LCH The Markets' Partner

# Basis Risk Add-on

## Technical Information Pack

LCH SwapClear

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# Introduction

This document is the technical specification of the LCH SwapClear Initial Margining model extension with the Basis Risk add-on.

It should be noted that the PAIRS methodology produces Initial Margin, which is the first of a number of safety mechanisms employed by SwapClear. Others include the Basis Risk add-on, Liquidity margin, credit multiplier.

This technical specification provides details of the Basis Risk add-on calculation, enabling the algorithm to be replicated.

Section 2 describes risk exposures which are considered in the methodology. Section 3 explains the Basis Risk add-on approaches used to calculate the Basis Risk add-on. First two approaches ( IM approaches) are model where Swapclear extend the number of risk factors used in the original IM model and revalue the initial margin calculation using the PAIRS methodology with a small modification of the parameters.
The third approach is a more complex calculation including methodology for calculation of Netted basis risk

# 1. Risk Definition

## 1.1 Tenor Basis Risk

### 1) Netted Basis risk

Basis risk arises from netting positions across different curves when calculating IM. To demonstrate this consider the below portfolio with EUR 1M and EUR 3M risk. (all figures shown in EUR). Taking a PV01 predict approach for simplicity, the IM calculation is based on the total EUR PV01 i.e. net across the 1M and 3M tenors.

| | EUR 1M | EUR 3M | Total | WCL Scenario | Scenario P&L |
|---|---|---|---|---|---|
| 2Y | -16 | 16 | 0 | 2.43 | 0 |
| 5Y | -140 | 130 | -10 | 14.04 | -140.4 |
| 10Y | -9220 | 9110 | -110 | 16.45 | -1809.5 |
| **Total** | **-9376** | **9256** | **-120** | | **-1949.9** |

The above example depicts a 1m v 3m basis swap. The IM charged only reflects the different payment schedules when priced against the same standard curve. As the risk is offsetting and the spread between 1M and 3M trades is not accounted for, margin levels are very low. Basis positions potentially have material risk, particularly during periods of market stress where the spread between tenors can widen significantly and have an increase in price volatility, as seen post 2007 during and after the Lehman Brothers crisis. If basis spreads widen (or narrow) basis positions such as these could have a negative P&L impact.

This potential loss on the tenor basis positions due to spread changes is not captured in the IM model. The IM model should be an accurate reflection of the potential probable future losses for the portfolios cleared. Not capturing this risk could result in LCH having to take a material loss against IM and the default fund. Therefore, basis risk needs to be captured and priced into the IM charged to members and clients. The following pages (section 2.3.1) outline a method for calculating this additional cost to address the potential under margin of basis risk in the IM model.

### 2) Reference Curve Risk

Reference curve risk arises from using one standard curve to calculate the risk and returns for trades in a particular currency and index regardless of fixing periodicity i.e. tenor. This creates a pricing mismatch in the IM calculation from pricing cash flows based on the standard curve rather than the relevant tenor curve e.g. in the case of EUR 3M cash flows, pricing based on 6M rather than 3M curve. This could potentially causes losses from the different behaviour of the two curves.

Now, consider two trades, EUR 3M trade and EUR 6M trade. Calculating IM separately for both trades using the relevant tenor curve gives fairly similar results. Therefore it is inappropriate to penalise for trading an outright EUR 3M trade and to charge for Reference curve risk. The stress approach explained later will exclude the impact of this risk.

## 1.2 OIS discounting Risk

SwapClear maintains the VM methodology to value NPV using rates from OIS curves for discounting of future cash flows. This produces market risk exposure to the OIS curve generally called OIS discounting risk.
As LCH maintains a single curve methodology in its IM model, where there is one standard curve for calculating both the forward rates and the discount rates for valuation. Thus, all the discounting

risk is on the same curve as the forward risk in IM valuation and the only OIS risk exposure is generated by OIS products. There is therefore LIBOR-OIS basis risk exposure to the size of the OIS discounting risk.

## 2. Basis risk margin approaches

Two approaches presented in this paper are utilised in the calculation of the Basis risk add-on.

1) IM approach.
In this approach, SwapClear incorporates new risk exposures and risk factors in the IM valuation. The approach is further split into two parts:

- OIS IM approach – revaluates IM incorporating all OIS discounting risk into calculation.
- Tenor curves IM approach – revaluates IM incorporating tenor basis curve risk factors.

2) Standalone Stress Approach.
Decouples the tenor basis risk from interest rates risk where tenor basis risk positions are stressed with historical series of 5 days basis spread returns. Netted Basis Risk is used to estimate exposure to the tenor basis risk (see below for details).

## 2.1 OIS IM approach

This incorporates OIS discounting risk into the current IM framework. The current scope is set up for major four currencies, EUR, GBP, USD, JPY and one minor currency MXN. SwapClear will keep this under review and may add other currencies.
The discounting curve for the MXN is not built of MXN OIS rates as there is no OIS market for MXN. It is built as implied discounting curve using cross currency basis spreads and FX Swap points for USD-MXN market. For further details refer to the SwapClear Zero Coupon Rate Curve Construction Methodology document.

Outright zero delta ladders calculated in the VM framework for all the above currencies including Libor/Euribor deltas are used and aligned to the IM fixed grid. It is done by a re-bucketing of the deltas from the VM maturity pillars to the IM fixed grid using linear time apportionment of deltas from VM to IM, which reflects the different number of pillars and different number of days to maturity between these two valuation frameworks. Also all the tenor curve delta ladders for each currency are aggregated to one ladder and added to the standard curve delta ladder (e.g. for EUR all the delta ladders from the curves EURIBOR_1M , EURIBOR_3M , EURIBOR_6M ,EURIBOR_12M are summed up and added to EURIBOR STD curve).
The IM delta ladders for all the other currencies are added to create a full set of deltas.

The new delta ladders are used to calculate new IM ($IM_{OIS}$) applying delta approximation method to calculate pnls where the production historical scaled return series are(Please refer to the SwapClear's PAIRS document for calculation of scaled return series and how the pnls are used to derive IM).
The only exception is that the start of the scenario series is fixed to the beginning of the year 2008 and the number of scenarios is dynamic and increasing every day by an increment of one as opposed to 2500 scenarios used in the production IM and the expected shortfall of the 4 largest

losses as opposed to 6 in production. This reflects the fact that the history of spread returns between OIS and Libor from before the year 2008 provides returns close to zero.

The OIS IM approach add-on margin is the difference between the $IM_{OIS}$ calculation and the production version IM values that are calculated also using the delta pnl approximation method,with the same shortened look-back period (i.e. only the scenarios since beginning of the year 2008 are used) and the 4 largest losses are used for expected shortfall calculation..

The Final OIS IM approach add-on is calculated as:

$$\text{OIS IM approach add-on} = IM_{OIS} - IM_{Production}$$

## 2.2 Tenor curve IM approach

This approach incorporates the full set of tenor basis curves as additional risk factors according to the same curves used in the Variation Margin calculation. The current scope includes all the tenor basis curves (1M, 3M, 6M and 12M) that have been introduced so far in the variation margin model valuation for the currencies EUR, GBP,USD and JPY. Only 1M, 3M and 6M curves are built for JPY.
SwapClear uses only one curve for projecting of the cash flows for MXN trades and no second MXN tenor curve is introduced in that market. Therefore, MXN is not part of the scope for Tenor curve IM approach. Due the same reason MXN is also not part of the scope for The Stress Approach, see below.

In a similar way to the OIS approach delta ladders from the VM valuation are taken, but this time the tenor curve deltas are not collapsed but rather stay assigned to each tenor curve so that the impact of additional tenor basis risk factors is calculated.

Additional time series of the zero yield tenor curves are built to calculate historical series of scaled returns  Please refer to the SwapClear's PAIRS document for calculation of scaled return series).
This includes all the tenor curves for the -  EUR, GBP, USD and JPY currencies.
The new scenarios are added to extend the current IM scenarios with the extra tenor curve risk factors.

The new delta ladders and the new set of scenarios series are used to calculate the tenor curve IM ($IM_{Tenor}$) applying the delta approximation method.
The same length of the return series used for the OIS IM approach is applied, whereby the start of the scenario series is fixed to the beginning of the year 2008 and also the expected shortfall of the 4 largest losses is calculated instead of 6 largest losses.

The tenor curve IM approach add-on margin is then calculated as the IM impact of including the tenor curve risk factors. It is estimated with the difference between the $IM_{OIS}$ before and the $IM_{Tenor}$ after the tenor curve risk factors are included. i.e.,

$$\text{Tenor curve IM approach add-on} = IM_{Tenor} - IM_{OIS}$$

Furthermore, the Total IM approach add-on is calculated as,

$$\text{Total IM approach add-on} = \text{OIS IM approach add-on} + \text{Tenor curve IM approach add-on}$$

Only the positive Total IM approach add-on margin is considered.

## 2.3 Standalone Stress Approach.

### 2.3.1 Netted Basis Risk calculation

This approach uses Netted Basis Risk as an exposure to be stressed by historical spread scenarios. It is important to note that in the context of netted basis risk defined above, there is only basis risk exposure where the outright basis deltas are in the opposite directions, i.e. long and short risk on different tenors. Therefore, there is no netted basis risk where:

1) Outright tenor risk exposures are in the same direction. For example, a position that is long 1M EUR and long 3M EUR has zero netted basis risk as this position is not netted and their total is captured in the IM model.

2) A portfolio with outright risk in only one tenor. For example, if a portfolio only contains 3M EUR has no netted basis risk and exhibits only Reference Curve Risk it is considered as inappropriate to include it in the netted basis margin approach as explained above.

To generalise the above two rules and to calculate the Netted Basis Delta the following formula is used for all the basis risk exposures to $spread\ curves = \{1s6s, 1s12s, 3s6s, 3s12s, 6s12s\}$ :

$$Netted\ Basis\ Delta_{ccy}^{sc} = Sign * Min\left[abs(outright\ delta\ tenorcurve1), abs(outright\ delta\ tenorcurve2)\right],$$

Where
$ccy \in \{EUR, GBP, USD, JPY\}$
$sc\ runs\ over\ all\ major\ pillar\ points\ (2Y, 5Y, 10Y\ and\ 30Y)\ of\ all\ spread\ curves.$

$$Sign = \begin{cases} 1, & \text{if } \text{“}outright\ delta\ tenorcurve1\text{”} < 0 \text{ and } \text{“}outright\ delta\ tenorcurve2\text{”} > 0, \\ -1, & \text{if } \text{“}outright\ delta\ tenorcurve1\text{”} > 0\ and\ \text{“}outright\ delta\ tenorcurve2\text{”} < 0, \\ 0, & \text{if } both\ \text{“}outright\ delta\ tenorcurve1\text{”} > 0\ and\ \text{“}outright\ delta\ tenorcurve2\text{”} > 0\ or \\ & \quad \text{“}outright\ delta\ tenorcurve1\text{”} < 0\ and\ \text{“}outright\ delta\ tenorcurve2\text{”} < 0, \\ 0, & \text{if either } \text{“}outright\ delta\ tenorcurve1\text{”} = 0\ or\ \text{“}outright\ delta\ tenorcurve2\text{”} = 0, \end{cases}$$

And where the *tenorcurve2* is the curve with longer reset period of payments, e.g. for 3s6s, the *tenorcurve*2 is the 6M curve, for 1s3s the *tenorcurve2* is the 3M curve and for 1s6s *tenorcurve2*, it is the 6M curve.

Examples 1 and 2 from the below table illustrate this.

If there is basis risk in more than two tenors then risk allocation rules will apply in order to avoid double counting risk in the 1 to 6 month tenors.

The following are rules for non-zero risk in the three tenors, 1M, 3M and 6M.
For curves with 6M as the standard curve (in order of priority)

1) Allocation is to 6s12s
2) Allocation is to 1s6s
3) Allocation is to 3s6s

4) Allocation is to 1s12s
5) Allocation is to 3s12s
6) Allocation is to 1s3s

Examples 3, 6 illustrate this.

For curves with 3M as the standard curve (in order of priority)

1) Allocation is to 3s12s
2) Allocation is to 3s6s
3) Allocation is to 1s3s
4) Allocation is to 1s12s
5) Allocation is to 6s12s
6) Allocation is to 1s6s

Examples 4,5,7 illustrate this.

The outright delta for allocation is decreased by the delta that has been already allocated in the previous allocation rule.
Consider example for the 6M standard curve where the 1M outright delta is EUR 5mm, the 3M outright delta is EUR -4mm and the 6M outright delta is EUR -3mm.Then, the 2nd rule allocation is applied and EUR -3mm is assigned to 1s6s basis risk and only EUR 2mm 1M outright delta left for the 6th rule (1s3s) that would be allocated as EUR -2mm to 1s3s basis risk.
In addition, examples 6 and 5 illustrate this.
The main principle is that reference against the standard curve in each currency takes highest priority. Then the next priority is the basis with the largest tenor gap i.e. for EUR 1s6s (5M gap) against 3s6s (3M gap).

The examples in the table below (for simplicity all figures shown in millions of EUR) and results in the appendices do not show basis risk for 12M curves which was recently implemented in our VM valuation.

For further illustration, Appendix 4 shows outright risk and netted basis risk for five members with the largest basis margin.

| **Outright rate deltas** | | | | | | | **Netted deltas** | | |
|---|---|---|---|---|---|---|---|---|---|
| Example no. | Standard Curve | 1M | 3M | 6M | Total | | 1s3s | 1s6s | 3s6s |
| 1 | 6M | | 10 | -10 | 0 | | 0 | 0 | -10 |
| 2 | 6M | | 10 | -20 | -10 | | 0 | 0 | -10 |
| 3 | 6M | 10 | 10 | -10 | 10 | | 0 | -10 | 0 |
| 4 | 3M | 10 | -10 | -5 | -5 | | -10 | 0 | 0 |
| 5 | 3M | 20 | -30 | 5 | -5 | | -20 | 0 | 5 |
| 6 | 6M | 15 | 15 | -20 | 10 | | 0 | -15 | -5 |
| 7 | 3M | 15 | -10 | 20 | 25 | | 0 | 0 | 10 |

To align these methodologies with the variation margin curves, the VM outright zero deltas are used for the three currencies in the scope(USD, EUR, GBP, JPY) and for all the relevant tenor curves (1M, 3M, 6M and 12M curve for USD, EUR, GBP and 1M, 3M and 6M for JPY). These currencies represent 95% of current total SwapClear outstanding trades and therefore capture the vast majority of the risk.

To calculate netted basis exposures across the SwapClear membership, the outright positions were bucketed into major pillar points 2Y, 5Y, 10Y and 30Y buckets. This is consistent with the bucketing methodology used for the Liquidity margin calculation and the default management bucketing.
The major pillars are defined with the same number of days to maturity as the pillars that are defined in the IM fixed grid.
For the description of how to bucket the sensitivities please refer to the SwapClear Liquidity margin document ( page 6 – First Principles Calc – Step1).
The Netted Risk is then calculate, using the rules above, at each major pillar point (2Y, 5Y, 10Y, 30Y) of all the relevant spread curves for each currency(i.e. for USD, EUR, GBP there are the following spread curves 1v3, 1v6, 1v12, 3v6, 3v12 and 6v12, for JPY only 1v3,1v6 and 3v6).

### 2.3.2 Stress Margin Calculation

#### Input market data

The model operates on the history of the tenor basis spread data, observed from the market. In addition to the spread data, FX rates expressed in the base currency are needed for the same duration of time for each local curve currency. The add-on is also calculated in the base currency.

#### Market Returns

The time series of the 5 days absolute overlapping returns of the tenor basis spreads for the bucketed pillars (2Y, 5Y, 10Y and 30Y) for each currency (ccy) and each spread curve (sc) are calculated as

$$\mathbf{R}^{\mathrm{sc}}_{\mathrm{ccy}} = \left\{ \mathrm{S}^{\mathrm{sc}}_{\mathrm{ccy,t}} - \mathrm{S}^{\mathrm{sc}}_{\mathrm{ccy,t-5}} \, , \mathrm{t} \in \mathrm{T} \right\} ,$$

$\mathbf{S}^{\mathrm{sc}}_{\mathrm{ccy}} = \left\{ \mathrm{S}^{\mathrm{sc}}_{\mathrm{ccy,t}} : \mathrm{t} \in \mathrm{T} \right\}$ is a time series of the tenor basis spreads observed from the market and T is the set of days in the history of tenor basis spread data. The bold typeface of the variable indicates that it is a time series.

The length of the return history starts from beginning of 2008. This reflects the fact that the history of the basis spread returns from before the year 2008 provides returns close to zero.

In addition to the history of the tenor basis spread returns the time series of the FX rates relative returns ($\mathbf{R}^{\mathrm{CCY}}$) are needed for the same duration of time for each local currency expressed in the base currency used to calculate basis risk add-on,

$$\mathbf{R}^{\mathrm{ccy}} = \left\{ \frac{\mathrm{FX}_t - \mathrm{FX}_{t-5}}{\mathrm{FX}_{t-5}} \, , \mathrm{t} \in \mathrm{T} \right\} ,$$

$\mathbf{FX}^{\mathrm{ccy}} = \{ \mathrm{FX}_t : \mathrm{t} \in \mathrm{T} \}$ is the time series of exchange rates from the base currency to the local, or counter, currency CCY at time t.

New FX series for each local currency is recalculated using the series of FX returns and FX rates for the day (N) when add-on is calculated:

$$\mathbf{FX}^{\mathbf{ccy}}_{\mathbf{N}} = \mathrm{FX}^{\mathrm{ccy}}_{\mathrm{N}} * \mathbf{R}^{\mathrm{ccy}} \quad .$$

It should be noted that neither the spread return nor FX return series are scaled.

### PnL series and Expected Shortfall Calculation

The method of the historical simulation is then applied, so that for each historic day in the series the P&L impact is calculated as an offset across all the tenor curves, creating the series of the local currency PnLs as

$$\mathrm{PnL}_{\mathrm{ccy}} = \left\{ \sum_{\mathrm{sc}} (\ \mathrm{R}^{\mathrm{sc}}_{\mathrm{ccy,t}} * Netted\ Basis\ Delta^{sc}_{ccy})\ , \mathrm{t} \in \mathrm{T} \right\}$$

$ccy \in \{EUR, GBP, USD, JPY\}$
$sc\ runs\ over\ all\ major\ pillar\ points (2Y, 5Y, 10Y\ and\ 30Y)\ of\ all\ spread\ curves.$

The next step is to convert the local currency PnL numbers into the base currency.

$$\mathbf{PnL} = \sum_{\mathrm{ccy}} \mathbf{PnL}_{\mathbf{ccy}} /\ \mathbf{FX}^{\mathbf{ccy}}_{\mathbf{N}} \quad .$$

From this **PnL** series the basis risk add-on margin for the stress approach is calculated as the expected shortfall (ES) of the top q largest losses. **PnL** is sorted to give $\mathbf{PnL}^{\mathbf{SORT}}$ and the smallest q numbers (q is set equal to 4) are used to create the average:

$$\text{Stress Approach addon} \quad = \frac{1}{\mathrm{q}} \sum_{\mathrm{t}=1}^{\mathrm{q}} PnL^{SORT}_{t} \quad .$$

The ES approach was chosen to match the approach used in the IM methodology, but due to the lower number of observations, an average of 4 is used as opposed to an average of 6 in the IM methodology.

## 3. Total Basis Risk add-on calculation

Please refer to the “LCH Risk Monitoring of Basis Risk” document where the total basis risk add-on liability calculation is described in detail based on the valuation described in this document.

# 4. Appendix

See the table below with an example of the risk allocation between all the basis risk items. Using a two trade portfolio as an example:

**Trade 1:** USD 3m reset 10y Swap & **Trade 2:** USD 6m reset 10y Swap

| Risk Curve Attribution | Pure IM | OIS IM | Tenor IM | Stress IM |
|---|---|---|---|---|
| USD ZERO LIBOR STD | Net Forward + Discount | Net Forward | | |
| USD ZERO LIBOR 3M | | | Forward Risk (Trade 1) | |
| USD ZERO LIBOR 6M | | | Forward Risk (Trade 2) | |
| USD ZERO 3x6 | | | | 3x6 Spread Risk |
| USD ZERO FEDFUNDS | | Discount | Discount | |
| Notes: | Single curve – All risk is assigned to one curve | Two curve – Discounting risk is assigned to the OIS curve | Multi curve – Tenor risk is assigned to specific tenor curves | Spread risk is calculated according to netting rules |