CVA, Regulatory CCR and IM Methodologies

QF622 Credit Risk Models

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Recap and Review

CCR exposure

Key Drivers

- Future uncertainty $\sim$ time value of an option.
- Moneyness of the portfolio $\sim$ intrinsic value of an option.
- Cashflow uncertainty – periodic vs. single and unmatched cashflow.
- Combination of profiles – CCS and physically settled swaptions.
- Netting and collateralisation.

Simulation-based quantification

- Scenario generation – evolution of risk factors: interest rate and FX modelling, other asset classes, and cross-asset correlations.
- Instrument valuation – pricing of portfolios: approximation, interpolation on the grid, and regression-based pricing.
- Portfolio aggregation – application of netting and collateralisation rules: treatment of the MPoR.

CVA

Overview

- Credit value adjustment was originally introduced as an adjustment to the risk-free value of a derivative to account for potential counterparty default.
- More recently, it has become an exit price concept.
- It could be defined as the difference between the value with and without the possibility of counterparty default considered.
- It is predominantly calculated with market-implied parameters (i.e., with risk neutral assumptions).

Components of CVA

Questions to answer

1. Does the counterparty default?
2. If the counterparty defaults, what’s is the exposure at the time?
3. How much of the exposure is lost?

Points to note

- They correspond to probability of default (PD), exposure at default (EAD), and loss given default (LGD).
- CVA could be seen as the price of one of the building blocks – random amount at default.

A credit derivative view of CVA

Recap on random amount at default

$$\hat{D}(t,T) = \mathbb{E}_t\left(\exp\left(-\int_t^\tau r(s)ds\right)\pi\left(\tau\right)\mathbf{1}_{\tau\leq T}\right).$$

Payments like this are akin to a random recovery (or loss) at default. We do need to know the full distribution of τ. Furthermore, the distribution of $\pi\left(\tau\right)$ may be linked to other risk factors.

In the CVA context

$$\underbrace{\mathrm{UCVA}(t)}_{\text{unilateral CVA}} = -\mathbb{E}_t\left(\exp\left(-\int_t^\tau r(s)ds\right)\overbrace{E^+\left(\tau\right)}^{\text{exposure at default time } \tau}\underbrace{\left(1-\pi\right)}_{\text{loss given default}}\mathbf{1}_{\tau\leq T}\right).$$

Direct simulation

Solving the expectation with a Monte Carlo simulation

1. Generate P random times of default τ consistent with the credit spread curve of the counterparty.
2. For each path $i \in \{1, \cdots, P\}$, compute the exposure $E^+(\tau_i)$ and discount back to time t.
3. For each path $i \in \{1, \cdots, P\}$, compute the loss given default (which may itself be random) at time τ.
4. For each path $i \in \{1, \cdots, P\}$, multiply the discounted exposure and loss given default at time τ.
5. Average across all paths.

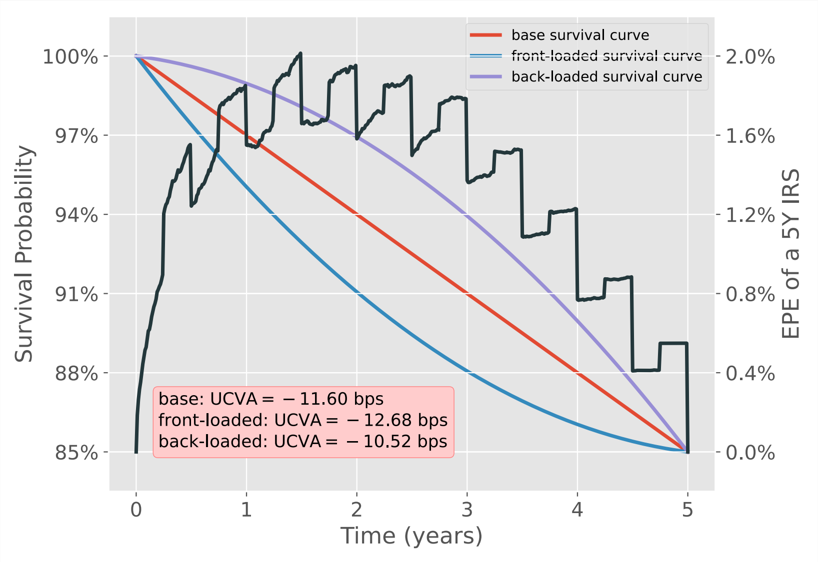
Pathwise simulation

Assuming that credit spread is deterministic and that exposure is independent of default time

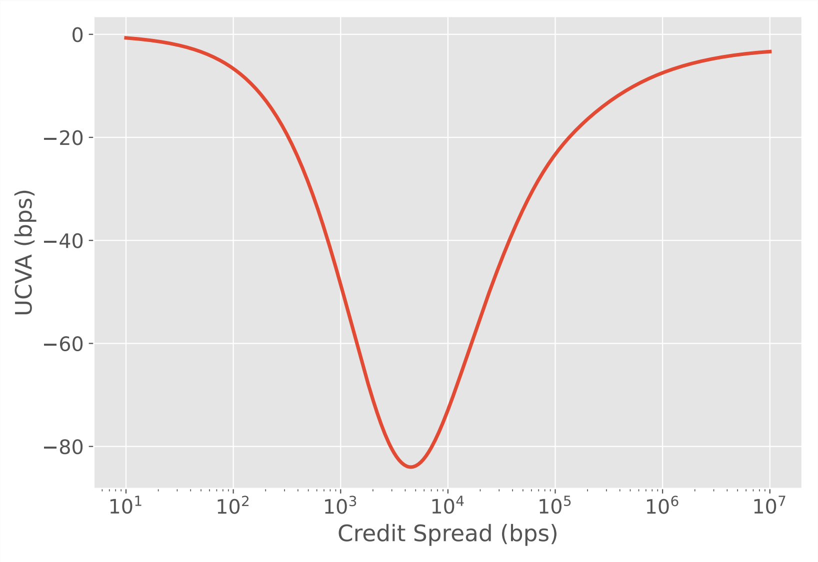
$$
\begin{aligned}
\mathsf{UCVA}(t) &= -\mathbb{E}_t\left(\exp\left(-\int_t^{\tau} r(s)ds\right)E^{+}(\tau)(1-\pi)\mathbf{1}_{\tau\le T}\right)\\
&= -(1-\pi)\int_t^{T}\lambda(u)\exp\left(-\int_t^{u} r(s)+\lambda(s)ds\right)\mathbb{E}_t(E^{+}(u))du\\
&= -\mathsf{LGD}\int_t^{T} Z(t,u)\mathsf{EPE}(u)\,d\left(-Q(t,u)\right)\\
&\approx -\mathsf{LGD}\sum_{i=1}^{m} Z(t,t_i)\mathsf{EPE}(t_i)\mathsf{PD}(t_{i-1},t_i)
\end{aligned}
$$

- The calculation of CVA is straightforward given the EPE profile.
- CVA is essentially a weighted time-average of the EPE profile.

Credit spread effects – term structure



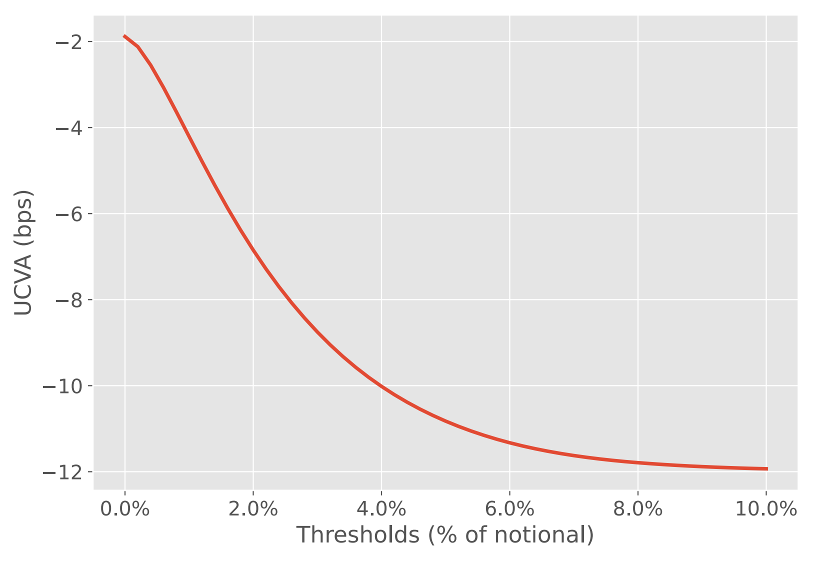
Credit spread effects – level



Impact of margin – overview

- The impact of margin on CVA follows from the impact of margin on exposure.
- Strong collateralisation implies low and even negligible CVA.
- Collateralisation is however not perfect with MPoR.
- Should banks care about CVA of collateralised counterparties (mostly inter-bank counterparties)?
- Initial margin, as a way of over-collateralisation, would further extinguish CVAs.

Impact of margin – example



Wrong-way risk – overview

- The pathwise simulation approach assumes that exposure and default are independent.
- This is equivalent to assuming there is no right-way or wrong-way risk (WWR).
- WWR however is a natural and unavoidable manifestation of the financial market.
- WWR is hard to identify, model and hedge.

Wrong-way risk – examples

Examples of WWR

1. Buying a put option on Bear Stearns from Lehman Brothers.
2. A Singaporean bank trading an FX forward with a Korean bank, paying KRW for SGD.
3. A bank entering into a receiver swap with a corporate when the economy is in recession.
4. Buying a CDS protection on Bear Stearns from Lehman Brothers.
5. Buying a CDS protection on Singapore government from a Singaporean bank.

Wrong-way risk – conditional EPE

Conditional EPE

An obvious way to incorporate WWR into the pathwise simulation approach is to replace unconditional EPE with EPE conditional on counterparty default.

$$\text{UCVA}(t) \approx -\text{LGD} \sum_{i=1}^{m} Z(t, t_i)\text{EPE}(t_i | t_i = \tau)\text{PD}(t_{i-1}, t_i)$$

This is a simple modification to achieve a heuristic treatment of WWR in CVA.

Wrong-way risk – more general approaches

Intensity approach

Credit intensity is stochastic and correlated with market risk factors driving the exposure. Default time is first simulated, with exposures at default calculated for paths where counterparty default occurs.

Copula approach

Given marginals of default time and exposures, a dependence structure is overlaid with a copula. Exposure distributions are re-used.

Jump approach

A more realistic approach for specific WWR, as the value of a contract is likely to jump and a counterparty default happens. This is especially relevant for FX products.

CVA as a spread

As the UCVA could be written as

$$\text{UCVA}(t) = -(1-\pi)\int_t^T Z(t,u)\text{EPE}\left(u\right) d\left(-Q(t,u)\right).$$

By assuming the EPE profile is flat and $\text{EPE} = \dfrac{1}{T-t}\displaystyle\int_t^T \text{EPE}\left(u\right) du$, we have

$$\text{UCVA}(t) = -\text{EPE}(1-\pi)\int_t^T Z(t,u)d\left(-Q(t,u)\right) = -\text{EPE}\times V^{prot}(t).$$

$$\Rightarrow \frac{\text{UCVA}(t)}{\hat{A}(t,T)} = -\text{EPE}\frac{V^{prot}(t)}{\hat{A}(t,T)} = -\text{EPE}\times S_t.$$

CVA could be represented as a running spread of $\text{EPE}\times S_t$.

Debt value adjustment

Going concern

So far we have assumed the party calculating CVA could not default (i.e., UCVA). This is consistent with the going concern concept, i.e., the business will remain in existence.

Exit price and price symmetry

Counterparty charges CVA on the party calculating CVA as well. It follows that if both parties ignore their own credit risk, they will (theoretically) disagree on the credit-adjusted value of the portfolio.

Debt value adjustment (DVA)

DVA is the value adjustment for the party's own credit risk, based on the the party's own credit spread and the ENE of the portfolio.

Bilateral CVA

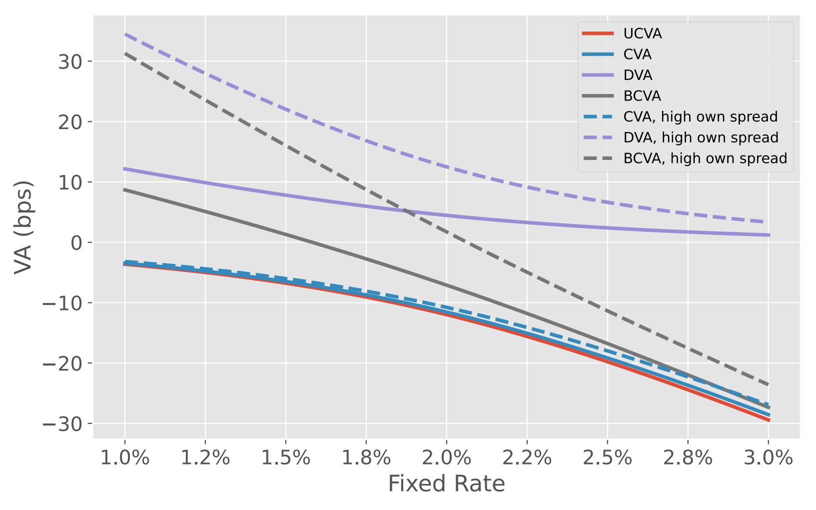
Bilateral CVA

- Bilateral CVA is the sum of CVA and DVA, each of which takes into account both parties' credit risk.
- DVA represents the situation where the party will "make a gain" on the negative exposure if it defaults.
- This gain is the opposite of the loss made by the counterparty.

$$\begin{aligned}
\mathrm{BCVA} &= \mathrm{CVA} + \mathrm{DVA} \\
\mathrm{CVA} &\approx -\mathrm{LGD}_C \sum_{i=1}^{m} Z(t,t_i)\mathrm{EPE}(t_i)\mathrm{PD}_C(t_{i-1},t_i)Q_B(t_{i-1}) \\
\mathrm{DVA} &\approx -\mathrm{LGD}_B \sum_{i=1}^{m} Z(t,t_i)\mathrm{ENE}(t_i)\mathrm{PD}_B(t_{i-1},t_i)Q_C(t_{i-1})
\end{aligned}$$

Bilateral CVA – example

CVA / DVA on a receiver 5Y IRS with different moneyness (2% ATM).



Regulatory CCR Measures

Credit risk capital charge

CCR is capitalised under the Basel framework consistently with other types of credit risk. The capital charge is essentially

$$\mathrm{EAD} \times \mathrm{RW}.$$

Standardised Approach

Risk weights are specified in the regulatory texts and are typically more conservative.

Internal rating-based approach (IRB)

The risk weight is a function of LGD, PD, and an effective maturity.

- Foundation IRB: internal estimates of PD.
- Advanced IRB: internal estimates of PD, LGD, and EAD.

Current exposure method (I)

The "old" standard

Current exposure method (CEM) had been widely used to calculate regulatory capital requirements before being replaced by SA-CCR.

It is based on the idea that EAD may be viewed as the sum of current exposure (CE) and the potential future exposure (PFE):

$$\mathrm{EAD} = \mathrm{RC} + \mathrm{AO}.$$

Current exposure

At the netting set level,

$$\mathrm{CE} = \mathrm{RC} = \max\left(\sum V_i, 0\right).$$

Current exposure method (II)

Potential future exposure

Add-ons are calculated at trade level based on a prescribed look-up table by asset class and maturity, as percentages of trade notional.

At the netting set level,

$$\mathsf{AO} = (0.4 + 0.6 \times \mathsf{NGR}) \sum \mathsf{AO}_i \quad \text{where} \quad \mathsf{NGR} = \frac{\mathsf{RC}}{\sum \max(V_i, 0)}$$

i.e., 60% of the current netting benefit may be recognised for PFE.

Effect of margin

Haircut margin currently held is deducted from the exposure.

Current exposure method (III)

- Simple to calculate and implement, i.e., could even be implemented with a spreadsheet.
- Look-up table for AO lacks granularity and is not risk sensitive.
- Treatments of netting and margin are rather crude.
- More advanced approach based on the same conceptual framework is possible, e.g., for banks' internal use.
- Replaced by SA-CCR, which is based on the same conceptual framework, as part of the Basel III reform.

Standardised approach for counterparty credit – overview

The new standard

Standardised approach for counterparty credit risk (SA-CCR) replaced CEM in the Basel III reform.

Again, EAD may be viewed as a combination of RC and PFE:

$$\mathrm{EAD} = \alpha\left(\mathrm{RC} + \mathrm{PFE}\right),$$

where $\alpha = 1.4$.

Its treatment on netting and margining are more refined and it is more risk sensitive.

SA-CCR – replacement cost (I)

Unmargined netting set

An unmargined netting set may be supported by collaterals, even though VMs are not exchanged. These collaterals are in the form of independent amount or initial margin.

$$\text{RC} = \max\left(V - C, 0\right)$$

where C is the cash-equivalent of net independent collateral amount (NICA) available using a one-year horizon. i.e., collaterals are subject to haircut accounting for one-year volatility.

SA-CCR – replacement cost (II)

Margined netting set

$$\mathsf{RC} = \max\Big(V - \overbrace{C}^{\text{cash-equivalent of collaterals held with a horizon of MPoR}}, \overbrace{\mathsf{TH} + \mathsf{MTA}}^{\text{sum of margin threshold and minimum transfer amount}} - \underbrace{\mathsf{NICA}}_{\text{ICA received offsets exposure while ICA posted increases exposure (unless segregated)}}, 0\Big)$$

where the first term in the max function is the current RC and the second term is the future RC.

ATM assumption

At the netting set level,

$$\mathsf{PFE} = W\left(\frac{V - C}{\mathsf{AO}}\right) \times \mathsf{AO},$$

where AO is calculated assuming the portfolio is ATM and the multiplier W reduces the value of the PFE when the collateral adjusted MtM is negative.

The multiplier

$$W(x) = \min\left(1, F + (1 - F)\exp\left(\frac{x}{2(1 - F)}\right)\right),$$

where $F = 0.05$ representing a 5% floor as $V - C \to -\infty$.

SA-CCR – trade-level addon

adjusted notional specified for asset class a to account for the size of the trade

supervisory factor specified for asset class a, incorporating volatility of primary risk factor

$$\mathsf{AO}_i^{(t)} = \delta_i^{(t)} \times d_i^{(a)} \times \mathsf{S}_i^{(a)} \times \mathsf{MF}_i^{(t)}$$

Delta of the trade, computed with supervisory formula, for its direction and scale of sensitivity to primary risk factor

maturity factor of the trade

SA-CCR – maturity factor

Unmargined trades

$$\mathsf{MF}_i^{(t)} = \sqrt{\frac{\min\left(M_i, 1\right)}{\text{1 year}}}$$

where M_i is the remaining time to maturity of the trade, subject to a floor of 10 business days.

Margined trades

$$\mathsf{MF}_i^{(t)} = \frac{3}{2}\sqrt{\frac{\text{MPoR}}{\text{1 year}}}$$

where MPoR is typically 10 business days for bilateral OTC derivatives.

SA-CCR – aggregation of addon (I)

- Hedging set is the largest collection of trades of an asset class within a netting set for which netting benefits are recognised.
- All trades of a given single-factor subset are driven by the same market factor, so full offset is allowed for such trades.
- Single-factor subsets are aggregated to a hedging-set level assuming imperfectly correlated risk factors.

1. Single-factor subset aggregation: $\mathrm{AO}_j^{(f)} = \sum_{i \in f_j} \mathrm{AO}_i^{(t)}$
2. Hedging set aggregation: $\mathrm{AO}_m^{(h)} = \sqrt{\sum_{j,k \in h_m} \rho_{j,k} \mathrm{AO}_j^{(f)} \mathrm{AO}_k^{(f)}}$
3. Netting set aggregation: $\mathrm{AO} = \sum_m \left| \mathrm{AO}_m^{(h)} \right|$

SA-CCR – aggregation of addon (II)

The framework is flexible enough to allow different levels of granularity. However, as per regulatory texts

- IR: one hedging set per currency, for each of which there are three single-factor subsets by maturity.
- FX: one hedging set per currency pair, each of which has a sole single-factor subset.
- CR/EQ: one single hedging set, where trades referencing the same entity are in a single-factor subset.
- CM: four hedging sets, namely energy, metals, agricultural and other, where trades referencing the same type of commodities (say copper or oil) are in a single-factor subset.

Internal model method – overview

- Internal model method (IMM) is the most advanced and risk sensitive approach for EAD measurement in the Basel framework.
- With an IMM approval granted by the regulator, a bank could use internal models to calculate EAD.
- Apart from being less punitive, it aligns regulatory capital to internal risk management tools.
- Even though internal models could produce time profiles of exposures, EAD is a single number to be plugged into the credit risk capital framework.

Internal model method – expsoures (I)

- Expected exposure (EE): the expected positive exposure.
- Expected positive exposure (EPE): the time-average of EE over the first year,

$$\text{EPE} = \sum \text{EE}_{t_k} \times \Delta t_k.$$

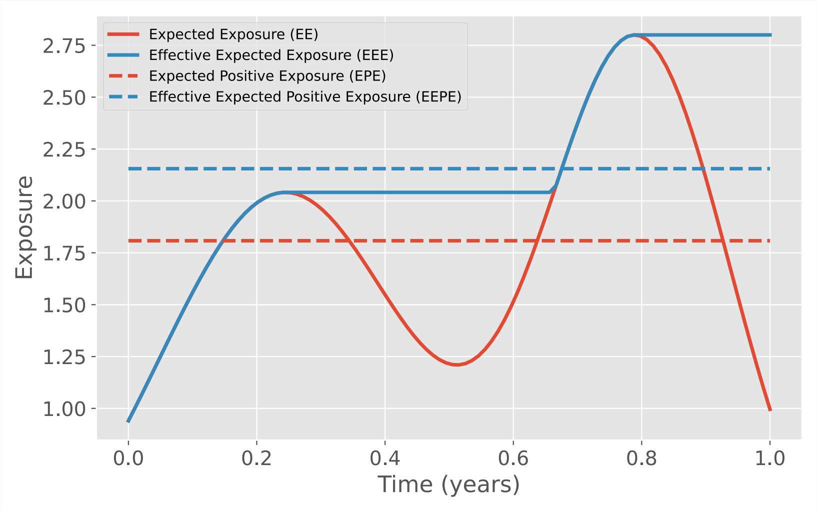
- Effective EE (EEE): the maximum EE that occurs at a specific date or any prior date,

$$\text{EEE}_{t_k} = \max\left(\text{EEE}_{t_{k-1}}, \text{EE}_{t_k}\right).$$

- Effective expected positive exposure (EEPE): the time-average of EEE over the first year,

$$\text{EEPE} = \sum \text{EEE}_{t_k} \times \Delta t_k.$$

Internal model method – expsoures (II)



Assumptions & alpha (I)

Underlying assumptions

- An infinitely large portfolio (number of counterparties) of small exposures, i.e., infinite diversification.
- Exposures are not correlated.
- There is no wrong-way or right-way risk.

None of these is realistic! So the EEPE is further scaled up:

$$\text{EAD} = \alpha \times \text{EEPE}.$$

Doesn't this look familiar?

Assumptions & alpha (II)

What's this magic number for?

Alpha is intended to correct the economic capital calculated assuming the exposure profile of each counterparty is fixed to align with the one calculated with full simulation, i.e., without making the aforementioned assumptions.

Values of alpha

- The default value is 1.4, which was calibrated in early 2000's.
- Banks may compute their own estimate of alpha subject to the regulatory approval and a floor of 1.2.
- The regulator may impose addon to alpha on a bilateral basis.

Back-testing (I)

Back-testing as a validation tool

- Back-testing is a form of outcome analysis, where the actual outcome is compared with model estimations.
- Within the Basel framework, the back-testing of market risk VaR is long established.

Back-testing of market risk VaR

- VaR is defined as the worst possible loss of 1-day horizon at the 99th percentile of confidence level.
- Realised P&L is compared with VaR of the previous day. If the realised loss is greater than VaR, an exception is recorded.
- On average, 2-3 exceptions are expected by the law of large numbers, if the model is accurate.

Back-testing (II)

Back-testing CCR models

Although the back-testing of VaR is fully specified in the Basel framework, the back-testing for IMM is far less well-defined.

- Multiple time horizons need to be considered. The need to test longer horizons means serial correlation and portfolio aging must be considered.
- Which one is the representative portfolio? There is one for each counterparty. How about hypothetical portfolios?
- What metrics to test? Risk factor level? PFE as a quantile-based measure (as VaR is but it is not used anywhere in IMM)? And how to back-test EE?

CVA capital charge

- CCR capital charge is part of the credit risk capital framework, accounting for default risk.
- CVA capital charge is part of the market risk capital framework, accounting for credit spread risk.
- It was introduced post GFC, as banks suffered from losses due to counterparty credit spread widening rather than just defaults.
- Currently, a standardised and an advanced approaches are available – to be replaced by a basic (BA-CVA) and a standardised (SA-CVA) approaches.

More on this later.

Initial Margin Methodologies

Overview

Purpose of initial margin

IM covers potential future exposure for the expected time between the last VM exchange and the liquidation of positions on the default the counterparty.

Components of IM calculation

1. Confidence level for the potential future exposure: the 99th percentile is the typical value.
2. Time horizon corresponding to the MPoR: 10 days for typical counterparty portfolios, 5 days for centrally cleared portfolios.

Simple appproaches

Example

For a single transaction, assuming the value of the trade follows a normal distribution with volatility σ. Given a confidence level $\alpha = 99\%$ and a one-day time horizon, the initial margin is

$$\mathrm{IM} = \Phi^{-1}(\alpha)\,\sigma\sqrt{\mathrm{MPoR}}.$$

Limitations

- The assumed distribution may not capture the tail behaviour.
- More complex transactions cannot be accounted for.
- Co-dependence across transactions is hard to incorporate.

Stress testing approaches

Example

For a portfolio of options and futures written on an equity index, a set of joint spot-volatility scenarios may be defined corresponding to typical and stressed daily moves. The portfolio is revalued under all scenarios with IM being the P&L of the worst scenario.

Remarks

- Suitable for exchange-traded portfolios of futures and options.
- Account for portfolio effects for trades on a single underlying.
- Hard to extend to OTC derivative portfolios which are typically high-dimensional.

VaR and Expected Shortfall – motivation

Revisting the components of IM

1. Confidence level for the potential future exposure: the 99th percentile is the typical value.
2. Time horizon corresponding to the MPoR: 10 days for typical counterparty portfolios, 5 days for centrally cleared portfolios.

IM is essentially a market risk measure, which could be quantified with traditional market risk models such as VaR and expected shortfall (ES).

VaR and Expected Shortfall – comparison (I)

VaR vs. ES

- VaR is a point measure corresponding to a percentile.
- ES is average loss provided that the loss is above a percentile.
- VaR is a point in the tail while ES is expected value of the tail.
- VaR is much easier to back-test than ES.
- VaR is not a coherent risk measure while ES is.
- VaR is theoretically not sub-additive.

VaR and Expected Shortfall – comparison (II)

Scenarios	Portfolio A	Portfolio B	Portfolio C	Total
Scenario 1	-10	50	10	50
Scenario 2	-20	80	30	90
Scenario 3	-30	-120	-30	-180
Scenario 4	-40	-100	-40	-180
Scenario 5	-50	-90	-20	-160
VaR (80%)	-40	-100	-30	-180
ES (80%)	-45	-110	-35	-180

- VaR(A+B+C) $= -180$, VaR(A) $+$ VaR(B) $+$ VaR(C) $= -170$
- ES(A+B+C) $= -180$, ES(A) $+$ ES(B) $+$ ES(C) $= -190$
- Trade 3 portfolios with 3 CCPs or trade all portfolios with 1 CCP?

Historical simulation – overview

“The method” for VaR/ES modelling

- Historical simulation is one of the three methods listed in text books for VaR calculations.
- In practice, it is the most widely used method for computing market risk VaR by far.
- Conceptually simple and self-consistent: the joint return of risk factors are taken from historical data with a look-back period.
- The fundamental assumption is that the history will repeat itself, or in other words, market will behave in the same way as it has in the past.

Historical simulation is widely used by CCPs for calculating IMs.

Historical simulation – steps

Simulation steps

1. Select a set of risk factors that jointly drive the value of the portfolio – risk factor coverage.
2. Calculate daily perturbations of risk factors over a look-back period – modelling of return and choice of look-back window.
3. Apply each set of daily perturbations to the risk factors and revalue the portfolio – portfolio revaluation.
4. Calculate the VaR or ES from the loss distribution built from the previous step.

Historical simulation – modelling of returns

Relative returns

For a risk factor with current value of x, the perturbed value with historical scenario s is

$$x^s = x \times \frac{x_{s+1}}{x_s}$$

where x_s and x_{s+1} are the starting and closing value of the risk factor for the historical scenario s.

Absolute returns

For a risk factor with current value of x, the perturbed value with historical scenario s is

$$x^s = x + (x_{s+1} - x_s)\,.$$

Historical simulation – example

- The modelling of returns has a material impact.
- Relative vs. absolute $\sim$ lognormal vs. normal.
- Is the value of the risk factor naturally bounded by zero?
- How about regime changes?

Historical Data		Historical Return		Current	Simulated Value	
Starting	Closing	Abs	Rel		Abs	Rel
3.00%	3.40%	0.40%	13.33%	1.50%	1.90%	1.700%
3.40%	3.90%	0.50%	14.71%	1.50%	2.00%	1.721%
3.90%	3.00%	-0.90%	-23.08%	1.50%	0.60%	1.154%
3.00%	2.50%	-0.50%	-16.67%	1.50%	1.00%	1.250%

Historical simulation – lookback period

1. Jumpy if too short, unrepresentative if too long.
2. Insufficient data points to build the loss distribution, too many portfolio revaluations if too long.
3. Regulatory requirements.

- How quickly should a crisis drop off from the look-back period?
- Think of the 2007-08 GFC or the 2020 Covid period.
- We never have the benefit of hindsight.

Historical simulation – liquidity horizon / MPoR

Example

Assuming that we need to calculate a 10-day VaR or IM and we have a look-back period of 3 years, i.e., 750 business days.

- Using non-overlapping 10-day returns, we only have 75 scenarios to build the loss distribution.
- Using overlapping 10-day returns, we face the problem of auto-correlation.
- Using 1-day returns and scale the VaR by $\sqrt{10}$ is what many do although a bit crude.

Historical simulation – responsiveness

The responsiveness of the model may be controlled by

- The length of look-back period.
- The weighting of scenarios, i.e., assigning more weights to the more recent scenarios.
- The scaling by volatility, i.e., scale the scenario P&L by the ratio of volatility between its current level and historical level.

- We would like the model to respond quickly when a crisis hits. But how quickly should it drop off?
- Scenario weighting and volatility scaling are both controlled by an additional parameter. How should we set it?

Historical simulation – procyclicality

Responsive vs. stable and conservative

- A responsive model produces IM that is high during crisis (i.e., when volatility is high) and low during quiet times.
- The lower IM encourages more risk taking at good times which would be hit hard by the higher IM during crisis. This procyclicality could lead to contagion.
- The alternative is to set IM at the higher through-the-cyle levels, which is less sensitive to the current market condition.

More on this later.

Bilateral initial margin

IMs in uncleared market

- IMs are exchanged in the uncleared OTCD market.
- The amount could be based on a standard margin schedule or an internal model.

Model requirements

- Covers 99-th percentile confidence level with 10-day MPoR.
- Calibrated to a data period of no more than 5 years including a period of stress.
- Stress period should be identified per asset class and data should be equally weighted for model calibration.
- Large and discrete calls for initial margin should be avoided.

ISDA Standard Initial Margin Model – motivation

Do internal models agree with each other?

- They simply do not – see annual benchmarking exercises conducted by the European Banking Authority (EBA).
- Using different internal models for IMs may lead to persistent disputes between counterparties.
- Coordinated by ISDA, a group of banks developed a standard initial margin model (SIMM).
- The methodology is influenced by the new standardised approach for market risk in the Basel framework.
- The model was set meet a list of criteria: non-procyclicality, ease of replication, transparency, quick to calculate, extensible, predictability, costs, governance, and margin appropriateness.

ISDA SIMM – overview of methodology (I)

- SIMM is based on the variance-covariance approach for VaR, yet another classical method in found in textbooks.
- Four product classes with no diversification benefit.

$$\mathsf{SIMM} = \mathsf{SIMM}_{\mathsf{IRFX}} + \mathsf{SIMM}_{\mathsf{CR}} + \mathsf{SIMM}_{\mathsf{EQ}} + \mathsf{SIMM}_{\mathsf{CM}}$$

- Six risk classes with diversification, including interest rate, credit (qualifying), credit (non-qualifying), equity, commodity, and FX. Within each product class,

$$\mathsf{SIMM}_{\mathsf{P}} = \sqrt{\sum_r \mathsf{IM}_r^2 + \sum_r \sum_{r \neq s} \psi_{r,s} \mathsf{IM}_r \mathsf{IM}_s}$$

ISDA SIMM – overview of methodology (II)

- The margin for each risk class is the sum of delta margin, vega margin, and curvature margin.

$$\mathrm{IM}_r = \mathrm{IM}_r^{(\mathrm{Delta})} + \mathrm{IM}_r^{(\mathrm{Vega})} + \mathrm{IM}_r^{(\mathrm{Curvature})}$$

- For the group of risk factors in a risk class, risk sensitivities across trades are netted at the risk-factor level.
- Net risk sensitivities are risk weighted at the risk-factor level and aggregated with correlations to the risk-class level.
- The SIMM is essentially a nested sequence of small variance-covariance aggregations.
- Re-calibrated annually with the most recent 3-year of data and a 1-year of stress data.

Further Reading

1. John Gregory. *Counterparty Credit Risk and Credit Value Adjustment*. Wiley, 2010.

   Chapters 12, 13, and 17