LCH The Markets' Partner

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Liquidity Margin

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1 Liquidity Margin Introduction

The purpose of margin held by a clearing house is to have sufficient funds available, on a member default, to ensure that all positions are returned to a cleared state between two non-defaulted members. The default management process is the mechanism used to achieve this desired end state, and is in simplest terms, defined by a period of hedging and then an auctioning of the portfolio of the defaulting member.

Initial margin serves to protect against market moves occurring at the time of default and for relatively small defaults it may be reasonably expected that this margin should be sufficient to achieve the above stated aim. However, in the case where a defaulting position is large and/or concentrated, there is an expectation that the market will be moved further by the act of hedging the book (or in auctioning a live risk book). The expected additional cost resulting from these exacerbated moves is covered by a Liquidity Margin, (referred to as Initial Margin Multiplier or IMM). In simple terms:

IM = Margin to cover market moves

IMM = Margin to cost of exiting positions

IMM is computed in two ways and then the maximum charge is taken, and these two ways look respectively at overall position size (IMM1) and concentration (IMM2). A member with a long position of GBP10mio spread across many markets and tenors is a different risk proposition to a member with a long position of the same size but all in one currency at one tenor.

IMM1 is a method to charge members who have built up large overall positions, but where these may be spread over many markets and tenors. From an IMMFP perspective each individual position may be seen as innocuous but the aggregation of them give rise to concerns about general market moves.

IMM2 (or IMM First Principles) is specifically aimed at finding large concentrated positions and computing the additional margin requirements that are required to mitigate. It is computed as a series of add-ons that are aggregated together by simple summation.

Each of these two methodologies are discussed in the following sections.

The liquidity margin charged is the maximum of the two methodologies:

$$LiquidityMargin = Max(IMM1, IMM2)$$

No charge is incurred if the computed value is less than GBP100,000. Any computed value over this threshold is charged in full.

2 IMM1 - Overview

2.1 Defining Large Positions

As stated, IMM1 looks to provide additional margin for large risk positions that may not be concentrated into particular products or currencies. There are a large number of metrics that could be used to define what is a large position including, but not limited to:

- Portfolio Value at Risk
- Portfolio Expected Shortfall
- Portfolio Net Delta
- Portfolio Absolute Delta

The measure used by SwapClear is the Expected Shortfall of the portfolio which is the Initial Margin.

2.2 Computation of IMM1

The existing implementation defines a set of ranges for IM and then defines a multiplicative add-on which is applied to the entire IM:

$$IMM1 = IM * MultiplierFunction(IM)$$

IM Range (GBP mio)		IM	IMM1	Total
0	799	1.0	0.0	1.0
800	899	1.0	0.3	1.3
900	999	1.0	0.4	1.4
1000	1099	1.0	0.5	1.5
1100	1199	1.0	0.75	1.75
1200	up	1.0	1.0	2.0

Up to an IM level of 800mio, no add-on is incurred, but beyond this level the multiplier increases reaching its maximum level at 1,200mio where the add-on is the same size as IM resulting in a doubling of margin held by the clearing house.

3 IMM2 – Survey

IMM2 (commonly referred to as IMMFP) used to measure and charge for the expected exit cost of positions, above and beyond market moves that are covered in the base IM model.

The membership of SwapClear is surveyed to calibrate the add-on charged for IMMFP. Historically, the survey was executed in notional terms, and banks were required to estimate both market volume and costs. The revised version of the survey changed the methodology to directly work in a risk measure (Delta or DV01), and the levels of risk were defined by the Clearing House. This was done to ensure all submissions were directly comparable and that the survey was aligned with the way the charge is computed.

Currencies and associated indices are split into three categories depending on market liquidity, and risk observed at the clearing house. The risk measure is USD denominated in all cases

	USD Delta	2y	5y	10y	30y	50y
Large	1,000,000					
	2,500,000					
	5,000,000					
	10,000,000					
	20,000,000					

	USD Delta	2y	5y	10y	30y	50y
Medium	250,000					
	500,000					
	1,000,000					
	2,500,000					
	5,000,000					

	USD Delta	2y	5y	10y	30y	50y
Small	50,000					
	100,000					
	200,000					
	500,000					
	1,000,000					

Responses from all members are aggregated using the following algorithm on a point-wise basis

Submissions	Method
1 to 3	Simple average
4 to 5	Remove highest and lowest, then average
6 to 9	Remove highest 2 and lowest 2, then average
10 or more	Remove highest 3 and lowest 3, then average

All data is then checked to ensure consistency, in particular that costs rise for increased risk. In the case of interest rates, it is also checked to ensure that longer tenors are not cheaper than short tenors. Due to the nature of the inflation market, it is expected that longer tenors may be cheaper than short tenors.

4 IMM2 - Risk Ladders for Rates

For each currency and index, a delta ladder is produced, and this risk is then re-bucketed into a sub set of points, 2 year, 5 year, 10 year and 30 year. The methodology for this re-bucketing is a simple linear re-distribution. The following table shows the approximate bucketing weights (exact dates should be used but these change on a daily basis).

	2y	5y	10y	30y
<=2y	**1.00**	**-**	**-**	**-**
3y	0.67	0.33	-	-
4y	0.33	0.67	-	-
5y	**-**	**1.00**	**-**	**-**
6y	-	0.80	0.20	-
7y	-	0.60	0.40	-
8y	-	0.40	0.60	-
9y	-	0.20	0.80	-
10y	**-**	**-**	**1.00**	**-**
12y	-	-	0.90	0.10
15y	-	-	0.75	0.25
20y	-	-	0.50	0.50
25y	-	-	0.25	0.75
30y	**-**	**-**	**-**	**1.00**
35y	-	-	-	1.00
40y	-	-	-	1.00
45y	-	-	-	1.00
50y	-	-	-	1.00

Members and clients should use the standard report 103 to source the raw risk for this calculation. All risk is then converted to USD using the spot fx rate. The following shows a hypothetical end result

Delta (USD)	AUDIRS	AUDOIS	...	CZKIRS	...	USDIRS	USDOIS	...
2y	1,441,646	368,875	...	-19,545	...	8,767,891	9,634,183	...
5y	568,244	88,389	...	138,061	...	5,180,308	977,707	...
10y	1,734,495	364,884	...	11,370	...	1,876,116	3,332,673	...
30y	1,873,374	6,152	...	0	...	6,326,530	6,248,132	...

This methodology is completely unchanged from the existing production method. It should be noted that OIS risk can come from discounting or forward projection, and as a result, a book comprised entirely of GBP LIBOR swaps versus fixed would likely show large LIBOR risk, but additional risk in SONIA from discounting. Similarly inflation swaps will show OIS discount risk.

5 IMM2 - Rates in Non-OIS Currencies

The methodology for computing Liquidity margin for currencies with no SwapClear cleared OIS market is unchanged, with the exception of a short end add-on. For each bucketed risk, the basis point charge is obtained from the relevant table for the currency. Linear interpolation is used on the table to produce the exact value that will be applied. Any risk below the lowest risk level on the table is attributed the basis point value for the lowest defined level (i.e. flat extrapolation). If the bucketed risk exceeds the maximum value on the grid, then linear extrapolation is used with the highest and second highest risk points used as the known points. The tabular value obtained is the basis point charge for that tenor, and is then multiplied by the bucketed risk to obtain the tenor charge.

$$IndividualBucketCharge = \varphi_{\Delta,b}.|\Delta_b|$$

where $|\Delta_b|$ is the absolute delta in bucket b

and $\varphi_{\Delta,b}$ is the basis point charge for bucket b, for a delta of Δ_b

Using CZK from the table above as a worked example, the CZK charge grid is:

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
CZKIRS	50,000	3.33	3.33	3.33	3.33	4	4.67	7	7
	100,000	5.33	5.33	5.33	5.33	7	7.67	9	9
	200,000	9.33	9.33	9.33	9.33	13	14	15	15
	500,000	12.67	12.67	12.67	12.67	18.33	21.67	25	25
	1,000,000	25	25	25	25	33.33	41.67	45	45

This gives the following charges for each tenor:

Delta (USD)	CZKIRS	BP Charge	Cost
2y	19,545	3.33	65,150
5y	138,061	9.28	1,281,711
10y	11,370	4.67	53,060
30y	0		0

In interest rates, it is cheaper to execute spread trades than would be implied from trading two opposing legs individually. In cases where the deltas have opposing signs for 2y and 5y, and 10y and 30y, the higher of the two charges is taken and the other is set to zero. In the CZK example, 5y and 2y have opposing signs, so the charge for 2y is set to zero. The base charge for liquidity for each currency is the simple sum of the four tenor charge values after the netting has been applied if appropriate.

Delta (USD)	CZKIRS	BP Charge	Cost	With Offset
2y	-19,545	3.33	65,150	-
5y	138,061	9.28	1,281,711	1,281,711
10y	11,370	4.67	53,060	53,060
30y	0		-	
			Total	1,399,921

6 IMM2 - Rates in OIS Currencies

SwapClear currently clears 7 currencies where there is both an OIS and LIBOR like index eligible for clearing. These currencies are AUD, CAD, CHF, EUR, GBP, JPY and USD. Historically in these currencies, the OIS and IBOR risk have been treated entirely independently. The new methodology looks to treat the two indices in a single currency in a more coherent way, and looks to analyse the overall position and evaluate the likely cost of exit in a market consistent way, through the use of basis trades to move risk to a single index.

The new method for evaluating exit costs first uses basis trades to eliminate any basis risk (i.e. by moving risk from one index to another). Then, as a secondary step, hedge the remaining directional risk in the usual way. The methodology is very simple, but is constructive in its approach to the portfolio of hedge trades that could be executed. The liquidity margin that is required to cover a position is then simply the cost of executing these trades.

For any currency with OIS and IBOR, for each tenor, two strategies will be evaluated:

1. Basis Swap the OIS risk to IBOR and hedge the resulting outright IBOR risk
2. Basis Swap the IBOR risk to OIS and hedge the resulting outright OIS risk

Note that in the model the basis swap itself is completely delta neutral and from a total risk perspective, either option is equally valid. The charge made will be the cost of the most efficient of these strategies. As a general rule of thumb this will result in the lower absolute risk being basis swapped out, though there are many cases where, due to liquidity differentials between OIS and IBOR, that this may be reversed. For longer maturities, the OIS market as an outright is generally less liquid that the corresponding IBOR market, and here it may be optimal to use basis swaps to clean out OIS risk even if the risk in OIS exceeds that of LIBOR.

The following two sections show stylised examples of how the new method works. In both cases only the 10Y USD point is considered, with delta in both the OIS and LIBOR indices.

6.1 Offsetting Risk Profiles

Here the delta is positive in LIBOR and negative in OIS. The current methodology would result in the following charge computation:

Current	Delta	Charge
IRS	10,547,395.77	46,360,044.48
OIS	-7,537,284.14	38,241,100.28
Total		**84,601,144.76**

In the new methodology the two alternative strategies above are evaluated. The first strategy is to use a basis swap to eliminate the OIS risk and hedge the resulting new delta in LIBOR on an outright basis.

Strategy 1	Delta	Charge
IRS	3,010,111.63	6,448,013.64
OIS	0	0
BAS	7,537,284.14	26,455,651.80
Total		**32,903,665.44**

The second strategy is to use a basis swap to eliminate the LIBOR risk and hedge the resulting new delta in OIS on an outright basis.

Strategy 2	Delta	Charge
IRS	0	0
OIS	3,010,111.63	8,460,416.33
BAS	10,547,395.77	44,479,449.33
Total		**52,939,865.66**

It can be seen that both of these strategies are cheaper than where the two indices are treated independently. The charge actually incurred would be the lower of the two strategies, resulting in a choice of strategy 1 giving a cost of USD 32.9mio. This is significantly lower than currently charged on this position and is a far more realistic estimate of the close out cost of position that is net much closer to flat that either leg would imply.

6.2 Additive Risk Profiles

Here the delta is positive in both LIBOR and OIS. The current methodology would result in the following charge computation:

Current	Delta	Charge
IRS	10,547,395.77	46,360,044.48
OIS	7,537,284.14	38,241,100.28
Total		**84,601,144.76**

It should be noted that while this represents a very different net rates exposure to the offsetting position above, the charge using current methods is identical.

In the new methodology the two alternative strategies above are evaluated. The first strategy is to use a basis swap to eliminate the OIS risk and hedge the resulting new delta in LIBOR on an outright basis.

Strategy 1	Delta	Charge
IRS	18,084,680	115,696,615
OIS	0	0
BAS	7,537,284	26,455,652
Total		**142,152,267**

The second strategy is to use a basis swap to eliminate the LIBOR risk and hedge the resulting new delta in OIS on an outright basis.

Strategy 2	Delta	Charge
IRS	0	0
OIS	18,084,679.91	156,669,633.43
BAS	10,547,395.77	44,479,449.33
Total		**201,149,082.76**

When the two strategies are evaluated, strategy 1 is shown to be cheaper and is used to compute the charge.

6.3 Hypothetical Example

The strategies detailed above are applied at each tenor for the relevant currencies. Using USD from the initial example shown again here:

Delta (USD)	AUDIRS	AUDOIS	...	CZKIRS	...	USDIRS	USDOIS	...
2y	1,441,646	368,875	...	-19,545	...	8,767,891	9,634,183	...
5y	568,244	88,389	...	138,061	...	5,180,308	977,707	...
10y	1,734,495	364,884	...	11,370	...	1,876,116	-3,332,673	...
30y	1,873,374	6,152	...	0	...	-6,326,530	6,248,132	...

In this case, strategy 1 wins in 2y, 5y and 30y with strategy 2 being cheapest in 10y, leading to the following computation:

				BP Charge			USD Cost		
Delta (USD)	**USDIRS**	**USDOIS**	**Basis**	**USDIRS**	**USDOIS**	**Basis**	**USDIRS**	**USDOIS**	**Basis**
2y	18,402,074	0	9,634,183	5.58	1.15	3.3	102,715,819	0	31,767,031
5y	6,158,015	0	977,707	3.01	1.35	0.87	18,539,033	0	852,438
10y	0	-1,456,557	1,876,116	1.05	1.82	1.49	0	2,644,210	2,787,878
30y	-78,398	0	6,248,132	1.38	2	4.27	108,374	0	26,696,433

Total	186,111,217

Whilst the deltas on 10y and 30y have opposing signs, they are on different indices and no offset is given. Should the basis strategy result in opposing signs in 2y/5y or 10y/30y in the same index, then offset is given as shown earlier.

7 IMM2 - Ultra Long and Short Addons

Some institutions have significant risk at the ultra long end of the tenor spectrum, which presents the risk that placing this risk into the 30 year bucket could result in an underestimate of the liquidation cost where 50y spreads are wider in the market than 30y. To ensure that significant ultra long risk is correctly margined, an additional margin add-on is applied.

The long end risk of the book is re-bucketed with the addition of a 50 year point. The table shows how the long end is re-bucketed into a 50 year point.

	50y
35y	0.25
40y	0.5
45y	0.75
50y	**1**

The risk at this 50 year point is then used to find a basis point charge as if it was in 30 year and as it is in the 50 year. The add-on is floored at zero should a case be encountered where 50y is surveyed to be more liquid than 30y.

The add-on for ultra long risk is thus computed as:

$$UltraLongAddOn = MAX(\varphi\Delta,50 \quad - \varphi_{\Delta,30}, 0)|\Delta_{50}|$$

where $|\Delta_b|$ is the absolute delta in bucket b

where $\varphi_{\Delta,b}$ is the basis point charge for bucket b, for a delta of Δ_b

The same addon methodology is applied at 3 month, 6 month and 1 year points also. Short end risk is re-bucketed on to these points along with 2y, and then the formula above is used but replacing 30y with 2y, and 50y with 3m/6m/1y as appropriate.

8 IMM2 - Inflation

Inflation risk is treated slightly differently to interest rate risk, though the fundamental principles are unchanged. The initial bucketing of risk is to tenors of 2Y, 5Y, 10Y, 20Y, 30Y and 50Y and all of these are used in the base computation. Appendix 5 shows how to compute the re-bucketed risk. It should be noted that the analytical formulae shown may differ from production values, as the re-bucketing is performed numerically by SwapClear.

As 50Y is included explicitly in the base, there is no ultra long add-on. Additionally, there is no tenor offset between indices, so all spread positions are charged on the basis of individual leg costs. Tables are found in Appendix 4.

For both rates and inflation, the cost matrices are applied using linear interpolation, with flat extrapolation for risk below the lowest surveyed value. In the case of interest rates, where a member's risk position exceeds the maximum surveyed, linear extrapolation is used to extend out the cost matrix. For inflation, a super-linear extrapolation methodology is used to compute the basis point cost (BPC), with the following functional form:

$$BPC = a\Delta^N + b$$

N is an exogenous parameter that controls the speed at which the BPC will rise. In case of IRS products, N = 1 which implies linear extrapolation. In the case of inflation, N has been set at 1.5 to give a super linear extrapolation function where by the BPC grows faster than a linear extrapolation.

The parameters a and b are set by using two conditions:

1. Continuous at the last surveyed delta, i.e. function at the Δ_X point has the same value as the surveyed value:

$$BPC_X = a(\Delta_X)^N + b$$

2. Smooth at the last surveyed delta, i.e. slope of the function equals linear interpolation slope between the last (X) and last but one (X-1) points:

$$\frac{\partial BPC}{\partial \Delta} = aN(\Delta_X)^{N-1} = \frac{BPC_X - BPC_{X-1}}{\Delta_X - \Delta_{X-1}} \quad where\ \Delta = \Delta_X$$

These two equations give the following definitions of a and b :

$$a = \left(\frac{BPC_X - BPC_{X-1}}{\Delta_X - \Delta_{X-1}}\right).\frac{1}{N(\Delta_X)^{N-1}}$$

$$b = BPC_X - a(\Delta_X)^N$$

9 IMM2 – Listed Products

Following the release of Spider in April 2016, the OTC SwapClear business and the Listed Rates business have been combined into a single service, with one mutualised default fund. At the same time, liquidity margin models for futures were partially harmonised with OTC model, and further harmonisation will occur as bond futures are also brought into portfolio margining.

9.1 STIRs

Interest rate risk for STIRs is included in the standard IMM2 risk ladders and charged for as part of the overall interest rate portfolio. This is done regardless of whether the member is participating in portfolio margining or not.

An additional charge is leveraged on all STIR contracts to reflect the basis cost against OTC products, where the position exceeds more than 50% of the per contract ADV. Note that each contract is charged individually, and no offset is given for spread positions.

		Short Sterling				Euribor			
		Front 4*	Red	Green	Rest	Front 4	Red	Green	Rest
Number of lots	1,000	1.00	1.00	1.00	1.50	0.50	0.50	0.50	1.00
	2,500	1.00	1.00	1.00	2.25	0.38	0.50	0.50	1.00
	5,000	1.00	1.25	1.75	2.75	0.38	0.50	0.75	2.50
	10,000	1.00	2.00	2.25	4.50	0.75	1.00	1.50	3.00
	25,000	1.00	2.50	4.00	8.00	1.00	1.50	2.50	5.00
	50,000	1.70	4.00	7.00	14.00	1.76	3.00	4.00	8.00

(*) An incremental charge is made of 4bp on the first contract, 5bp on the second and 6bp on the third, where this includes serial futures.

9.2 Bond Futures

Bond futures lie outside the current IMM models and are dealt with using the LCRM charge.

Appendix 1 – LIBOR Equivalent Grids

	NORMAL MARKET								
	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
USDIRS	1,000,000	0.75	0.75	0.75	1.00	1.00	1.00	1.50	2.00
	2,500,000	0.75	1.00	1.00	1.50	1.75	2.00	2.50	3.25
	5,000,000	1.75	2.00	2.00	2.50	2.75	3.00	4.25	5.50
	10,000,000	2.75	3.00	3.25	4.00	4.25	4.75	6.50	8.00
	20,000,000	4.00	4.50	5.00	6.25	6.75	7.25	9.75	11.75

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
GBPIRS	1,000,000	1.00	1.00	1.25	1.50	1.75	1.75	2.25	2.75
	2,500,000	1.75	2.00	2.25	2.50	2.75	3.00	3.75	4.50
	5,000,000	2.50	3.00	3.00	3.50	4.00	4.25	5.50	6.50
	10,000,000	3.75	4.25	4.50	5.25	5.75	6.25	8.00	9.25
	20,000,000	6.00	6.50	6.75	7.75	8.75	9.25	11.25	13.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
JPYIRS	1,000,000	2.25	2.25	2.25	2.50	2.50	2.75	4.00	7.25
	2,500,000	3.00	3.25	3.25	3.50	3.75	4.25	6.00	9.50
	5,000,000	4.50	4.50	4.75	5.00	5.25	6.25	8.75	12.75
	10,000,000	7.50	7.00	7.75	8.00	8.25	10.25	14.25	19.25
	20,000,000	13.50	12.00	13.75	14.00	14.25	18.25	25.25	32.25

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
EURIRS	1,000,000	0.75	0.75	0.75	1.00	1.00	1.00	1.50	2.25
	2,500,000	1.25	1.25	1.50	1.50	1.75	1.75	2.75	3.50
	5,000,000	1.50	1.50	1.75	2.00	2.50	2.75	4.25	5.50
	10,000,000	2.50	3.00	3.00	3.25	4.00	4.50	6.25	8.25
	20,000,000	4.25	4.50	5.00	5.25	6.25	7.00	9.25	12.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
CADIRS	250,000	1.00	1.00	1.25	1.50	1.50	1.75	2.25	2.25
	500,000	1.75	2.00	2.50	2.50	2.50	3.00	3.75	3.75
	1,000,000	3.00	3.25	3.75	3.75	3.75	5.00	6.50	6.50
	2,500,000	4.75	5.00	5.25	5.50	6.00	7.75	10.50	10.50
	5,000,000	7.00	7.75	8.00	7.75	8.50	10.50	13.00	18.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
CHFIRS	250,000	1.25	1.25	1.75	2.00	2.00	2.25	3.25	3.25
	500,000	2.00	2.25	2.50	3.00	3.00	3.25	5.00	5.00
	1,000,000	3.25	3.50	4.00	4.50	4.50	5.00	7.75	7.75
	2,500,000	4.75	5.00	5.75	6.50	6.75	7.50	11.50	11.50
	5,000,000	7.00	7.50	9.00	9.25	9.50	10.75	15.50	15.50

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
DKKIRS	250,000	2.25	2.25	2.25	2.25	2.50	2.75	3.75	5.75
	500,000	3.75	3.75	3.75	3.75	4.00	4.25	5.50	8.25
	1,000,000	5.00	5.00	5.00	5.00	5.50	6.00	8.00	12.00
	2,500,000	6.75	6.75	6.75	6.75	7.75	8.00	11.25	17.00
	5,000,000	9.50	9.50	9.50	9.50	11.00	11.50	15.75	23.75

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
SEKIRS	250,000	2.25	2.25	2.25	2.25	2.25	2.75	4.25	6.50
	500,000	3.50	3.50	3.50	3.50	3.75	4.00	6.00	9.00
	1,000,000	4.75	4.75	4.75	4.75	5.25	5.50	8.50	12.75
	2,500,000	6.75	6.75	6.75	6.75	7.25	8.00	11.75	17.75
	5,000,000	9.50	9.50	9.50	9.50	10.25	11.00	16.00	24.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
NOKIRS	250,000	3.00	3.00	3.00	3.00	3.25	3.50	5.00	7.50
	500,000	4.75	4.75	4.75	4.75	5.00	5.25	7.50	11.25
	1,000,000	6.75	6.75	6.75	6.75	7.50	8.00	11.75	17.75
	2,500,000	9.25	9.25	9.25	9.25	10.50	11.00	15.25	23.00
	5,000,000	12.50	12.50	12.50	12.50	14.25	15.00	19.00	28.50

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
AUDIRS	250,000	1.00	1.00	1.25	1.75	2.25	2.25	4.25	5.00
	500,000	1.75	1.75	2.25	2.75	3.25	3.50	6.25	7.50
	1,000,000	2.25	2.50	3.00	4.00	4.50	5.00	8.75	9.50
	2,500,000	3.75	4.00	4.75	5.75	6.75	7.25	11.75	12.50
	5,000,000	5.75	6.00	7.00	8.25	9.75	10.50	14.75	16.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
HKDIRS	50,000	4.50	4.50	4.50	4.50	4.50	4.50	4.50	6.75
	100,000	4.50	4.50	4.50	4.50	4.50	4.50	6.50	9.75
	200,000	4.50	4.50	4.50	4.50	5.25	6.50	9.75	14.75
	500,000	6.75	6.75	6.75	6.75	7.75	9.75	14.75	22.25
	1,000,000	9.25	9.25	9.25	9.25	11.00	13.75	20.75	31.25

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
NZDIRS	250,000	5.08	5.08	5.08	5.08	5.83	6.96	12.46	41.67
	500,000	6.75	6.75	6.75	6.75	7.50	9.25	16.00	50.00
	1,000,000	8.75	8.75	8.75	8.75	10.50	12.75	23.75	75.00
	2,500,000	14.75	14.75	14.75	14.75	19.50	23.25	47.00	150.00
	5,000,000	24.75	24.75	24.75	24.75	34.50	40.75	85.75	275.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
SGDIRS	50,000	2.50	2.50	2.50	2.50	2.50	3.25	5.00	7.50
	100,000	3.75	3.75	3.75	3.75	3.75	4.50	6.75	10.25
	200,000	5.50	5.50	5.50	5.50	5.75	6.75	10.25	15.50
	500,000	8.75	8.75	8.75	8.75	8.75	10.00	15.00	22.50
	1,000,000	13.25	13.25	13.25	13.25	13.50	15.00	22.50	33.75

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
CZKIRS	50,000	3.33	3.33	3.33	3.33	4.00	4.67	7.00	7.00
	100,000	5.33	5.33	5.33	5.33	7.00	7.67	9.00	9.00
	200,000	9.33	9.33	9.33	9.33	13.00	14.00	15.00	15.00
	500,000	12.67	12.67	12.67	12.67	18.33	21.67	25.00	25.00
	1,000,000	25.00	25.00	25.00	25.00	33.33	41.67	45.00	45.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
HUFIRS	50,000	4.50	4.50	4.50	4.50	5.00	5.75	35.00	52.50
	100,000	6.25	6.25	6.25	6.25	7.25	8.50	55.00	82.50
	200,000	10.25	10.25	10.25	10.25	13.25	15.25	60.00	90.00
	500,000	17.75	17.75	17.75	17.75	22.75	27.25	65.00	97.50
	1,000,000	31.00	31.00	31.00	31.00	34.00	46.75	70.00	105.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
PLNIRS	50,000	2.25	2.25	2.25	2.25	2.75	3.00	35.00	52.50
	100,000	3.50	3.50	3.50	3.50	4.00	4.50	55.00	82.50
	200,000	5.00	5.00	5.00	5.00	5.75	6.75	60.00	90.00
	500,000	7.00	7.00	7.00	7.00	9.00	11.00	65.00	97.50
	1,000,000	14.25	14.25	14.25	14.25	17.00	18.75	70.00	105.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
ZARIRS	50,000	3.75	3.75	3.75	3.75	4.25	4.50	35.00	52.50
	100,000	5.50	5.50	5.50	5.50	6.00	6.75	55.00	82.50
	200,000	9.25	9.25	9.25	9.25	11.25	12.50	60.00	90.00
	500,000	16.50	16.50	16.50	16.50	19.00	21.50	65.00	97.50
	1,000,000	24.50	24.50	24.50	24.50	28.00	30.50	70.00	105.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
MXNIRS	50,000	2.50	2.50	2.50	2.50	3.00	3.25	17.00	25.50
	100,000	4.00	4.00	4.00	4.00	4.25	4.50	28.00	42.00
	200,000	6.75	6.75	6.75	6.75	7.00	7.25	38.25	57.50
	500,000	11.00	11.00	11.00	11.00	11.00	11.00	45.00	67.50
	1,000,000	16.50	16.50	16.50	16.50	16.50	16.50	55.00	82.50

Appendix 2 – OIS Grids

	NORMAL MARKET								
	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
USDOIS	1,000,000	1.25	1.25	1.25	1.50	1.75	2.00	2.50	2.50
	2,500,000	1.75	2.00	2.00	2.50	2.75	3.00	4.00	4.00
	5,000,000	3.00	3.25	3.25	3.75	4.25	4.75	6.25	6.25
	10,000,000	4.50	4.75	5.00	5.75	6.50	7.00	9.25	11.00
	20,000,000	6.75	7.25	7.75	9.00	9.75	10.75	13.50	15.50

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
GBPOIS	1,000,000	1.75	1.75	2.00	2.25	2.25	2.50	3.00	3.00
	2,500,000	2.75	3.00	3.25	3.50	3.75	4.00	5.00	5.00
	5,000,000	4.00	4.50	4.50	5.00	5.50	6.25	7.75	7.75
	10,000,000	5.75	6.25	6.50	7.25	8.00	8.75	11.00	11.50
	20,000,000	8.50	9.00	9.25	10.25	11.25	12.25	15.00	16.50

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
JPYOIS	250,000	1.25	1.25	1.25	1.50	1.75	2.00	2.75	4.25
	500,000	2.25	2.25	2.25	2.50	2.50	2.75	3.75	5.75
	1,000,000	3.25	3.25	3.25	3.50	3.75	4.25	5.75	8.75
	2,500,000	4.25	4.50	4.50	4.75	5.00	6.00	8.00	12.00
	5,000,000	6.00	6.00	6.25	6.50	7.00	8.25	11.25	17.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
EUROIS	1,000,000	1.00	1.00	1.00	1.25	1.50	1.50	2.00	2.00
	2,500,000	1.50	1.50	1.75	1.75	2.25	2.50	3.25	3.25
	5,000,000	2.25	2.25	2.50	2.75	3.25	3.50	4.75	4.75
	10,000,000	3.25	3.75	3.75	4.00	4.75	5.50	7.00	7.00
	20,000,000	5.00	5.25	5.75	6.00	7.00	7.75	10.00	10.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
CADOIS	250,000	1.50	1.50	1.75	2.00	2.25	2.25	2.25	3.50
	500,000	2.25	2.50	3.00	3.00	3.25	3.25	3.25	5.00
	1,000,000	3.00	3.25	3.75	3.75	4.00	4.50	4.75	7.25
	2,500,000	4.75	5.00	5.25	5.50	6.25	9.00	9.25	14.00
	5,000,000	6.75	7.50	7.75	7.50	8.50	12.00	12.25	18.50

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
CHFOIS	250,000	2.50	2.50	3.00	3.25	3.25	5.00	5.00	7.50
	500,000	3.50	3.75	4.00	4.50	5.00	9.75	9.75	14.75
	1,000,000	5.25	5.50	6.00	6.50	7.25	18.00	18.00	27.00
	2,500,000	7.50	7.75	8.50	9.25	10.25	24.00	24.00	36.00
	5,000,000	10.50	11.00	12.50	12.75	13.25	36.00	36.00	54.00

	USD DELTA	3m	6m	1y	2y	5y	10y	30Y	50Y
AUDOIS	250,000	1.50	1.50	1.75	2.25	2.50	5.50	7.50	12.00
	500,000	2.25	2.25	2.75	3.25	3.75	7.00	11.00	20.00
	1,000,000	3.00	3.25	3.75	4.75	5.50	9.50	14.50	30.00
	2,500,000	4.50	4.75	5.50	6.50	8.00	13.50	19.00	35.00
	5,000,000	6.25	6.50	7.50	8.75	10.75	17.00	25.00	40.00

Appendix 3 – Basis Grids

	Normal Market					
	USD DELTA	2y	5y	10y	30Y	50Y
USDBAS	1,000,000	1.00	1.00	1.00	1.50	2.25
	2,500,000	1.50	1.50	1.75	2.25	3.50
	5,000,000	2.50	2.75	3.00	3.75	5.75
	10,000,000	4.00	4.25	4.50	5.75	8.75
	20,000,000	6.00	6.25	6.75	8.25	12.50

	USD DELTA	2y	5y	10y	30Y	50Y
GBPBAS	1,000,000	1.25	1.50	1.50	1.75	2.75
	2,500,000	2.00	2.00	2.25	2.50	3.75
	5,000,000	2.75	3.00	3.25	3.75	5.75
	10,000,000	4.00	4.25	4.75	5.50	8.25
	20,000,000	5.75	6.00	6.50	7.50	11.25

	USD DELTA	2y	5y	10y	30Y	50Y
JPYBAS	250,000	0.75	1.00	1.00	1.50	2.25
	500,000	1.25	1.25	1.50	2.00	3.00
	1,000,000	1.75	2.00	2.25	3.00	4.50
	2,500,000	2.75	2.75	3.25	4.50	6.75
	5,000,000	3.75	3.75	4.75	6.00	9.00

	USD DELTA	2y	5y	10y	30Y	50Y
EURBAS	1,000,000	0.75	0.75	0.75	1.00	1.00
	2,500,000	1.25	1.25	1.25	1.50	1.75
	5,000,000	1.50	1.75	1.75	2.00	2.25
	10,000,000	2.50	2.50	2.50	3.00	3.00
	20,000,000	3.50	3.50	3.50	4.25	4.25

	USD DELTA	2y	5y	10y	30Y	50Y
CADBAS	250,000	1.75	1.75	1.75	2.00	3.00
	500,000	2.50	2.50	2.75	2.75	4.25
	1,000,000	3.50	3.50	4.25	4.50	6.75
	2,500,000	4.75	5.25	6.50	6.50	9.75
	5,000,000	6.50	7.00	8.00	8.00	12.00

	USD DELTA	2y	5y	10y	30Y	50Y
CHFBAS	250,000	2.00	2.00	3.00	4.50	6.75
	500,000	3.00	3.50	5.25	8.00	12.00
	1,000,000	4.75	5.00	7.50	11.25	17.00
	2,500,000	6.75	7.00	10.50	15.75	23.75
	5,000,000	9.25	9.75	14.75	22.25	33.50

	USD DELTA	2y	5y	10y	30Y	50Y
AUDBAS	250,000	1.75	2.00	3.50	5.00	5.00
	500,000	2.75	3.00	4.75	6.50	6.50
	1,000,000	4.25	4.75	6.75	8.75	8.75
	2,500,000	5.75	6.25	9.50	11.50	11.50
	5,000,000	7.25	8.25	12.00	14.75	15.00

Appendix 4 – Inflation Grids

	NORMAL MARKET						
	Delta USD	2y	5y	10y	20Y	30Y	50Y
USDINF	50,000	10.50	7.25	7.00	7.75	7.75	7.75
	100,000	20.00	14.00	13.50	14.25	14.25	14.25
	200,000	30.25	20.50	20.25	21.00	21.00	21.00
	500,000	40.50	28.00	27.50	28.75	28.75	28.75
	1,000,000	43.50	29.75	29.25	30.75	30.75	30.75

	Delta USD	2y	5y	10y	20Y	30Y	50Y
GBPINF	250,000	9.50	7.75	4.50	2.75	2.75	3.00
	500,000	16.50	14.75	8.00	5.25	5.25	5.25
	1,000,000	24.25	22.00	12.50	8.00	8.00	8.25
	2,500,000	33.00	29.25	17.25	11.25	11.25	11.25
	5,000,000	38.75	33.50	19.50	13.50	13.50	13.50

	Delta USD	2y	5y	10y	20Y	30Y	50Y
FRFINF	50,000	2.75	3.25	3.25	3.50	3.25	3.25
	100,000	5.00	6.00	6.00	6.25	6.25	6.25
	200,000	8.25	9.75	9.25	9.25	9.00	9.00
	500,000	12.50	13.75	12.75	13.50	12.75	12.75
	1,000,000	17.50	16.75	15.25	16.00	16.00	16.00

	Delta USD	2y	5y	10y	20Y	30Y	50Y
EURINF	250,000	5.75	4.25	3.50	3.75	3.75	3.75
	500,000	10.25	8.25	7.00	7.00	6.75	6.75
	1,000,000	14.25	12.75	11.00	10.75	10.50	10.50
	2,500,000	19.75	18.75	15.50	15.00	14.50	14.50
	5,000,000	24.50	22.75	19.75	18.50	17.75	17.75

Appendix 5 – Inflation Projection

Inflation deltas are available for all buckets on the IM curve. For the purposes of IMM FP these need to be re-bucketed to specific key tenor points (2y, 5y, 10y, 20y, 30y and 50y).

IM Buckets that match the IMMFP pillars are allocated on a 1:1 basis.

For all points beyond 2Y that are not core pillar points, the risk will be bucketed into the two surrounding pillars (Zm and Zn where m<n). Subscript i is used to denote the date that needs re-bucketing. In this context, i, m and n can all be considered integers representing the year length of the point. For example, rebucketing of 7y risk to 5y and 10y pillars, i = 7, m = 5 and n = 10.

The standard chain rule is the basis for the re-allocation:

1. $$\frac{\partial PV}{\partial Z_m} = \frac{\partial PV}{\partial Z_i}\frac{\partial Z_i}{\partial Z_m}$$

2. $$\frac{\partial PV}{\partial Z_n} = \frac{\partial PV}{\partial Z_i}\frac{\partial Z_i}{\partial Z_n}$$

The curve construction interpolation chosen is log linear in CPI levels:

3. $$\ln CPI_i = \ln CPI_m + \frac{i-m}{n-m}.(\ln CPI_n - \ln CPI_m)$$

This translates directly into par rate space in the case of the piecewise indices, and can be applied in the linear index cases (USD is the only case currently) with minimal error:

4. $$CPI_a = (1+Z_a)^a.CPI_0$$

Direct substitution of 4 into 3 (CPI0 all cancel out):

5. $$i\ln(1+Z_i) = m\ln(1+Z_m) + \frac{i-m}{n-m}.(n\ln(1+Z_n) - m\ln(1+Z_m))$$

Combining like terms gives :

6. $$\ln(1+Z_i) = \frac{m(n-i)}{i(n-m)}\ln(1+Z_m) + \frac{n(i-m)}{i(n-m)}\ln(1+Z_n)$$

Exponentiate:

7. $$Z_i = (1+Z_m)^{\frac{m(n-i)}{i(n-m)}}.(1+Z_n)^{\frac{n(i-m)}{i(n-m)}}$$

Differentiate and simplify to obtain the two required formulae for 1 and 2:

8. $$\frac{\partial Z_i}{\partial Z_m} = \frac{m(n-i)}{i(n-m)}.\left(\frac{1+Z_n}{1+Z_m}\right)^{\frac{n(i-m)}{i(n-m)}}$$

9. $$\frac{\partial Z_i}{\partial Z_n} = \frac{n(i-m)}{i(n-m)}.\left(\frac{1+Z_n}{1+Z_m}\right)^{\frac{m(n-i)}{i(n-m)}}$$

Bucketing from shorter pillars to 2Y pillar follows a similar pattern but is complicated by the fact that there is no 0y rate, and the points are interpolated from the last known index level, which may not be CPI0. This is the scaling formula for short end inflation deltas to compute IMMFP. All deltas below 2y should be **divided** by this factor.

$$\frac{\partial Z_T}{\partial Z_i} = \frac{i(T-L)}{T(i-L)} C_0^{\frac{i(T-L)}{12(i-T)}} C_L^{\frac{i(T-L)}{12(T-i)}} (1+Z_T)^{\frac{L(T-i)}{i(T-L)}}$$

All times are measured in months.

T = first IMMFP tenor = 24

i = the delta we want to move to 2y (for 1y delta, i = 12)

L = the difference in months from the base index (C0 in standard quote) to the last published index (this is not necessarily the market lag)

C_0 is the market standard base for the instruments

C_L is the last published index.