e. credit valuation adjustment – CVA – risk) associated with a deterioration in the credit worthiness of a counterparty.

Those falling under the jurisdiction of this regulation must set aside capital for MTM losses stemming from changes in counterparty risk, or the volatility of credit risk or CVA.

Two approaches can be taken to calculate the CVA capital charge (BCBS 2010). The first is to use the advanced methodology based on an internal risk model available to those institutions that have had their methodologies approved by regulatory bodies. The second is to use prescribed standardized rules[21] to calculate this capital requirement.

The advanced method calculates the possible change in CVA over a 10-day horizon by simulating daily credit default swap (CDS) spreads. The standardized method assumes a normal distribution of the variance of this spread. Since CDS for the GoC is not regularly traded, our assumption is that counterparties would use the standardized formula to calculate their CVA capital.

Bank dealers' CVA capital is calculated with an adjustment weight (0.7% for the credit quality of the GoC of AAA) and an effective maturity (five years).[22] Since we assume that the GoC is required to set aside capital, its CVA capital is calculated with an adjustment weight (e.g., 0.8% for credit quality of A-rated bank dealers). Here, we use the assumption of the required returns in Table 4.

A number of bank dealers (e.g., European banks) may, because of jurisdictional regulatory decisions, be exempt from setting aside CVA capital for sovereign counterparties such as Canada. Moreover, if bank dealers elsewhere hedge CVA capital using single-name CDS for Canada or an appropriate index hedge, they may be exempt from setting aside CVA capital. Thus, any charges passed on to the GoC would likely be immaterial. In this analysis, we consider both cases: (i) when bank dealers set aside the CVA capital, and (ii) when bank dealers do not set aside capital because of regulatory exemptions or appropriate hedges.
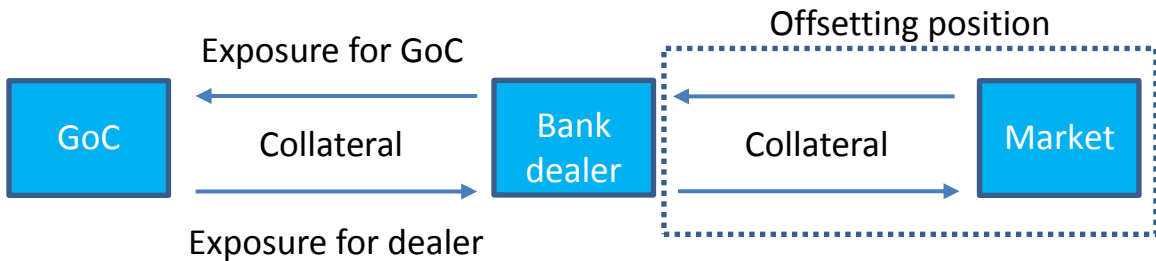
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[21] Designed to be conservative approximations of the advanced methodology.
[22] For modelling purposes, the portfolio average maturity is assumed to be five years.

3.3 Cost of collateral funding for bank dealers and the Government of Canada

A variation margin protects transacting parties in over-the-counter trades from the changing MTM values of the swaps since inception. Market standard CSAs typically call for a symmetric posting of the variation margin for the two respective counterparties, consistent with trades cleared via a clearing house. In the case of the GoC, and the prevailing CSA prior to 2015, collateral agreements allow for the GoC not to post collateral.
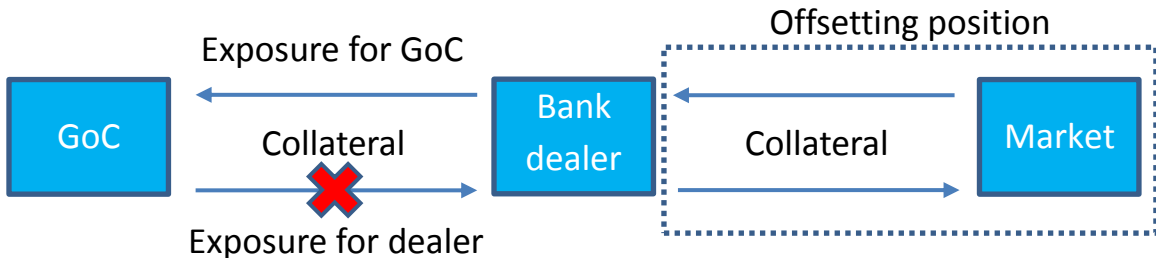
We assume that bank dealers through the course of market making will minimize any risk positions (market risk). Through the course of trading the Government of Canada's CCS, bank dealers fully hedge their GoC market risk exposure with other clients or other bank dealers. Therefore, when bank dealers post a variation margin for a given position, they cover that requirement by receiving collateral from an offsetting position (Figure 2). This ability to repledge received collateral is referred to as rehypothecation, and also more broadly encompasses the reuse of assets received as collateral. Allowing rehypothecation allows a bank dealer to eliminate any additional "funding" or "liquidity" costs, since they merely pass on the collateral received from offsetting positions. This describes the margining policy tested in scenario VM-ReHyp and VM-ReHyp-IM in Table 2.

Figure 2: Posting variation margin to bank dealers

If a counterparty does not allow rehypothecation, or does not post collateral, its counterparty must raise any collateral required by the offsetting position at its own funding cost. Figure 3 is characteristic of the prevailing GoC CSA (or scenario 1-Way): the GoC does not post any collateral to its bank dealers and thus incurs a "liquidity charge" under the new regulatory environment.

Figure 3 Posting variation margin without rehypothecation

In Figure 3, collateral posted by the bank dealer in the offsetting position will usually return either EONIA (Euro OverNight Index Average) or the federal funds rate; either of these can be far below the counterparty's own cost of funds. Because a counterparty does not post a variation margin (the GoC in Figure 3), or posts it without rehypothecation rights, the bank dealer would charge a variation margin cost. If, however, the GoC posts a

variation margin with rehypothecation rights, the bank dealer has no need to raise additional collateral. The variation margin cost for bank dealers would be zero.

This analysis assumes that the GoC will be fully charged by bank dealers to cover their cost of funding for the offsetting positioning (Figure 3) (Hull and White 2012).[23] As a result, this charge figures into the overall cost of the transaction.

When calculating the costs associated with the variation margin, we note that the cost of funding the collateral is different depending on each party's creditworthiness. The GoC, as a highly rated sovereign, has a funding cost lower than its bank dealer counterparties. For the purposes of this analysis, marginal funding costs for the GoC, and representative low-cost (LCD) and high-cost bank dealers (HCD), are conservatively estimated.[24] Table 5 shows the results in terms of basis points (bps).

Table 5: Estimated funding costs

	GoC	Low-cost bank dealer (LCD)	High-cost bank dealer (HCD)
Funding cost	35 bps	70 bps	140 bps

Bank dealer funding costs charged to the fixed-income treasury groups of bank dealers are not publicly available. However, unlike the required return on capital, funding costs are relatively easier to observe from bond markets. The GoC funding cost is set lower than bank dealers because of its relative creditworthiness.

3.4   Cost of risk faced by the Government of Canada

3.4.1   An implicit cost

Until now, in the case of Canada, the first three costs discussed in Table 3 (i.e., $C_{\text{Regulatory Capital for Bank Dealers}}$, $C_{\text{Collateral Funding for Bank Dealers}}$ and $C_{\text{Collateral Funding for GoC}}$) are explicit costs. These costs are truly incurred when bank dealers charge the GoC as a result of the various characteristics of the CSAs tested in Table 2. For example, the cost of any collateral raised by the GoC in Scenario VM-ReHyp is an explicit cost incurred by the GoC. As well, any cost of collateral funding by bank dealers (i.e., $C_{\text{Collateral Funding for Bank Dealers}}$) as a result of scenario 1-Way is passed on to the GoC and thus is an explicit cost. For the last cost considered in Table 3, the cost of risk faced by the GoC (i.e., $C_{\text{Risk Faced by GoC}}$) is an implicit cost rather than explicit: in practice, the GoC currently does not set aside any capital as a result of its exposure to bank dealers. However, not acknowledging this cost of risk faced by the GoC stemming from the various characteristics of the CSAs tested (particularly for the prevailing CSA) would truly underestimate the total costs in equation (1). Our analysis acknowledges that this treatment of the cost of risk faced by the GoC may be different for other OIs: those OIs who do not set aside any capital for the risks stemming from their OTC derivatives portfolio may deem the cost of risk to be zero, unlike the GoC. On the other hand, other OIs who in practice set aside capital for their derivatives portfolio would deem the cost of risk faced by OIs as an explicit cost.

3.4.2   GoC's credit value adjustment (expected credit loss)

For the GoC, the cost of risk stemming from the credit value adjustment (expected credit loss) is a result of the non-zero thresholds for posting of variation margins by bank dealers under scenario 1-Way. Scenarios VM, VM-

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[23] Some academics argue against including this "funding value adjustment" in derivatives prices. However, practitioners are often of a different view and commonly include it in their pricing.

[24] Funding costs are estimated based on corporate bond spreads over treasuries.

ReHyp and VM-ReHyp-IM have zero-zero thresholds with daily transfers and thus the credit value adjustment is zero. For LCD, we assume an average default probability of 0.027%, and for HCD we assume 0.063%.[25] Finally, we assume that their average loss-given-default rate is 45%.

3.4.3 GoC's capital cost estimates: counterparty credit risk and credit valuation adjustment capital

In this analysis, we assume that the GoC sets aside capital according to the Basel rules just like its bank dealer counterparties. As with bank dealers, the cost for setting aside CCR capital for the GoC is calculated based on the CCR capital amount (BCBS 2010) and the GoC's cost of capital (i.e., required return on capital). The CCR capital amount for the GoC is higher than that for bank dealers because of the higher credit risk posed by the bank dealers. The effective EPE for the GoC is capped at the CSA variation margin threshold plus the EPE over the close-out period. The required return on capital for the GoC is assumed to be higher than that of LCD due to its risk-averse nature (Table 4).

The GoC's CVA capital is calculated with an adjustment weight (e.g., 0.8% for bank dealers with a credit rating in the "A" category) coupled with a required return on capital of 25% for the GoC.

3.5 Initial margin (IM)

3.5.1 Required amount of potential exposure protection

In event of default, the initial margin helps protect transacting parties from potential exposures arising from future changes in the MTM values, from the time of default to the time it takes to close out the positions. Many CSAs do not require the posting of initial margins. In the case of the GoC, under the prevailing CSA prior to 2015, "independent amount" clauses are included,[26] which are meant to add protection similar to that of an initial margin. In this analysis we consider whether adding initial margins would help reduce the cost of risks while achieving an appropriate balance between the cost of risks and total costs. An initial margin is considered in scenario VM-ReHyp-IM, as outlined in Table 2.

Both the Office of the Comptroller of the Currency et al. (2014) and the Basel Committee on Banking Supervision/International Organization of Securities Commissions (BCBS/IOSCO 2012) propose that an appropriate IM is one that covers the 99th percentile of price movements over a 10-day time horizon. Others, however, use different levels of protection (e.g., 10-day 99.7% for OTC transactions (Sidanius and Zikes 2012)).

Several approaches can be taken to calculate the initial margin, including an internal margin model and standardized look-up tables. The internal margin model created by the Bank of Canada, based on Monte Carlo simulation,[27] estimates the exposure distribution across a 10-day close-out period. This approach offers a more accurate picture of the close-out exposure by taking into consideration the key risk factors (interest rate, FX, volatility, etc.) that determine the MTM of a CCS. We compare the simulated results to actual 10-day historical daily changes in exposure for the GoC's existing swap portfolio, to estimate the required amount of protection under different assumptions (Table 6).

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[25] Based on historical default probabilities from major credit rating agencies.
[26] Under this type of clause, the "independent amount" must be posted when one party's credit rating falls to a pre-default rating (e.g., BBB+) or lower. The clauses were previously deemed warranted given the higher creditworthiness of the GoC over the bank counterparties.
[27] Please refer to Appendix A.2.

Table 6: Estimated initial margin requirements (% of notional)

Parameter	Simulation	Historical
10-day 90%	2.9%	2.0%
10-day 95%	3.9%	2.6%
10-day 99%	5.5%	4.5%
10-day 99.9%	8.0%	6.8%
10-day 99.99%	8.2%	7.4%

Price movements over the 10-day close-out period at the 99th percentile are estimated to be between 4.5% and 5.5% by the different methods.

The IM requirement proposed by regulators for the standardized method is shown below. Regulators (OCC, FRB, FDIC, FCA and FHFA[28]) propose a prudent range of 3–9% of notional exposure for foreign exchange/cross-currency swaps, while the BCBS initially proposed 6% (Table 7).

Table 7: Standardized minimum initial margin requirements

Remaining term to maturity	OCC	BCBS and IOSCO
Foreign exchange/currency	3–9%	6%
Interest rate: Less than two years	0–2%	1%
Interest rate: Two to five years	1–3%	2%
Interest rate: Longer than five years	2–6%	4%

The BCBS/IOSCO (2013) revised their recommendation in 2013, stating that initial margin requirements do not apply to FX transactions associated with the exchange of principal of cross-currency swaps. In their revision, the BCBS recommends that the "interest rate portion of the standardised initial margin schedule" should be used.

Adhering to the recommendation from regulators is computationally straightforward, as well as easy to implement and maintain. However, these advantages are offset by the fact that standardized margin requirements may be less accurate in cases where a model approach would assess the risk factors differently. To ensure that the relatively simple calculations under the standardized method work in all scenarios, estimates of the initial margin should be conservative, resulting in higher IM requirements.

The appropriate choice of an IM methodology is driven by the need to balance computational complexity with consistency and accuracy of results. Given the lack of diversification and netting benefits in the GoC swap portfolio (i.e., all CCS are homogeneous in nature: long CAD, short USD, EUR, or YEN) and the potential for frequent disputes with counterparties arising from any internal margin model, we propose that initial margin requirements should be determined using a fixed amount pre-agreed by both counterparties, similar to a look-up table.

This analysis proposes up to 5.5% of the notional as an appropriate level, consistent both with our simulation results and the recommendations made by regulatory authorities.

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[28] OCC: Office of the Comptroller of the Currency; FRB: Federal Reserve Banks; FDIC: Federal Deposit Insurance Corporation; FCA: Financial Conduct Authority; FHFA: Federal Housing Finance Agency.

Furthermore, from a financial system stability point of view, unlike an internal margin model, a standardized pre-agreed percentage table does not introduce procyclical effects. If an internal margin model is used in times of market stress, initial margin requirements or demand for collateral could increase, potentially exacerbating the already-reduced liquidity of financial markets. Since the pre-agreed percentage table structure does not depend on credit ratings, it also aligns well with the G20's financial stability policy of eliminating the mechanical use of ratings in counterparty risk mitigation.

Section 4.4 revisits the choice of an initial margin level for further analysis.

3.5.2   Initial margin cost estimate

Unlike a variation margin, an initial margin should not be rehypothecated in order to ensure that collateral is available in the event of a counterparty default. If a bank dealer posts an initial margin, the close-out risk is reduced significantly and the GoC does not need to set aside the regulatory capital stemming from counterparty credit risk (CCR) or a credit value adjustment (CVA), as outlined in section 3.4.2. In the simple case where the GoC's bank dealer counterparty posts an initial margin (i.e., scenario VM-ReHyp-IM in Table 2), the costs of CCR and CVA are assumed to be zero for the GoC. However, we revise that assumption for a more detailed analysis of the initial margin later. The costs associated with funding this initial margin for bank dealers are included in the overall cost of collateral funding for bank dealers. The cost to raise IM by bank dealers is outlined in Table 5.
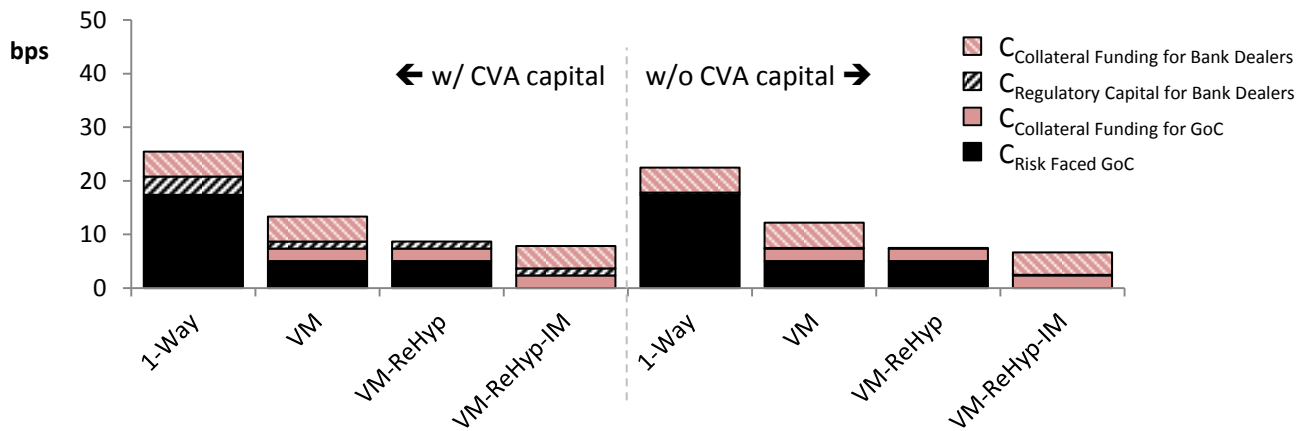
4 Results: total costs to the GoC

4.1 Summary of results

Again, for the sake of completeness, we assume that all costs incurred by a bank dealer are passed through to the GoC as a charge and thus the total cost includes both bank dealer (cost/charge) and GoC costs.
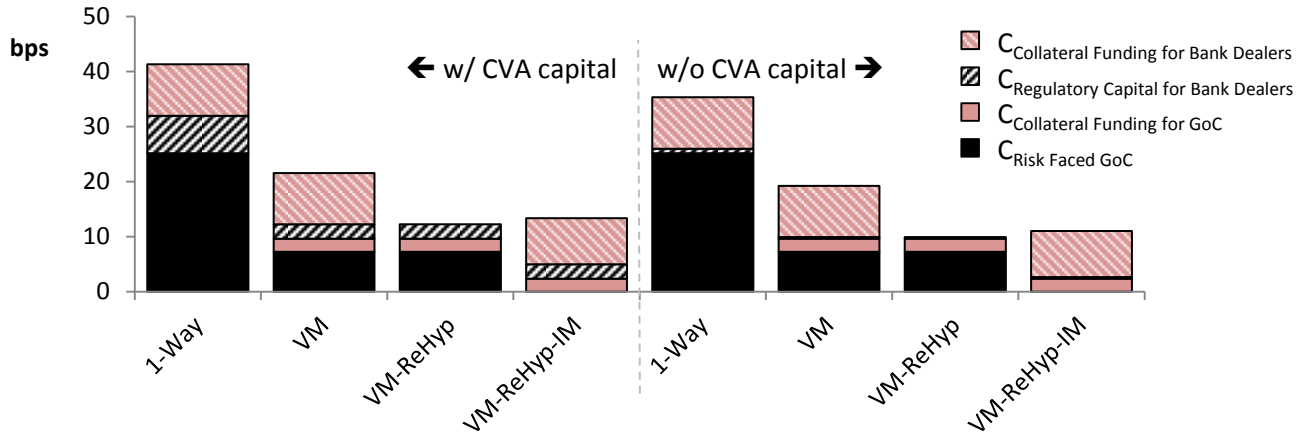
Chart 1 and Chart 2 show the total costs as outlined in Table 3 stemming from the various CSA margining policies tested as outlined from Table 2. Two cases are considered: when bank dealers set aside CVA capital (labelled "w/ CVA capital") and when they do not (labelled "w/o CVA capital"), because they could be exempt from CVA capital requirements at the discretion of their jurisdictional regulators (see the explanation in section 3.2.2).

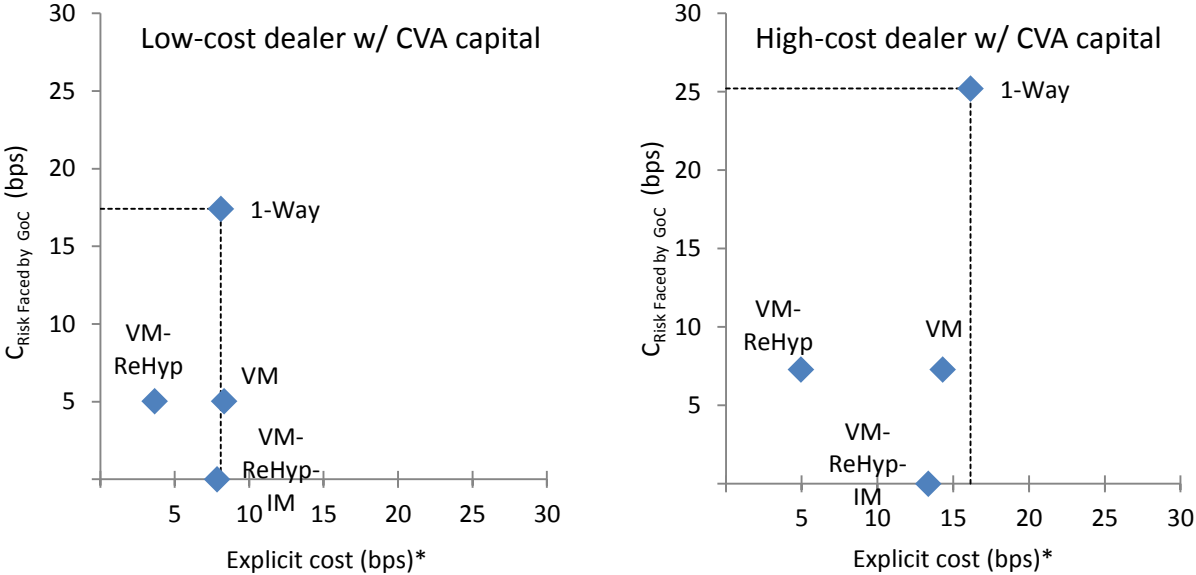Chart 1: Total cost to GoC from low-cost bank dealers

Note: Total cost to GoC = $C_{\text{Collateral Funding for Bank Dealers}} + C_{\text{Regulatory Capital for Bank Dealers}} + C_{\text{Collateral Funding for GoC}} + C_{\text{Risk Faced by GoC}}$.

Chart 2: Total cost to GoC from high-cost bank dealers

Note: Total cost to GoC = $C_{\text{Collateral Funding for Bank Dealers}} + C_{\text{Regulatory Capital for Bank Dealers}} + C_{\text{Collateral Funding for GoC}} + C_{\text{Risk Faced by GoC}}$.
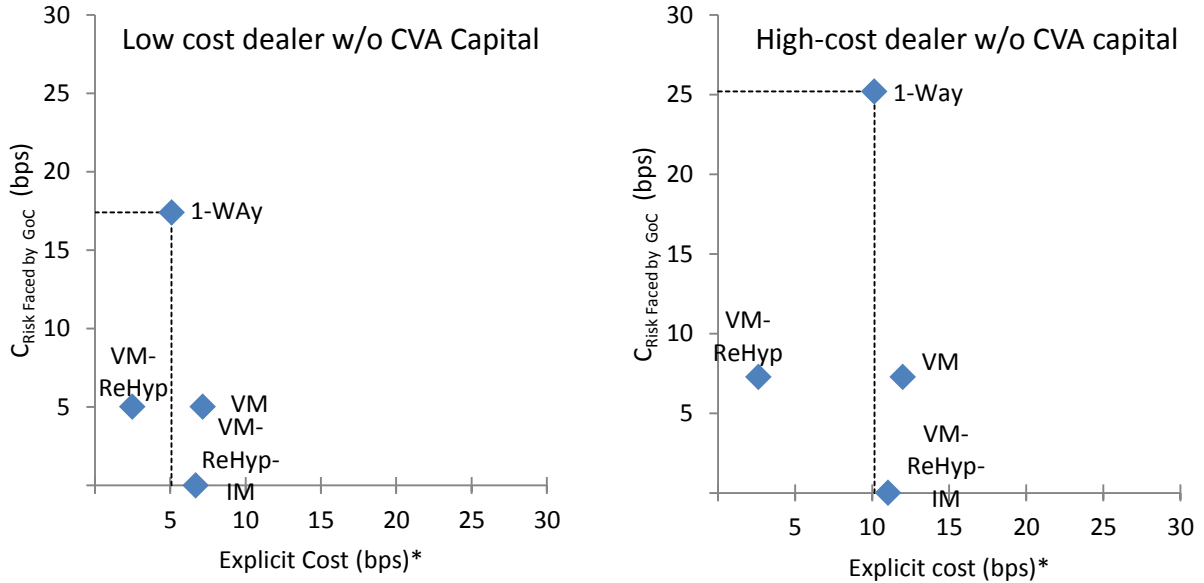
Chart 1 and Chart 2 show that, for both LCD and HCD cases, total costs to the GoC for scenario 1-Way or the prevailing CSA prior to 2015 are higher than those of all other scenarios. Unsurprisingly, in scenarios where we allow for rehypothecation of posted collateral (scenarios VM-ReHyp and VM-ReHyp-IM), bank dealer costs are reduced, because bank dealers do not need to raise additional collateral to offset fully any hedges.

As mentioned earlier, this framework assumes that any Basel capital charges faced by the bank dealer as a result of the CSA are passed to the GoC by bank dealers, but they are reduced substantially when OTC derivatives are collateralized symmetrically as in scenarios VM, VM-ReHyp and VM-ReHyp-IM (Chart 1 and 2). This again is not a surprise, even when we assume that the GoC must set aside CVA capital. The net costs are lower, since the GoC cost of funding is always lower than the Basel capital costs passed on by bank dealers.

To further the analysis, we present the results along two dimensions: implicit and explicit costs, which were first discussed in section 3.4.1. More specifically, in Chart 3 we look at the implicit cost of risk faced by the GoC (i.e., $C_{\text{Risk Faced by GoC}}$) vs. the explicit cost or the sum of all other costs (i.e., $C_{\text{Collateral Funding for Bank Dealers}} + C_{\text{Regulatory Capital for Bank Dealers}} + C_{\text{Collateral Funding for GoC}}$). The implicit cost (y-axis) can change depending on the risk tolerance or level of risk aversion of the GoC. The cost of risk faced by the GoC, $C_{\text{Risk Faced by GoC}}$, is driven mostly by the CSA variation margin thresholds, which can be thought of as an unsecured loan to its bank dealers, as is characteristic of scenario 1-Way, the prevailing CSA. This stems from the fact that the variation margin is not posted by bank dealers until a threshold is breached, dictated by credit rating triggers.

Chart 3: Implicit Cost (Risk) vs. Explicit Cost Analysis

Low cost dealer w/o CVA Capital

$C_{\text{Risk Faced by GoC}}$ (bps)

Explicit Cost (bps)*

1-WAy
VM-ReHyp
VM
VM-ReHyp-IM

High-cost dealer w/o CVA capital

$C_{\text{Risk Faced by GoC}}$ (bps)

Explicit cost (bps)*

1-Way
VM-ReHyp
VM
VM-ReHyp-IM

Note: Explicit cost (bps)* = $C_{\text{Collateral Funding for Bank Dealers}}$ + $C_{\text{Regulatory Capital for Bank Dealers}}$ + $C_{\text{Collateral Funding for GoC}}$.

The key findings from the results are:

1. The 1-Way CSA is dominated by scenario VM-ReHyp, in all cases tested here.
2. The 1-Way CSA is dominated by scenario VM-ReHyp-IM in cases where bank dealers set aside CVA capital. However, VM-ReHyp-IM may not dominate in the case where bank dealers do not set aside CVA capital.
3. The scenario VM is always dominated by scenario VM-ReHyp simply because collateral posted by the GoC cannot be rehypothecated by bank dealers. For the same level of risk on the y-axis, the distance between VM-ReHyp and VM-ReHyp-IM shows the saving brought by rehypothecation of collateral.
4. All scenarios (VM, VM-ReHyp and VM-ReHyp-IM) have a lower cost of risk faced by the GoC (i.e., $C_{\text{Risk Faced by GoC}}$) than the status quo, irrespective of CVA capital exemptions for the GoC and irrespective of low- or high-cost bank dealers; scenarios VM-Rehyp and VM-ReHyp-IM dominate scenario VM in all cases.
5. In this framework, the dominant scenarios are VM-ReHyp and VM-ReHyp-IM.
6. The difference in funding costs between low- and high-cost bank dealers affects the minimum total costs to the GoC between scenarios VM-ReHyp and VM-ReHyp-IM.

Given the degree of risk aversion by the GoC (as first discussed in section 3.2.2) and results in Table 4, the status quo (1-Way) CSA is dominated by the more symmetric scenarios: VM, VM-ReHyp and VM-ReHyp-IM. In this total cost framework, scenarios VM-ReHyp and VM-ReHyp-IM dominate all other scenarios. The decision on the need for, and appropriate level of, IM is the main variable that requires further analysis, since scenario VM-ReHyp has no IM required of bank dealers, and VM-ReHyp-IM does have such a requirement. The choice between VM-ReHyp and VM-ReHyp-IM will depend on the tolerance for close-out risk, which could be mitigated by IM.

Recall that the optimal margining policy depends primarily on assumptions used in the framework: funding costs and required return on capital. As a result, the framework may provide other official institutions a different optimal policy (e.g., remaining in the prevailing one-way CSA), depending on the applicable assumptions.

Section 4.3 further examines these scenarios' intermediate optimal policies, specifically between scenario VM-ReHyp (without IM) and scenario VM-ReHyp-IM (with IM).

4.2   Testing other margining policy scenarios

In addition to the above four margining policy scenarios, the analysis also considered a fifth margining policy scenario: scenario VM-ReHyp-IM-both, one that is the same as scenario VM-ReHyp-IM in all respects, but as with the bank dealer, the GoC also posts the initial margin. The results are somewhat ambiguous. In the instances where bank dealers are exempt from setting aside CVA capital, scenario VM-ReHyp-IM dominates scenario VM-ReHyp-IM-both, but only marginally for both LCD and HCD. However, in the instance where bank dealers are not exempt from setting aside CVA capital (irrespective of a low- or high-cost bank dealer), scenario VM-ReHyp-IM-both, where there is a symmetric posting of IM, dominates scenario VM-ReHyp-IM.
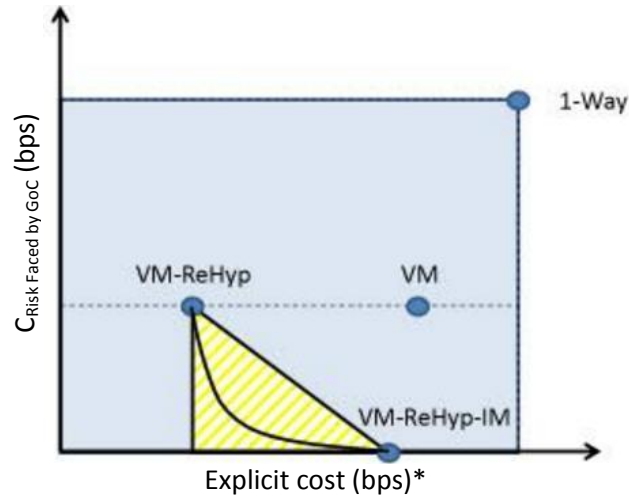
Finally, another margining policy scenario, scenario VM-ReHyp-IM-GoC, was considered. It was the same in all respects as margining policy VM-ReHyp-IM, but only the GoC posted IM and the bank dealer did not. Again, the results are ambiguous. In the instances where bank dealers are exempt from setting aside CVA capital, the cost and risk trade-offs between VM-ReHyp and VM-ReHyp-IM-GoC are nearly identical. However, in the instance where bank dealers are not exempt from setting aside CVA capital, scenario VM-ReHyp-IM-GoC dominates scenario VM-ReHyp.

These findings suggest that the intermediate policy scenarios between scenario VM-ReHyp-IM-both and VM-ReHyp-IM-GoC is what requires further analysis, and not scenario VM-ReHyp and VM-ReHyp-IM, as described in the previous section. This analysis suggests that it may be beneficial for official institutions to investigate the cost and risk trade-offs between symmetric IM posting and one where only the official institution posts IM. However, in the case of Canada, having the GoC post IM to its bank dealers was deemed inappropriate given the GoC's high creditworthiness relative to its bank dealers, and it would be preferable for the GoC to obtain protection from risk upon the default of a bank dealer.

4.3   Refining the initial margin cost analysis through risk sharing

The previous section identifies two dominant scenarios to retain, as set out in Chart 4: scenario VM-ReHyp (symmetric variation margin with zero thresholds, rehypothecation permitted for the VM, and no initial margin from the bank dealer) and scenario VM-ReHyp-IM (the same, except for the requirement for the bank dealer to post an initial margin to address close-out risk exposure equal to 5.5% of the notional of the swap).

Chart 4: Stylized illustration of margining policy trade-offs

Note: Explicit cost (bps)* = $C_{\text{Collateral Funding for Bank Dealers}} + C_{\text{Regulatory Capital for Bank Dealers}} + C_{\text{Collateral Funding for GoC}}$.

The difference between scenario VM-ReHyp and VM-ReHyp-IM relates only to IM. If the increase in costs stemming from collateral funding for bank dealers (i.e., $C_{\text{Collateral Funding for Bank Dealers}}$) as a result of the additional IM is equal to the decrease in cost of risk faced by the GoC ($C_{\text{Risk Faced by GoC}}$), or, in other words, if there is a linear relationship, any amount of IM requested will not decrease the total costs to the GoC (i.e., $C_{\text{Regulatory Capital for Bank Dealers}} + C_{\text{Collateral Funding for Bank Dealers}} + C_{\text{Collateral Funding for GoC}} + C_{\text{Risk Faced by GoC}}$). However, because the decrease in the cost of risk faced by the GoC ($C_{\text{Risk Faced by GoC}}$) may be non-linear, an optimal amount of IM (closest to the lower left corner) could be identified.

In this section we interpolate policy scenarios between VM-ReHyp and VM-ReHyp-IM by changing the amount of the initial margin, and thus changing the cost of collateral funding by the bank dealer ($C_{\text{Collateral Funding for Bank Dealers}}$), and the cost of risk faced by the GoC ($C_{\text{Risk Faced by GoC}}$). The cost of collateral funding by the bank dealer ($C_{\text{Collateral Funding for Bank Dealers}}$) increases linearly with the amount of IM required, while the benefit – in terms of reduced cost of risk faced by the GoC ($C_{\text{Risk Faced by GoC}}$) – is concave. Thus, there exists an optimal point[29] between VM-ReHyp and VM-ReHyp-IM where the marginal reduction in cost of risk faced by the GoC ($C_{\text{Risk Faced by GoC}}$) is equal to the marginal increase in cost of collateral funding by the bank dealer ($C_{\text{Collateral Funding for Bank Dealers}}$).
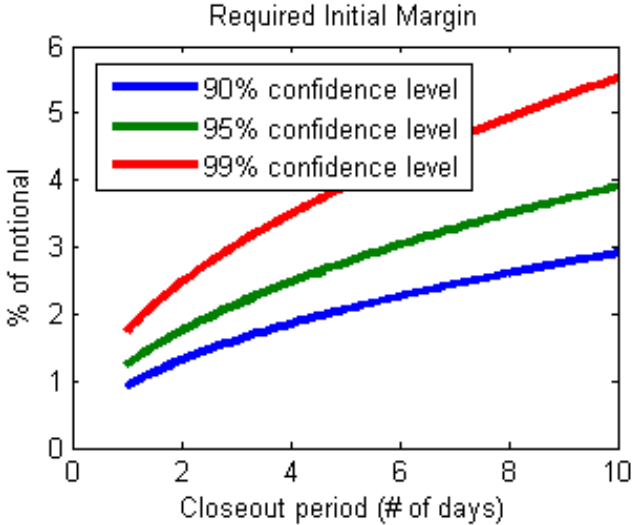
The main consideration in this analysis is, therefore, the level of initial margin that should be requested from bank dealers. In the end, we believe a flat non-time-varying or pre-agreed level of IM is preferred to a model-based methodology, to minimize procyclicality issues and inevitable disputes around model-based estimates.

Table 6 in section 3.5.1 shows both the simulation model and historical methods of estimating IM requirements for a limited set of parameters. Results from the simulation model can be expanded using the distribution of simulated exposures to determine the required IM level for any combination of parameters. The level of IM, and its associated cost, is driven by two variables: the close-out risk period and the confidence level of coverage.

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[29] The optimal point is a local optimum, since we set the IM at B as the upper bound where the cost of collateral exceeds the benefits of IM. Theoretically, it is possible that the global optimum may lie where the IM is higher than the level set at B.

Using results from our simulation model, Chart 5 shows the required initial margin as a function of close-out days and confidence levels.

Chart 5: Required initial margin levels (% of notional) by varying factors

This level of required IM determines the IM cost combined with the bank dealers' costs of funding (as assumed in section 3.5.2). They are shown as running bps (rbps) in Chart 6 and Chart 7. Again, we assume that these costs would be fully passed through to the GoC.

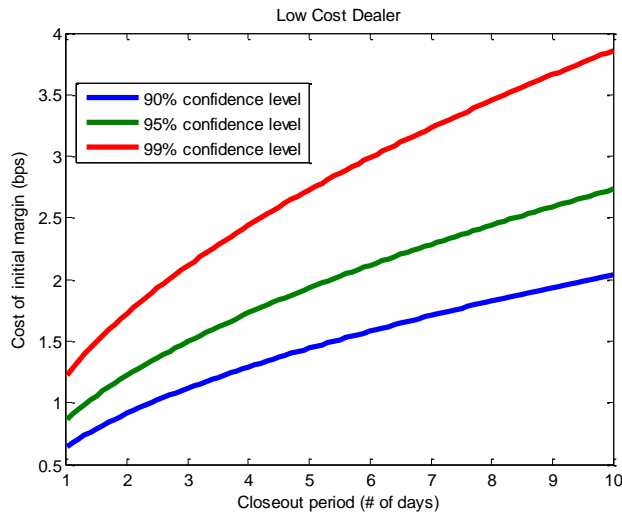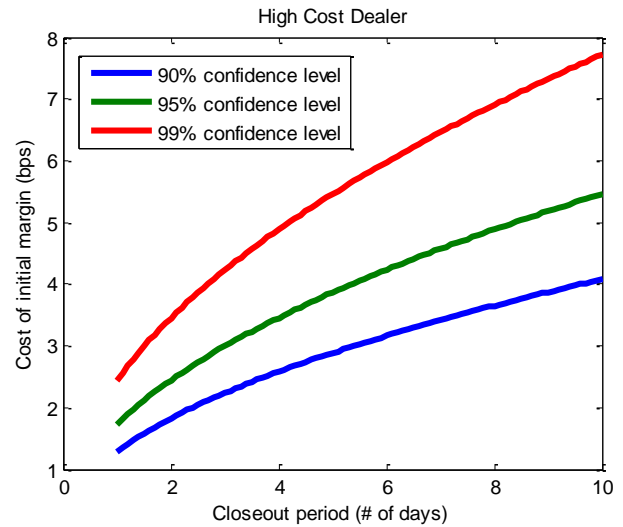**Chart 6: Initial margin costs (bps) by varying close-out period, LCD**

Low Cost Dealer

Chart 7: Initial margin costs (bps) by varying close-out period, HCD
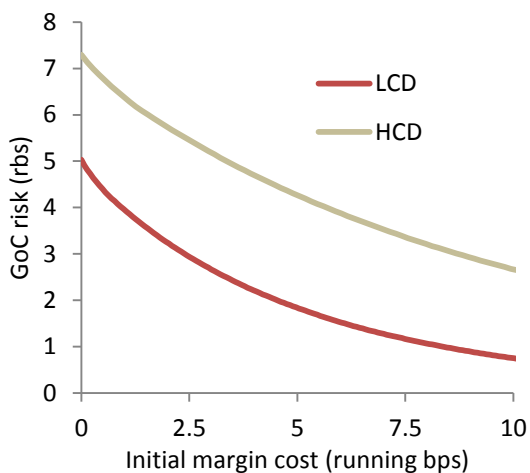

High Cost Dealer

From Chart 6 and Chart 7, we see that for the required IM of 5.5% of the notional swap to cover 99% confidence and a 10-day close-out period, the cost in running bps is nearly 4 bps for low-cost bank dealers, and nearly 8 bps for their high-cost counterparts[30] for scenario VM-ReHyp-IM.

4.4 Optimal IM level

In order to find the optimal IM level, we analyze the curve depicted in Chart 4 containing all policy scenarios between VM-ReHyp and VM-ReHyp-IM. As the IM increases from zero (moving from scenario VM-ReHyp to VM-ReHyp-IM), the results from the simulation confirm the intuition of a sharp fall in the cost of risk faced by the GoC ($C_{\text{Risk Faced by GoC}}$) relative to an increase in costs. However, we then transition to a flatter slope as scenario VM-ReHyp-IM is approached (i.e., a small fall in the cost of risk faced by the GoC for large increases in costs), as Chart 8 illustrates.
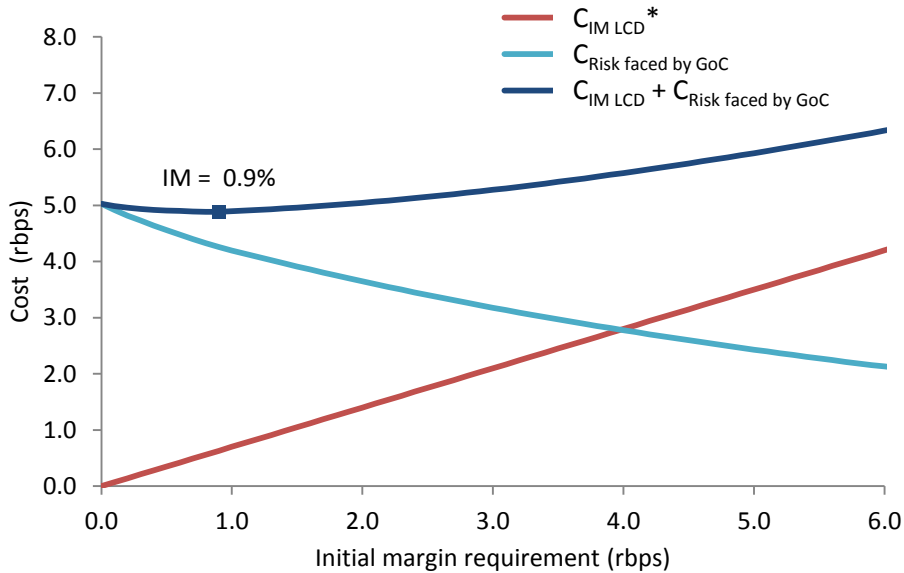
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[30] If we follow the recommendation (6% of the notional) in both the OCC and BCBS proposals, the cost would be 4.2 bps (LCD) and 8.4 bps (HCD).

Chart 8: Curve of policies between options B and C

The posting of even a small amount of IM covers a large portion of possible close-out scenarios, compensating for potential financial losses for most outcomes. However, as demonstrated in the convexity of the above curves, higher levels of IM cover an increasingly smaller set of unlikely financial scenarios given default, and in fact become less effective or less efficient at covering close-out risk compared to the linearly increasing cost of posting IM. To determine an optimal level of IM, the analysis should consider both the cost of risk faced by GoC ($C_{\text{Risk Faced by GoC}}$) and the bank dealer funding cost, which is charged back to the GoC. Chart 9 shows the cost of risk faced by GoC ($C_{\text{Risk Faced by GoC}}$), the LCD IM funding cost, and their combined total faced by the GoC for varying levels of IM requirements.

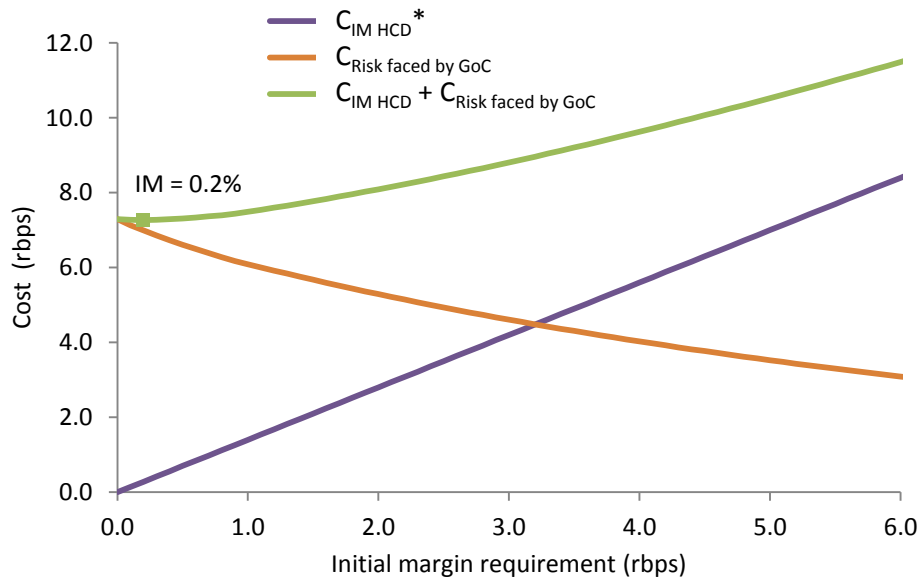**Chart 9: Risks and costs to GoC and LCD by varying IM**

When no IM is posted (0% IM far left in Chart 9), the costs stemming from the IM are obviously zero. Thus, the total cost (dark blue) is equal to the GoC risk (light blue). As more IM is posted (e.g., going from 0 to 1% of IM), the LCD's IM funding cost increases ($C_{\text{Collateral Funding for Bank Dealers}}$) linearly (straight red line), whereas the cost of risk faced by the GoC, $C_{\text{Risk Faced by GoC}}$, decreases non-linearly due to the posted IM (downward slope of the light blue curve). Through to around 1% of IM, the linear increase of the LCD's IM funding cost is more than offset by the non-linear decrease of the cost of risk faced by the GoC. Therefore, the sum of the two (dark blue curve) declines until 0.9% of IM.

In the case of the LCD, the analysis of IM costs indicates that close-out risk and its costs passed on to the GoC from posting IM could be cost-effective for values of IM up to 0.9% of the notional. Beyond 0.9%, the estimated increase in the cost of IM is larger than the decrease in the cost of risk. These numbers are sensitive to a variety of assumptions such as bank dealer cost pass-through and their funding costs.

When conducting a similar analysis for high-cost bank dealers (Chart 10), we find that the green curve (cost of risk faced by the GoC + HCD's IM funding cost) increases nearly monotonically: the minimum cost is achieved when very little IM (0.2%) is posted. Thus, asking a bank dealer to post an IM given its high funding cost is an expensive way to reduce the cost of risk faced by the GoC. This result could appear counterintuitive since it suggests that counterparties with higher funding costs, typically resulting from their lower credit quality, should have a lower (null) level of IM imposed upon them.

This counterintuitive result could possibly be explained by the fact that the optimal IM amount is determined by the joint minimization of a bank dealer's IM funding cost and the GoC's implicit risk cost. There, the funding cost would definitely increase from LCD to HCD. However, the major determinant of the GoC's risk cost, the required capital to set aside facing a dealer, may not increase as proportionally as does the dealer funding cost. Thus, if the GoC's self-protection against credit risk (setting aside capital) becomes more effective, a joint minimization would promote more of self-protection and less of the required amount of IM.
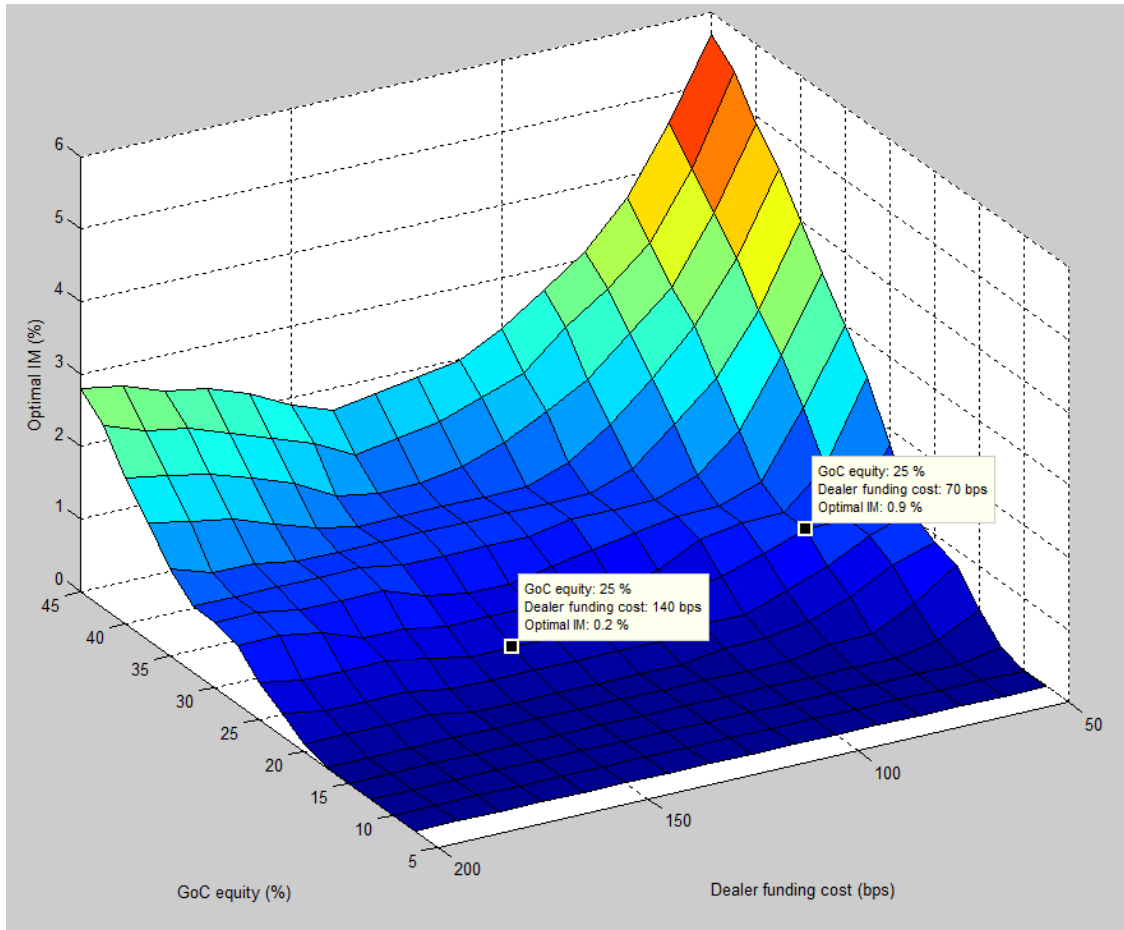
Chart 10: Risks and costs to GoC and HCD by varying IM

$$*C_{IM\ HCD} = \text{portion of } C_{Collateral\ Funding\ for\ Bank\ Dealers} \text{ attributable to IM}$$

The optimal level of IM depends on the assumptions of bank dealer costs and GoC risk costs. This level is inversely related to bank dealer costs and positively related to GoC risk tolerance, or capital costs. Chart 11 sets out the dependencies for the optimally priced IM as a function of GoC capital cost and bank dealer funding cost.

Chart 11: Efficient required IM pricing as a function of GoC and bank dealer costs

With the aim of cost minimization between the GoC and its counterparties under the assumptions made, our analysis supports approximately 0.9% of the notional as an appropriate amount for IM for low-cost bank dealers, and 0.2% for their high-cost counterparts.

The current conclusion and the derivation of this lower required IM level hinge on the relative cost advantage of the GoC versus its counterparties. Other sovereigns, with possibly higher levels of capital cost, either as a direct or indirect measure of risk aversion, may prefer a higher optimal IM level, because an exchange of IM would be relatively cheap compared with the high cost of setting aside their own capital. Other cases, where all counterparties enjoy relatively low funding costs, would also prefer a higher optimal IM level as IM exchanges became more attractive.

Ideally, if the IM can be set dealer by dealer, the optimal policy could be achieved. This may, however, not be feasible because:

- Imposing different IM levels by the credit quality of each counterparty prevailing at the time of execution of a new trade may be difficult for official institutions to operationalize.

- In terms of risk sharing, the optimal approach suffers from wrong-way risk, since it appears to reward lower creditworthiness with the benefit of having to post less IM.
- The credit quality of counterparties evolves (improves or deteriorates) over time, but it would be difficult to change the IM clause during the duration of a CCS if their credit qualities change, and yet not rely on external credit ratings.
- Retaining different sets of contractual agreements across counterparties adds an extra level of operational burden.

For these reasons, the optimal IM for official institutions could depend on their circumstances.

4.5   Reconciling required IM amounts

The initial analysis recommends protecting against price movements up to 5.5% of the notional, before taking into consideration the cost and risk trade-offs discussed in this section. However, once the cost and risk trade-offs are considered, given that the GoC observes a distinct funding advantage over its counterparties even with a high cost of capital (risk-averse), a lower IM level than 5.5% is favourable. The wide array of GoC swap counterparties, some of whom may experience relatively high funding costs, allows the GoC to achieve appropriate cost and risk trade-offs with an IM amount of approximately 0 to 1%.

However, recommendations for system-wide required IM amounts from various regulatory bodies may not take into account relative funding advantages among each market participant, or reliance on proper self-insurance, which could result in lower required IM conclusions than we derived from this cost-minimization exercise.

Another discrepancy between the required IM from our analysis and that from regulatory bodies such as the BCBS and IOSCO is due to their assumption that IM for cross-currency swaps is calculated based on the interest rate portion only, exempting the principal exchange portion.

5 Conclusion

Our framework can be used by official institutions (OIs) to assess the appropriate margining policies for portfolios of OTC derivatives.

In the proposed framework, firstly, margining policies under consideration are identified. Secondly, an exposure profile of OTC derivatives portfolios under each policy is obtained by Monte Carlo simulation. Thirdly, the total cost of each margining policy is calculated under many assumptions regarding the OI and its counterparty bank dealers. Lastly, the most desirable margining policy is identified by considering the costs, risks and their trade-offs of different policies.

In the case of Canada, our analysis shows that an asymmetric CSA is unlikely to be the most desirable margining structure, because it carries the highest risk charges and pass-through of bank dealer costs. The symmetric variation margin scenarios have lower risk and, with rehypothecation, result in lower pass-through of both the bank dealers' funding costs and Basel capital charges. The analysis appears to be consistent with the practices of certain OIs, some of which have moved to more symmetric structures.

Close-out risk should be mitigated with the posting of an initial margin from bank dealers. However, mitigating close-out risk (using the IM or alternatives) would increase costs. The optimal margining policy for the GoC is one whereby both the GoC and the bank dealer post a variation margin and allow rehypothecation, and in addition only the bank dealer posts an IM. The optimal amount of IM depends on the bank dealer funding cost and the risk tolerance of the GoC against counterparty credit risk.

Our framework can identify the optimal amount of IM for each bank dealer. The optimal policy of setting IM dealer by dealer, however, may not be feasible for official institutions. Therefore, even if our framework identifies the appropriate margining policy (IM amount), the true optimal policy for OIs could depend on their circumstances.

Appendix A: Regulatory Capital Charges and Libor Market Model

A.1 Abbreviations

BCBS:	Basel Committee on Banking Supervision
CCR:	Counterparty Credit Risk
CCS:	Cross-Currency Swap
CDS:	Credit Default Swap
CSA:	Credit Support Annex
CVA:	Credit Value Adjustment
CVA capital:	Credit Value Adjustment Capital
EE:	Expected Exposure
EEE:	Effective Expected Exposure
EEPE:	Effective Expected Positive Exposure
EONIA:	Euro Overnight Index Average
EPE:	Expected Positive Exposure
GoC:	Government of Canada
HCD:	High-Cost bank Dealer
IM:	Initial Margin
IOSCO:	International Organization of Securities Commissions
LCD:	Low-Cost bank Dealer
MTM:	Mark-To-Market
OCC:	Office of the Comptroller of the Currency
OTC:	Over-The-Counter
VM:	Variation Margin

A.2 Libor Market Model Framework

Monte Carlo simulations are used to determine exposures and the separate amounts of collateral required for the GoC and each counterparty. The cost of posting collateral is then estimated for the GoC and each counterparty. Finally, the total costs for both the GoC and its counterparties are compared among several margining policy options.
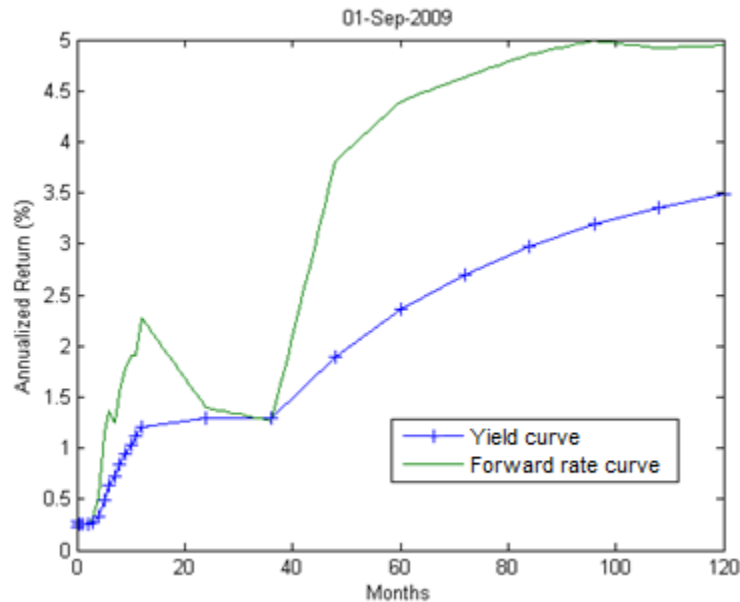
A.2.1 Input data

Pricing cross-currency swaps (CCS) requires modelling of the dynamics of the yield curve term structure. A single curve is used for each currency.

A Libor forward curve is generated using standard bootstrapping methodology (Kenyon and Stamm 2012). The yield curve is fixed on a monthly time grid in order to exactly reprice each market instrument. The market instruments used for bootstrapping are:

- interest rate deposit contracts covering the window from today up to 1 year
- interest rate swap contracts covering the window from 2 years up to 10 years

Intermediate forward rates are obtained by interpolation on the grid of the yield curve. Then, the forward rate curve is generated from the interpolated yield curve. Chart 12 shows a sample forward rate curve.[31]

Chart 12: Sample Forward Rate Curve

A.2.2 Simulation model

In order to simulate possible future valuations, we need a robust and appropriate simulation model. The model must measure both risk factors that affect the potential exposure of cross-currency swaps: interest rates and foreign exchange rates (Pykhtin 2005). Indeed, an appropriate model must be able to meet the criteria set forth in section 3.1.

The Brace, Gatarek and Musiela (1997) model, often referred to as the Libor market model or simply BGM, after its creators, is a multi-factor statistical term-structure model, based on underlying principal factors to describe historical curve movements.[32] It expresses forward rates with the following formula:

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[31] Although this curve differs from those used for pricing, it provides a representative historical sample.

[32] While simpler models exist, they suffer from various drawbacks. For example, the Vasicek (1977) model is simple to calibrate, but could potentially generate negative interest rates, and may face difficulties matching the observed term structure of interest rates. The Hull and White (1990) model is superior to the Vasicek (1977) model in that it has a time-varying drift

$$dF_j(t) = \sigma_j(t)F_j(t)dW_j(t) \quad j=1,\dots n$$

$F_j(t)$: forward rate between times t_j and t_{j+1} at time t

$\sigma(t)_j$: volatility of $F_j(t)$

$dW_j(t)$: Brownian motion process (dW across different js are correlated)

It is flexible in terms of calibration, since the model can perfectly match the term structure of both interest rates and volatility, as observed by market rates. Further, since BGM models the instantaneous growth of the forward rate as a normally distributed variable, it ensures that the forward rate – and consequently the interest rate – itself is strictly non-negative.

A simulation takes each tenor in a yield curve as a random process, and thus can generate a variety of yield curve fluctuations, including parallel shifts, steepening and curve inversions, which are often observed.

The Libor market model is expressed in terms of forward rates (Hull and White 2000):

$$\frac{dF_i(t)}{F_i(t)} = \sum_{j=m(t)}^{i} \frac{\delta_j F_j(t) \sum_{q=1}^{p} \sigma_{i,q}(t)\sigma_{j,q}(t)}{1+\delta_j F_j(t)} dt + \sum_{q=1}^{p} \sigma_{i,q}(t)dz_q \ .$$

$F_i(t)$: Forward rate observed at time t for the period (t_i, t_{i+1}), expressed with a compounding period of δ_i .

p: Number of factors that describe a chosen fraction of the variation of the historical forward curve

$\sigma_{i,q}$: q^{th} component of the volatility of $F_i(t)$

m(t): Index for the next reset date at time t

dz_q: Wiener processes (independent across q)

A.2.3 Multi-currency

Canada's foreign reserves are principally funded by swapping CAD to several foreign currencies (e.g., USD, EUR and YEN). When domestic and foreign interest rate curves are simulated, only forward interest rates are generated, with forward foreign exchange rates being derived as a direct by-product through interest rate parity.[33] Therefore, at each time step, only spot foreign exchange (FX) rates are required to price cross-currency swaps in addition to domestic and foreign forward interest rate curves. To generate spot FX rates, at each time step, short-term forward FX rates (to the next time step) are simulated, and at their expiry (the next time step) are treated as spot FX rates. Here, at each time step the forward FX rates need to be adjusted to satisfy the parity relationship based on the prompt (or next) maturing forward domestic and foreign interest rates. Both domestic and foreign forward interest rates are assumed to have non-stochastic (i.e., deterministic) volatilities (Brace 2008; Cesari et al. 2009).

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term for the short rate that helps it better match the observed term structure, but it still suffers from the drawback that it generates negative interest rates.

[33] Forward exchange rates must generate equal payoffs on equal investments in different currencies.

A.2.4 Calibration to market-observed volatilities

Simulated future exposures should be consistent with real market-observable measures (market quotes), and, when those measures are not available, estimated based on historical data. Market risk factors that affect potential future exposures are interest rates and foreign exchange rates. According to Basel III, a model can be considered an internal model method if it is designed to use the most conservative of either current market conditions or a historical period of market stress.

We choose to estimate the variance-covariance matrix of forward rates based on 261 business days of observed rates during the stress period of 15 September 2008 to 15 September 2009. Historical volatilities estimated using this approach are then recalibrated to match implied volatilities (available from swaption quotes) as the preferred estimate of future volatility, to capture the current market condition (Gregory 2010). The existence of the volatility risk premium may overestimate future volatility, but leads the modelling process to a more conservative result.

To match volatilities used in the simulation model to market-observed implied volatilities, instantaneous volatilities are assumed to be a homogeneous spline function in a parametric form, as (Brigo and Mercurio 2001):

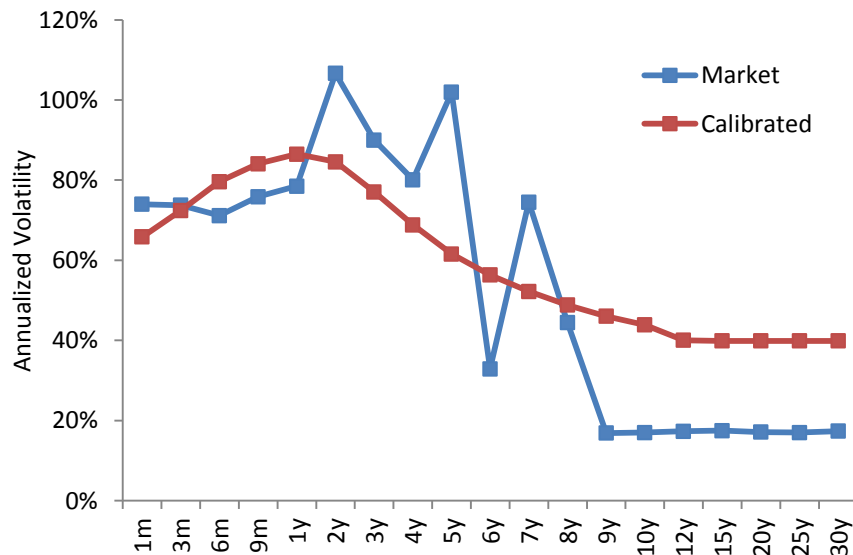$$\sigma_i(t) = [a(T_{i-1} - t) + d] e^{-b(T_{i-1} - t)} + c .$$

The volatility is dependent only on the time to maturity, but not on the maturity itself. With parameters a, b, c and d, the form allows a humped shape as a function of the time to maturity.

Once the instantaneous volatility is defined, average instantaneous variance over time can be calculated as follows:

$$v_i(t) = \sqrt{\frac{1}{T_{i-1}} \int_0^{T_{i-1}} \left([a(T_{i-1} - t) + d] e^{-b(T_{i-1} - t)} + c \right)^2 dt} .$$

The parameters are calibrated so that market volatilities fit to the model volatilities $v_i(t)$ as closely as possible (Chart 13).

Chart 13: Volatility calibration

A.2.5 Pricing function

Once forward interest rates and spot foreign exchange rates are simulated, a cross-currency swap transaction can be priced using standard cash flow analysis.

Each future cash flow is separated for each leg of the cross-currency swap (both the domestic CAD and foreign FX legs). Each leg makes fixed-rate payments at known intervals, modified following business day conventions according to set calendars depending on the geographic region of each swap, or floating-rate payments based on the Libor fixing two days before the payment date, which are estimated from implied forwards on the most recent Libor curve.

Each cash flow has its mark-to-market valuation priced as follows, as the difference between the CAD amount received and the FX amount paid, both evaluated using USD as a base currency:

$$MTM = \frac{USD}{CAD} \sum_{i=1}^{n} \frac{CF_{i,CAD}}{\prod_{j=1}^{i}(1 + F_{j,CAD}\Delta t)} - \frac{USD}{FX} \sum_{i=1}^{n} \frac{CF_{i,FX}}{\prod_{j=1}^{i}(1 + F_{j,FX}\Delta t)}$$

$$\text{where } CF_{i,FX} = \text{cash flow at time i for currency FX}$$

$$FX \in USD, EUR, YEN.$$

The pricing function is validated by comparing model results with those generated by an in-house trade capture and valuation system (Findur[34]).

Future cash flows should be discounted at the rate at which they would be funded. Prior to 2007, the market standard discount rate for swap pricing purposes was Libor funding. However, for collateralized trades, some bank dealers have started using overnight index swap rates to reflect the funding cost or the interest rate paid on collateral. Most GoC counterparties have already begun using overnight index swap rates instead of the Libor discount for swap pricing. However, the simulation model uses Libor for pricing purposes to be consistent with our in-house system.[35]

A.2.6 Exposure estimate

At each time step, the distribution of MTM is estimated. Then, the positive and negative exposures are estimated. The exposures at different confidence levels are estimated, but the relevant inputs to the cost estimate are the expected exposures (EE),[36] effective expected exposure (EEE) and effective expected positive exposure (EEPE) (BCBS 2006).

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[34] Findur is an integrated financial market solution system produced by OpenLink Financial.
[35] The swap valuation results of the model are compared to those of the Bank of Canada's in-house trade capture and valuation system for the validation of pricing function.
[36] This can be considered as the loan equivalent of the swap MTM, measuring the expected amount to be owed.

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