OCTOBER 2014

MOODY'S ANALYTICS

MODELING METHODOLOGY

Standardized Approach for Capitalizing Counterparty Credit Risk Exposures

Author

Pierre-Etienne Chabanel
Managing Director,
Regulatory & Compliance Solutions

Contact Us

Americas
+1-212-553-1653
clientservices@moodys.com

Europe
+44.20.7772.5454
clientservices.emea@moodys.com

Asia (Excluding Japan)
+85 2 2916 1121
clientservices.asia@moodys.com

Japan
+81 3 5408 4100
clientservices.japan@moodys.com

Summary

In March, 2014, the Basel Committee on Banking Supervision (BCBS) published the final standard on the new standardized approach (SA-CCR) for capitalizing counterparty credit risk associated with OTC derivatives, exchange-traded derivatives, and long settlement transactions. This new method is intended to replace the existing non-internal methods — Current Exposure Method (CEM) and Standardized Method (SM) — which have been criticized for not being risk sensitive. In addition, the IMM shortcut method will be eliminated from the framework once the SA-CCR takes effect which is scheduled for January 1, 2017. Midway between the CEM and SM approaches, the SA-CCR addresses the known deficiencies of both and is designed to maintain a balance between simplicity and risk sensitivity. The SA-CCR approach is calibrated to a stress period. It accurately recognizes the effects of collateralization and provides for a benefit from over-collateralization (margined and centrally cleared transactions). It also gives regard to incentives for centralised clearing of derivative transactions, appropriately accounts for offsetting under legal netting arrangements and minimizes the discretion that can be exercised by national authorities as well as the use of banks' internal estimates.

Similarly to the CEM, under the SA-CCR the exposure at default (EAD) is calculated as the sum of (i) replacement cost (RC), which reflects the current value of the exposure adjusted for the effects of net collateral including thresholds, minimum transfer amounts, and independent amounts; and (ii) potential future exposure (PFE), which reflects the potential increase in exposure until the closure or replacement of the transactions. The PFE portion consists of a multiplier that accounts for over-collateralization and the aggregate add-on derived from the summation of add-ons for each asset class (interest rate, foreign exchange, credit, equity, and commodity), in turn calculated at hedging set level. The paper covers in detail the proposed methodology, and it includes a flow chart of the key steps and illustrations in the appendices.

SA-CCR will also be the required method for calculating exposure size under the large exposures framework, the leverage ratio framework and exposures to central counterparties as specified by BCBS in the respective final standards.

The Basel Committee had initially published a consultative document in June 2013, followed by a joint quantitative impact study (JQIS) to assess the difference in exposure and overall capital requirements between the SA-CCR and the CEM. The final standard takes into account the feedback received from respondents to the consultative paper and the results of the JQIS.

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1. Counterparty Credit Risk Capital

The Basel II counterparty credit risk (CCR) framework for derivatives capitalizes against the risk of losses due to counterparties that default before meeting all their contractual obligations on bilateral transactions.

CCR Capital = (EAD from the bilateral transaction) × (Counterparty risk weight as per Standardized or IRB approach)

EAD is computed at the netting set level over a one-year time horizon. It depends on:

» Bilateral nature of the transaction with the counterparty

» Fluctuations in their market risk factors (such as prices, volatilities, and correlations)

» Legal netting sets and collateral agreements

1.1 Non-Internal Methodologies for EAD Calculation

Currently, apart from the internal model approach (IMM) for calculating EAD, which requires supervisory approval, the following two non-internal model approaches of calculating EAD are available:

1.1.1 Current Exposure Methodology (CEM)

EAD = Max (Current Market Value; 0) + Potential Future Exposure

» Where:
  – Potential Future Exposure (PFE) reflects the potential change in the instrument's market value when the contract is replaced or closed out in the case of a counterparty default.

» PFE at trade level = Notional Amount × Supervisory add-on factor (based on asset class and remaining maturity)

» PFE at netting set level = (0.4 × Agross) + (0.6 × NGR × Agross)
  – where Agross = sum of the individual PFE add-ons for each trade.
  – NGR = net to gross ratio which reflects the current level of hedging and netting benefits.

1.1.2 Standardized Methodology (SM)

EAD = ∑ (Net Exposure for each Hedging Set)

» Within the same hedging set, the delta-equivalent notional amount of each leg of a derivative transaction can offset the other leg.

» A supervisory credit conversion factor (CCF) applies to the net risk position in a hedging set to reflect its potential future change when the contract is replaced or closed out in the case of a counterparty default.

» SM is a more risk-sensitive approach than CEM.

1.2 Limitations of Current Non-Internal Methodologies

» The CEM and SM models provide no differentiation between margined and un-margined transactions.

» The supervisory add-on factors and CCFs do not sufficiently capture the level of volatility observed over the recent stress periods.

» NGR is too simplistic to fully recognize the hedging and netting benefits.

» Delta-equivalent calculations in the standardized method require internal model capabilities.

1.3 Standardized Approach for measuring EAD for CCR (SA-CCR)

The Basel Committee has replaced both the CEM and the SM with a single standardized method (SA-CCR) for measuring EAD for counterparty credit risk. The SA-CCR will apply only to OTC derivatives, exchange-traded derivatives and long settlement transactions and will become effective on 1 January 2017, given the significant change in methodology from the current non-internal model method approaches. SA-CCR will also be the required method for calculating the exposures from derivative transactions (excluding securities financing transactions) under the large exposures framework and the exposures to central counterparties (client exposures and clearing member exposures to central counterparties & clients) as specified in the respective final standards published by BCBS in April, 2014.[1]

The SA-CCR method, while retaining the structure of CEM, is calibrated to a stress period. It recognizes the benefit of collateral and is more reflective of legal netting arrangements. SA-CCR covers a wide variety of derivatives transactions (margined and un-margined, as well as bilateral and cleared), minimizes discretion used by national authorities and banks, and improves significantly the risk sensitivity of the capital framework. Under this approach, the exposure will be calculated as follows:

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

- Where:
  - alpha =1.4 (scaling multiplier as used under IMM approach)
  - RC = replacement cost (for margined / un-margined trades)
  - PFE = multiplier (partial recognition of excess collateral) × Add-on^{agg} (aggregate of asset class add-ons)
- RC and PFE are calculated differently for margined and unmargined netting sets. EAD for a margined netting set is capped at the EAD of the same netting set calculated on an unmargined basis.
  - For un-margined transactions, RC captures the loss due to the default of the counterparty, assuming immediate closure of transactions. The PFE add-on represents any potential increase in exposure from the present up to one year into the future.
  - For margined trades, RC captures the loss due to the default of the counterparty, assuming immediate closure and replacement of transactions. However, closeout of a trade upon a counterparty default may not be instantaneous and there may be a period between closeout and replacement of the trades in the market. The PFE add-on represents the potential change in value of the trades during this period.
  - When determining the RC component of a netting set, banks may net transactions with a counterparty in a currency and value date when meeting specific conditions as specified by Basel.

1.3.1 Replacement Cost *(computed at netting set level)*

For un-margined transactions

$$RC = \max(V - C; 0)$$

- Where:
  - V = the value of the derivative transactions in the netting set
  - C = the net collateral value (no variation margin in case of un-margined transactions) held after haircut
- Haircuts are applied to non-cash collateral to account for the potential change in value of the collateral during the appropriate time period (one year for un-margined trades and the margin period of risk for margined trades)
- When V-C < 0, banks hold excess collateral giving a negative mark-to market value, which will in turn reduce the PFE value by reducing the multiplier

[1] Capital requirements for bank exposures to central counterparties – BCBS final standard
Supervisory framework for measuring and controlling large exposures – BCBS final standard

For margined transactions

$$RC = Max\ (V - C;\ TH + MTA - NICA;\ 0)$$

- Where:
  - V = the value of the derivative transactions in the netting set as defined above
  - C = the net collateral value (includes variation margin) held after haircut
  - TH = positive threshold before the counterparty must send collateral to the bank
  - MTA = minimum transfer amount applicable to the counterparty
  - NICA = net collateral, other than VM (unsegregated or segregated) posted to the bank minus the unsegregated collateral posted by the bank. Collateral that a bank has posted to a segregated, bankruptcy remote account would presumably be returned upon the bankruptcy of the counterparty.
  - (TH + MTA – NICA) represents the largest net exposure, including all collateral held or posted under the margin agreement, that would not trigger a collateral call.
- When multiple margin agreements apply to a single netting set, the netting set should be broken down into sub-netting sets that align with the respective margin agreement for calculating both RC and PFE.
- When a single margin agreement applies to a multiple netting sets:
  - For calculating RC, common collateral (C_{MA}) should be reduced from the sum of netting set un-margined exposures (V_{NS})

$$RC_{MA} = Max\ \{(\textstyle\sum_{NS \in MA} max\ (V_{NS};\ 0)) - C_{MA};\ 0\}$$

  - For calculating PFE, netting set level un-margined PFEs should be calculated and aggregated

1.3.2 PFE Add-ons *(computed for each asset class and then aggregated)*

SA-CCR defines a "hedging set" as a set of transactions within a single netting set which can be partially or fully offset for the purpose of calculating the PFE add-on. Add-on calculations for each asset class are performed first at the hedging set level and then at the asset class level. Depending on the asset class, partial or full offsetting benefits are recognized for long and short positions within a hedging set.

The Basel Committee proposes the following methodologies for calculating the add-ons and forming hedging sets:

- Interest rate derivatives: The hedging set consists of all interest rate derivatives in the same currency. Long and short offsetting are allowed within same maturity. By default, partial offsetting is allowed across maturities. However, banks may choose to not offset positions across maturities.
- Foreign exchange derivatives: The hedging set consists of foreign exchange derivatives that reference the same currency pair, such as USD/Euro. Long and short positions in the same currency pair are allowed to fully offset, but no offset is recognized across currency pairs.
- Credit derivatives: All credit derivatives are considered as a single hedging set. Long and short positions referencing the same entity are allowed to fully offset. Partial offsetting is allowed between long and short derivatives that reference different entities, depending upon a supervisory correlation parameter.
- Equity derivatives: All equity derivatives are considered as a single hedging set. Long and short positions referencing the same entity are allowed to fully offset. Partial offsetting is allowed between long and short derivatives that reference different entities, depending upon a supervisory correlation parameter.
- Commodity derivatives: Four hedging sets will be used (one each for energy, metals, agriculture, and other commodities). Full offsetting is allowed for long and short derivative positions of the same commodity type within a hedging set. Partial offsetting is allowed for derivative positions of different commodity types within a hedging set, depending upon a supervisory correlation parameter. No offsetting is allowed between derivative positions of different hedging sets. Unlike CEM, SA-CCR does not treat

gold derivatives similarly to foreign exchange derivatives. Instead, they are treated as commodity derivatives and placed in the metals hedging set.

» Hedging sets for basis and volatility transactions: For each asset class, basis transactions[2] and volatility transactions[3] will form separate hedging sets in their respective asset classes. These hedging sets will be assigned specific supervisory factors and will follow the hedging set aggregation rules defined for the relevant asset class.

 - All basis transactions denominated in a single currency that belong to the same asset class and reference the same pair of risk factors form a single hedging set. For example, all three-month Libor versus six-month Libor swaps in the same currency form a single basis hedging set.

 - Volatility transactions form hedging sets according to the rules of their respective asset classes. For example, all equity volatility transactions form a single volatility hedging set.

General steps for calculating add-ons

» Trade Classification: For each transaction, the primary risk factor is determined and attributed to one of the five asset classes: interest rate, foreign exchange, credit, equity, or commodity. More complex trades that may have more than one risk factor (such as cross-currency swaps) may be allocated to one or more asset classes.

» Trade-level adjusted notional calculation: The adjusted notional amount based on actual notional or price is calculated at the trade level. When the trade notional amount is not stated clearly / not fixed until maturity, the same has to be determined based on the specific rules specified by Basel.

» For interest rate and credit derivatives, the adjusted notional amount incorporates supervisory measure of duration.

 - For interest rate and credit derivatives, the adjusted notional amount is the product of the trade notional amount in domestic currency, and the supervisory duration SD_i.

 $SD_i = \frac{\exp(-0.05 \times S_i) - \exp(-0.05 \times E_i)}{0.05}$ where S_i[4] and E_i[5] are start and end dates, respectively. SD_i is floored by 10 business days.

 - For foreign exchange derivatives, the adjusted notional amount is the domestic currency value of the foreign currency leg of the contract. If both legs of a foreign exchange derivative are denominated in currencies other than the domestic currency, the leg with the larger domestic currency value is the adjusted notional amount.

 - For equity and commodity derivatives, the adjusted notional amount is the product of the current price of one unit of the stock or commodity and the number of units referenced by the trade.

» Maturity Adjustment: Maturity factor for margined transactions ($MF_t^{(margined)}$) and for un-margined transactions ($MF_t^{(unmargined)}$), reflecting the type of transaction, are applied to the trade-level adjusted notional.

$MF_t^{(unmargined)} = \sqrt{\frac{\min(M_i\,;\,1\text{ year})}{1\text{ year}}}$ where M_i[6] is the remaining maturity of transaction i floored by 10 business days

$MF_t^{(margined)} = \frac{3}{2} \times \sqrt{\frac{MPOR_i}{1\text{ year}}}$ where $MPOR_i$ is the margin period of risk for the margin agreement containing the transaction i

MPOR must be:

 - At least 10 business days for non-centrally-cleared derivative transactions subject to daily margin agreements

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2 A basis transaction is a non-foreign-exchange transaction (i.e. both legs are denominated in the same currency) in which the cash flows of both legs depend on different risk factors from the same asset class

3 A volatility transaction is one in which the reference asset depends on the volatility (historical or implied) of a risk factor

4 M_i of a contract is the latest date when the contract may still be active. If a derivative contract has another derivative contract as its underlying (e.g., a swaption) and may be physically exercised into the underlying contract, then maturity of the contract is the final settlement date of the underlying derivative contract

5 S_i is the start date of the time period referenced by an interest rate or credit contract. If the derivative references the value of another interest rate or credit instrument (e.g. swaption or bond option), the time period must be determined on the basis of the underlying instrument

6 E_i is the end date of the time period referenced by an interest rate or credit contract. If the derivative references the value of another interest rate or credit instrument (e.g. swaption or bond option), the time period must be determined on the basis of the underlying instrument

  - 5 business days for centrally cleared derivative transactions subject to daily margin agreements between clearing members and their clients
  - 20 business days for netting sets consisting of 5,000 transactions that are not with a central counterparty
  - Doubled for netting sets with outstanding disputes consistent with specific conditions

» Supervisory delta adjustment: Applied to the trade-level adjusted notional amount based on the position (long or short) and non-linearity (option, CDO trance or neither), resulting in an effective notional amount that is aggregated at the hedging set level. See Appendix A for supervisory delta-adjustment values.

» Supervisory Factor: A factor specific to each asset class is used to convert the effective notional amount into Effective Expected Positive Exposure (EPE) based on the measured volatility of the asset class. Each factor is calibrated to reflect the Effective EPE of a single at-the-money linear trade of unit notional and one-year maturity. See Appendix A for supervisory factor values.

» Supervisory correlation parameters: Applied only to equity, credit, and commodity derivatives asset classes. The parameters are derived from a single-factor model and specify the weight between systematic and idiosyncratic components. See Appendix A for correlation values.

» Aggregation method: Applied to aggregate the trade-level add-ons to hedging set level and subsequently to asset-class level. For credit, equity, and commodity derivatives, a supervisory correlation parameter is applied to capture important basis risks and diversification.

Add-on calculations for asset classes

	EFFECTIVE NOTIONAL CALCULATION	SUPERVISORY FACTOR APPLICATION	SUPERVISORY CORRELATION PARAMETERS APPLICATION	AGGREGATION
Interest Rate Derivatives	Step 1 → Supervisory duration calculation Step 2 → Trade-level adjusted notional = Trade Notional (domestic currency) × supervisory duration Step 3 → Maturity bucket-level effective notional = Σ(trade-level adjusted notional × supervisory delta × maturity factor) with full offsetting for each maturity bucket (less than one year, between one and five years and more than five years) in a hedging set (same currency)	Add-on for each maturity bucket in a hedging set (same currency) = Maturity bucket-level effective notional amount × interest rate supervisory factor	Hedging set-level add-on = Σ(maturity bucket-level add-on) by aggregating across maturity buckets for a hedging set. Uses either partial offsetting or no offsetting, in which the absolute value of add-on's across maturity buckets are simply aggregated	Simple summation of add-ons for different hedging sets
Foreign Exchange Derivatives	Step 1 → Trade-level effective notional amount = (trade-level adjusted notional × supervisory delta × maturity factor) Step 2 → Currency pair-level effective notional amount = Σ(trade-level effective notional) with full offsetting	Add-on for each currency pair = currency pair-level effective notional amount × supervisory factor (same for all currency pairs)	Hedging set-level add-on = absolute value of currency pair-level add-on	Simple summation of add-ons for different hedging sets

	EFFECTIVE NOTIONAL CALCULATION	SUPERVISORY FACTOR APPLICATION	SUPERVISORY CORRELATION PARAMETERS APPLICATION	AGGREGATION
Credit Derivatives	Consists of a single hedging set. Step 1 → Supervisory duration calculation Step 2 → Trade-level adjusted notional = Trade Notional (domestic currency) × supervisory duration Step 3 → Trade-level effective notional amount = (trade-level adjusted notional × supervisory delta × maturity factor) Step 4 → Entity-level effective notional amount = Σ(trade-level effective notional) for trades referencing the same entity (either a single entity or an index) with full offsetting	Add-on for each entity in a hedging set = Entity-level effective notional × supervisory factor (determined by the reference name's credit rating or grade of index - investment/speculative)	Single-factor model divides the entity level add-ons into systematic and idiosyncratic components weighted by the correlation factor (credit indices' references are treated as single name references with higher correlation factors, leading to higher systemic components)	Aggregation of entity-level add-ons with full offsetting in the systematic component and no offsetting benefit in the idiosyncratic component
Equity Derivatives	Consists of a single hedging set. Step 1 → Trade-level effective notional amount = (trade-level adjusted notional × supervisory delta × maturity factor) Step 2 → Entity-level effective notional amount = Σ(trade-level effective notional) for trades referencing the same entity (either a single entity or an index) with full offsetting	Add-on for each entity in a hedging set = entity-level effective notional × supervisory factor (estimate of individual entity volatility based on estimates of the market volatility of equity indices and beta factor of the entity)	Single-factor model divides the entity level add-ons into systematic and idiosyncratic components weighted by the correlation factor (equity indices' references are treated as single name references with higher correlation factors, leading to higher systemic components)	Aggregation of entity-level add-ons with full offsetting in the systematic component and no offsetting benefit in the idiosyncratic component
Commodity Derivatives	Consists of four hedging sets for broad categories of commodities: energy, metals, agriculture, and other commodities Step 1 → Trade-level effective notional amount = (trade-level adjusted notional × supervisory delta × maturity factor) Step 2 → Commodity-type effective notional amount = Σ(trade-level effective notional) for trades referencing the same commodity type with full offsetting allowed in each hedging set	Add-on for each commodity-type in a hedging set = commodity-type effective notional × supervisory factor	Single-factor model divides the commodity-type add-ons in a hedging set into systematic and idiosyncratic components weighted by the correlation factor	Step 1 → Aggregation of commodity-type add-ons with full offsetting in the systematic component and no offsetting benefit in the idiosyncratic component in each hedging set Step 2 → Simple summation of absolute values of add-ons for the four hedging sets

Add-on aggregation across asset classes

The Basel Committee proposes to not allow any diversification benefit across asset classes and therefore requires simple summation of asset class add-ons.

$$\text{Add-on}^{agg} = \sum \text{Add-on}^{a}$$

Recognition of excess collateral and negative mark-to-market

The Basel Committee takes into account over-collateralization by reducing the PFE. The Committee has introduced a multiplier to the PFE add-on component that decreases as excess collateral increases without reaching zero (the multiplier is floored at 5% of the PFE add-on). The multiplier is also activated when the current value of the derivative transactions is negative. In case of under-utilization, the multiplier is equal to 1.

$$\text{multiplier} = \min\left\{1;\ \text{Floor} + (1-\text{Floor}) \times \exp\left(\frac{V-C}{2 \times (1-\text{Floor}) \times \text{Add-on}^{agg}}\right)\right\}$$

Calibration

The SA-CCR has been calibrated by asset class using a three-step process:

1. An initial calibration established the key volatilities and correlations to be used in each asset class.
2. The initial calibration was compared to the results of a supervisory CCR model for a variety of portfolios.
3. The results of the SA-CCR were compared to IMM results using some banks' internal models.

The SA-CCR is not calibrated to account for certain risk factors, such as implicit volatilities, or certain products, such as exotic trades. As a result, the SA-CCR builds in a level of conservatism to capitalize these factors adequately. The Basel Committee has chosen the number of risk factors to be approximately the same as in the CEM and SM.

Appendix A: Parameter Values

Supervisory Delta-Adjustment Values

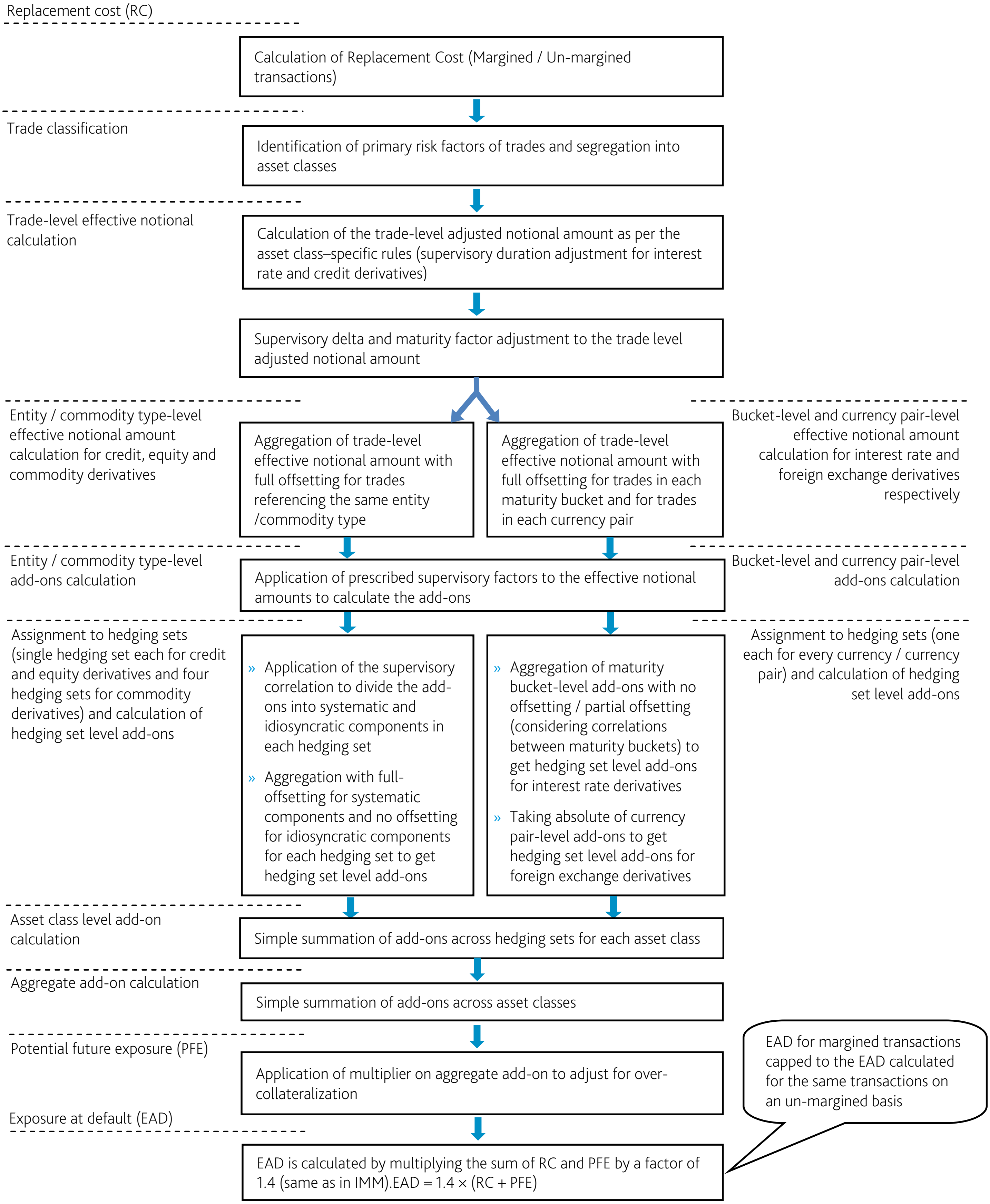
Instrument Type	Long	Short	
Linear instruments (neither options nor CDO tranches)	+1	-1	
Call Options	$+\Phi\left(\frac{\ln(P_i/K_i)+0.5\times\sigma_i^2\times T_i}{\sigma_i\times\sqrt{T_i}}\right)$	$-\Phi\left(\frac{\ln(P_i/K_i)+0.5\times\sigma_i^2\times T_i}{\sigma_i\times\sqrt{T_i}}\right)$	Φ - Standard normal cumulative distribution function P_i : Underlying price (spot, forward, average, etc.) K_i : Strike price T_i : Latest contractual exercise date of the option σ_i : Supervisory volatility of an option (given below)
Put Options	$-\Phi\left(-\frac{\ln(P_i/K_i)+0.5\times\sigma_i^2\times T_i}{\sigma_i\times\sqrt{T_i}}\right)$	$+\Phi\left(-\frac{\ln(P_i/K_i)+0.5\times\sigma_i^2\times T_i}{\sigma_i\times\sqrt{T_i}}\right)$	
CDO tranches	$+\frac{15}{(1+14\times A_i)\times(1+14\times D_i)}$	$-\frac{15}{(1+14\times A_i)\times(1+14\times D_i)}$	A_i : Attachment point of the CDO tranche D_i : Detachment point of the CDO tranche

Supervisory Factor and Correlation Parameter Values

Asset Class	Subclass	Supervisory factor#	Correlation	Supervisory option volatility
Interest rate		0.50%	N/A	50%
Foreign exchange		4.0%	N/A	15%
Credit, Single Name	AAA	0.38%	50%	100%
	AA	0.38%	50%	100%
	A	0.42%	50%	100%
	BBB	0.54%	50%	100%
	BB	1.06%	50%	100%
	B	1.60%	50%	100%
	CCC	6.0%	50%	100%
Credit, Index	IG	0.38%	80%	80%
	SG	1.06%	80%	80%
Equity	Single Name	32%	50%	120%
	Index	20%	80%	75%
Commodity	Electricity	40%	40%	150%
	Oil/Gas	18%	40%	70%
	Metals	18%	40%	70%
	Agricultural	18%	40%	70%
	Other	18%	40%	70%

Supervisory factor of basis transaction hedging set = 0.5 × Supervisory factor of relevant asset class
Supervisory factor of volatility transaction hedging set = 5 × Supervisory factor of relevant asset class

Appendix B: Flowchart Outlining EAD Calculations Under SA-CCR



Appendix C: Maturity, Start Date and End Date for Sample Transactions

INSTRUMENT	M_i	S_i	E_i
Interest rate or credit default swap maturing in 10 years	10 years	0	10 years
10-year interest rate swap, forward starting in 5 years	15 years	5 years	15 years
Forward rate agreement for time period starting in 6 months and ending in 12 months	1 year[7]	0.5 year	1 year
Cash-settled European swaption referencing 5-year interest rate swap with exercise date in 6 months	0.5 year	0.5 year	5.5 years
Physically-settled European swaption referencing 5-year interest rate swap with exercise date in 6 months	5.5 years	0.5 year	5.5 years
10-year Bermudan swaption with annual exercise dates	10 years	1 year	10 years
Interest rate cap or floor specified for semi-annual interest rate with maturity 5 years	5 years	0	5 years
Option on a bond maturing in 5 years with the latest exercise date in 1 year	1 year	1 year	5 years
3-month Eurodollar futures that matures in 1 year	1 year	1 year	1.25 years
Futures on 20-year treasury bond that matures in 2 years	2 years	2 years	22 years
6-month option on 2-year futures on 20-year treasury bond	2 years	2 years	22 years

7 The maturity of 1 year in this example assumes a physically settled FRA. In practice, for a cash settled FRA, the maturity will actually be 0.5 year.

Appendix D: Illustrations

ILLUSTRATION	DERIVATIVES INVOLVED	MARGIN AGREEMENT	COLLATERAL EXCHANGE	REPLACEMENT COST	MATURITY AND/OR CURRENCY MISMATCH	OFFSET BETWEEN MATURITY BUCKETS	LINK
Illustration 1A	Interest Rate	No	No	Positive	Yes	Yes	Netting Set 1A
Illustration 1B	Interest Rate	No	No	Positive	Yes	No	Netting Set 1B
Illustration 2	Credit	No	No	Negative	No	N/A	Netting Set 2
Illustration 3	Commodity	No	No	Positive	N/A	N/A	Netting Set 3
Illustration 4A	Interest Rate & Credit	No	No	Positive	Yes	Yes	Netting Set 4A
Illustration 4B	Interest Rate & Credit	No	No	Positive	Yes	No	Netting Set 4B
Illustration 5A	Interest Rate & Commodity	Yes	Yes	Negative	Yes	Yes	Netting Set 5A
Illustration 5B	Interest Rate & Commodity	Yes	Yes	Negative	Yes	No	Netting Set 5B

Netting Set 1A not subject to a margin agreement
no exchange of collateral at inception

Trade	Nature	Residual Maturity (Y)	Base Currency	Notional (USD)	Pay leg	Receive leg	Market Value (USD)
1	Interest Rate swap	10	USD	10,000,000	Fixed	Floating	30,000
2	Interest Rate swap	4	USD	10,000,000	Floating	Fixed	-20,000
3	European swaption	1 into 10 years	EUR	5,000,000	Floating	Fixed	50,000

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (60{,}000 + 346{,}877.57) = \mathbf{569{,}628.59}$$

$\alpha = 1.4$

RC =max (V – C; 0)
c = 0 because no collateral exchange
v= 30,000 – 20,000 + 50,000 = 60,000
RC = max (60,000 – 0; 0) = **60,000**

PFE = multiplier × Add-on^{agg}
= 1 × 346,877.57
= **346,877.57**

$$\text{multiplier} = \min\left\{1;\ \text{Floor} + (1-\text{Floor}) \times \exp\left(\frac{V-C}{2 \times (1-\text{Floor}) \times \text{Add-on}^{agg}}\right)\right\}$$

= min (1; 0.05 + 0.95 × e(60000 / (2 × 0.95 × 346877.57))
= **1** (If RC is positive, multiplier = 1)

$$\text{AddOn}_j^{(IR)} = SF_i^{(IR)} \times \text{EffectiveNotional}_j^{(IR)}$$

= 0.005 × 69,375,513.04
= **346,877.57**

Asset Class	Supervisory factor
Interest rate	0.50%

$$\text{Effective Notional } D_{jk}^{(IR)} = \sum_{i \in (CCYj,\ MBk)} \delta_i \times d_i^{(IR)} \times MF_i^{(type)}$$

Hedging set	Time Bucket	Adjusted Notional $d_i^{(IR)}$	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Time Bucket level Effective Notional $D_{jk}^{(IR)}$	Hedging Set level Effective Notional $D_{jk}^{(IR)}$
HS 1 (USD)	3	78,693,868.06	1	1	78,693,868.06	59,269,963.46 (Partial offset)
	2	36,253,849.38	-1	1	-36,253,849.38	
HS 2 (EUR)	3	37,427,961.41	-0.27	1	-10,105,549.58	10,105,549.58
						69,375,513.04 (No offset between hedging sets)

$$d_i^{(IR)} = \text{Trade Notional} \times \{\exp(-0.05 \times S_i) - \exp(-0.05 \times E_i)\} / 0.05$$

Trade	Notional Amount	Time Bucket	S_i	E_i	Supervisory Duration SD_i	Adjusted Notional $d_i^{(IR)}$
Trade 1	10,000,000	3	0	10	7.869386806	78,693,868.06
Trade 2	10,000,000	2	0	4	3.625384938	36,253,849.38
Trade 3	5,000,000	3	1	11	7.485592282	37,427,961.41

Trade	δi	Instrument Type
Trade 1	1	linear, long (forward and swap)
Trade 2	-1	linear, short (forward and swap)
Trade 3	$-\Phi\left(\frac{\ln(P_i / K_i) + 0.5 \times \sigma_i^2 \times T_i}{\sigma_i \times \sqrt{T_i}}\right) = -0.27$	sold call option

$$\text{Effective notional}^{(IR)}_{USD} = [(D_{j2}^{(IR)})^2 + (D_{j3}^{(IR)})^2 + 1.4 \times D_{j2}^{(IR)} \times D_{j3}^{(IR)}]^{1/2}$$

$= [(-36{,}253{,}849.38)^2 + 78{,}693{,}868.06^2 + 1.4 \times (-36{,}253{,}849.38) \times 78{,}693{,}868.06]^{1/2}$

= **59,269,963.46**

Netting Set 1B not subject to a margin agreement
no exchange of collateral at inception

no offset between maturity buckets

Trade	Nature	Residual Maturity (Y)	Base Currency	Notional (USD)	Pay leg	Receive leg	Market Value (USD)
1	Interest Rate swap	10	USD	10,000,000	Fixed	Floating	30,000
2	Interest Rate swap	4	USD	10,000,000	Floating	Fixed	-20,000
3	European swaption	1 into 10 years	EUR	5,000,000	Floating	Fixed	50,000

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (60{,}000 + 625{,}266.34) = \mathbf{959{,}372.87}$$

$\alpha = 1.4$

RC =max (V – C; 0)
c = 0 because no collateral exchange
v= 30,000 – 20,000 + 50,000 = 60,000
RC = max (60,000 – 0; 0) = **60,000**

$PFE = multiplier \times Add\text{-}on^{agg}$
$= 1 \times 625{,}266.34$
$= \mathbf{625{,}266.34}$

$$multiplier = \min\left\{1; Floor + (1-Floor) \times \exp\left(\frac{V-C}{2 \times (1-Floor) \times Add\text{-}on^{agg}}\right)\right\}$$
= min (1; 0.05 + 0.95 × e(60000 / (2 × 0.95 × 625266.34))
= **1** (If RC is positive, multiplier = 1)

$$AddOn_j^{(IR)} = SF_i^{(IR)} \times EffectiveNotional_j^{(IR)}$$
$= 0.005 \times 125{,}053{,}267.02$
$= \mathbf{625{,}266.34}$

Asset Class	Supervisory factor
Interest rate	0.50%

$$\text{Effective Notional } D_{jk}^{(IR)} = \sum_{i \in (CCYj,\ MBk)} \delta_i \times d_i^{(IR)} \times MF_i^{(type)}$$

Hedging set	Time Bucket	Adjusted Notional $d_i^{(IR)}$	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Time Bucket level Effective Notional $D_{jk}^{(IR)}$	Hedging Set level Effective Notional $D_{jk}^{(IR)}$
HS 1 (USD)	3	78,693,868.06	1	1	78,693,868.06	114,947,717.44 (No offset)
	2	36,253,849.38	-1	1	-36,253,849.38	
HS 2 (EUR)	3	37,427,961.41	-0.27	1	-10,105,549.58	10,105,549.58
						125,053,267.02 (No offset between hedging sets)

$$d_i^{(IR)} = \text{Trade Notional} \times \{\exp(-0.05 \times S_i) - \exp(-0.05 \times E_i)\} / 0.05$$

Trade	Notional Amount	Time Bucket	S_i	E_i	Supervisory Duration SD_i	Adjusted Notional $d_i^{(IR)}$
Trade 1	10,000,000	3	0	10	7.869386806	78,693,868.06
Trade 2	10,000,000	2	0	4	3.625384938	36,253,849.38
Trade 3	5,000,000	3	1	11	7.485592282	37,427,961.41

Trade	δi	Instrument Type
Trade 1	1	linear, long (forward and swap)
Trade 2	-1	linear, short (forward and swap)
Trade 3	$-\Phi\left(\frac{\ln(P_i / K_i) + 0.5 \times \sigma_i^2 \times T_i}{\sigma_i \times \sqrt{T_i}}\right) = -0.27$	sold call option

$$\text{Effective notional}^{(IR)}_{USD} = |D_{j2}^{(IR)}| + |D_{j3}^{(IR)}|$$
$= |-36{,}253{,}849.38| + |78{,}693{,}868.06|$
$= \mathbf{114{,}947{,}717.44}$

Netting Set 2 not subject to a margin agreement
no exchange of collateral at inception

Trade	Nature	Counterparty	Rating	Residual Maturity (Y)	Base Currency	Notional (USD)	Position	Direction	Market Value ($)
1	Single name CDS	Firm A	AA	3	USD	10,000,000	Protection Buyer	Long	20,000
2	Single name CDS	Firm B	BBB	6	EUR	10,000,000	Protection Seller	Short	- 40,000
3	CDS Index	CDX IG 5y	IG	5	USD	10,000,000	Protection Buyer	Long	0

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (0 + 272{,}313.08) = \mathbf{381{,}238.32}$$

$\alpha = 1.4$

$RC = \max(V - C; 0)$
c = 0 because no collateral exchange
v= 20,000 – 40,000 + 0 = -20,000
RC = max (-20,000 – 0; 0) = **0**

$PFE = \text{multiplier} \times \text{Add-on}^{agg}$
$= .96521 \times 282{,}128.83$
$= \mathbf{272{,}313.08}$

$$\text{multiplier} = \min\left\{1; \text{Floor} + (1-\text{Floor}) \times \exp\left(\frac{V-C}{2 \times (1-\text{Floor}) \times \text{Add-on}^{agg}}\right)\right\}$$

$= \min(1; 0.05 + 0.95 \times e(-20{,}000 / (2 \times 0.95 \times 282{,}128.83)) = .96521$

Systematic Component / Idiosyncratic Component

$$AddOn^{(Credit)} = \left[\left(\sum_k \rho_k^{CR} \times Addon(Entity_k)\right)^2 + \sum_k \left(1 - (\rho_k^{CR})^2\right) \times (Addon(Entity_k))^2\right]^{1/2}$$

Trade	ρ	Addon(Entity$_k$)	$\rho \times$ Addon(Entity$_k$)	$(1-\rho^2)$	$(1-\rho^2) \times (Addon(Entity_k))^2$
Trade 1	50%	105,861.94	52,930.97	0.75	8,405,062,424.65
Trade 2	50%	-279,916.32	-139,958.16	0.75	58,764,860,350.32
Trade 3	80%	168,111.40	134,489.12	0.36	10,174,120,000.53
		Systematic Component	47,461.93	Idiosyncratic Component	77,344,042,775.51

$AddOn^{(Credit)} = ((47{,}461.93)^2 + 77{,}344{,}042{,}775.51)^{1/2} = \mathbf{282{,}128.83}$

Asset Class	Subclass	ρ	SF
Credit, Single Name	AA	50%	0.38%
Credit, Single Name	BBB	50%	0.54%
Credit, Index	IG	80%	0.38%

$$AddOn(Entity_k) = SF_k^{(Credit)} \times EffectiveNotional_k^{(credit)}$$

Trade	Effective Notional	Supervisory factor SF	Addon (Entity)
Trade 1	27,858,404.71	0.38%	105,861.94
Trade 2	-51,836,355.86	0.54%	-279,916.32
Trade 3	44,239,843.39	0.38%	168,111.40

$$\text{Effective Notional}_k^{(Credit)} = \sum_{i \in Entity k} \delta_i \times d_i^{(Credit)} \times MF_i^{(type)}$$

Trade	Adjusted Notional $d_i^{(credit)}$	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Entity Level Effective Notional $D_{ik}^{(IR)}$
Trade 1	27,858,404.71	1	1	27,858,404.71
Trade 2	51,836,355.86	-1	1	-51,836,355.86
Trade 3	44,239,843.39	1	1	44,239,843.39

$$d_i^{(Credit)} = \text{Trade Notional} \times \{\exp(-0.05 \times S_i) - \exp(-0.05 \times E_i)\} / 0.05$$

Trade	Notional Amount	S_i	E_i	Supervisory Duration SD_i	Adjusted Notional $d_i^{(IR)}$
Trade 1	10,000,000	0	3	2.785840471	27,858,404.71
Trade 2	10,000,000	0	6	5.183635586	51,836,355.86
Trade 3	10,000,000	0	5	4.423984339	44,239,843.39

Trade	δ_i	Instrument Type
Trade 1	1	linear, long (forward and swap)
Trade 2	-1	linear, short (forward and swap)
Trade 3	1	linear, long (forward and swap)

Netting Set 3 not subject to a margin agreement
no exchange of collateral at inception

Trade	Nature	Underlying	Residual Maturity	Notional	Position	Direction	Market Value
1	Forward	(WTI) crude OIL	9 months	10,000,000	Protection Buyer	Long	-50,000
2	Forward	(Brent) crude OIL	2 years	20,000,000	Protection Seller	Short	- 30,000
3	Forward	Silver	5 years	10,000,000	Protection Buyer	Long	100,000

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (20{,}000 + 3{,}841{,}154.27) = \mathbf{5{,}405{,}615.98}$$

α = 1.4

RC =max (V – C; 0)
c = 0 because no collateral exchange
v= 100,000 – 30,000 – 50,000 = 20,000
RC = max (20,000 – 0; 0)
= **20,000**

$PFE = multiplier \times Add\text{-}on^{agg}$

= 1 × 3,841,154.27 = **3,841,154.27**

$$multiplier = \min\left\{1;\ Floor + (1-Floor) \times \exp\left(\frac{V-C}{2 \times (1-Floor) \times Add\text{-}on^{agg}}\right)\right\}$$

= min (1; 0.05 + 0.95 × e(20,000 / (2 × 0.95 × 3,841,154.27))
= **1** (If RC is positive, multiplier = 1)

$$Add\text{-}on^{(COM)} = \sum_{j=1}^{n} Addon_{HSj}^{(COM)}$$

= 2,041,154.27 + 1,800,000 = **3,841,154.27**

Systematic Component Idiosyncratic Component

$$AddOn_{HSj}^{(COM)} = \left[\left(\sum_k \rho_{HSj}^{(COM)} \times Addon(Type_k^{HSj})\right)^2 + \sum_k (1-(\rho_{HSj}^{(COM)})^2) \times (Addon(Type_k^{HSj}))^2\right]^{1/2}$$

Hedging Set	Commodity Type	ρ	Addon($Type_k$)	Systematic Component $(\Sigma\rho \times Addon(Entity_k))^2$	$(1-\rho^2)$	Idiosyncratic Component $(1-\rho^2) \times (Addon(Entity_k))^2$	$AddOn_{HSi}$ (Only one commodity type in HS)
Energy	Crude Oil	40%	-2,041,154.27	$(-816{,}461.70)^2$	0.84	$0.84 \times (-2{,}041{,}154.27)^2$	2,041,154,27
Metals	Silver	40%	1,800,000	$(720{,}000)^2$	0.84	$0.84 \times (1{,}800{,}000)^2$	1,800,000

Asset Class	Subclass	ρ	SF
Commodity	Oil / Gas	40%	18%
Commodity	Metals	40%	18%

$$AddOn(Type_k^j) = SF_{Typek}^{(Com)} \times EffectiveNotional_{Typek}^{(Com)}$$

Hedging Set	Commodity Type	Effective Notional	Supervisory factor SF	Addon by HS and Commodity type
Energy	Crude Oil	-11,339,745.96	18%	-2,041,154.27
Metals	Silver	10,000,000	18%	1,800,000

$$Effective\ Notional_{Typek}^{(Com)} = \sum_{i \in Typek} \delta_i \times d_i^{(Com)} \times MF_i^{(type)}$$

Hedging Set	Commodity Type	Trade	Adjusted Notional	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Effective $Notional_{Typek}^{(Com)}$
Energy	Crude Oil	Trade 1	10,000,000	1	$\sqrt{9/12}$= .866025404	.866025404 ×1 ×10,000,000 – 1 × 20,000,000 × 1 = 11,339,745.96
Energy	Crude Oil	Trade 2	20,000,000	-1	1	
Metals	Silver	Trade 3	10,000,000	1	1	10,000,000

$d_i^{(COM)}$ = current price by unit × number of units in the trade

Trade	δ	Instrument Type
Trade 1	1	linear , long (forward & swap)
Trade 2	-1	linear, short (forward & swap)
Trade 3	1	linear, long (forward & swap)

Netting Set 4A not subject to a margin agreement
no exchange of collateral at inception

Trade	Nature	Counterparty	Rating	Residual Maturity (Y)	Base Currency	Notional (USD)	Pay leg	Receive leg	Position	Direction	Market Value (USD)
1	Interest Rate swap			10	USD	10,000,000	Fixed	Floating			30,000
2	Interest Rate swap			4	USD	10,000,000	Floating	Fixed			- 20,000
3	European swaption			1 into 10 years	EUR	5,000,000	Floating	Fixed			50,000
4	Single name CDS	Firm A	AA	3	USD	10,000,000			Protection Buyer	Long	20,000
5	Single name CDS	Firm B	BBB	6	EUR	10,000,000			Protection Seller	Short	- 40,000
6	CDS Index	CDX IG 5y	IG	5	USD	10,000,000			Protection Buyer	Long	0

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (40{,}000 + 629{,}006.40) = \mathbf{936{,}08.96}$$

$\alpha = 1.4$

$RC = \max(V - C; 0)$
c = 0 because no collateral exchange
v= 30,000 – 20,000 + 50,000 + 20000 – 40000 = 40,000
RC = max (40,000 – 0; 0) = **40,000**

$PFE = \text{multiplier} \times \text{Add-on}^{agg}$
= 1 × 629,006.40
= **629,006.40**

$$\text{multiplier} = \min\left\{1; \text{Floor} + (1-\text{Floor}) \times \exp\left(\frac{V-C}{2 \times (1-\text{Floor}) \times \text{Add-on}^{agg}}\right)\right\}$$

= min (1; 0.05 + 0.95 × e(40000 / (2 × 0.95 × 629,006.40))
= **1** (If RC is positive, multiplier = 1)

$$\text{Add-on}^{agg} = \sum \text{Add-on}^{a} = \text{Add-on}^{(IR)} + \text{Add-on}^{(Credit)}$$

(As calculated in Netting Set 1A) (As calculated in Netting Set 2)

= 346,877.57 + 282,128.83 = **629,006.40**

Netting Set 4B not subject to a margin agreement no offset between maturity buckets
no exchange of collateral at inception

Trade	Nature	Counterparty	Rating	Residual Maturity (Y)	Base Currency	Notional (USD)	Pay leg	Receive leg	Position	Direction	Market Value (USD)
1	Interest Rate swap			10	USD	10,000,000	Fixed	Floating			30,000
2	Interest Rate swap			4	USD	10,000,000	Floating	Fixed			- 20,000
3	European swaption			1 into 10 years	EUR	5,000,000	Floating	Fixed			50,000
4	Single name CDS	Firm A	AA	3	USD	10,000,000			Protection Buyer	Long	20,000
5	Single name CDS	Firm B	BBB	6	EUR	10,000,000			Protection Seller	Short	- 40,000
6	CDS Index	CDX IG 5y	IG	5	USD	10,000,000			Protection Buyer	Long	0

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (40{,}000 + 907{,}395.17) = \mathbf{1{,}326{,}353.23}$$

$$\alpha = 1.4$$

$$PFE = \text{multiplier} \times \text{Add-on}^{agg}$$

$= 1 \times 907{,}395.17$
$= \mathbf{907{,}395.17}$

$$RC = \max(V - C; 0)$$

c = 0 because no collateral exchange
v= 30,000 – 20,000 + 50,000 + 20000 – 40000 = 40,000
RC = max (40,000 – 0; 0) = **40,000**

$$\text{multiplier} = \min\left\{1; \text{Floor} + (1-\text{Floor}) \times \exp\left(\frac{V-C}{2 \times (1-\text{Floor}) \times \text{Add-on}^{agg}}\right)\right\}$$

= min (1; 0.05 + 0.95 × e(40000 / (2 × 0.95 × 907,395.17))
= **1** (If RC is positive, multiplier = 1)

$$\text{Add-on}^{agg} = \sum \text{Add-on}^{a} = \text{Add-on}^{(IR)} + \text{Add-on}^{(Credit)}$$

Add-on(IR): (As calculated in Netting Set 1B)
Add-on(Credit): (As calculated in Netting Set 2)

= 625,266.34 + 282,128.83 = **907,395.17**

Netting Set 5A subject to a margin agreement
exchange of collateral at inception

Trade	Nature	Underlying	Residual Maturity (Y)	Base Currency	Notional (USD)	Pay leg	Receive leg	Position	Direction	Market Value (USD)
1	Interest Rate swap		10	USD	10,000,000	Fixed	Floating			30,000
2	Interest Rate swap		4	USD	10,000,000	Floating	Fixed			- 20,000
3	European swaption		1 into 10 years	EUR	5,000,000	Floating	Fixed			50,000
4	Forward	(WTI) crude OIL	9 months		10,000,000			Protection Buyer	Long	-50,000
5	Forward	(Brent) crude OIL	2 years		20,000,000			Protection Seller	Short	- 30,000
6	Forward	Silver	5 years		10,000,000			Protection Buyer	Long	100,000

Margin Agreement	Margin Frequency	Threshold (Th)	Minimum Transfer Amount (MTA)	Independent Amount (IA)	Collateral Currently Held
1	Weekly	0	5,000	150,000	200,000

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (0 + 1{,}342{,}328.56) = \mathbf{1{,}879{,}259.99}$$

$$\alpha = 1.4$$

$$PFE = \text{multiplier} \times \text{Add-on}^{agg}_{margin}$$

$= .95812 \times 1{,}401{,}002.55$

$= \mathbf{1{,}342{,}328.56}$

$$RC = \max(V - C;\ Th + MTA - NICA;\ 0)$$

C = 200,000 (collateral currently held)

V = 30,000 – 20,000 + 50,000 – 50,000 – 30,000 + 100,000 = 80,000

Th + MTA – NICA = 0 + 5,000 – 150,000 = -145,000

RC = max (80,000 – 200,000; –145,000; 0) = **0**

$$\text{Add-on}^{agg} = \sum \text{Add-on}^{a} = \text{Add-on}^{(IR)} + \text{Add-on}^{(COM)}$$

$= 123{,}129.32 + 1{,}277{,}873.23$

$= \mathbf{1{,}401{,}002.55}$

$$\text{multiplier} = \min\left\{1;\ Floor + (1 - Floor) \times \exp\left(\frac{V-C}{2 \times (1-Floor) \times \text{Add-on}^{agg}_{margin}}\right)\right\}$$

$= \min(1;\ 0.05 + 0.95 \times e(-120{,}000 / (2 \times 0.95 \times 1{,}401{,}002.55)))$

$= .95812$

$$\text{AddOn}_j^{(IR)} = SF_j^{(IR)} \times \text{EffectiveNotional}_j^{(IR)}$$

$= 0.005 \times 24{,}625{,}864.21$

$= \mathbf{123{,}129.32}$

Asset Class	Supervisory factor
Interest rate	0.50%

(From Netting Set 1A)

$$\text{Effective Notional } D_{jk}^{(IR)} = \sum_{i \in (CCYj,\ MBk)} \delta_i \times d_i^{(IR)} \times MF_i^{(type)}$$

Hedging set	Time Bucket	Adjusted Notional $d_i^{(IR)}$	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Time Bucket level Effective Notional $D_{jk}^{(IR)}$	Hedging Set level Effective Notional $D_{jk}^{(IR)}$
HS 1 (USD)	3	78,693,868.06	1	$1.5 \times \sqrt{14/250}$	27,933,552.11	21,038,749.96 (Partial offset)
	2	36,253,849.38	-1	$1.5 \times \sqrt{14/250}$	-12,868,839.92	
HS 2 (EUR)	3	37,427,961.41	-0.27	$1.5 \times \sqrt{14/250}$	-3,587,114.25	3,587,114.25
						24,625,864.21 (No offset between hedging sets)

$$\text{Effective notional}^{(IR)}_{USD} = [(D_{j2}^{(IR)})^2 + (D_{j3}^{(IR)})^2 + 1.4 \times D_{j2}^{(IR)} \times D_{j3}^{(IR)}]^{1/2}$$

$= [(-12{,}868{,}839.92)^2 + 27{,}933{,}552.11^2 + 1.4 \times (-12{,}868{,}839.92) \times 27{,}933{,}552.11]^{1/2}$

$= \mathbf{21{,}038{,}749.96}$

$$\text{Add-on}^{(COM)} = \sum_{j=1}^{n} \text{Addon}_{HSj}^{(COM)}$$

= 638,936.61 + 638,936.61 = **1,277,873.23**

Systematic Component — Idiosyncratic Component

$$\text{AddOn}_{HSj}^{(COM)} = \left[\left(\sum_k \rho_{HSj}^{(COM)} \times \text{Addon}\left(\text{Type}_k^{HSj}\right)\right)^2 + \sum_k \left(1-\left(\rho_{HSj}^{(COM)}\right)^2\right) \times \left(\text{Addon}\left(\text{Type}_k^{HSj}\right)\right)^2\right]^{1/2}$$

Hedging Set	Commodity Type	ρ	$\text{Addon}(\text{Type}_k)$	Systematic Component $(\Sigma\rho \times \text{Addon}(\text{Entity}_k))^2$	$(1-\rho^2)$	Idiosyncratic Component $(1-\rho^2) \times (\text{Addon}(\text{Entity}_k))^2$	AddOn_{HSi} (Only one commodity type in HS)
Energy	Crude Oil	40%	-638,936.61	$(-255{,}574.64)^2$	0.84	$0.84 \times (-638{,}936.61)^2$	638,936.61
Metals	Silver	40%	638,936.61	$(255{,}574.64)^2$	0.84	$0.84 \times (638{,}936.61)^2$	638,936.61

Asset Class	Subclass	ρ	SF
Commodity	Oil / Gas	40%	18%
Commodity	Metals	40%	18%

$$\text{AddOn}(\text{Type}_k^j) = SF_{Typek}^{(Com)} \times \text{EffectiveNotional}_{Typek}^{(Com)}$$

Hedging Set	Commodity Type	Effective Notional	Supervisory factor SF	Addon by HS and Commodity type
Energy	Crude Oil	-3,549,647.87	18%	-638,936.61
Metals	Silver	3,549,647.87	18%	638,936.61

$$\text{Effective Notional}_{Typek}^{(Com)} = \sum_{i \in Typek} \delta_i \times d_i^{(Com)} \times MF_i^{(type)}$$

Hedging Set	Commodity Type	Trade	Adjusted Notional	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	$\text{Effective Notional}_{Typek}^{(Com)}$
Energy	Crude Oil	Trade 1	10,000,000	1	$1.5 \times \sqrt{14/250}$	$1 \times 10{,}000{,}000 \times 1.5 \times \sqrt{14/250} - 1 \times 20{,}000{,}000 \times 1.5 \times \sqrt{14/250}$ = -3,549,647.87
Energy	Crude Oil	Trade 2	20,000,000	-1	$1.5 \times \sqrt{14/250}$	
Metals	Silver	Trade 3	10,000,000	1	$1.5 \times \sqrt{14/250}$	3,549,647.87

Netting Set 5B subject to a margin agreement no offset between maturity buckets
exchange of collateral at inception

Trade	Nature	Underlying	Residual Maturity (Y)	Base Currency	Notional (USD)	Pay leg	Receive leg	Position	Direction	Market Value (USD)
1	Interest Rate swap		10	USD	10,000,000	Fixed	Floating			30,000
2	Interest Rate swap		4	USD	10,000,000	Floating	Fixed			- 20,000
3	European swaption		1 into 10 years	EUR	5,000,000	Floating	Fixed			50,000
4	Forward	(WTI) crude OIL	9 months		10,000,000			Protection Buyer	Long	-50,000
5	Forward	(Brent) crude OIL	2 years		20,000,000			Protection Seller	Short	- 30,000
6	Forward	Silver	5 years		10,000,000			Protection Buyer	Long	100,000

Margin Agreement	Margin Frequency	Threshold (Th)	Minimum Transfer Amount (MTA)	Independent Amount (IA)	Collateral Currently Held
1	Weekly	0	5,000	150,000	200,000

$$EAD = \alpha \times (RC + PFE) = 1.4 \times (0 + 1{,}441{,}066.53) = \mathbf{2{,}017{,}493.14}$$

$\alpha = 1.4$

$PFE = \text{multiplier} \times \text{Add-on}^{agg}_{margin}$

$= .96083 \times 1{,}499{,}820.76$

$= \mathbf{1{,}441{,}066.53}$

$RC = \max(V - C;\ Th + MTA - NICA;\ 0)$

C = 200,000 (collateral currently held)

V = 30,000 – 20,000 + 50,000 – 50,000 – 30,000 + 100,000 = 80,000

Th + MTA – NICA = 0 + 5,000 – 150,000 = -145,000

RC = max (80,000 – 200,000; –145,000; 0) = **0**

$\text{Add-on}^{agg} = \sum \text{Add-on}^{a} = \text{Add-on}^{(IR)} + \text{Add-on}^{(COM)}$

$= 221{,}947.53 + 1{,}277{,}873.23$

$= \mathbf{1{,}499{,}820.76}$

$$\text{multiplier} = \min\left\{1;\ Floor + (1 - Floor) \times \exp\left(\frac{V - C}{2 \times (1 - Floor) \times \text{Add-on}^{agg}_{margin}}\right)\right\}$$

$= \min(1;\ 0.05 + 0.95 \times e(-120{,}000 / (2 \times 0.95 \times 1{,}499{,}820.76))$

$= .96083$

$\text{AddOn}_j^{(IR)} = SF_j^{(IR)} \times \text{EffectiveNotional}_j^{(IR)}$

$= 0.005 \times 44{,}389{,}506.29$

$= \mathbf{221{,}947.53}$

Asset Class	Supervisory factor
Interest rate	0.50%

(From Netting Set 1B)

$$\text{Effective Notional } D_{jk}^{(IR)} = \sum_{i \in (CCYj,\ MBk)} \delta_i \times d_i^{(IR)} \times MF_i^{(type)}$$

Hedging set	Time Bucket	Adjusted Notional $d_i^{(IR)}$	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Time Bucket level Effective Notional $D_{jk}^{(IR)}$	Hedging Set level Effective Notional $D_{jk}^{(IR)}$
HS 1 (USD)	3	78,693,868.06	1	$1.5 \times \sqrt{14/250}$	27,933,552.11	40,802,392.04 (No offset)
	2	36,253,849.38	-1	$1.5 \times \sqrt{14/250}$	-12,868,839.92	
HS 2 (EUR)	3	37,427,961.41	-0.27	$1.5 \times \sqrt{14/250}$	-3,587,114.25	3,587,114.25
						44,389,506.29 (No offset between hedging sets)

$\text{Effective notional}^{(IR)}_{USD} = |D_{j2}^{(IR)}| + |D_{j3}^{(IR)}|$

$= |-12{,}868{,}839.92| + |27{,}933{,}552.11|$

$= \mathbf{40{,}802{,}392.04}$

$$\text{Add-on}^{(COM)} = \sum_{j=1}^{n} \text{Addon}_{HSj}^{(COM)}$$

$= 638{,}936.61 + 638{,}936.61 \quad = \mathbf{1{,}277{,}873.23}$

Systematic Component | Idiosyncratic Component

$$\text{AddOn}_{HSj}^{(COM)} = \left[\left(\sum_k \rho_{HSj}^{(COM)} \times \text{Addon}(\text{Type}_k^{HSj})\right)^2 + \sum_k \left(1 - (\rho_{HSj}^{(COM)})^2\right) \times \left(\text{Addon}(\text{Type}_k^{HSj})\right)^2\right]^{1/2}$$

Hedging Set	Commodity Type	ρ	Addon(Type$_k$)	Systematic Component $(\Sigma\rho \times \text{Addon(Entity}_k))^2$	$(1-\rho^2)$	Idiosyncratic Component $(1-\rho^2) \times (\text{Addon(Entity}_k))^2$	AddOn$_{HSi}$ (Only one commodity type in HS)
Energy	Crude Oil	40%	-638,936.61	$(-255{,}574.64)^2$	0.84	$0.84 \times (-638{,}936.61)^2$	638,936.61
Metals	Silver	40%	638,936.61	$(255{,}574.64)^2$	0.84	$0.84 \times (638{,}936.61)^2$	638,936.61

$$\text{AddOn}(\text{Type}_k^j) = SF_{Typek}^{(Com)} \times \text{EffectiveNotional}_{Typek}^{(Com)}$$

Asset Class	Subclass	ρ	SF
Commodity	Oil / Gas	40%	18%
Commodity	Metals	40%	18%

Hedging Set	Commodity Type	Effective Notional	Supervisory factor SF	Addon by HS and Commodity type
Energy	Crude Oil	-3,549,647.87	18%	-638,936.61
Metals	Silver	3,549,647.87	18%	638,936.61

$$\text{Effective Notional}_{Typek}^{(Com)} = \sum_{i \in Typek} \delta_i \times d_i^{(Com)} \times MF_i^{(type)}$$

Hedging Set	Commodity Type	Trade	Adjusted Notional	Supervisory Delta δi	Maturity Factor $MF_i^{(type)}$	Effective Notional$_{Typek}^{(Com)}$
Energy	Crude Oil	Trade 1	10,000,000	1	$1.5 \times \sqrt{14/250}$	$1 \times 10{,}000{,}000 \times 1.5 \times \sqrt{14/250} - 1 \times 20{,}000{,}000 \times 1.5 \times \sqrt{14/250} = -3{,}549{,}647.87$
Energy	Crude Oil	Trade 2	20,000,000	-1	$1.5 \times \sqrt{14/250}$	
Metals	Silver	Trade 3	10,000,000	1	$1.5 \times \sqrt{14/250}$	3,549,647.87

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SP27130