# An Algorithm to Estimate the Total Amount of Collateral Required Before and After Financial Reform Initiatives in Various Regulatory Jurisdictions

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## Introduction

The interactive algorithm attempts to estimate the total amount of collateral that would be required ($A$) to satisfy initial margin requirements for those types of swaps that are currently cleared and will continue to be cleared in the future, perhaps across an increasingly broad base of market participants, ($B$) to satisfy initial margin requirements for those types of swaps deemed clearable after the relevant effective date, ($C$) to provide sufficient collateral to collateralize uncleared OTC swaps entered into after the relevant effective date (independent amount and mark to market amount), and ($D$) to continue to provide sufficient collateral (independent amount and mark to market amount) to collateralize existing uncleared OTC swaps (that will eventually mature) that were entered into prior to the relevant effective date, pursuant to the pre-existing terms that have been bilaterally negotiated. $A$ through $D$ above correspond to the major components of the algorithm, specifically with respect to interest rate, credit default, and foreign exchange swaps (see below). The algorithm also allows for additive factors for Total Collateral to reflect the the additional collateral requirements that would be associated with energy, commodity, weather, and event-driven swaps, as well as exchange-traded futures and options. The algorithm is based upon 10 periods, presumed to be years. Users may elect to modify the number of years. We selected a time horizon of 10 years because we assume that a material proportion of the relevant collateral requirements may accumulate over 10 periods, especially with regard to OTC swaps that may be enacted in distant periods.

## Definitions

**Initial Margin** a.k.a performance bond, or performance collateral is collateral posted by a market participant to protect the counterparty to the trade from loss over and above the protection afforded by Variation Margin (q.v.), should the original counterparty become insolvent during the life of the contract or otherwise be unable or unwilling to perform under the terms of the contract and should the Variation Margin be insufficient to cover the exposure. Initial margin is the term of art used when discussing cleared derivatives instruments, whether exchange traded or OTC.

*The opinions expressed in this paper are those of the authors and may or may not reflect any position of the Federal Reserve Bank of Chicago or of the Board of Governors of the Federal Reserve System.

**Independent Amount** is the same concept as initial margin except that the term independent amount only applies to uncleared OTC swaps that are collateralized and initial margin applies to derivatives of all types that are cleared.

**Variation Margin** is the mark to market amount of a position from period $t$ to period $t+1$. For exchange traded and cleared OTC products, the prices used to revalue positions are determined by the clearing organization (CCP, see below) responsible for clearing the positions. For uncleared OTC positions, each counterparty runs its own proprietary valuation models to determine current prices, and material valuation disputes are subject to resolution procedures between counterparties. For cleared products, market participants holding losing positions are required to pay variation margin in cash. For uncleared OTC positions, mark to market losses are collateralized with collateral (which may wholly or partially be cash) pursuant to the terms of the bilateral ISDA Credit Support Annex (CSA) that governs such collateral.[1]

**The ISDA Master Netting Agreement** (Master Netting Agreement) is a bilateral agreement that reflects the legally binding bilateral netting arrangement between two counterparties. At all times, but most importantly if one of the counterparties were to become insolvent, it prevents the trustee for the insolvent party from retaining those positions that are profitable and disavowing (as debt) those positions that are unprofitable, a practice known colloquially as "cherry-picking." On a mutually agreed upon (but usually daily) basis, there will be a single mark to market valuation of the entire portfolio. One party (the one ahead on the positions of the entire portfolio) will accept collateral (becoming the secured party) and the other party will provide collateral pursuant to the Credit Support Annex that complements the terms of their bilateral Master Netting Agreement.

**Credit Support Annex** (CSA) is an addendum to a Master Netting Agreement, (the parameters of which are negotiated between counterparties) that sets forth which collateral with what haircuts shall be exchanged and with what frequency.

**Rehypothecation** is a right that may be granted optionally by a counterparty that permits a Secured Party to use collateral received as though it were their own, and thus reuse it to provide collateral to other OTC counterparties. Cash collateral, like other cash, has the property of fungibility which means that rehypothecation *per se* may not be a relevant consideration. A depositor will not withdraw the exact cash that was deposited. A Secured Party receiving cash collateral would currently be expected to re-use that cash, unless specifically prohibited from doing so (in which case, see Segregation below).[2] It remains to be seen in the various regulatory jurisdictions if the fungibility of cash has a meaningful impact on its ability (or requirement) to be nonetheless held in custody. OTC collateral within the system tends to get counted over and over again as collateral practitioners report the amount of collateral that they have received or given. Much of that collateral is cash or rehypothecable securities collateral and has been passed along sequentially among collateral practitioners over and over.

The rehypothecation rate should be thought of as the denominator of a quotient

[1] International Swaps and Derivatives Association (ISDA) is a global trade association for OTC derivatives. ISDA developed the master agreement that is the industry standard agreement used for OTC agreements.

[2] While current practice among collateral practitioners is to rehypothecate cash collateral, it is not clear how the various financial reform initiatives of relevant countries will address the practice of rehypothecation or distinguish between cash and non-cash collateral.

where the numerator is the total amount of collateral taken (and counted multiple times). The quotient would provide the actual amount of collateral required, system-wide, to satisfy all participants' collateral obligations, given that rehypothecation is present.

It should be noted however that rehypothecation is neither perfect nor instantaneous. Some collateral that is technically rehypothecable will not in practice be re-used, because it may be of a type for which there is no other practical use. Collateral is generally "at call," and thus Secured Parties may elect not to rehypothecate all collateral to avoid problems associated with recalled collateral which cannot be retrieved expeditiously from a Secured Party.

Lastly, payment and settlement systems for different currencies and securities are generally closed for a substantial part of the global business day, so the effective transfer of rehypothecable collateral may often be delayed one or more business days.

**Segregation** is the practice of requiring a Secured Party to hold collateral (cash or securities) separate from its own assets. Generally, this will preclude rehypothecation. Some financial reform initiatives may require that persons that accept collateral from other persons to secure, margin or guarantee performance on a swap, offer the option for that collateral to be segregated. In doing so, the Secured Party must specifically identify and account for such collateral, by individual counterparty and must place it at a third party custodian location. Unlike rehypothecable collateral, segregated collateral may not be used by the Secured Party as though it were its own; it may only hold the collateral in custody and may only seize that collateral if the specific counterparty fails to perform. Because segregated collateral cannot be rehypothecated, an OTC collateralization regime that requires OTC collateral to be segregated will require far more collateral than one that permits rehypothecation.

**CCP** is a central counterparty, a clearing organization.

**Notional Value** is the stated value of the underlying financial contract that is subject to price movement.

**Compression Ratios** are factors by which notional values are decreased due to multilateral netting of cleared positions.

**The effective date** of the algorithm (for the United States) is one year and one day after the Dodd-Frank Act was signed into law, or July 16th, 2011 (unless amended). Other relevant regulatory jurisdictions will have differing effective dates as to when collateralization or clearing of OTC swaps may be required.

# Assumptions

1. Cash variation margin for exchange traded derivatives contracts is not included in the model. Variation margin always takes the form of cash and represents real profits and losses on open and liquidated derivatives contracts. As a zero sum, it always balances to the penny; for every loser there is a winner.

2. Collateralization requirements for uncleared OTC swaps that were entered into before the relevant effective date will not be altered retrospectively by the relevant financial reform initiative. Bilaterally negotiated terms will remain in effect on these contracts until they mature.

3. The model expects to have 10 periods, generally assumed to be years.

4. It is assumed that the minimum collateralization requirements for uncleared OTC swaps that are entered into after the effective date will be greater than those currently in effect among most counterparties. This will cause a "ramp up" of demand for collateral for these kinds of contracts, especially if minimum independent amounts are substantially higher than current industry practice or if rehypothecation is no longer permitted. This will have a material effect on $C$. It is also possible that different regulatory jurisdictions may have materially different minimum collateralization requirements.

5. The model makes no assumption about whether rehypothecation of independent amounts and variation margin will be permitted in any relevant jurisdiction. If rehypothecation of independent amounts is not permitted the IA-specific rehypothecation factor should be set to 1. If rehypothecation of independent amounts is permitted, this factor should be set to an appropriate value greater than 1. The MTM-specific rehypothecation factor similarly should either be set to 1 if rehypothecation is not permitted or to an appropriate value greater than 1 if it is.

6. The model currently assumes that there is but one CCP for each relevant asset class. It does not yet address the potential increase in aggregate collateral that would likely be necessitated by the potential fragmentation in the clearing of OTC swaps by multiple CCPs per asset class. We hope to address this potential fragmentation effect in a subsequent release of the model.

7. The model provides for clearing of non-spot foreign exchange (FX) contracts. The determination to include FX contracts (or not) as OTC derivatives contracts under the various relevant jurisdictions has yet to be determined. If FX is not included in the relevant jurisdiction, the FX vector of notional principal values should be set to zero. Alternatively, the FX column could be thought of as a placeholder for an additional asset class, deemed relevant in a future period by a relevant regulator.

8. OTC swaps currently being cleared are already subject to the multilateral netting phenomenon commonly known as compression. Therefore, there are no compression factors contained in $A$.

9. It is assumed that for each period, some new types of swaps will be deemed clearable. Thereafter, any new swaps in that type and asset class will need to be cleared. In our model, those types of swaps that were executed prior to the date that that category of swaps was deemed clearable will continue to be collateralized and reflected in $A$ (types of previously cleared swaps) and those new swap types executed after that date will be reflected in $B$ (new types of swaps that must be cleared). Any swaps of the immediately aforementioned type that were executed prior to the relevant effective date would likely be reflected in $D$. One would think that over 10 periods the amount of new *types* of swaps that would be deemed (newly) clearable would decline.

10. The model does not yet reflect the current industry practice of dealer provided portfolio margining between OTC and exchange traded products.

# Model

With these definitions in mind, we develop the following model for estimating the collateral impact of the relevant financial reform regulations. Let

$$
\begin{aligned}
TC_t &= \text{Total Collateral required for derivatives market participants, at time } t \\
&= (1+K)\left[2A_t + 2B_t + C_t + D_t\right] + E_t,
\end{aligned}
$$

where all variables reflect collateral requirements associated with the following:

$$
\begin{aligned}
A_t &= \text{Types of swaps currently cleared} \\
B_t &= \text{New types of swaps cleared after the effective date} \\
C_t &= \text{Uncleared swaps executed after the effective date} \\
D_t &= \text{Uncleared swaps existing prior to the effective date} \\
E_t &= \text{Exchange-traded futures and options} \\
K &= \text{Factor to compensate for additional swap types} \\
&\quad\ \text{(energy, commodity, weather, and event-driven swaps)}
\end{aligned}
$$

Below, we discuss $A$, $B$, $C$, and $D$. We note briefly that $E$ will vary over time, while $K$ is assumed to be constant between 6% and 11%.

Let asset classes be denoted by the index $j$, and let its values be

$$
j = \begin{cases} i & \text{interest rate swaps} \\ c & \text{credit default swaps} \\ fx & \text{foreign exchange swaps} \end{cases}
$$

Let market participant classes be denoted by the index $k$, and let its values be

$$
k = \begin{cases} d & \text{dealer} \\ msp & \text{major swap participant} \\ cp & \text{corporate} \end{cases}
$$

### $A =$ Types of swaps currently cleared

The formula for $A$ reflects the initial margin required for swap types that are cleared as of the effective date. This collateral requirement may increase over time if the estimated notional principal of swap types that are currently cleared increases, that is, that the estimated notional principal of new deals exceeds the estimated notional principal of maturing swaps for any period $t$. The estimated notional principle could also increase if the user assumes that an expanded base of market participants may clear existing swap types in distant periods. The notional principal of these types of currently cleared swaps would decline if the estimated notional principal of maturing swaps exceeded the estimated notional principal of new deals for any period $t$. Note that currently cleared trades are already compressed, so that there is no compression ratio in the equation below. For each period $t$, each asset class $j$, and each market participant class $k$ we compute the product of the notional value and the margin factor for that asset class and market participant class.[3] In symbols,

$$A_t = \sum_{j=i,c,fx} \sum_{k=d,msp,cp} M^{j,k} N_t^{j,k} \tag{1}$$

$A_t$ = amount of collateral held for swap types currently cleared
$M$ = margin factor in (1) applied by participant type and asset class
$N_t$ = total estimated notional value of types of swaps required to be cleared in period $t$, by participant type and asset class, that are required to be cleared as of $t = 0$

$B$ = **New types of swaps cleared after the effective date**

The formula for $B$ reflects the initial margin that will be required for swaps that are deemed clearable after the relevant effective date, but importantly were not required to be cleared before. This collateral requirement may increase over time if the notional principal of swap types that will be required to be cleared in the future increases, that is, that the notional principal of new deals exceeds the notional principal of maturing swaps for any period $t$. The notional principal of these swaps types that will be required to be cleared in the future would decline if the notional principal of maturing swaps exceeded the notional principal of new deals for any period $t$. $B$ would be zero if the relevant regulator did not require that any new swaps types would be required to be cleared beyond the relevant effective date.

For each period $t$, each asset class $j$, and each market participant class $k$, we compute the product of the notional value and the margin factor for that asset class and market participant class multiplied by the compression ratio[4] for that asset class. This is done for each period for new swap types executed after the effective date that are deemed clearable. This will logically be an iterative process, where, in each period, a (presumably) decreasing number of new swaps categories will be deemed newly clearable. $M_{new}$ and $N_{new,t}$ differ from $M$ and $N_t$ in equation (1) since they only apply to swaps that will be deemed clearable after the effective date.[5] In symbols,

$$B_t = \sum_{j=i,c,fx} \sum_{k=d,msp,cp} \frac{M_{new}^{j,k} N_{new,t}^{j}}{cr^j} \tag{2}$$

[3]The formula will require a $3 \times 3$ matrix of data; asset class by market participant class.

[4]For example, the compression ratios for IRS and CDS are believed to be approximately 4.5-to-1 and 13.5-to-1.

[5]For example, the notional principal of N (new,t) is the gross notional principal of all such swaps before novation by the CCP(s) that clear them.

$$
\begin{aligned}
M_{new} &= \text{margin factor in (2) applied by participant type and asset class} \\
N_{new,t} &= \text{total estimated notional value of new types of swaps required to be cleared} \\
&\quad \text{in period } t\text{, by participant type and asset class, that would not have} \\
&\quad \text{been required to be cleared at } t = 0 \\
cr &= \text{compression ratio by asset class (assumed constant in each period)}
\end{aligned}
$$

**$C$ = Uncleared swaps executed after the effective date**

The formula for $C$ reflects collateral that will be required after the effective date to support OTC swaps pursuant to the minimum collateralization standards stipulated by the relevant regulator. Determining the amount of collateral required to collateralize uncleared OTC swaps has two major components, calculating the independent amount and the mark to market amount. The total amount of such collateral may increase over time as new bilateral, non-clearable contracts are executed and will be required to be collateralized at no less than some minimum amount. It may also increase to the degree that regulatory requirements encourage collateralization of bilateral derivatives, will require Independent Amounts, and will require segregation of collateral, potentially increasing the future collateral requirement.

The independent amount (IA) is determined by multiplying the estimated independent amount factor by OTC swap amounts.[6] This is multiplied by 2, recognizing that both counterparties may be required to provide an independent amount. The aggregate independent amount is then divided by an IA-specific rehypothecation denominator. For those relevant jurisdictions that do not permit the rehypothecation of IA for collateralized uncleared swaps executed after the effective date, this factor should be set to 1. The mark to market (MTM) amount is calculated by multiplying the product of estimated market volatility (for that asset class) and a constant, $m_t$,[7] by the estimated notional value for that period, asset class and market participant class.[8] The aggregate mark to market amount is then divided by an MTM-specific rehypothecation denominator. If rehypothecation is not permitted in the relevant regulatory jurisdiction, this rehypothecation factor should be set to 1. In symbols,

$$
C_t = \sum_{j=i,c,fx} \quad \sum_{k=d,msp,cp} \frac{2 \times IA^{j,k} OTC_t^{j,k}}{R_{IA}} + \frac{V_t^j \times m_t^j \times OTC_t^{j,k}}{R} \tag{3}
$$

[6]This would be represented by a $3 \times 3$ matrix with the three asset types going across one vector and the three market participant categories across the other. It is possible that US regulators may proscribe uniform independent amount coverage levels across all market participant categories. Then again, other national authorities that might have an interest in this tool might care to vary the independent amount coverage levels by market participant category. Hence the equation makes accommodation for this possibility.

[7]Constant $m_t$ converts observable or estimated market volatility to the magnitude of the mark to market amount. It can be back tested for accuracy and integrity (by asset class). The relationship between volatility and mark to market amounts may not be linear for credit default swaps, but will be linear for modeling purposes.

[8]While $V_t$ and $m_t$ will not vary across market participant class, this formula requires notional values at that level, hence it might appear that the mark to market portion of the formula is unduly complex. It is only because the data sets necessary to drive this equation necessitate that degree of resolution.

$$
\begin{aligned}
IA &= \text{independent amount factor} \\
OTC_t &= \text{estimated notional value of OTC swaps, by participant type and asset class} \\
V_t &= \text{observable market volatility, by asset class (to calculate MTM)} \\
m_t &= \text{constant applied to volatility, by asset class (to calculate MTM)} \\
R_{IA} &= \text{constant rehypothecation factor applied to IA} \\
R &= \text{constant rehypothecation factor applied to MTM}
\end{aligned}
$$

### $D =$ **Uncleared swaps existing prior to the effective date**

The formula for $D$ reflects collateral that will be required after the relevant effective date to back existing OTC swaps that will mature. $D_0$ represents the baseline amount of collateral currently used to provide credit support for OTC swaps pursuant to the terms of existing CSAs. As these swaps mature, over the 10 periods, there will be a negative growth rate reflecting the gradual maturity of these swaps i.e., the time-varying decay rate, $d_t$.[9] Note that both the independent amount and the mark to market amount may be rehypothecated on swaps existing prior to the effective date, as this is largely consistent with current practice.[10] The rehypothecation factor in equation (4) is the same as $R$, the MTM-specific rehypothecation factor, in equation (3). In symbols,

$$
D_0 = \sum_{j=i,c,fx} \quad \sum_{k=d,msp,cp} \frac{IA^{j,k} OTC_0^{j,k} + V_t^j \times m_t^j \times OTC_0^{j,k}}{R} \tag{4}
$$

$$
D_t = D_{t-1}(1 - d_t) \tag{5}
$$

$$
\begin{aligned}
D_0 &= \text{amount today of collateral held for OTC swaps} \\
IA &= \text{independent amount factor} \\
OTC_0 &= \text{estimated notional value of currently collateralized OTC swaps} \\
V_t &= \text{observable market volatility, by asset class (to calculate MTM)} \\
m_t &= \text{constant applied to volatility, by asset class (to calculate MTM)} \\
R &= \text{constant rehypothecation factor applied to IA and MTM} \\
d_t &= \text{rate of decay (swap maturity) in period } t
\end{aligned}
$$

### $E =$ **Exchange-traded futures and options**

$E_t$ reflects the user's estimate of aggregate initial margin required for exchange-traded futures and options at time $t$ for the relevant jurisdiction.

[9] Should counterparties selectively elect to backload formerly collateralized swaps into cleared swaps, the estimated notional value (by period) would be reflected in the decay factor in equation (5).

[10] This assumption is based upon public statements made by CFTC Chairman Gensler that it would seem unfair to materially change the economic value of existing collateralized instruments, retrospectively.

## Data and Collateral Tool

Below is a list of data required as inputs into the tool which will calculate collateral under a given regulatory regime.

1. Formula (1) for $A$ will require:

   - A $3 \times 3$ Margin Factor matrix (asset types versus market participant types).
   - A $3 \times 3 \times 10$ matrix of estimated notional values of swaps. Data in this matrix vary by asset class, market participant type and period. These values may be automatically generated by using the Automated Entry System, which can apply fixed organic growth rates to notional values over time.

2. Formula (2) for $B$ will require:

   - A $3 \times 3$ Margin Factor matrix (asset types versus market participant types) (same as above).
   - A $3 \times 3 \times 10$ matrix of estimated notional values of swaps that are not currently cleared and will be deemed to be required to be cleared in future periods. Data in this matrix vary by asset class, market participant type and period. These values may be automatically generated by using the Automated Entry System, which can apply fixed organic growth rates to notional values over time.
   - A compression ratio for IRS, CDS and FX which is assumed to be constant across periods.

3. Formula (3) for $C$ will require:

   - A $3 \times 3$ matrix of estimates of independent amounts by asset class and by market participant class. These estimates are presumed to be constant across periods.[11]
   - A $3 \times 3 \times 10$ matrix of estimated notional values of swaps that will be collateralized after the effective date pursuant to the provisions of financial reform legislation. Data in this matrix vary by asset class, market participant type and period. These values may be automatically generated by using the Automated Entry System, which can apply fixed organic growth rates to notional values over time.[12]
   - Estimates of market volatility for IRS, CDS and FX for all periods.
   - A factor that can convert estimates of market volatility into a number that when extended by estimated notional value, would produce an estimate of the mark to market amount for that period and for that asset class. These factors are presumed to be linear and constant across periods.

[11] It is not known if, in the US, minimum collateralization coverage levels (independent amounts) will vary across types of market participants. The model nonetheless provides for this possibility should such be the case in the US or elsewhere where this tool might be deployed.

[12] At a future date and after consulting with leading collateral practitioners, we expect to add a slippage factor to the aggregate independent amount that will be required to collateralize swaps pursuant to the terms of financial reform legislation. This factor would reflect that portion of the aggregate independent amount that will not be subject to segregation requirements and may be rehypothecated. It should be noted that some national authorities that use this tool may have differing regulatory regimes regarding segregation of OTC collateral versus the rehypothecation of same.

- A rehypothecation factor applied to the independent amount component that reflects the number of times that IA is rehypothecated from collateral practitioner to collateral practitioner.
- A rehypothecation factor applied to the mark to market component that reflects the number of times that MTM is rehypothecated from collateral practitioner to collateral practitioner.[13]

4. Formulas (4) and (5) for $D$ will require:

   - A $3 \times 3$ matrix of independent amounts[14] for swaps that are currently cleared under the provisions of existing CSAs. The data in the matrix would vary by asset class and by market participant type.
   - A $3 \times 3$ matrix of notional values of swaps that are currently collateralized pursuant to the provisions of existing CSAs. Data in this matrix vary by asset class and market participant type.
   - A rehypothecation factor that reflects current industry practice. This factor is assumed to be constant across periods.
   - A rate of decay that estimates the term maturity structure of existing collateralized swaps. Not knowing if this factor can be assumed to be constant across asset type, market participant and period, it can be varied by each.

5. $E$ will require:

   - A $1 \times 10$ matrix of initial margin amounts for exchange-traded futures and options. Period 0 will be an actual observation(s) for the relevant jurisdiction. Periods 1 through 9 will be estimates.

[13] For example, a rehypothecation factor of 8 would mean that if 100 survey respondents reported that they each held $10 million in mark to market collateral, ($1.0 billion in total) it would only take $125 million to accomplish this among all 100 respondents.

[14] For example, the typical independent amount required on $100 million notional value.