|  |
| --- |
| Deliverable Swap Future  Pricing & Risk Management Methodology |

26 August 2014

Document History

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Version** | **Author** | **Summary of Changes** |
| 18th August 2014 | 1.0 | Paul Savage | Original draft |
| 26th August 2014 | 1.1 | Paul Savage | Document expanded to accommodate ***all*** the DSF-related material submitted to ERCO |
| 3rd September 2014 | 1.2 | Marc Huglin | Updates to sections 6 & 7 to reflect updated default management procedures following ERCo discussion |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Table of Contents

[Document History 2](#_Toc397077494)

[Abbreviations 5](#_Toc397077495)

[Introduction 6](#_Toc397077496)

[Background 6](#_Toc397077497)

[Purpose of the Document 6](#_Toc397077498)

[1 Product Specification - LSEG 7](#_Toc397077499)

[1.1 USD 7](#_Toc397077500)

[1.2 EUR 7](#_Toc397077501)

[1.3 GBP 8](#_Toc397077502)

[2 Product Specification - NLX 9](#_Toc397077503)

[2.1 USD 9](#_Toc397077504)

[2.2 EUR 9](#_Toc397077505)

[2.3 GBP 10](#_Toc397077506)

[3 Overview of Existing NLX Initial Margin Methodology 11](#_Toc397077507)

[3.1 Product Coverage 11](#_Toc397077508)

[3.2 Pricing Methodologies 11](#_Toc397077509)

[3.3 Relevant Risk Factors 11](#_Toc397077510)

[3.4 Look-Back Period 12](#_Toc397077511)

[3.5 Historic Risk Factor Returns 13](#_Toc397077512)

[3.6 Historic Volatility 13](#_Toc397077513)

[3.7 Re-Scaled Returns 14](#_Toc397077514)

[3.8 Simulated Risk Factors 14](#_Toc397077515)

[3.9 Simulated P&L 15](#_Toc397077516)

[3.10 Initial Margin Estimation 15](#_Toc397077517)

[3.11 Pro-Cyclicality Buffer 16](#_Toc397077518)

[3.12 Initial Margin Floor 16](#_Toc397077519)

[4 Pricing Methodologies 17](#_Toc397077520)

[4.1 STIR Futures 17](#_Toc397077521)

[4.2 Government Bond Futures 18](#_Toc397077522)

[4.3 Deliverable Swap Futures 21](#_Toc397077523)

[5 Initial Margin Methodology Implications 27](#_Toc397077524)

[5.1 New Risk Factors 27](#_Toc397077525)

[5.2 PAIRS Harmonisation 28](#_Toc397077526)

[6 Settlement Pricing & Delivery Implications 29](#_Toc397077527)

[6.1 Settlement Pricing 29](#_Toc397077528)

[6.2 Delivery Mechanism 29](#_Toc397077529)

[6.3 Delivery Margin 29](#_Toc397077530)

[7 Default Management Process Implications 31](#_Toc397077531)

[7.1 Default Management Framework 31](#_Toc397077532)

[7.2 Default Management Process 32](#_Toc397077533)

[8 Additional Margin Methodology Implications 35](#_Toc397077534)

[8.1 Liquidity & Concentration Risk Margin 35](#_Toc397077535)

[8.2 Credit Risk Margin 38](#_Toc397077536)

[9 Acceptability for Clearing 39](#_Toc397077537)

[9.1 Membership 39](#_Toc397077538)

[9.2 Contract Standardisation 39](#_Toc397077539)

[9.3 Pricing 39](#_Toc397077540)

[9.4 Market Risk 39](#_Toc397077541)

[9.5 Operational Risk 40](#_Toc397077542)

[9.6 Legal Risk 40](#_Toc397077543)

[9.7 Settlement Risk 40](#_Toc397077544)

[9.8 Liquidity Risk 40](#_Toc397077545)

[9.9 Issuer Risk 40](#_Toc397077546)

[9.10 Foreign Exchange Risk 40](#_Toc397077547)

[10 Other Methodological / Implementation Points 41](#_Toc397077548)

[10.1 Curve Interpolation / Extrapolation 41](#_Toc397077549)

[10.2 Curve Tenor Points / Time Factors 41](#_Toc397077550)

[10.3 Historic Risk Factor Returns & Scenario Dates 42](#_Toc397077551)

[10.4 Initial Margin Buffer / Scaling Factor 42](#_Toc397077552)

[10.5 STIR Futures – Pricing Data / Assumptions 43](#_Toc397077553)

[10.6 Government Bond Futures – Pricing Data / Assumptions 43](#_Toc397077554)

[11 Reporting & Other Analytical Requirements 45](#_Toc397077555)

[11.1 Theoretical Prices vs. Actual Prices 45](#_Toc397077556)

[11.2 Cheapest-to-Deliver Bond Spreads 45](#_Toc397077557)

[11.3 Sensitivity Analysis 46](#_Toc397077558)

[11.4 Stress Testing 46](#_Toc397077559)

[Appendix 1 – Examples of New Risk Factors 48](#_Toc397077560)

[ Index Curves 48](#_Toc397077561)

[ OIS Discount Curves 51](#_Toc397077562)

[Appendix 2 – Product Spec. for Yield-Based DSF 54](#_Toc397077563)

[ USD 54](#_Toc397077564)

[ EUR 54](#_Toc397077565)

[ GBP 54](#_Toc397077566)

[Appendix 3 – Risk Factor Back-Testing Results 55](#_Toc397077567)

[ EUR – 1 Day / Up Breaches 55](#_Toc397077568)

[ EUR – 1 Day / Down Breaches 55](#_Toc397077569)

[ EUR – 2 Day / Up Breaches 55](#_Toc397077570)

[ EUR – 2 Day / Down Breaches 56](#_Toc397077571)

[ USD – 1 Day / Up Breaches 56](#_Toc397077572)

[ USD – 1 Day / Down Breaches 56](#_Toc397077573)

[ USD – 2 Day / Up Breaches 56](#_Toc397077574)

[ USD – 2 Day / Down Breaches 56](#_Toc397077575)

[ GBP – 1 Day / Up Breaches 56](#_Toc397077576)

[ GBP – 1 Day / Down Breaches 57](#_Toc397077577)

[ GBP – 2 Day / Up Breaches 57](#_Toc397077578)

[ GBP – 2 Day / Down Breaches 57](#_Toc397077579)

[Appendix 4 - Price Alignment Interest & Potential Implications of Convexity Bias 58](#_Toc397077580)

[Introduction 58](#_Toc397077581)

[Work Undertaken 58](#_Toc397077582)

[Results 59](#_Toc397077583)

[Conclusion 61](#_Toc397077584)

Abbreviations

**ADV** - Average Daily Volume

**BOE** - Bank of England

**CALM** - Collateral & Liquidity Management

**CCP** - Central Counterparty

**CME** - Chicago Mercantile Exchange

**CRIM** - Credit Risk Margin

**CSD** - Central Securities Depository

**CTD** - Cheapest-to-Deliver

**DMG** - Default Management Group

**DMP** - Default Management Process

**DSF** - Deliverable Swap Future

**EMIR** - European Market Infrastructure Regulation

**ERCO** - Executive Risk Committee

**ESMA** - European Securities and Markets Authority

**EWMA** - Exponentially Weighted Moving Average

**FRA** - Forward Rate Agreement

**GC** - General Collateral

**HVAR** - Historic Value-at-Risk

**IM** - Initial Margin

**IMM** - International Monetary Market

**IRS** - Interest Rate Swap

**LCHC** - LCH.Clearnet Group Limited

**LCRM** - Liquidity & Concentration Risk Margin

**LSEDM** - London Stock Exchange Derivatives Market

**LSEG** - London Stock Exchange Group

**MRMC** - Market Risk Management Committee

**MTF** - Multilateral Trading Facility

**NPV** - Non-Par Value

**OIS** - Overnight Indexed Swap

**OTC** - Over-the-Counter

**OTCDN** - OTC DerivNet

**PAI** - Price Alignment Interest

**PAIRS** - Portfolio Approach to Interest Rate Scenarios

**RIE** - Recognised Investment Exchange

**STIR** - Short Term Interest Rate

**VWAP** - Volume-Weighted Average Price

Introduction

Background

As part of a wider initiative to grow its (derivatives) business across multiple asset classes, the London Stock Exchange Group (LSEG) has been in discussion with a number of sell side and other institutions to launch a shared ownership entity to license intellectual property relating to fixed income derivatives. The consortium is known as “Rita” and includes certain banks that are both members of OTC DerivNet (OTCDN) and shareholders in LCH.Clearnet Group Limited (LCHC).

LSEG’s aspirations in fixed income derivatives are driven by a number of strategic and commercial factors, as follows:

* The dislocation created by the regulatory reforms arising from the “commitments” made by the G20 leaders at Pittsburgh in September 2009;
* To deliver a market leading cross-margining solution to existing LCHC members and clients;
* Create more competition in the listed derivatives market; and
* To develop the listed derivatives clearing business within LCHC.

In light of the changes introduced under European Market Infrastructure Regulation (EMIR), Dodd-Frank and Basle III, certain market participants anticipate a potential trend towards so-called “futurisation”: an increasing standardisation of derivatives products and their migration from an over-the-counter (OTC), bilateral, voice-broked market to a model in which exchange traded futures contracts are electronically traded and centrally cleared.

LSEG has therefore identified an opportunity to launch a suite of fixed income derivatives products that will:

* Take advantage of the opportunity created by regulatory reform;
* Provide new and innovative risk management and risk transfer solutions for end-users, clearing members and their customers reflecting the requirements of the EMIR and Dodd-Frank regulations;
* Leverage LSEG and LCHC assets;
* Develop and deepen the partnership model in place at LSEG and LCHC; and
* Establish a competitive advantage.

A deliverable swap future (DSF) – launched on the London Stock Exchange Derivatives Market (LSEDM) and portfolio-margined against the existing risk exposures in the Listed Rates default fund – is the entry point into fixed income derivatives for the Rita consortium.

In addition, a very similar product has been developed by NLX in order to complement its own (existing) fixed income derivatives offering of short-term interest rate (STIR) futures and government bond futures.

Purpose of the Document

The primary purpose of this document is to articulate both the ***pricing*** and ***initial margin*** (IM) methodologies for the DSF.

At the same time, the document includes a detailed description of the corresponding methodologies for products already covered by LCHC’s existing clearing service for NLX, thereby providing relevant context / background for the integration of the DSF into the same (Listed Rates) default fund as the NLX products.

The ***wider*** risk management implications of clearing the DSF – principally those relating to delivery, default management and the various additional margin requirements – are also discussed in some detail.

For completeness, the document also incorporates a piece of quantitative analysis (originally undertaken in December 2013) on the potential implications of convexity bias in relation to the (LSEDM) DSF. This is reproduced in Appendix 4.

# Product Specification - LSEG

The product specification for the DSF developed by LSEG and the Rita consortium can be summarised as follows:

|  |  |
| --- | --- |
| Currencies | USD, EUR and GBP |
| Tenors | USD & EUR: 2, 5, 10 and 30 years / GBP: 10 years |
| Delivery Type | Physical delivery into LCHC SwapClear OTC interest rate swap (IRS) on last trading day |
| Quoting / Pricing Convention | 100 + Non-Par Value (NPV) |
| Price Alignment Interest | Excluded |
| Expiry Date / Cycle | One quarterly expiry / Standard International Monetary Market (IMM) dates in March, June, September and December |
| Fixed Rate | Set by exchange at the time when a contract is first listed |
| Settlement Prices | Daily: Based on exchange activity  Final / Expiry: Based on SwapClear OTC curves |
| Buy / Sell Convention | Buy = Receive Fixed / Sell = Pay Fixed |

The contract specifics for each currency listed in the table above are shown below.

## USD

|  |  |
| --- | --- |
| Notional Contract Size | USD 100,000 |
| Fixed Rate Basis | Semi-Annual 30/360 |
| Floating Rate Basis | 3M LIBOR Actual/360 |
| Floating Rate Reference | USD-LIBOR / Security ID = US0003M |
| Business Day(s) | London, New York |
| Business Day Convention | Modified Following |
| Hours | 07:00 – 21:00 London Time |
| Last Trading Time / Day | 2pm London Time / 2 business days prior to the 3rd Wednesday of delivery month |

|  |  |  |  |
| --- | --- | --- | --- |
| **Tenor** | **Min. Price Increment** | **Approx. Yield Equivalent** | **Block Size** |
| 2Y | 0.01 | 1/2bp | 2,000 |
| 5Y | 0.01 | 1/5bp | 1,500 |
| 10Y | 0.02 | 1/4bp | 1,000 |
| 30Y | 0.02 | 1/10bp | 500 |

## EUR

|  |  |
| --- | --- |
| Notional Contract Size | EUR 100,000 |
| Fixed Rate Basis | Annual 30/360 |
| Floating Rate Basis | 6M EURIBOR Actual/360 |
| Floating Rate Reference | EUR-EURIBOR / Security ID = EUR006M |
| Business Day(s) | TARGET |
| Business Day Convention | Modified Following |
| Hours | 07:00 – 18:00 London Time |
| Last Trading Time / Day | 9am London Time / 2 business days prior to the 3rd Wednesday of delivery month |

|  |  |  |  |
| --- | --- | --- | --- |
| **Tenor** | **Min. Price Increment** | **Approx. Yield Equivalent** | **Block Size** |
| 2Y | 0.01 | 1/2bp | 2,000 |
| 5Y | 0.01 | 1/5bp | 1,500 |
| 10Y | 0.02 | 1/4bp | 1,000 |
| 30Y | 0.02 | 1/10bp | 500 |

## GBP

|  |  |
| --- | --- |
| Notional Contract Size | GBP 100,000 |
| Fixed Rate Basis | Semi-Annual Actual/365F |
| Floating Rate Basis | 6M LIBOR Actual/365F |
| Floating Rate Reference | GBP-LIBOR / Security ID = BP0006M |
| Business Day(s) | London |
| Business Day Convention | Modified Following |
| Hours | 07:00 – 18:00 London Time |
| Last Trading Time / Day | 9am London Time / On the 3rd Wednesday of delivery month |

|  |  |  |  |
| --- | --- | --- | --- |
| **Tenor** | **Min. Price Increment** | **Approx. Yield Equivalent** | **Block Size** |
| 10Y | 0.02 | 1/4bp | 500 |

# Product Specification - NLX

The product specification for the DSF developed by NLX can be summarised as follows:

|  |  |
| --- | --- |
| Currencies | USD, EUR and GBP |
| Tenors | 2, 5 and 10 years (for all currencies) |
| Delivery Type | Physical delivery into LCHC SwapClear OTC IRS on last trading day |
| Quoting / Pricing Convention | 100 + NPV |
| Price Alignment Interest | Excluded |
| Expiry Date / Cycle | Three quarterly expiries / Standard IMM dates in March, June, September and December |
| Fixed Rate | Announced by exchange at the time when a contract is first listed |
| Settlement Prices | Based on exchange activity |
| Buy / Sell Convention | Buy = Receive Fixed / Sell = Pay Fixed |

The contract specifics for each currency listed in the table above are shown below.

## USD

|  |  |
| --- | --- |
| Notional Contract Size | USD 100,000 |
| Fixed Rate Basis | Semi-Annual 30/360 |
| Floating Rate Basis | 3M LIBOR Actual/360 |
| Floating Rate Reference | USD-LIBOR / Security ID = US0003M |
| Business Day(s) | London, New York |
| Business Day Convention | Modified Following |
| Hours | 08:00 – 20:00 London Time |
| Last Trading Time / Day | 8pm London Time / 2 business days prior to the 3rd Wednesday of delivery month |

|  |  |  |
| --- | --- | --- |
| **Tenor** | **Min. Price Increment** | **Approx. Yield Equivalent** |
| 2Y | 0.005 | 1/4bp |
| 5Y / 10Y | 0.01 | 1/5bp / 1/8bp |

## EUR

|  |  |
| --- | --- |
| Notional Contract Size | EUR 100,000 |
| Fixed Rate Basis | Annual 30/360 |
| Floating Rate Basis | 6M EURIBOR Actual/360 |
| Floating Rate Reference | EUR-EURIBOR / Security ID = EUR006M |
| Business Day(s) | TARGET |
| Business Day Convention | Modified Following |
| Hours | 08:00 – 17:00 London Time |
| Last Trading Time / Day | 4.15pm London Time / 2 business days prior to the 3rd Wednesday of delivery month |

|  |  |  |
| --- | --- | --- |
| **Tenor** | **Min. Price Increment** | **Approx. Yield Equivalent** |
| 2Y | 0.005 | 1/4bp |
| 5Y / 10Y | 0.01 | 1/5bp / 1/8bp |

## GBP

|  |  |
| --- | --- |
| Notional Contract Size | GBP 100,000 |
| Fixed Rate Basis | Semi-Annual Actual/365F |
| Floating Rate Basis | 6M LIBOR Actual/365F |
| Floating Rate Reference | GBP-LIBOR / Security ID = BP0006M |
| Business Day(s) | London |
| Business Day Convention | Modified Following |
| Hours | 08:00 – 17:00 London Time |
| Last Trading Time / Day | 4.15pm London Time / On the 3rd Wednesday of delivery month |

|  |  |  |
| --- | --- | --- |
| **Tenor** | **Min. Price Increment** | **Approx. Yield Equivalent** |
| 2Y | 0.005 | 1/4bp |
| 5Y / 10Y | 0.01 | 1/5bp / 1/8bp |

# Overview of Existing NLX Initial Margin Methodology

The Listed Rates default fund covers a range of listed interest rate derivative products that are cleared by LCHC as part of its NLX service.

It is proposed to include the DSF in the same default fund and, in so doing, adopt the same general approach to pricing ***and*** the wider specifics of the IM methodology that underpin the existing NLX service.

This section summarises the existing NLX IM methodology – which has been independently validated by Ernst & Young ***and*** approved for use by the Bank of England (BOE) – as well as providing a lead into a more detailed section on Pricing Methodologies in which the NLX pricing framework is applied specifically to the DSF.

The IM methodology is based on an historic value-at-risk (HVAR) simulation and forms part of LCHC’s harmonised Portfolio Approach to Interest Rate Scenarios (PAIRS) model for estimating margin across three of its clearing services i.e. NLX, RepoClear and SwapClear.

## Product Coverage

The existing NLX service covers the following products:

* 3-Month EURIBOR Futures
* 3-Month Short Sterling Futures
* Long Gilt Futures
* Euro-Schatz Futures
* Euro-Bobl Futures
* Euro-Bund Futures

The products listed above clearly fall into two distinct categories, namely STIR futures and government bond futures.

## Pricing Methodologies

Underlying LCHC’s approach to pricing the various products listed in section 3.1 above is the principle of ***forward pricing***.

Specifically, STIR futures are priced in accordance with the relevant underlying forward interest rate and government bond futures are priced in accordance with the relevant underlying cheapest-to-deliver (CTD) bond i.e. as evaluated on a forward basis.

Pursuant to the above, each class of product has a specific (closed-form) pricing function. These are covered in section 4 below.

## Relevant Risk Factors

The risk factors underlying the NLX IM model fall into 4 broad categories as follows:

* Index Curves
* Sovereign Discount Curves
* Repo / General Collateral (GC) Curves
* Foreign Exchange Rates

The index curves are used to estimate / project forward interest rates, which are in turn used to price the range of 3-month STIR futures.

The sovereign discount and repo / GC curves are used to forward-price the various CTD bonds that underlie the range of government bond future contracts.

The foreign exchange rates are used to translate any non-GBP denominated P&L vectors (generated as part of the HVAR simulation) into “base” currency equivalents.

### Index Curves

In keeping with the contracts that they are ultimately used to price, the index curves for EUR and GBP are each bootstrapped using a strip of STIR futures prices (i.e. as opposed to the LIBOR, forward-rate agreement (FRA) and IRS rates that are used to generate forward rate-setting curves as part of the SwapClear service).

For the same reason, no convexity adjustment is made in this particular bootstrapping process.

The complete list of index curves and underlying tenor points is as follows:

|  |  |
| --- | --- |
| **Risk Factor** | **Tenors** |
| EUR CASH | 24 quarterly time buckets spanning 6 years  i.e. 3M, 6M, 9M, 1Y ... 6Y at 3M intervals |
| GBP CASH | 24 quarterly time buckets spanning 6 years  i.e. 3M, 6M, 9M, 1Y ... 6Y at 3M intervals |

These curves are composed of ***annually*** compounded zero-coupon rates and use an ***Actual/365*** day basis.

### Sovereign Discount Curves

The zero-coupon sovereign discount curves are consistent with those used in the RepoClear service and are as follows:

|  |  |
| --- | --- |
| **Risk Factor** | **Tenors** |
| EUR BOND DE I016 | 18 time buckets spanning 30 years  i.e. 1D, 1W, 1M, 3M, 6M, 1Y ... 10Y at annual intervals, 15Y, 20Y and 30Y |
| GBP BOND GB I022 | 18 time buckets spanning 30 years  i.e. 1D, 1W, 1M, 3M, 6M, 1Y ... 10Y at annual intervals, 15Y, 20Y and 30Y |

As above, these curves are composed of ***annually*** compounded zero-coupon rates and use an ***Actual/365*** day basis.

### Repo / General Collateral Curves

In the existing NLX IM model, only the ***current*** repo rate for each government bond future’s CTD is used i.e. in order to derive the prevailing theoretical forward price thereof in accordance with the methodology described in section 4.2 below.

These rates are expressed as ***annually*** compounded zero-coupon rates and use an ***Actual/365*** day basis.

The repo / GC curve histories do ***not*** form part of the existing HVAR simulation.

### Foreign Exchange Rates

The foreign exchange rates are consistent with those used in both the SwapClear and RepoClear services and are as follows:

|  |  |
| --- | --- |
| **Risk Factor** | **Tenors** |
| EUR/GBP | Spot foreign exchange rate only |

## Look-Back Period

The look-back period for the NLX HVAR simulation is ***1,250 days*** or 5 years.

This is in contrast to the 2,500 days or 10 years used in the equivalent RepoClear and SwapClear IM calculations.

## Historic Risk Factor Returns

Historic risk factor returns are calculated over an assumed holding period of ***2 days*** (i.e. sufficient to hedge or liquidate a defaulted member’s portfolio) and are either ***absolute*** or ***relative***, depending on the underlying risk factor.

Absolute returns are calculated for index curves and sovereign discount curves as follows:

, where

Meanwhile, relative returns are calculated for foreign exchange rates as follows:

## Historic Volatility

The historic volatility of each risk factor’s returns over the assumed holding period is estimated with an exponentially weighted moving average (EWMA) model, as follows:

, where

For the existing NLX IM model, the EWMA decay factor has been set to a value of ***0.97***. This is the same as that for RepoClear, but different to the equivalent factor used in SwapClear (0.992).

However, with the potential introduction of new products (and hence new underlying risk factors) into both the NLX service and the wider Listed Rates (default fund) macrocosm, the EWMA decay factor above is ultimately subject to change at a risk factor level. Therefore, from a technology and general “future-proofing” perspective, it should be implemented as a ***configurable*** parameter setting at risk factor level.

### Seed Volatility

Clearly, in order to initiate the recursive calculation above and hence estimate the ***first*** volatility in the series (), it is necessary to have an estimate of i.e. the so-called seed volatility. For each risk factor () this is based on the simple arithmetic average of the first 60 squared returns in the series as follows:

, where

It should be noted that in order for there to be ***at least*** 1,250 (i.e. 5 years’ worth of) 2-day returns and corresponding volatility estimates for each risk factor, it follows that each time series needs to have ***at least*** 1,312 historic (value) observations in it i.e. 1,250 (look-back period) + 2 (assumed holding period) + 60 (seed volatility observation period).

It should also be noted that for each risk factor () the corresponding seed volatility () is set only ***once***. Nevertheless, when a particular time series of returns is lengthened (e.g. from 5 years to 10 years) it will obviously be necessary to “re-seed” the corresponding volatility series and hence recalculate ***all*** the values therein (i.e. as a one-off exercise).

## Re-Scaled Returns

In order to make them relevant for current market conditions, historic risk factor returns are rescaled using the ratio between so-called “mid-volatility” and historic volatility levels, as follows:

, where

Alternative approaches to volatility-based scaling include the Hull & White method (see below) and one based on an historic measure of standard deviation over a configurable look-back period.

The Hull & White method scales historic risk factor returns using a simple ratio of current and historic volatility levels, as follows:

With the potential introduction of new products (and hence new underlying risk factors) into both the NLX service and the wider Listed Rates space, the volatility-based scaling method above is ultimately subject to change at a risk factor level (i.e. just like the EWMA decay factor discussed in section 3.6 above). Therefore, from a technology and general “future-proofing” perspective, it should be implemented as a ***configurable*** parameter setting at risk factor level – specifically covering the 3 options above i.e. a choice of (a) mid-volatility, (b) Hull & White or (c) historic over a user-defined look-back period.

## Simulated Risk Factors

For each risk factor, simulated scenarios are generated by applying the set of rescaled returns above to its current level, in accordance with the relevant formula below.

For index curves and sovereign discount curves (i.e. where the historic risk factor returns are calculated on an ***absolute*** basis):

, where

Similarly, for foreign exchange rates (i.e. where the historic risk factor returns are calculated on a ***relative*** basis):

## Simulated P&L

The simulated scenarios above are then applied to each ***contract*** in order to generate a series of perturbed prices. This series is then translated into a corresponding P&L vector (denominated in the underlying contract’s currency) by subtracting the relevant current price from each perturbed amount, as follows:

, where

The lot size is product specific e.g. EUR 2,500 for 3-month EURIBOR futures, GBP 1,250 for 3-month Short Sterling futures etc.

Where the P&L vector above is ***not*** denominated in LCHC’s “base” currency of GBP, it is necessary to translate each entry therein using the corresponding simulated foreign exchange rate as follows:

, where

## Initial Margin Estimation

Having generated a GBP-denominated P&L vector for each contract, it is a straightforward process to aggregate these in the precise combination that corresponds to a particular member’s portfolio of positions e.g. long 10 lots of contract A and short 5 lots of contract B. This step obviously results in a portfolio-specific GBP-denominated P&L vector.

In order to generate an IM estimate from this vector, the simulated P&Ls are ranked from highest to lowest, with the 4 largest losses (equivalent to a ***99.7% confidence interval***, given a look-back period of 1,250 days - see below1) forming the basis of an ***expected shortfall*** calculation.

The expected shortfall is defined as the average of first to fourth largest losses and this taken to be the IM estimate.

1

## Pro-Cyclicality Buffer

Under Article 28 of EMIR, a central counterparty (CCP) must ensure that its policy for selecting and revising (a) the confidence interval, (b) the holding / liquidation period and (c) the look-back period underlying any of its HVAR-based margin models delivers forward-looking, stable and prudent IM requirements that limit pro-cyclicality. To this end, a CCP shall employ at least one of the following options:

* Applying (to the calculated IM) a margin buffer of at least 25%, which it allows to be temporarily exhausted in periods where margin requirements are rising significantly;
* Assigning an additional 25% weight to stressed observations in the look-back period; and
* Ensuring that its margin requirements are not lower than those that would be calculated using volatility estimated over a 10-year historic look-back period.

Clearly, in any HVAR margin model, the shorter the chosen look-back period the more pro-cyclical will be the IM estimates generated. This is basically the thinking behind using a suitably long historic look-back period, specifically one that is 10 years in length (as above).

As far as the NLX HVAR margin model is concerned, the use of a 5-year look-back period (i.e. as opposed to a 10-year one) is therefore accompanied by the adoption of a ***25% IM buffer*** that is permitted to be temporarily exhausted in periods where margin requirements are rising significantly i.e. in accordance with the first of the (anti) pro-cyclicality options under EMIR above.

In addition, LCHC maintains flexibility in respect of the other aforementioned key model calibration parameters, namely the confidence interval and the assumed holding / liquidation period.

## Initial Margin Floor

Pursuant to LCHC’s recent interactions with the BOE and the European Securities and Markets Authority (ESMA) in relation to its application for authorisation as a CCP under EMIR, it is proposed to apply a margin ***floor*** based on an un-scaled 99th percentile HVAR measure. It follows that this will need to be calculated alongside the (mid-volatility) scaled 99.7th percentile expected shortfall measure described above.

# Pricing Methodologies

This section begins by summarising the set of pricing functions that are currently in use as part of the existing NLX service. It then goes on to define a suitable pricing model for the DSF that is based on exactly the same basic principles, albeit with a requirement for some additional new risk factors. The latter are discussed in section 5 below.

## STIR Futures

Each 3-month STIR futures contract is priced in accordance with the relevant underlying forward interest rate as follows:

, where

The implied forward interest rate above is derived from the relevant underlying cash curve (e.g. EUR CASH) as follows:

, where

For index curves composed of ***annually*** compounded zero-coupon rates, the discount factor above is calculated as follows:

, where

For index curves composed of ***continuously*** compounded zero-coupon rates, the discount factor above is calculated as follows:

, where

### Example

For the purposes of demonstrating how the calculation defined above works in practice, the 3-month EURIBOR future expiring on Monday 16th March 2015 was chosen.

The relevant contract static data are as follows:

|  |  |
| --- | --- |
| **Contract Details / Delivery Month** | **3-Month EURIBOR Future / March 2015** |
| Expiry Date | 16th March 2015 |
| Deposit Start Date | 18th March 2015 |
| Deposit End Date | 16th June 2015 |
| Contract Day Basis | Actual/360 |
| Index Curve | EUR CASH |
| Evaluation Date | 17th February 2014 |

Given the above, the relevant tenor points on the EUR CASH index curve (as at 17th February 2014, the chosen evaluation date) are as follows:

|  |  |
| --- | --- |
| **Years (Actual/365)** | **Annually Compounded Zero-Coupon Rate** |
| 1.00 | 0.260046% |
| 1.25 | 0.265988% |
| 1.50 | 0.276551% |

Pursuant to all of the above, the pricing calculation proceeds as follows:

|  |  |
| --- | --- |
| t |  |
| T |  |
|  | 0.261934% (i.e. as linearly interpolated from EUR CASH index curve using t = 1.0795) |
|  | 0.269200% (i.e. as linearly interpolated from EUR CASH index curve using T = 1.3620) |
|  |  |
|  |  |
|  |  |
|  |  |
|  | **(i.e. as rounded to the nearest 0.005)** |

On 17th February 2014, the ***actual*** closing (exchange) price of the March 2015 3-month EURIBOR future (internal reference F-NLX-FUT-NINI-20150300) was also 99.705.

## Government Bond Futures

Each government bond futures contract is priced in accordance with the relevant underlying CTD bond – evaluated on a forward basis – as follows:

, where

The theoretical clean price of the underlying CTD (i.e. as quoted for ***standard*** settlement date) is derived by discounting its cash flows using the relevant sovereign (annually compounded zero-coupon) discount curve as follows:

, where

### Example

For the purposes of demonstrating how the calculation defined above works in practice, the March 2014 Euro-Schatz future (expiring on Thursday 6th March 2014) was chosen.

The relevant contract static data are as follows:

|  |  |
| --- | --- |
| **Contract Details / Delivery Month** | **Euro-Schatz Future / June 2014** |
| Expiry Date | 6th June 2014 |
| Delivery Date | 10th June 2014 |
| CTD Details | DE0001141604 / 2.75% / Maturity Date 8th April 2016 |
| CTD Standard Settlement Date | T+3 |
| CTD Conversion Factor | 0.945174 |
| CTD Coupon Frequency | Annual |
| CTD Coupon Day Basis | Actual/Actual |
| CTD Clean Quoted Price | 105.625 |
| Repo Rate | -0.09% |
| Repo Day Basis | Actual/365 |
| Evaluation Date | 17th February 2014 |

The relevant tenor points on the EUR BOND DE I016 sovereign discount curve (as at 17th February 2014, the chosen evaluation date) are as follows:

|  |  |
| --- | --- |
| **Years (Actual/365)** | **Annually Compounded Zero-Coupon Rate** |
| 0.0822 | 0.0680% |
| 0.2466 | 0.0680% |
| 0.4932 | 0.0880% |
| 1.0000 | 0.0830% |
| 2.0000 | 0.1090% |
| 3.0000 | 0.2120% |

In addition, the outstanding cash flows on the CTD (per EUR 100 of notional principal) as at 20th February 2014 (the corresponding settlement date) are as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Coupon Rate / Principal** | **Period Start Date** | **Period End Date / Cash Flow Date** | **Cash Flow**  **(CF)** |
| 2.75% | 08/04/2013 | 08/04/2014 | 2.7500 |
| 2.75% | 08/04/2014 | 08/04/2015 | 2.7500 |
| 2.75% | 08/04/2015 | 08/04/2016 | 2.7500 |
| 100.00% | - | 08/04/2016 | 100.0000 |

Given the above, the ***unadjusted*** theoretical clean price of the CTD (per EUR 100 of notional principal) is calculated as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Cash Flow**  **(CF)** | **Cash Flow Date ()**  **(Actual/365)** | **Linearly-Interpolated Discount Rate ()**  **[= 0.0680%]** |  |
| 2.7500 | 0.1370 | 0.0680% | 2.7498 |
| 2.7500 | 1.1370 | 0.0866% | 2.7473 |
| 2.7500 | 2.1397 | 0.1234% | 2.7428 |
| 100.0000 | 2.1397 | 0.1234% | 99.7370 |
|  |  | *Less*: Accrued Interest () | (2.3959) |
|  |  | **Unadjusted Price** | **105.5810** |

This differs from the CTD’s ***actual*** clean price (of 105.625) by minus 0.0440, which is equivalent to a flat spread ***under*** the sovereign discount curve of ***1.9851 basis points*** (calculated using a simple iterative solving process) as shown below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Cash Flow**  **(CF)** | **Cash Flow Date ()**  **(Actual/365)** | **Spread-Adjusted Discount Rate ()**  **[ = 0.0481%]** |  |
| 2.7500 | 0.1370 | 0.0481% | 2.7498 |
| 2.7500 | 1.1370 | 0.0667% | 2.7479 |
| 2.7500 | 2.1397 | 0.1035% | 2.7439 |
| 100.0000 | 2.1397 | 0.1035% | 99.7792 |
|  |  | *Less*: Accrued Interest () | (2.3959) |
|  |  | **Actual Price** | **105.6250** |

Pursuant to all of the above, the pricing calculation (per EUR 100 of notional principal) proceeds as follows:

|  |  |
| --- | --- |
|  | 1 / 0.945174 = 1.058006 |
|  | 105.6250 |
|  |  |
|  | -0.09% |
|  |  |
|  |  |
|  |  |
|  | **(i.e. as rounded to the nearest 0.005)** |

On 17th February 2014, the ***actual*** closing (exchange) price of the June 2014 Euro-Schatz future (internal reference F-NLX-FUT-NSNS-20140600) was 110.860, a (relative) difference of just 0.0135% compared to the figure above. This difference is equivalent to just under 0.7 basis points in terms of yield.

### Delivery Margin

For each government bond future position that has entered the delivery cycle, it is necessary to calculate IM between expiry / notice date and the corresponding delivery date. This particular type of IM is called ***delivery margin***.

Within each relevant (margin) account, the calculation of delivery margin relies on the following:

* The segregation of all so-called “tendered” positions (i.e. those that have entered the delivery cycle) from all other open positions; and
* The ongoing generation of a P&L vector for each relevant underlying contract (i.e. between expiry / notice date and delivery date).

Thereafter, the sub-portfolio of tendered positions is (portfolio) margined separately to the complementary sub-portfolio of open (i.e. non-tendered) positions, with the two resulting IM calculations being subsequently added together at account level. By segregating tendered positions in this way, it follows that the benefit of any risk / margin offsets that previously existed between them and the other open positions is lost during the delivery cycle.

As far as the ongoing generation of P&L vectors is concerned, LCHC’s margining systems routinely set the delivery date for each government bond future contract to be the latest date permitted under the terms of the relevant product specification (e.g. the last business day of the delivery month for long gilt futures). This ensures that each such contract is always ***capable*** of being included in the HVAR simulation (i.e. should there be a corresponding “tendered” position in the clearing system) between expiry date and the ***last possible*** delivery date.

Furthermore, when a particular government bond delivery is late / overdue for some reason, the corresponding future’s delivery date (as defined by the LAST\_TRADING\_DATE field – see section 10.6 below) can be moved forward in time in order to ensure that the offending position continues to be included in the HVAR simulation (and hence margined appropriately) until such time as delivery is made successfully.

## Deliverable Swap Futures

In harmony with the forward pricing approach adopted in respect of the existing NLX product set, it is proposed to price each DSF contract in accordance with the relevant underlying forward-starting IRS – discounted to the DSF’s delivery / effective date on a standard overnight indexed swap (OIS) basis – as follows:

, where

The implied forward interest rates above are derived from the relevant underlying index curve (e.g. 6M EURIBOR) as follows:

, where

For index curves composed of ***continuously*** compounded zero-coupon rates, the discount factor above is calculated as follows:

, where

Similarly, for OIS discount curves composed of ***continuously*** compounded zero-coupon rates, the discount factor in the original DSF pricing function is calculated as follows:

, where

It should be noted that all of the above is ***identical*** in every material respect to the SwapClear valuation methodology for forward-starting IRS.

### Example

For the purposes of demonstrating how the calculation defined above works in practice, a hypothetical 2-year EUR-denominated DSF expiring on Monday 16th June 2014 was chosen.

The underlying is therefore a 2-year EUR-denominated IRS for delivery / value on Wednesday 18th June 2014 and the relevant contract static data are as follows:

|  |  |
| --- | --- |
| **Contract Details / Delivery Month** | **2-Year EUR DSF / June 2014** |
| Expiry Date | 16th June 2014 |
| Delivery / Effective Date | 18th June 2014 |
| Maturity Date | 20th June 2016 |
| Fixed Rate | 1.0000% |
| Fixed Rate Basis | Annual 30/360 |
| Floating Rate Index Curve | 6M EURIBOR |
| Floating Rate Basis | Semi-Annual Actual/360 |
| Evaluation Date | 17th February 2014 |

Given the above, the relevant tenor points on the 6M EURIBOR index curve (as at 17th February 2014, the chosen evaluation date) are as follows:

|  |  |  |
| --- | --- | --- |
| **Tenor (Bucket)** | **Years (Actual/365)** | **Continuously Compounded**  **Zero-Coupon Rate** |
| 3M | 0.2493 | 0.242062% |
| 6M | 0.4986 | 0.249838% |
| 9M | 0.7479 | 0.249148% |
| 1Y | 1.0000 | 0.252944% |
| 18M | 1.4986 | 0.270552% |
| 2Y | 2.0000 | 0.441251% |
| 3Y | 3.0000 | 0.589888% |

Similarly for the EUR OIS (i.e. EONIA) discount curve:

|  |  |  |
| --- | --- | --- |
| **Tenor (Bucket)** | **Years (Actual/365)** | **Continuously Compounded Zero-Coupon Rate** |
| 9M | 0.7479 | 0.111183% |
| 10M | 0.8329 | 0.107051% |
| 11M | 0.9151 | 0.109802% |
| 1Y | 1.0000 | 0.108375% |
| 15M | 1.2493 | 0.110441% |
| 18M | 1.4986 | 0.116103% |
| 21M | 1.7479 | 0.124050% |
| 2Y | 2.0000 | 0.141610% |
| 3Y | 3.0000 | 0.270992% |

Pursuant to all of the above, the pricing calculation for the fixed leg proceeds as follows:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 1 | 0.3315 | 1.3315 | 1.0000% | 1.0000 | 0.1123% | 0.998506 | 0.998506% |
| 2 | 1.3315 | 2.3397 | 1.0000% | 1.0056 | 0.1856% | 0.995668 | 1.001199% |

Similarly, for the floating leg:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| 1 | 0.3315 | 0.8329 | 0.2509% | 0.5083 | 0.1071% | 0.999109 | 0.127448% |
| 2 | 0.8329 | 1.3315 | 0.2847% | 0.5056 | 0.1123% | 0.998506 | 0.143697% |
| 3 | 1.3315 | 1.8329 | 0.6938% | 0.5083 | 0.1300% | 0.997621 | 0.351866% |
| 4 | 1.8329 | 2.3397 | 0.8700% | 0.5139 | 0.1856% | 0.995668 | 0.445144% |

, so it follows that:

(i.e. as rounded to the nearest 0.01)

Although there is obviously no ***actual*** price against which to compare it, this result can nevertheless be rationalised by considering the difference between the contract’s fixed rate (i.e. 1.000%) and the prevailing 2-year forward par swap rate (i.e. as implied by the index and discount curves reproduced above).

The 2-year forward par swap rate is in fact 0.5342%, which differs from the contract’s fixed rate by minus 46.58 basis points. Given that the underlying is a 2-year receive-fixed swap, this is equivalent to ***plus*** 0.93 points in terms of price i.e. exactly the same as that implied by the calculation above.

### Adaptation for Yield-Based Deliverable Swap Futures

As detailed in section 1 above, the DSF contracts developed by both LSEG and NLX are quoted on a ***price*** basis (i.e. 100 + NPV) and each underlying forward-starting IRS has a fixed rate that is set / announced by the exchange when the corresponding contract is first listed.

An alternative to such a price-based DSF is a yield-based one that differs in the following ways:

* Each contract is quoted on a yield basis i.e. 100 *minus* the prevailing forward par swap rate; and
* The underlying forward-starting IRS is a par swap, which effectively means that the (projected) fixed rate is re-set every time the price of the DSF changes.

At any given point in time, the prevailing forward par swap rate that corresponds to a particular DSF contract () is defined as follows:

, where

It follows that the theoretical quoted price of the corresponding DSF contract () is as per the expression below:

Clearly, this pricing function shares the same variables / risk factors as the price-based equivalent, although unlike the latter the yield-based formulation is of little or no use from a P&L simulation perspective. This follows from the fact the pricing function says nothing about the ***value*** of the underlying deliverable IRS, but is instead merely a means of quoting the price of the DSF.

In order to generate an equivalent price for the yield-based DSF that also expresses the underlying IRS’s value, the price-based function should be used instead, as follows:

Since the underlying is a ***par*** swap, the equivalent ***current*** price generated in accordance with the above expression is always 100.

Crucially though, the formulation provides a suitable means of revaluing the deliverable IRS (i.e. as values of the various underlying risk factors change, with being fixed) and hence the initial / current price of 100 is merely the zero-P&L reference point for the subsequent HVAR simulation.

It follows that the overall IM methodology for a yield-based DSF (as per the specific description thereof above) is very similar to that for the price-based equivalent, and in fact only requires the additional step of calculating in order to:

(a) Generate a theoretical price for each contract (i.e. for comparison to the corresponding actual exchange-traded price); and

(b) Establish the fixed rate on the underlying deliverable IRS for the purposes of calculating (i.e. using both the current and perturbed values of the various underlying risk factors as part of the HVAR simulation).

Other than that, the methodologies are ***identical***.

It should be noted that for a given re-pricing scenario (i.e. a set of simulated risk factor returns), the change in above can also be expressed in terms of the difference between and the equivalent forward par swap rate () that is consistent with the perturbed values of the various risk factors and corresponding pricing parameters – i.e. , and – as follows:

, and

However, we know that:

It follows that:

The accumulation factor – i.e. – at the end of the above expression effectively defines the (variable) tick-size for each contract e.g. USD 1.9985 for the 2-year (USD) DSF, USD 4.8633 for the 5-year DSF, USD 9.0216 for the 10-year DSF etc. The maximum move in this factor is likely to be of the order of +/-1.5% per day, or +/-0.5% per hour in a typical 9-hour trading day.

Pursuant to the above, the draft product specification for the yield-based DSF ***originally*** developed by NLX is summarised in Appendix 2 below. This specification was subsequently replaced with one referencing a price-based DSF (i.e. as detailed in section 1 above), although the content is still relevant for the purposes of designing / building a generic yield-based DSF model.

# Initial Margin Methodology Implications

The introduction of the DSF into the existing Listed Rates / NLX IM framework entails not only the development of a new pricing function, but also the sourcing of new market data.

The various new risk factors underlying the DSF pricing model described in section 4, as well as the associated market data requirements and appropriate sources thereof, are detailed in section 5.1 below.

Otherwise than that, and notwithstanding the comments in section 5.2 below, it is proposed to leave the existing Listed Rates / NLX HVAR methodology unchanged following the introduction of the DSF. This will reduce the number of model-related changes / enhancements requiring BOE approval and this will in turn shorten the projected time-to-market for the DSF.

## New Risk Factors

The additional risk factors required to price and margin the DSF fall into 3 distinct categories as follows:

* Index Curves
* OIS Discount Curves
* Foreign Exchange Rates

Each of these categories is discussed in further detail below.

### Index Curves

The DSF index curves are used to estimate / project the forward interest rates that form the basis of the underlying IRS’s floating leg. It follows that the underlying curve construction methodology must incorporate market instruments that are IRS-specific i.e. as opposed to the strip of STIR futures that underlie each of the NLX cash curves detailed in section 3.3.1 above.

The relevant DSF index curves and underlying tenor points are therefore as follows:

|  |  |
| --- | --- |
| **Risk Factor /**  **Swap Generator** | **Tenors** |
| EUR\_EURIBOR  / EURIBOR A 6M | 1D, 1W, 1M, 2M, 3M, 6M, 9M, 1Y, 18M, 2Y ... 10Y at annual intervals, 12Y, 15Y, 20Y, 25Y, 30Y, 35Y, 40Y, 45Y, 50Y |
| GBP\_LIBOR  / GBP LIBOR S 6M | 1D, 1W, 1M, 2M, 3M, 6M, 9M, 1Y, 18M, 2Y ... 10Y at annual intervals, 12Y, 15Y, 20Y, 25Y, 30Y, 35Y, 40Y, 45Y, 50Y |
| USD\_LIBOR  / USD LIBOR A 3M | 1D, 1W, 1M, 2M, 3M, 6M, 9M, 1Y, 18M, 2Y ... 10Y at annual intervals, 12Y, 15Y, 20Y, 25Y, 30Y, 35Y, 40Y, 45Y, 50Y |

These curves are all used as part of the daily IM calculations in SwapClear and can therefore be sourced directly from that service. An example of each curve above is reproduced in Appendix 1.

### OIS Discount Curves

The OIS discount curves are used to discount the cash flows on both the fixed and floating legs of the underlying IRS.

The relevant OIS discount curves and underlying tenor points are as follows:

|  |  |
| --- | --- |
| **Risk Factor** | **Tenors** |
| EUR\_EONIA | 1D, 1W, 2W, 3W, 1M ... 1Y at monthly intervals, 15M, 18M, 21M, 2Y ... 10Y at annual intervals, 12Y, 15Y, 20Y, 25Y, 30Y, 35Y, 40Y, 45Y, 50Y |
| GBP\_SONIA | 1D, 1W, 2W, 3W, 1M ... 1Y at monthly intervals, 15M, 18M, 21M, 2Y ... 10Y at annual intervals, 12Y, 15Y, 20Y, 25Y, 30Y, 35Y, 40Y, 45Y, 50Y |
| USD\_FEDFUND | 1D, 1W, 2W, 3W, 1M ... 1Y at monthly intervals, 15M, 18M, 21M, 2Y ... 10Y at annual intervals, 12Y, 15Y, 20Y, 25Y, 30Y, 35Y, 40Y, 45Y, 50Y |

As above, these curves are all used as part of the daily IM calculations in SwapClear and can therefore be sourced directly from that service. An example of each curve above is reproduced in Appendix 1.

### Foreign Exchange Rates

In addition, a means of translating each simulated USD-denominated P&L into an equivalent “base” currency (i.e. GBP) amount is required, as follows:

|  |  |
| --- | --- |
| **Risk Factor** | **Tenors** |
| GBP/USD | Spot foreign exchange rate only |

## PAIRS Harmonisation

As mentioned above, it is proposed to leave the key calibration aspects of the existing Listed Rates / NLX HVAR methodology unchanged following the introduction of the DSF. This includes the use of:

* A holding period of ***2 days*** (i.e. sufficient to hedge or liquidate a defaulted member’s portfolio);
* A look-back period of ***1,250 days*** or 5 years;
* Absolute returns for index / discount curves and relative returns for foreign exchange rates;
* An EWMA model with a decay factor of ***0.97*** for estimating historic volatility;
* The ratio between mid-volatility and historic volatility levels for scaling historic risk factor returns;
* An expected shortfall calculation to estimate IM; and
* A 25% IM buffer to compensate for the use of a 5-year (i.e. as opposed to a 10-year) look-back period.

Whilst such an approach serves to perpetuate a number of inconsistencies with the equivalent SwapClear PAIRS model (notably in respect of the look-back period and EWMA decay factor), these are nevertheless ***pre-existing*** incongruities and therefore deemed to be acceptable in the short-term.

If considered necessary in the future, the eradication of such inconsistencies would form part of a separate PAIRS harmonisation exercise.

It should be noted that the justification of the aforementioned methodology / calibration assumptions – both in the context of the existing NLX service and subsequent to the incorporation the DSF into the Listed Rates default fund – is an ongoing process and beyond the scope of this document.

# Settlement Pricing & Delivery Implications

This section not only addresses the final settlement pricing issue that was raised at the Market Risk Management Committee (MRMC) meeting on 1st July 2014 – at which the DSF proposal was first presented and discussed – but also describes other key risk-related aspects of the overall delivery process (i.e. into SwapClear).

## Settlement Pricing

As per the detailed contract specification for the LSEG DSF, each daily settlement price will be calculated using a volume-weighted average price (VWAP) method and each final settlement price will be generated by SwapClear at the appropriate (expiry) date and time.

Although this creates an operational dependency on SwapClear, the final settlement price will nevertheless be owned and published by LSEG. Therefore, the calculation of the final settlement price is merely outsourced to SwapClear and nothing more.

It follows that LCHC / SwapClear will ***not*** become a pricing benchmark in this regard.

At the same time, it should be noted that both the daily and final settlement prices for the various NLX DSF contracts will be determined by NLX and hence there is no dependency whatsoever on SwapClear.

## Delivery Mechanism

As detailed in section 1 above, the various LSEG DSF contracts will expire at the following times:

|  |  |
| --- | --- |
| EUR | 9am London Time / 2 business days prior to the 3rd Wednesday of delivery month |
| USD | 2pm London Time / 2 business days prior to the 3rd Wednesday of delivery month |
| GBP | 9am London Time / On the 3rd Wednesday of delivery month |

Similarly, as per section 2 above, the equivalent NLX DSF contracts will expire as follows:

|  |  |
| --- | --- |
| EUR | 4.15pm London Time / 2 business days prior to the 3rd Wednesday of delivery month |
| USD | 8pm London Time / 2 business days prior to the 3rd Wednesday of delivery month |
| GBP | 4.15pm London Time / On the 3rd Wednesday of delivery month |

Positions that have not been closed-out prior to these times will be converted into what are effectively pseudo bi-lateral OTC IRS trades and passed to SwapClear as part of the delivery process.

Given the various distinct expiry dates / times detailed above, it follows that each expiry / delivery quarter will involve the processing of 6 separate packages of IRS trades across the 2 exchanges i.e. one for each combination of market and currency.

In order to minimise the risk of market participants erroneously failing to close-out an open position and hence having to take / receive delivery of the underlying physical IRS, expiry reminders will be issued prior to the above expiry times.

In addition, the “Deliverable Swap Futures Service Procedures” for the LSEDM stipulates that any party to a DSF contract will need to be approved to participate in the SwapClear service as a clearing member or, alternatively, will need to appoint an agent which participates in the SwapClear service to act on its behalf. It follows that it is not possible for a DSF market participant to reach expiry / delivery without having pre-arranged clearing capability for the underlying physical IRS.A similar requirement and accompanying wording is envisaged for the NLX DSF market.

In order to remove the risk of trades being rejected by SwapClear members, where the Swapclear member is a different legal entity to the futures clearing member, the delivery process will be underpinned by a legal guarantee similar to an NCM/GCM agreement that exists in other services whereby the SwapClear member guarantees to meet the delivery obligations of the futures participant provided they receive the applicable initial margin held. We anticipate that in most cases this agreement will be between entities in the same group;  however the service will be offered to entities in different groups provided the SwapClear member is willing to sign the legal guarantee agreement.

## Delivery Margin

As well as having pre-arranged clearing ***capability*** for the underlying physical IRS, each LSEDM and NLX DSF market participant will also be required to hold sufficient IM with LCHC in order to facilitate the guaranteed registration of each package of (delivered) IRS trades in SwapClear at expiry. This will be achieved by increasing the margin requirement from 2 days’ worth to either 5 days’ or 7 days’ worth (i.e. depending on whether the market participant is a member of SwapClear or not) during the period just prior to expiry. The total initial margin that is then held in relation to the deliverable position will be transferred into and be regarded as SwapClear margin simultaneously to the registration of the new SwapClear transaction. The mechanism for doing so is based on the existing Listed Rates delivery margin methodology i.e. as implemented for NLX government bond future deliveries.

As described in section 4.2.2 above, the latter involves defining a sub-portfolio of government bond future positions that are in delivery phase (i.e. “tendered”) and margining them separately to the rest of the relevant member’s open positions. Adopting the same approach for about-to-expire DSF contracts involves defining 6 further sub-portfolios for each account (i.e. one for each combination of market and currency) and margining these separately to (a) each other, (b) any prevailing government bond future delivery sub-portfolio(s) and (c) the remaining portfolio of open positions.

Having established the relevant sub-portfolios, a margin multiplier of or is applied to each expiry / delivery package 2 business days prior to expiry.

All this ensures that – upon expiry – each package of (delivered) IRS trades has a specifically calculated sub-portfolio IM that corresponds to the specific requirements of SwapClear i.e. 5 days’ or 7 days’ worth depending on nature of the destination account.

The various packages and their corresponding expiry dates / times are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **London Time / Date in Delivery Month** | **Market** | **Currency** | **Contracts in Package** |
| 1 | 9am / 2 days prior to 3rd Weds | LSEDM | EUR | 2Y, 5Y, 10Y, 30Y |
| 2 | 2pm / 2 days prior to 3rd Weds | LSEDM | USD | 2Y, 5Y, 10Y, 30Y |
| 3 | 4.15pm / 2 days prior to 3rd Weds | NLX | EUR | 2Y, 5Y, 10Y |
| 4 | 8pm / 2 days prior to 3rd Weds | NLX | USD | 2Y, 5Y, 10Y |
| 5 | 9am / 3rd Weds | LSEDM | GBP | 10Y |
| 6 | 4.15pm / 3rd Weds | NLX | GBP | 2Y, 5Y, 10Y |

The calling of additional (delivery) margin and the corresponding contract expiries follow the following timetable in the run-up to the 3rd Wednesday of each delivery month:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **EUR** | **USD** | **GBP** |
| Thursday | Delivery margin called | Delivery margin called | - |
| Friday | - | - | - |
| Monday | DSF contracts expire / Margin and position passed to SwapClear | DSF contracts expire / Margin and position passed to SwapClear | Delivery margin called |
| Tuesday | - | - | - |
| Wednesday | - | - | DSF contracts expire / Margin and position passed to SwapClear |

# Default Management Process Implications

This section provides a brief outline of the key phases of the Listed Rates default management ***framework***, all of which will remain unchanged following the introduction of the DSF.

It also provides relevant details of the default management ***process*** (DMP), as it pertains to the DSF specifically.

For a more detailed description of the default management framework, reference should be made to the document entitled “Default Management Framework – NLX Service Volume”.

## Default Management Framework

The Listed Rates default management framework is designed to ensure the successful management of a defaulting member’s portfolio and is composed of eight distinct phases, each of which is covered in turn below.

### Phase I – Pre-Default

The primary objectives of this phase are to ensure that (a) LCHC is prepared operationally for the potential default and (b) the appropriate stakeholders are made aware and hence begin preparatory activities.

For phase I to be activated, LCHC must have reasonable grounds to believe that a member could default. Throughout phase I, a heightened degree of member monitoring / evaluation will be conducted.

Specifically, the stage focuses on:

* Information gathering on the Listed Rates portfolio;
* Risk analysis on the potentially defaulting member’s portfolio; and
* External communication with stakeholders.

### Phase II-III – Activation & Stabilisation

The initial objectives here are (a) to confirm the default and (b) the immediate execution of the default notice. The remainder of phase II and phase III focuses on the first hour of the default, including:

* Assembling the default management team;
* Suspending all trading access; and
* Assessment of the defaulting member’s portfolio and LCHC’s exposure.

### Phase IV – Information Gathering

The objective of Phase IV is to reduce LCHC’s exposure to neutral – or as near to neutral as is practically possible and indeed acceptable – and then to unwind and close-out the defaulting member’s positions in a manner that is consistent with the overall default strategy. This phase consists of two principal activities, as follows:

* Information gathering; and
* Close-out / unwinding the portfolio.

Although information gathering is clearly an essential pre-requisite to gaining a thorough understanding of the defaulting member’s portfolio, it may be necessary to take some trading / close-out decisions before all the relevant data has been gathered and analysed. It follows that the two activities above do not always run sequentially.

### Phase V – Close-Out

The key objective of this phase is to (a) follow the main principles of and (b) achieve the priorities of the DMP, which are as follows:

* **Maintain ongoing performance of LCHC’s obligations vis-à-vis all other clearing members** – LCHC must seek to continue to meet its obligations such as meeting payment and delivery obligations in a timely manner (including those of the defaulting member).
* **Preservation of the default fund** – LCHC must seek to preserve the default fund and its skin-in-the-game capital contribution.
* **Manage the transfer of all individually segregated accounts** – LCHC will seek to manage the transfer of the defaulting member’s segregated client positions to other clearing members in a manner that causes minimal incremental disruption to the market.
* **Manage the transfer of all omnibus accounts** – LCHC will seek to manage the transfer of the defaulting member’s non-segregated client positions to another clearing member if those clients have elected to transfer to a single clearing member. Where this is not the case the account will be closed-out.

### Phase VI – Service Continuity / Loss Allocation

In the unlikely event that the close-out of a defaulting member’s portfolio (an in-extremis default) has exhausted all available resources in the fund, the service will move into the service continuity phase.

During this phase, uncovered losses accrued by the defaulting member during the DMP will be covered by the non-defaulting clearing members through a process of loss allocation. The share of uncovered losses will be determined by calculating a suitable loss distribution charge that can only be met by a cash payment.

### Phase VII – Service Closure

If a decision to continue imposing loss distribution charges is not reached the DMP will then move into the service closure phase, during which any remaining uncovered losses will be calculated and distributed across all remaining non-defaulting clearing members. All open positions registered in the default fund will be cash-settled with the non-defaulting clearing members.

At the point of entry into this phase, the following procedures will be initiated:

* After loss allocation, service closure is triggered by LCHC making a so-called “insufficient resources determination” which means that it does not have sufficient resources to meet its obligations in relation to the default fund.
* The day after LCHC makes such a determination, all open positions in the relevant default fund are closed-out.
* The close-out price for each contract will be calculated in accordance with the corresponding end-of-day margin methodology. Where the necessary pricing data is not available, the close-out price will be the last price used by LCHC in order to calculate variation margin for the contract in question.
* In respect of each clearing member, all losses in respect of open positions owed to / from the clearing member are netted-off into a single amount.
* All clearing members owing money to LCHC must pay in full.

### Phase VIII – Post-Default

The objectives of Phase VIII are to (a) ensure the effective closure of the default, (b) complete all administrative activities and (c) establish a suitable audit trail in order that LCHC can account for all decisions and actions undertaken during the default.

## Default Management Process

From a DMP perspective and for the purposes of the narrative in this section, each open DSF position and the equivalent corresponding (delivered) OTC IRS trade can be thought of as existing in 4 distinct states as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Time (t)** | **Contract Status** | **Default Fund** | **DMP Stage** |
|  | Future | Listed Rates | Listed Rates – BAU |
|  | Future | Listed Rates | Listed Rates – Pre-Expiry |
|  | OTC IRS | Listed Rates | Listed Rates – Post-Expiry |
|  | OTC IRS | SwapClear | SwapClear – BAU |

Each of the aforementioned DMP stages is discussed below:

### Listed Rates – Business as Usual

In the event of a default more than 2 days prior to expiry, open DSF positions will be closed-out / hedged in accordance with the established principles of the existing DMP within Listed Rates.

Specifically, the close-out / hedging of an open DSF position will be achieved by applying the following strategies in order of preference:

* Buying or selling the corresponding contract (i.e. on the same market)
* Buying or selling any other contract (e.g. a “lookalike” contract on a different market) that will generate a market risk neutral position
* Buying or selling a more liquid and / or later expiring contract in the same or another derivative market that has a high correlation to the contract in question

As far as USD-denominated DSF contracts are concerned, there are very similar contracts listed on both the Chicago Mercantile Exchange (CME) and Eris Exchange. In particular, the CME contracts are identical to both the LSEDM and NLX offerings with the exception of having the potential for slightly different fixed rates. However, from a hedge effectiveness point-of-view the latter has little effect and the correlation between any particular LSEDM / NLX DSF contract and the corresponding CME one (i.e. the one with the same quarterly expiry date) is estimated to be upward of 99.95% (based on the relationship between 1-day changes in theoretical price).

By contrast, there is little or no volume in any of the CME’s EUR-denominated DSF contracts and there are no GBP-denominated swap future contracts of any type (i.e. deliverable ***or*** cash-settled) listed on other futures markets. It follows that for defaulted open DSF positions denominated in these two currencies, any potential close-out / hedging strategy will be limited to activity on the LSEDM and / or NLX.

Irrespective of the close-out / hedging strategy, the cost thereof will be borne in accordance with the ***Listed Rates default waterfall***.

### Listed Rates – Pre-Expiry

In the event of a default during the 2 days prior to expiry, open DSF positions will be closed-out / hedged in accordance with the same strategies described above, but it should be noted that the additional margin collected immediately prior to expiry will also be available..

Irrespective of the close-out / hedging strategy, the cost thereof will be borne in accordance with the ***Listed Rates default waterfall***.

### Listed Rates – Post-Expiry

Once the delivery date is passed, any remaining positions must be accepted by the SwapClear member under the guarantee arrangement with the transfer of the appropriate level of margin. The position will then be closed out by the SwapClear DMG.

Any cost associated with this particular close-out / hedging strategy will be borne in accordance with the ***SwapClear default waterfall***.

### SwapClear – Business as Usual

In the event of a default after registration in SwapClear, open positions will be closed-out / hedged in accordance with the established principles of the existing DMP within SwapClear.

It should be noted that – by this stage of proceedings – the IM has already been increased from 2-days’ worth to 5 days’ or 7 days’ worth and is therefore commensurate with that required to support a close-out / hedging strategy in the OTC market by the DMG.

In such a situation, the cost of the close-out / hedging strategy will be borne in accordance with the ***SwapClear default waterfall***.

# Additional Margin Methodology Implications

For the existing Listed Rates / NLX service, the various ***additional*** margin requirements (i.e. over-and-above the IM described in section 3 above) are described in the Group Risk document entitled “Rates: Additional Margin Methodology – Listed Derivatives”.

The introduction of the DSF into this framework has particular implications in respect of (a) liquidity and concentration risk margin (LCRM) and (b) credit risk margin (CRIM). These ramifications are discussed in detail below.

## Liquidity & Concentration Risk Margin

For each particular contract and market in question, LCHC’s LCRM framework references the average daily volume (ADV) as a key measure of prevailing liquidity. At its core, the methodology assumes that any close-out / hedging activity cannot consume more than 25% of the typical volume on any given day. In a Listed Rates and DSF context, it follows that open positions that are equivalent to more than 50% of ADV will be assumed to take longer than 2 days to close-out / hedge and hence will attract a margin add-on.

Given the start-up nature of both the LSEDM and NLX DSF markets, it is proposed – at inception – to use a ***volume floor*** based on projected estimates of ADV across the two markets supplemented by the incorporation of actual volume figures for the corresponding USD-denominated DSF contracts listed on the CME. Including the latter is justified on the grounds that the CME contracts are identical to the LSEDM and NLX equivalents in every respect bar the fixed rate and as such are likely to be near-perfect hedges from a market risk point-of-view.

Pursuant to the above, the LCRM volume denominator is therefore specific to the contract and market in question (e.g. the 1-year GBP DSF listed on the LSEDM), but adapted to account for the aforementioned volume floor as follows:

, where

Having established in accordance with the above, the LCRM add-on is calculated as follows:

, where

The specific calibration of suitable volume floor estimates for the various DSF contracts is discussed in further detail below.

### Volume Floor Estimates

For the LSEDM, the projected estimates of ADV are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Average Daily Volume (ADV)** | | | |
| **Currency** | **Total ADV** | **2-Year** | **5-Year** | **10-Year** | **30-Year** |
| USD | 3,647 | 201 | 1,447 | 1,779 | 220 |
| EUR | 3,282 | 181 | 1,302 | 1,601 | 198 |
| GBP | 365 | - | - | 365 | - |

For NLX, the equivalent figures (based on the very low end of NLX’s volume projections) are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Average Daily Volume (ADV)** | | | |
| **Currency** | **Total ADV** | **2-Year** | **5-Year** | **10-Year** | **30-Year** |
| USD | 2,500 | 138 | 992 | 1,370 | - |
| EUR | 2,250 | 124 | 893 | 1,223 | - |
| GBP | 250 | 14 | 99 | 137 | - |

For CME, the equivalent figures over the first 6 months of 2014 (USD contracts only) were as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Average Daily Volume (ADV)** | | | |
| **Currency** | **Total ADV** | **2-Year** | **5-Year** | **10-Year** | **30-Year** |
| USD | 5,546 | 306 | 2,200 | 2,705 | 335 |

Combining all these figures in the manner proposed above gives rise to the following volume floor estimates:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Average Daily Volume (ADV)** | | | |
| **Currency** | **Total ADV** | **2-Year** | **5-Year** | **10-Year** | **30-Year** |
| USD | 11,693 | 644 | 4,639 | 5,854 | 556 |
| EUR | 5,532 | 305 | 2,195 | 2,834 | 198 |
| GBP | 615 | 14 | 99 | 502 | - |

Using the above in the LCRM would imply that any open positions greater than those shown below would incur a commensurate additional margin requirement:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **50% x ADV** | | | |
| **Currency** | **Total** | **2-Year** | **5-Year** | **10-Year** | **30-Year** |
| USD | 5,847 | 322 | 2,320 | 2,927 | 278 |
| EUR | 2,766 | 152 | 1,097 | 1,417 | 99 |
| GBP | 308 | 7 | 50 | 251 | - |

In order to facilitate a comparison to the underlying OTC IRS market, the figures in the above table are equivalent to the following notional amounts:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **50% x ADV – Notional Equivalent (m)** | | | |
| **Currency** | **Total** | **2-Year** | **5-Year** | **10-Year** | **30-Year** |
| USD | 585 | 32 | 232 | 293 | 28 |
| EUR | 277 | 15 | 110 | 142 | 10 |
| GBP | 31 | 1 | 5 | 25 | - |

Given that there will be 5 members of the “Rita” consortium participating in the LSEDM (out of a total of 32 market participants), all of whom are capable of bridging liquidity into the huge equivalent OTC market – see below for further details – it doesn’t seem unreasonable to assume a 2-day close-out period for open DSF positions up to the notional sizes indicated in the table above.

As at COB 25th June 2014, the OTC IRS trade repository revealed the following levels of ADV (calculated over the previous 30 days):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Contract Code** | **Exchange Source** | **Currency** | **Maturity** | **ADV – Notional** |
| OTC | SDRV | USD | 2-Year | USD 9.4bn |
| OTC | SDRV | USD | 5-Year | USD 43.7bn |
| OTC | SDRV | USD | 10-Year | USD 24.4bn |
| OTC | SDRV | EUR | 2-Year | EUR 3.6bn |
| OTC | SDRV | EUR | 5-Year | EUR 7.5bn |
| OTC | SDRV | EUR | 10-Year | EUR 4.7bn |
| OTC | SDRV | GBP | 2-Year | GBP 1.6bn |
| OTC | SDRV | GBP | 5-Year | GBP 2.4bn |
| OTC | SDRV | GBP | 10-Year | GBP 1.1bn |

The ability of participants to bridge liquidity between the DSF market and the equivalent OTC market is borne out by the tight bid / ask spreads (and commensurately low bid / ask costs) observed in the former, despite the relatively low volume. This is demonstrated by the table below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Contract Code** | **Exchange Source** | **Description** | **Bid / Ask Cost**  **Futures Market** | **Bid / Ask Cost**  **OTC Market** |
| CTP | CBT | USD DSF 2-Year | USD 23.44 | USD 16.50 |
| CFP | CBT | USD DSF 5-Year | USD 31.25 | USD 44.00 |
| CNP | CBT | USD DSF 10-Year | USD 62.50 | USD 88.00 |
| CBP | CBT | USD DSF 30-Year | USD 93.75 | USD 165.00 |
| PTE | CBT | EUR DSF 2-Year | EUR 20.00 | EUR 16.50 |
| PFE | CBT | EUR DSF 5-Year | EUR 30.00 | EUR 44.00 |
| PNE | CBT | EUR DSF 10-Year | EUR 40.00 | EUR 88.00 |

As shown above, each of the CME’s USD and EUR denominated DSF contracts has a bid / ask cost that is comparable to (and generally lower than) that observed in the equivalent part of the OTC market. The bid / ask cost estimates for the OTC market are based on a 1.1 basis point spread, which is a typical on-screen value for USD 25-50m notional bid size.

## Credit Risk Margin

Pursuant to the launch of the LSEDM DSF, the Listed Rates service will cover ***two*** distinct markets (i.e. the LSEDM and NLX). For any particular member, it follows that (where applicable) the margin multipliers etc. that form the basis of LCHC’s CRIM framework will need to be applied simultaneously across the two markets.

In practice, this should be straightforward as the two markets are to be portfolio-margined and hence each member of ***Listed Rates*** (as opposed to member of the LSEDM or NLX) will have a single IM requirement in the first place. Therefore, the application of the following multipliers etc. at this particular (i.e. top) level of the hierarchy should be a trivial exercise:

|  |  |  |
| --- | --- | --- |
| **Internal Credit Score** | **Initial Margin Multiplier** | **Additional Funds to**  **Cover x% of Stress Losses** |
| 6 | 110% | 25% |
| 7 | 120% | 50% |
| 8 | 130% | 100% |
| 9 | 140% | 100% |
| 10 | Issue default notice | Issue default notice |

# Acceptability for Clearing

This section outlines the various additional criteria (i.e. over and above those addressed in earlier sections) that have been evaluated by Group Risk in order to ensure that the DSF is acceptable for clearing.

## Membership

There are currently 32 members of the LSEDM (including the 5 members of the “Rita” consortium) and 9 participants in the existing Listed Rates / NLX service, of which 6 are active.

Pursuant to the launch of the LSEDM DSF and its incorporation into an expanded Listed Rates service, it follows that there is likely to be an increase in the number of participants therein.

The 5 members of the “Rita” consortium alone will take the total number of participants in the Listed Rates service to 11, a number that is deemed adequate in order to clear the DSF.

## Contract Standardisation

Both the LSEDM and NLX DSF contracts possess the standardised features that are typical of futures contracts e.g. quarterly IMM expiry tenors (i.e. March, June, September and December), standard IRS maturity tenors (2-year, 5-year, 10-year and 30-year), standard data basis conventions and floating rate reference indices for each underlying currency etc.

## Pricing

The LSEDM DSF contracts will be listed on London Stock Exchange PLC, a Recognised Investment Exchange (RIE). In line with regulatory obligations, the RIE will publish real-time, delayed and historical prices for all contracts through its data distributors. The RIE will also publish daily and final settlement prices as well as volume and open interest data.

The NLX DSF contracts will be listed on Nasdaq OMX NLX Limited, a regulated Multilateral Trading Facility (MTF). In line with the Markets in Financial Instruments Directive, MTFs must comply with various operating rules including those relating to pre-trade and post-trade price transparency. Specifically, prices of existing orders must be publicly available and those of any trades carried out on the platform must be published in real-time. As well as being transparent, prices and charges must be applied consistently across all members.

As above, NLX will publish real-time, delayed and historical prices for all contracts through its data distributors (i.e. Bloomberg, CQG and Reuters). NLX will also publish daily and final settlement prices as well as volume and open interest data.

LCHC’s price validation controls are set to the following:

|  |  |  |  |
| --- | --- | --- | --- |
| **Contract** | **Price Change** | **Zero / Null Price Control** | **Negative Price Control** |
| USD DSF | +/- 3% | Yes | Yes |
| EUR DSF | +/- 3% | Yes | Yes |
| GBP DSF | +/- 3% | Yes | Yes |

## Market Risk

Potential future exposure is measured by the IM model. The IM methodology is based on an HVAR simulation and forms part of LCHC’s harmonised PAIRS model for estimating margin across three of its clearing services i.e. NLX, RepoClear and SwapClear.

The model’s performance has been assessed by conducting a back-testing exercise at risk factor level, the results of which reproduced in Appendix 3. These show that the model demonstrated acceptable performance over a range of risk factors between 31st December 2007 and 29th May 2014.

Further tests are underway to assess the model’s performance at both contract and portfolio level, with relevant results and conclusions to be shared with the Executive Risk Committee (ERCO) prior to launch.

## Operational Risk

Prior to launch, it is necessary for an operational risk assessment to be completed.

## Legal Risk

Given the RIE status of London Stock Exchange PLC and the existing regulatory permissions associated therewith – coupled with the fact that there is an existing service relationship between the LSEDM and LCHC – it follows that the launch of the LSEDM DSF will not give rise to any new tax, regulatory or jurisdictional issues.

The same applies to the launch of the NLX DSF, which will represent a simple (product) extension to pre-existing service.

## Settlement Risk

At expiry, each DSF contract delivers into a physical IRS – specifically one that is cleared through LCHC’s SwapClear service.

The delivered IRS is an agreement to exchange a series of cash-flows between buyer and seller over a pre-determined period and is therefore ***not*** a security requiring settlement at a central securities depository (CSD) or settlement bank. Instead, delivery is satisfied by the settlement of the delivery invoice payment (based on the final settlement price) and the registration of the IRS in SwapClear (i.e. the legal novation to LCHC).

Since there is no true (security-like) physical delivery there is therefore no risk of settlement failure, and no custodian-related risk arising from reliance on a CSD.

## Liquidity Risk

Since there is no security delivery / settlement, the liquidity requirements for Collateral & Liquidity Management (CALM) are commensurately low.

The underlying DSF currencies are restricted to USD, EUR and GBP. LCHC must maintain minimum amounts of excess liquidity in each of these currencies every day.

It follows that the launch of the LSEDM and NLX DSF contracts is not expected to impact the liquidity requirements of LCHC in respect of USD, EUR and GBP.

## Issuer Risk

This is not relevant for futures contracts.

## Foreign Exchange Risk

In order to calculate IM in LCHC’s “base” currency, all P&L vectors generated by the underlying HVAR model are ultimately denominated in GBP.

All simulated P&Ls that are ***originally*** denominated in currencies other than GBP (e.g. those associated with EUR-denominated and USD-denominated DSF contracts) are translated using a corresponding set of ***simulated*** foreign exchange rates, thereby capturing the risk associated with currency translation in the core of the IM model.

Moreover, conservative foreign exchange haircuts (circa 4-5%) are applied to non-cash collateral denominated in currencies other than GBP.

The inclusion of currency translation risk in the IM model and the existence of the aforementioned collateral haircuts ensure that currency risk is sufficiently mitigated.

# Other Methodological / Implementation Points

During the process of developing Excel-based prototypes of both (a) the specific implementation of the PAIRS HVAR model for the NLX service and (b) the various pricing functions that underlie it (i.e. as outlined in sections 3 and 4 respectively), a number of methodological / implementation-related issues were highlighted. These are summarised below.

## Curve Interpolation / Extrapolation

The interpolation and extrapolation of zero-coupon rates from the various curves that underlie the NLX HVAR model is performed according to the following rules:

* Linear interpolation (according to time) ***between*** available tenors / time buckets;
* Linear extrapolation (according to time) ***beyond the last*** available tenor / time bucket (i.e. using the relevant curve’s zero-coupon rate gradient between the last two available tenors / time buckets); and
* Flat extrapolation ***before the first*** available tenor / time bucket (i.e. using the relevant curve’s zero-coupon rate at the first available tenor / time bucket).

The same rules will be applied to the DSF index and (OIS) discount curves detailed in section 5.1 above.

## Curve Tenor Points / Time Factors

The NLX index curves and sovereign discount curves (as detailed in sections 3.3.1 – 3.3.2 above) have all been ***pre-fitted*** to standard tenor points. In order to facilitate the subsequent interpolation / extrapolation of rates from a particular curve (i.e. in accordance with the methodology above), each tenor point thereon is associated with a fixed time factor. These time factors are expressed in years and calculated in accordance with the curve’s underlying day basis (generally Actual/365).

The NLX index curves (i.e. EUR CASH and GBP CASH) use the following time factors:

|  |  |
| --- | --- |
| **Tenor** | **Time Factor** |
| 3M | 0.25 |
| 6M | 0.50 |
| 9M | 0.75 |
| 1Y | 1.00 |
| 1Y3M | 1.25 |
| 1Y6M | 1.50 |
| 1Y9M | 1.75 |
| 2Y | 2.00 |
| 2Y3M | 2.25 |
| 2Y6M | 2.50 |
| 2Y9M | 2.75 |
| 3Y | 3.00 |
| 3Y3M | 3.25 |
| 3Y6M | 3.50 |
| 3Y9M | 3.75 |
| 4Y | 4.00 |
| 4Y3M | 4.25 |
| 4Y6M | 4.50 |
| 4Y9M | 4.75 |
| 5Y | 5.00 |
| 5Y3M | 5.25 |
| 5Y6M | 5.50 |
| 5Y9M | 5.75 |
| 6Y | 6.00 |

The NLX sovereign discount curves (i.e. EUR BOND DE I016 and GBP BOND GB I022) use the following time factors:

|  |  |
| --- | --- |
| **Tenor** | **Time Factor** |
| 1D | 0.0027 |
| 1W | 0.0192 |
| 1M | 0.0822 |
| 3M | 0.2466 |
| 6M | 0.4932 |
| 1Y | 1.0000 |
| 2Y | 2.0000 |
| 3Y | 3.0000 |
| 4Y | 4.0000 |
| 5Y | 5.0000 |
| 6Y | 6.0000 |
| 7Y | 7.0000 |
| 8Y | 8.0000 |
| 9Y | 9.0000 |
| 10Y | 10.0000 |
| 15Y | 15.0000 |
| 20Y | 20.0000 |
| 30Y | 30.0000 |

The time / accrual factors that will apply to the DSF index and OIS discount curves (i.e. EUR\_EURIBOR, GBP\_LIBOR and USD\_LIBOR) are included as part of the (curve) extracts in Appendix 1.

## Historic Risk Factor Returns & Scenario Dates

Clearly, the value of each of the risk factors outlined in section 3.3 above can only be observed on days when the relevant underlying market is / was open for business. It follows that there is a potentially ***different*** observation schedule for each risk factor, and each of these is potentially different again to the chosen set of (1,250) scenario dates in the NLX HVAR model.

Therefore, in order to ensure that ***genuine*** 2-day returns are calculated whenever possible, it is essential that for each chosen scenario date all risk factor returns are calculated using the relevant ***risk factor specific*** observation schedule and not the overarching set of scenario dates. The same principle applies to the corresponding sets of (risk factor) volatility estimates.

In other words, 2-day returns should ***not*** be calculated using risk factor values observed 2 dates apart in the schedule of chosen scenario dates as these may (in practice) be more than 2 business days apart for the particular risk factor in question.

In practice, the set of scenario dates should be chosen so as to coincide with the 1,250 most recent dates for which each and every underlying risk factor is simultaneously observable. In other words, the scenario dates should correspond to the ***common*** set of risk factor observation dates.

As detailed in section 3.8 above, simulated scenarios for each risk factor are generated by applying a set of rescaled returns (i.e. one per chosen scenario date above) to its ***current*** level. In order to have the flexibility to generate an IM run on ***any*** particular date (i.e. including those where one or more of the underlying risk factor markets is closed), the current level of each risk factor is always taken to be the most recent observation thereof. In practice, this may relate to a previous (i.e. non-current) business day.

## Initial Margin Buffer / Scaling Factor

The current implementation of the NLX HVAR model incorporates the 25% IM buffer mentioned in section 5.2 above by scaling ***every*** P&L generated as part of the simulation process by a factor of 1.25. This scaling factor could equally be applied at member portfolio level at the ***end*** of the P&L vector aggregation and IM estimation process.

## STIR Futures – Pricing Data / Assumptions

As demonstrated by the example in section 4.1 above, there are a number of static data requirements underlying the pricing function for STIR futures. The table below specifies the various sources of such data as well as the assumptions made when the required data is unavailable from the available source file.

The relevant source file for the various fields below is called:

GRI.FANDO\_POSITIONS\_VW\_yymmdd

|  |  |  |
| --- | --- | --- |
| **Contract Attribute** | **Specific Field** | **Assumption(s)** |
| Name / Reference | REFERENCE | - |
| Contract Type | LOGICAL\_COMMODITY\_CODE | - |
| Currency | TRADING\_CURRENCY | - |
| Lot Size | LOT\_SIZE | - |
| Tick Denomination | - | 200 for EBR contracts  100 for STL contracts |
| Business Day(s) | - | TARGET for EUR contracts  London for GBP contracts |
| Business Day Conv. | - | Modified Following |
| Expiry Date | LAST\_TRADING\_DATE | - |
| Deposit Period | MATURITY\_PERIOD | - |
| Deposit Start Date | - | Expiry Date + 2 bus. days for EBR contracts  Expiry Date + 0 bus. days for STL contracts |
| Deposit End Date | - | Deposit Start Date + MATURITY\_PERIOD |
| Contract Day Basis | - | Actual/360 for EUR contracts  Actual/365 for GBP contracts |
| Index Curve | - | EUR CASH for EUR contracts  GBP CASH for GBP contracts |
| Actual Closing Price | PRICE\_VALUE | - |

It should be noted that the current implementation of the NLX HVAR model assumes that ***all*** STIR futures contracts have a deposit period of 90 days. This is of course incorrect as all such contracts are based on a 3-month deposit, the period of which is generally ***not*** precisely 90 days in length.

## Government Bond Futures – Pricing Data / Assumptions

As above, there are a number of static data requirements underlying the pricing function for government bond futures. The table below specifies the various sources of such data as well as the assumptions made when the required data is unavailable from the available source file.

The relevant source file for the various fields below is called:

GRI.FANDO\_BONDPOSITIONS\_VW\_yymmdd

|  |  |  |
| --- | --- | --- |
| **Contract Attribute** | **Specific Field** | **Assumption(s)** |
| Name / Reference | REFERENCE | - |
| Contract Type | LOGICAL\_COMMODITY\_CODE | - |
| Currency | TRADING\_CURRENCY | - |
| Lot Size | LOT\_SIZE | - |
| Tick Denomination | - | 200 for SCH contracts  100 for LGT, BOB and BUN contracts |
| Business Day(s) | - | TARGET for EUR contracts  London for GBP contracts |
| Business Day Conv. | - | Modified Following |
| Expiry Date | LAST\_TRADING\_DATE | - |
| Delivery Date | LAST\_TRADING\_DATE | - |
| CTD Coupon Rate | COUPON\_RATE | - |
| CTD Maturity Date | MATURITY\_DATE | - |
| CTD Business Day(s) | - | TARGET for EUR bonds  London for GBP bonds |
| CTD Business Day Conv. | - | Modified Following |
| CTD Settlement Date | - | T+3 for EUR bonds  T+1 for GBP bonds |
| CTD Conversion Factor | CTD\_CONV\_FACTOR | - |
| CTD Coupon Frequency | PAY\_FREQ\_PERIOD  PAY\_FREQ\_MULTIPLIER | - |
| CTD Coupon Day Basis | - | Actual/Actual |
| CTD Clean Quoted Price | BOND\_PRICE | - |
| Repo Rate | IMP\_REPO\_RATE | - |
| Discount Curve | - | EUR BOND DE I016 for EUR bonds  GBP BOND GB I022 for GBP bonds |
| Actual Closing Price | PRICE\_VALUE | - |

As noted in section 4.2.1 above, each government bond future’s delivery date (i.e. as defined by the LAST\_TRADING\_DATE field) is initially set to the latest date permitted under the terms of the relevant product specification and can be moved forward in time in order to accommodate late / overdue deliveries should the need arise.

It should also be noted that although the government bond future pricing function (i.e. as defined in section 4.2 above) is not dependent on an expiry date per se, it is nevertheless necessary to assign such a date for completeness purposes. This follows from the fact – even though it isn’t used in the subsequent calculation itself – the technological implementation of the pricing function includes expiry date as one of its expected input fields.

In addition, notionally setting the expiry date equal to the (last possible) delivery date ensures that the aforementioned pricing function doesn’t fail in the period between the two, during which it may still be necessary to generate one or more contract-level P&L vectors in order to facilitate the calculation of delivery margin for a sub-portfolio of tendered positions in accordance with section 4.2.2 above.

# Reporting & Other Analytical Requirements

As well as producing GBP-denominated P&L vectors by contract (which are contained in the varlosses.csv output file), the NLX HVAR model also needs to be able to satisfy various other reporting and analytical requirements as part of the overall service. These are outlined below.

It should be noted that, where applicable, the various DSF contracts will be subject to the same requirements.

## Theoretical Prices vs. Actual Prices

At the heart of the NLX HVAR model are a number of pricing functions that – between them – generate a current theoretical price for each contract. As described in section 3.9 above, these current prices act as the zero-P&L reference points for the subsequent HVAR simulation.

In order to check that these functions are performing correctly and generating accurate prices, a daily comparison of theoretical and actual (exchange) prices should be undertaken.

On any particular evaluation date, a suitable report to facilitate such an exercise might look as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Contract Reference** | **Theoretical Price** | **Actual Price** | **Difference (%)** |
| F-NLX-FUT-NINI-20140300 | 99.7250 | 99.7400 | -0.02% |
| F-NLX-FUT-NINI-20140400 | 99.7400 | 99.7450 | -0.01% |
| F-NLX-FUT-NINI-20140500 | 99.7700 | 99.7600 | +0.01% |
| F-NLX-FUT-NINI-20140600 | 99.7700 | 99.7600 | +0.01% |
| F-NLX-FUT-NINI-20140700 | 99.7650 | 99.7450 | +0.02% |
| F-NLX-FUT-NINI-20140900 | 99.7500 | 99.7550 | -0.01% |
| …… | …… | …… | …… |

The theoretical price of each contract is included in the “results.csv” file.

## Cheapest-to-Deliver Bond Spreads

As detailed in section 4.2 above, one of the key parts of the pricing function for government bond futures is the calculation of a theoretical clean price for each underlying CTD bond. This involves deriving the flat spread over / under the sovereign discount curve, as implied by the CTD’s actual clean price.

In order to check that this particular part of the pricing function is performing correctly, a daily review of these implied spreads should be undertaken.

On any particular close-of-business date, a suitable report to facilitate such an exercise might look as follows:

|  |  |  |
| --- | --- | --- |
| **Contract Reference** | **Underlying CTD** | **CTD Spread (bp)** |
| F-NLX-FUT-NSNS-20140300 | DE0001137446 | -0.7262 |
| F-NLX-FUT-NSNS-20140600 | DE0001141604 | -1.9851 |
| F-NLX-FUT-NSNS-20140900 | DE0001135309 | -2.8603 |
| F-NLX-FUT-NUNU-20140300 | DE0001102309 | +0.3493 |
| F-NLX-FUT-NUNU-20140600 | DE0001102309 | +0.3493 |
| F-NLX-FUT-NUNU-20140900 | DE0001102325 | +0.6088 |
| F-NLX-FUT-NRNR-20140300 | GB0030880693 | +1.8946 |
| F-NLX-FUT-NRNR-20140600 | GB0030880693 | +1.8946 |
| F-NLX-FUT-NRNR-20140900 | GB0030880693 | +1.8946 |
| …… | …… | …… |

The CTD spread for each government bond future contract (expressed in absolute terms) is included in the “results.csv” file.

## Sensitivity Analysis

For risk management purposes, it is also a requirement for the NLX HVAR model to generate a range of sensitivity measures for each contract as follows:

* Zero-rate PV01 ladder for each STIR futures contract;
* Zero-rate PV01 ladder for each government bond futures contract; and
* Repo rate PV01 for each government bond futures contract.

All these measures are calculated on a “per lot” basis ***without*** using the price rounding implied by each contract’s underlying tick denomination.

In addition, each PV01 ladder references the set of tenor points associated with the relevant underlying curve, as shown in the example below.

### Futures PV01 Example

As at 17th February 2014, the PV01 sensitivities (denominated in EUR per lot) for the March and June 2014 EURIBOR futures were as follows:

|  |  |  |
| --- | --- | --- |
| **Risk Factor** | **F-NLX-FUT-NINI-20140300** | **F-NLX-FUT-NINI-20140600** |
| EUR CASH 3M | -14.2694 | +22.2926 |
| EUR CASH 6M | -10.3364 | -28.8884 |
| EUR CASH 9M | +0.0000 | -18.0185 |
| EUR CASH 1Y | +0.0000 | +0.0000 |
| …… | …… | …… |

It should be noted that these particular futures have no sensitivity to zero-coupon index rates beyond the 9-month point. Hence, the zero “per lot” sensitivities to this section of the relevant underlying curve (EUR CASH) have not been reproduced in the table above.

The zero-rate PV01 ladder for each contract is contained in the “bktDelta.csv” file.

In addition, the total “parallel shift” PV01 for each contract – classified according to broad sensitivity type i.e. PV01 (Disc), PV01 (Index) and PV01 (Repo) – is included in the “results.csv” file.

## Stress Testing

In addition to running P&L simulations over the prescribed 1,250 day / 5 year historic look-back period, the NLX HVAR model also needs to cater for a variety of pre-determined stress scenarios. The P&L simulations generated from these scenarios (using the same pricing functions as the standard HVAR run) are used to inform the size of the Listed Rates default fund.

Each scenario is identified by a name (e.g. “368\_SWP His – relative 04/10/1999”) and is provided in the following format:

|  |  |  |
| --- | --- | --- |
| **Risk Factor** | **Return Type** | **Scenario Return** |
| GBP/EUR Spot | FACTOR | 0.9795 |
| EUR CASH 3M | ABSOLUTE | 0.0045 |
| EUR CASH 6M | ABSOLUTE | 0.0045 |
| EUR CASH 9M | ABSOLUTE | 0.0045 |
| EUR CASH 1Y | ABSOLUTE | 0.0045 |
| …… | …… | …… |
| EUR CASH 5Y3M | ABSOLUTE | 0.0045 |
| EUR CASH 5Y6M | ABSOLUTE | 0.0045 |
| EUR CASH 5Y9M | ABSOLUTE | 0.0045 |
| EUR CASH 6Y | ABSOLUTE | 0.0045 |

Each scenario return is applied to the current value of the corresponding risk factor as follows:

For index curves and sovereign discount curves (i.e. where the stress scenario returns are defined on an ***absolute*** basis):

, where

Similarly, for foreign exchange rates (i.e. where the stress scenario returns are defined on a ***factor*** basis):

Thereafter, the P&L simulation process follows that for a single HVAR scenario (i.e. as per section 3.9 above).

The stress P&Ls for each contract (i.e. one per scenario) are included in the “results.csv” file.

Appendix 1 – Examples of New Risk Factors

* Index Curves

**EUR\_EURIBOR**

**Murex Swap Generator = EURIBOR A 6M**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tenor (Bucket)** | **Close Date** | **Maturity Date** | **Acc. Factor (Actual/365)** | **Zero Rate (Continuous)** | **Discount Factor** |
| 1D | 05/12/2013 | 06/12/2013 | 0.0027 | 0.091250% | 0.999998 |
| 1W | 05/12/2013 | 12/12/2013 | 0.0192 | 0.102863% | 0.999980 |
| 1M | 05/12/2013 | 04/01/2014 | 0.0822 | 0.141627% | 0.999884 |
| 2M | 05/12/2013 | 03/02/2014 | 0.1644 | 0.178385% | 0.999707 |
| 3M | 05/12/2013 | 06/03/2014 | 0.2493 | 0.216369% | 0.999461 |
| 6M | 05/12/2013 | 05/06/2014 | 0.4986 | 0.238465% | 0.998812 |
| 9M | 05/12/2013 | 04/09/2014 | 0.7479 | 0.247014% | 0.998154 |
| 1Y | 05/12/2013 | 05/12/2014 | 1.0000 | 0.257282% | 0.997430 |
| 18M | 05/12/2013 | 05/06/2015 | 1.4986 | 0.285391% | 0.995732 |
| 2Y | 05/12/2013 | 05/12/2015 | 2.0000 | 0.475522% | 0.990535 |
| 3Y | 05/12/2013 | 04/12/2016 | 3.0000 | 0.659280% | 0.980416 |
| 4Y | 05/12/2013 | 04/12/2017 | 4.0000 | 0.903913% | 0.964489 |
| 5Y | 05/12/2013 | 04/12/2018 | 5.0000 | 1.161316% | 0.943588 |
| 6Y | 05/12/2013 | 04/12/2019 | 6.0000 | 1.395734% | 0.919667 |
| 7Y | 05/12/2013 | 03/12/2020 | 7.0000 | 1.606939% | 0.893610 |
| 8Y | 05/12/2013 | 03/12/2021 | 8.0000 | 1.798551% | 0.865988 |
| 9Y | 05/12/2013 | 03/12/2022 | 9.0000 | 1.971294% | 0.837431 |
| 10Y | 05/12/2013 | 03/12/2023 | 10.0000 | 2.125545% | 0.808516 |
| 12Y | 05/12/2013 | 02/12/2025 | 12.0000 | 2.373924% | 0.752111 |
| 15Y | 05/12/2013 | 01/12/2028 | 15.0000 | 2.620901% | 0.674938 |
| 20Y | 05/12/2013 | 30/11/2033 | 20.0000 | 2.773634% | 0.574229 |
| 25Y | 05/12/2013 | 29/11/2038 | 25.0000 | 2.786273% | 0.498292 |
| 30Y | 05/12/2013 | 28/11/2043 | 30.0000 | 2.754046% | 0.437703 |
| 35Y | 05/12/2013 | 26/11/2048 | 35.0000 | 2.751823% | 0.381693 |
| 40Y | 05/12/2013 | 25/11/2053 | 40.0000 | 2.753650% | 0.332385 |
| 45Y | 05/12/2013 | 24/11/2058 | 45.0000 | 2.757530% | 0.289127 |
| 50Y | 05/12/2013 | 23/11/2063 | 50.0000 | 2.763623% | 0.251123 |

Source: SwapClear

**GBP\_LIBOR\_6M**

**Murex Swap Generator = GBP LIBOR S 6M**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tenor (Bucket)** | **Close Date** | **Maturity Date** | **Acc. Factor (Actual/365)** | **Zero Rate (Continuous)** | **Discount Factor** |
| 1D | 05/12/2013 | 06/12/2013 | 0.0027 | 0.467497% | 0.999987 |
| 1W | 05/12/2013 | 12/12/2013 | 0.0192 | 0.474358% | 0.999909 |
| 1M | 05/12/2013 | 04/01/2014 | 0.0822 | 0.483811% | 0.999602 |
| 2M | 05/12/2013 | 03/02/2014 | 0.1644 | 0.496141% | 0.999185 |
| 3M | 05/12/2013 | 06/03/2014 | 0.2493 | 0.508881% | 0.998732 |
| 6M | 05/12/2013 | 05/06/2014 | 0.4986 | 0.531977% | 0.997351 |
| 9M | 05/12/2013 | 04/09/2014 | 0.7479 | 0.551904% | 0.995881 |
| 1Y | 05/12/2013 | 05/12/2014 | 1.0000 | 0.573685% | 0.994280 |
| 18M | 05/12/2013 | 05/06/2015 | 1.4986 | 0.642649% | 0.990415 |
| 2Y | 05/12/2013 | 05/12/2015 | 2.0000 | 0.842426% | 0.983293 |
| 3Y | 05/12/2013 | 04/12/2016 | 3.0000 | 1.176731% | 0.965314 |
| 4Y | 05/12/2013 | 04/12/2017 | 4.0000 | 1.542129% | 0.940179 |
| 5Y | 05/12/2013 | 04/12/2018 | 5.0000 | 1.874424% | 0.910537 |
| 6Y | 05/12/2013 | 04/12/2019 | 6.0000 | 2.159671% | 0.878464 |
| 7Y | 05/12/2013 | 03/12/2020 | 7.0000 | 2.403400% | 0.845153 |
| 8Y | 05/12/2013 | 03/12/2021 | 8.0000 | 2.609999% | 0.811558 |
| 9Y | 05/12/2013 | 03/12/2022 | 9.0000 | 2.784622% | 0.778321 |
| 10Y | 05/12/2013 | 03/12/2023 | 10.0000 | 2.928348% | 0.746145 |
| 12Y | 05/12/2013 | 02/12/2025 | 12.0000 | 3.140947% | 0.685975 |
| 15Y | 05/12/2013 | 01/12/2028 | 15.0000 | 3.338184% | 0.606090 |
| 20Y | 05/12/2013 | 30/11/2033 | 20.0000 | 3.472594% | 0.499315 |
| 25Y | 05/12/2013 | 29/11/2038 | 25.0000 | 3.494852% | 0.417399 |
| 30Y | 05/12/2013 | 28/11/2043 | 30.0000 | 3.476448% | 0.352419 |
| 35Y | 05/12/2013 | 26/11/2048 | 35.0000 | 3.443404% | 0.299635 |
| 40Y | 05/12/2013 | 25/11/2053 | 40.0000 | 3.382314% | 0.258483 |
| 45Y | 05/12/2013 | 24/11/2058 | 45.0000 | 3.351276% | 0.221336 |
| 50Y | 05/12/2013 | 23/11/2063 | 50.0000 | 3.327875% | 0.189392 |

Source: SwapClear

**USD\_LIBOR\_3M**

**Murex Swap Generator = USD LIBOR A 3M**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tenor (Bucket)** | **Close Date** | **Maturity Date** | **Acc. Factor (Actual/365)** | **Zero Rate (Continuous)** | **Discount Factor** |
| 1D | 05/12/2013 | 06/12/2013 | 0.0027 | 0.104430% | 0.999997 |
| 1W | 05/12/2013 | 12/12/2013 | 0.0192 | 0.111315% | 0.999979 |
| 1M | 05/12/2013 | 04/01/2014 | 0.0822 | 0.142482% | 0.999883 |
| 2M | 05/12/2013 | 03/02/2014 | 0.1644 | 0.177198% | 0.999709 |
| 3M | 05/12/2013 | 06/03/2014 | 0.2493 | 0.213072% | 0.999469 |
| 6M | 05/12/2013 | 05/06/2014 | 0.4986 | 0.237780% | 0.998815 |
| 9M | 05/12/2013 | 04/09/2014 | 0.7479 | 0.247990% | 0.998147 |
| 1Y | 05/12/2013 | 05/12/2014 | 1.0000 | 0.260913% | 0.997394 |
| 18M | 05/12/2013 | 05/06/2015 | 1.4986 | 0.301248% | 0.995496 |
| 2Y | 05/12/2013 | 05/12/2015 | 2.0000 | 0.380408% | 0.992421 |
| 3Y | 05/12/2013 | 04/12/2016 | 3.0000 | 0.685046% | 0.979658 |
| 4Y | 05/12/2013 | 04/12/2017 | 4.0000 | 1.123296% | 0.956063 |
| 5Y | 05/12/2013 | 04/12/2018 | 5.0000 | 1.567310% | 0.924626 |
| 6Y | 05/12/2013 | 04/12/2019 | 6.0000 | 1.974868% | 0.888259 |
| 7Y | 05/12/2013 | 03/12/2020 | 7.0000 | 2.322402% | 0.849958 |
| 8Y | 05/12/2013 | 03/12/2021 | 8.0000 | 2.607829% | 0.811698 |
| 9Y | 05/12/2013 | 03/12/2022 | 9.0000 | 2.843819% | 0.774186 |
| 10Y | 05/12/2013 | 03/12/2023 | 10.0000 | 3.040161% | 0.737849 |
| 12Y | 05/12/2013 | 02/12/2025 | 12.0000 | 3.351960% | 0.668823 |
| 15Y | 05/12/2013 | 01/12/2028 | 15.0000 | 3.651278% | 0.578283 |
| 20Y | 05/12/2013 | 30/11/2033 | 20.0000 | 3.899575% | 0.458445 |
| 25Y | 05/12/2013 | 29/11/2038 | 25.0000 | 4.015026% | 0.366500 |
| 30Y | 05/12/2013 | 28/11/2043 | 30.0000 | 4.069309% | 0.294996 |
| 35Y | 05/12/2013 | 26/11/2048 | 35.0000 | 4.053607% | 0.242013 |
| 40Y | 05/12/2013 | 25/11/2053 | 40.0000 | 4.048843% | 0.197990 |
| 45Y | 05/12/2013 | 24/11/2058 | 45.0000 | 3.996664% | 0.165547 |
| 50Y | 05/12/2013 | 23/11/2063 | 50.0000 | 3.948080% | 0.138895 |

Source: SwapClear

* OIS Discount Curves

**EUR\_EONIA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tenor (Bucket)** | **Close Date** | **Maturity Date** | **Acc. Factor (Actual/365)** | **Zero Rate (Continuous)** | **Discount Factor** |
| 1D | 05/12/2013 | 06/12/2013 | 0.0027 | 0.128764% | 0.999996 |
| 1W | 05/12/2013 | 12/12/2013 | 0.0192 | 0.129086% | 0.999975 |
| 2W | 05/12/2013 | 19/12/2013 | 0.0384 | 0.131009% | 0.999950 |
| 3W | 05/12/2013 | 26/12/2013 | 0.0575 | 0.135137% | 0.999922 |
| 1M | 05/12/2013 | 04/01/2014 | 0.0822 | 0.149197% | 0.999877 |
| 2M | 05/12/2013 | 03/02/2014 | 0.1644 | 0.144686% | 0.999762 |
| 3M | 05/12/2013 | 06/03/2014 | 0.2493 | 0.136467% | 0.999660 |
| 4M | 05/12/2013 | 05/04/2014 | 0.3315 | 0.132744% | 0.999560 |
| 5M | 05/12/2013 | 06/05/2014 | 0.4164 | 0.131306% | 0.999453 |
| 6M | 05/12/2013 | 05/06/2014 | 0.4986 | 0.130856% | 0.999348 |
| 7M | 05/12/2013 | 05/07/2014 | 0.5808 | 0.130891% | 0.999240 |
| 8M | 05/12/2013 | 05/08/2014 | 0.6658 | 0.130821% | 0.999129 |
| 9M | 05/12/2013 | 04/09/2014 | 0.7479 | 0.130882% | 0.999022 |
| 10M | 05/12/2013 | 05/10/2014 | 0.8329 | 0.131415% | 0.998906 |
| 11M | 05/12/2013 | 04/11/2014 | 0.9151 | 0.132142% | 0.998792 |
| 1Y | 05/12/2013 | 05/12/2014 | 1.0000 | 0.134015% | 0.998661 |
| 15M | 05/12/2013 | 06/03/2015 | 1.2493 | 0.139847% | 0.998254 |
| 18M | 05/12/2013 | 05/06/2015 | 1.4986 | 0.149580% | 0.997761 |
| 21M | 05/12/2013 | 04/09/2015 | 1.7479 | 0.165194% | 0.997117 |
| 2Y | 05/12/2013 | 05/12/2015 | 2.0000 | 0.186198% | 0.996283 |
| 3Y | 05/12/2013 | 04/12/2016 | 3.0000 | 0.347243% | 0.989637 |
| 4Y | 05/12/2013 | 04/12/2017 | 4.0000 | 0.582401% | 0.976973 |
| 5Y | 05/12/2013 | 04/12/2018 | 5.0000 | 0.837865% | 0.958972 |
| 6Y | 05/12/2013 | 04/12/2019 | 6.0000 | 1.077745% | 0.937382 |
| 7Y | 05/12/2013 | 03/12/2020 | 7.0000 | 1.297924% | 0.913150 |
| 8Y | 05/12/2013 | 03/12/2021 | 8.0000 | 1.500399% | 0.886892 |
| 9Y | 05/12/2013 | 03/12/2022 | 9.0000 | 1.683387% | 0.859414 |
| 10Y | 05/12/2013 | 03/12/2023 | 10.0000 | 1.848825% | 0.831202 |
| 12Y | 05/12/2013 | 02/12/2025 | 12.0000 | 2.120818% | 0.775305 |
| 15Y | 05/12/2013 | 01/12/2028 | 15.0000 | 2.409351% | 0.696698 |
| 20Y | 05/12/2013 | 30/11/2033 | 20.0000 | 2.610181% | 0.593311 |
| 25Y | 05/12/2013 | 29/11/2038 | 25.0000 | 2.656427% | 0.514733 |
| 30Y | 05/12/2013 | 28/11/2043 | 30.0000 | 2.647924% | 0.451863 |
| 35Y | 05/12/2013 | 26/11/2048 | 35.0000 | 2.642775% | 0.396543 |
| 40Y | 05/12/2013 | 25/11/2053 | 40.0000 | 2.654838% | 0.345786 |
| 45Y | 05/12/2013 | 24/11/2058 | 45.0000 | 2.656250% | 0.302609 |
| 50Y | 05/12/2013 | 23/11/2063 | 50.0000 | 2.669217% | 0.263261 |

Source: SwapClear

**GBP\_ SONIA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tenor (Bucket)** | **Close Date** | **Maturity Date** | **Acc. Factor (Actual/365)** | **Zero Rate (Continuous)** | **Discount Factor** |
| 1D | 05/12/2013 | 06/12/2013 | 0.0027 | 0.428597% | 0.999988 |
| 1W | 05/12/2013 | 12/12/2013 | 0.0192 | 0.424983% | 0.999918 |
| 2W | 05/12/2013 | 19/12/2013 | 0.0384 | 0.424465% | 0.999837 |
| 3W | 05/12/2013 | 26/12/2013 | 0.0575 | 0.424468% | 0.999756 |
| 1M | 05/12/2013 | 04/01/2014 | 0.0822 | 0.424470% | 0.999651 |
| 2M | 05/12/2013 | 03/02/2014 | 0.1644 | 0.424962% | 0.999302 |
| 3M | 05/12/2013 | 06/03/2014 | 0.2493 | 0.424884% | 0.998941 |
| 4M | 05/12/2013 | 05/04/2014 | 0.3315 | 0.425082% | 0.998592 |
| 5M | 05/12/2013 | 06/05/2014 | 0.4164 | 0.425623% | 0.998229 |
| 6M | 05/12/2013 | 05/06/2014 | 0.4986 | 0.427045% | 0.997873 |
| 7M | 05/12/2013 | 05/07/2014 | 0.5808 | 0.428139% | 0.997516 |
| 8M | 05/12/2013 | 05/08/2014 | 0.6658 | 0.429386% | 0.997145 |
| 9M | 05/12/2013 | 04/09/2014 | 0.7479 | 0.431818% | 0.996775 |
| 10M | 05/12/2013 | 05/10/2014 | 0.8329 | 0.434137% | 0.996391 |
| 11M | 05/12/2013 | 04/11/2014 | 0.9151 | 0.435870% | 0.996019 |
| 1Y | 05/12/2013 | 05/12/2014 | 1.0000 | 0.438736% | 0.995622 |
| 15M | 05/12/2013 | 06/03/2015 | 1.2493 | 0.454629% | 0.994336 |
| 18M | 05/12/2013 | 05/06/2015 | 1.4986 | 0.482075% | 0.992802 |
| 21M | 05/12/2013 | 04/09/2015 | 1.7479 | 0.519209% | 0.990966 |
| 2Y | 05/12/2013 | 05/12/2015 | 2.0000 | 0.570246% | 0.988660 |
| 3Y | 05/12/2013 | 04/12/2016 | 3.0000 | 0.858510% | 0.974574 |
| 4Y | 05/12/2013 | 04/12/2017 | 4.0000 | 1.192313% | 0.953427 |
| 5Y | 05/12/2013 | 04/12/2018 | 5.0000 | 1.505182% | 0.927503 |
| 6Y | 05/12/2013 | 04/12/2019 | 6.0000 | 1.778482% | 0.898787 |
| 7Y | 05/12/2013 | 03/12/2020 | 7.0000 | 2.015445% | 0.868419 |
| 8Y | 05/12/2013 | 03/12/2021 | 8.0000 | 2.216506% | 0.837511 |
| 9Y | 05/12/2013 | 03/12/2022 | 9.0000 | 2.389771% | 0.806477 |
| 10Y | 05/12/2013 | 03/12/2023 | 10.0000 | 2.535191% | 0.776065 |
| 12Y | 05/12/2013 | 02/12/2025 | 12.0000 | 2.760729% | 0.717999 |
| 15Y | 05/12/2013 | 01/12/2028 | 15.0000 | 2.990303% | 0.638556 |
| 20Y | 05/12/2013 | 30/11/2033 | 20.0000 | 3.186806% | 0.528686 |
| 25Y | 05/12/2013 | 29/11/2038 | 25.0000 | 3.260522% | 0.442582 |
| 30Y | 05/12/2013 | 28/11/2043 | 30.0000 | 3.275306% | 0.374340 |
| 35Y | 05/12/2013 | 26/11/2048 | 35.0000 | 3.238507% | 0.321912 |
| 40Y | 05/12/2013 | 25/11/2053 | 40.0000 | 3.197056% | 0.278365 |
| 45Y | 05/12/2013 | 24/11/2058 | 45.0000 | 3.163068% | 0.240898 |
| 50Y | 05/12/2013 | 23/11/2063 | 50.0000 | 3.145691% | 0.207454 |

Source: SwapClear

**USD\_FEDFUNDS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tenor (Bucket)** | **Close Date** | **Maturity Date** | **Acc. Factor (Actual/365)** | **Zero Rate (Continuous)** | **Discount Factor** |
| 1D | 05/12/2013 | 06/12/2013 | 0.0027 | 0.091250% | 0.999998 |
| 1W | 05/12/2013 | 12/12/2013 | 0.0192 | 0.090697% | 0.999983 |
| 2W | 05/12/2013 | 19/12/2013 | 0.0384 | 0.090174% | 0.999965 |
| 3W | 05/12/2013 | 26/12/2013 | 0.0575 | 0.090615% | 0.999948 |
| 1M | 05/12/2013 | 04/01/2014 | 0.0822 | 0.090137% | 0.999926 |
| 2M | 05/12/2013 | 03/02/2014 | 0.1644 | 0.090106% | 0.999852 |
| 3M | 05/12/2013 | 06/03/2014 | 0.2493 | 0.091104% | 0.999773 |
| 4M | 05/12/2013 | 05/04/2014 | 0.3315 | 0.090387% | 0.999700 |
| 5M | 05/12/2013 | 06/05/2014 | 0.4164 | 0.092024% | 0.999617 |
| 6M | 05/12/2013 | 05/06/2014 | 0.4986 | 0.092221% | 0.999540 |
| 7M | 05/12/2013 | 05/07/2014 | 0.5808 | 0.092221% | 0.999465 |
| 8M | 05/12/2013 | 05/08/2014 | 0.6658 | 0.095483% | 0.999365 |
| 9M | 05/12/2013 | 04/09/2014 | 0.7479 | 0.094559% | 0.999293 |
| 10M | 05/12/2013 | 05/10/2014 | 0.8329 | 0.095949% | 0.999201 |
| 11M | 05/12/2013 | 04/11/2014 | 0.9151 | 0.099471% | 0.999090 |
| 1Y | 05/12/2013 | 05/12/2014 | 1.0000 | 0.101089% | 0.998990 |
| 15M | 05/12/2013 | 06/03/2015 | 1.2493 | 0.113751% | 0.998580 |
| 18M | 05/12/2013 | 05/06/2015 | 1.4986 | 0.126849% | 0.998101 |
| 21M | 05/12/2013 | 04/09/2015 | 1.7479 | 0.159078% | 0.997223 |
| 2Y | 05/12/2013 | 05/12/2015 | 2.0000 | 0.192550% | 0.996156 |
| 3Y | 05/12/2013 | 04/12/2016 | 3.0000 | 0.469740% | 0.986007 |
| 4Y | 05/12/2013 | 04/12/2017 | 4.0000 | 0.875715% | 0.965578 |
| 5Y | 05/12/2013 | 04/12/2018 | 5.0000 | 1.297631% | 0.937178 |
| 6Y | 05/12/2013 | 04/12/2019 | 6.0000 | 1.691732% | 0.903478 |
| 7Y | 05/12/2013 | 03/12/2020 | 7.0000 | 2.025679% | 0.867797 |
| 8Y | 05/12/2013 | 03/12/2021 | 8.0000 | 2.306447% | 0.831507 |
| 9Y | 05/12/2013 | 03/12/2022 | 9.0000 | 2.537943% | 0.795794 |
| 10Y | 05/12/2013 | 03/12/2023 | 10.0000 | 2.729822% | 0.761106 |
| 12Y | 05/12/2013 | 02/12/2025 | 12.0000 | 3.039472% | 0.694380 |
| 15Y | 05/12/2013 | 01/12/2028 | 15.0000 | 3.338084% | 0.606099 |
| 20Y | 05/12/2013 | 30/11/2033 | 20.0000 | 3.586323% | 0.488086 |
| 25Y | 05/12/2013 | 29/11/2038 | 25.0000 | 3.708879% | 0.395652 |
| 30Y | 05/12/2013 | 28/11/2043 | 30.0000 | 3.765038% | 0.323191 |
| 35Y | 05/12/2013 | 26/11/2048 | 35.0000 | 3.751396% | 0.269015 |
| 40Y | 05/12/2013 | 25/11/2053 | 40.0000 | 3.747592% | 0.223345 |
| 45Y | 05/12/2013 | 24/11/2058 | 45.0000 | 3.699591% | 0.189225 |
| 50Y | 05/12/2013 | 23/11/2063 | 50.0000 | 3.655038% | 0.160812 |

Source: SwapClear

Appendix 2 – Product Spec. for Yield-Based DSF

The product specification for the yield-based DSF ***originally*** developed by NLX is summarised below:

|  |  |
| --- | --- |
| Currencies | USD, EUR and GBP |
| Tenors | 2, 5 and 10 years (for all currencies) |
| Delivery Type | Physical delivery into LCHC SwapClear OTC IRS on last trading day |
| Quoting / Pricing Convention | 100 – Fixed rate for a par swap quoted to 1/10th of a basis point |
| Minimum Price Increment | 0.001% i.e. 1/10th of a basis point |
| Price Alignment Interest | Excluded |
| Expiry Date / Cycle | Standard quarterly IMM dates in March, June, September, December |
| Fixed Rate | Prevailing par swap rate on last trading day |
| Settlement Prices | Daily: Based on exchange activity  Final / Expiry: ISDA fix ***or*** closing auction in NLX central limit order book |
| Buy / Sell Convention | Buy = Receive Fixed / Sell = Pay Fixed |

The contract specifics for each currency listed in the table above are shown below.

* USD

|  |  |
| --- | --- |
| Notional Contract Size | USD 100,000 |
| Fixed Rate Basis | Semi-Annual 30/360 |
| Floating Rate Basis | 3M LIBOR Actual/360 |
| Floating Rate Reference | USD-LIBOR / Security ID = US0003M |
| Business Day(s) | London, New York |
| Business Day Convention | Modified Following |
| Hours | 08:00 – 20:00 London Time |
| Last Trading Day | 2 business days prior to the 3rd Wednesday of delivery month |

* EUR

|  |  |
| --- | --- |
| Notional Contract Size | EUR 100,000 |
| Fixed Rate Basis | Annual 30/360 |
| Floating Rate Basis | 6M EURIBOR Actual/360 |
| Floating Rate Reference | EUR-EURIBOR / Security ID = EUR006M |
| Business Day(s) | TARGET |
| Business Day Convention | Modified Following |
| Hours | 08:00 – 17:00 London Time |
| Last Trading Day | 2 business days prior to the 3rd Wednesday of delivery month |

* GBP

|  |  |
| --- | --- |
| Notional Contract Size | GBP 100,000 |
| Fixed Rate Basis | Semi-Annual Actual/365F |
| Floating Rate Basis | 6M LIBOR Actual/365F |
| Floating Rate Reference | GBP-LIBOR / Security ID = BP0006M |
| Business Day(s) | London |
| Business Day Convention | Modified Following |
| Hours | 08:00 – 17:00 London Time |
| Last Trading Day | The 3rd Wednesday of delivery month |

Appendix 3 – Risk Factor Back-Testing Results

The back-testing window spanned the period from 31st December 2007 to 29th May 2014, representing approximately 1,650 business days.

The tables reproduced below show the coverage ratio and statistical proportion of failure test result for each of the key interest rate risk factors underlying the 3 DSF-related index curves (i.e. EUR\_EURIBOR, GBP\_LIBOR and USD\_LIBOR).

Both 1-day and 2-day (overlapping) holding periods were tested using the HVAR measure instead of expected shortfall, the latter being problematic for statistical testing. In addition, both the upper and lower tails were tested individually.

The statistical tests failed to reject the null (i.e. “the model is correct”) hypothesis with 95% confidence for all risk factors tested except the upper tail of the GBP 5-year zero coupon LIBOR rate (for which the null hypothesis ***was*** rejected). The results nevertheless indicate strong performance for nearly all the risk factors tested.

Closer inspection of the GBP 5-year zero coupon LIBOR rate time series revealed the following:

* A cluster of 3 breaches in June 2013 owing to tapering by the United States Federal Reserve, which resulted in a sudden increase in rates of 29 basis points; and
* A cluster of 5 breaches between April and June 2008 during which interest rates increased by up to 30 basis points as a result of inflation fears and Central Banks indicating higher borrowing costs over the ensuing year.

The two clusters of breaches represent the largest interest rate moves over the period (of approximately 6.5 years) and are arguably unprecedented stress events.

* EUR – 1 Day / Up Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **EUR – 2Y** | **EUR – 5Y** | **EUR – 10Y** |
| No. of days in back-testing window | 1,650 | 1,650 | 1,650 |
| Total no. of breaches | 5 | 4 | 5 |
| Coverage ratio | 99.70% | 99.76% | 99.70% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* EUR – 1 Day / Down Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **EUR – 2Y** | **EUR – 5Y** | **EUR – 10Y** |
| No. of days in back-testing window | 1,650 | 1,650 | 1,650 |
| Total no. of breaches | 7 | 5 | 7 |
| Coverage ratio | 99.58% | 99.70% | 99.58% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* EUR – 2 Day / Up Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **EUR – 2Y** | **EUR – 5Y** | **EUR – 10Y** |
| No. of days in back-testing window | 1,649 | 1,649 | 1,649 |
| Total no. of breaches | 4 | 7 | 8 |
| Coverage ratio | 99.76% | 99.58% | 99.51% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* EUR – 2 Day / Down Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **EUR – 2Y** | **EUR – 5Y** | **EUR – 10Y** |
| No. of days in back-testing window | 1,649 | 1,649 | 1,649 |
| Total no. of breaches | 8 | 5 | 8 |
| Coverage ratio | 99.51% | 99.70% | 99.51% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* USD – 1 Day / Up Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **USD – 2Y** | **USD – 5Y** | **USD – 10Y** |
| No. of days in back-testing window | 1,650 | 1,650 | 1,650 |
| Total no. of breaches | 3 | 3 | 3 |
| Coverage ratio | 99.82% | 99.82% | 99.82% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* USD – 1 Day / Down Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **USD – 2Y** | **USD – 5Y** | **USD – 10Y** |
| No. of days in back-testing window | 1,650 | 1,650 | 1,650 |
| Total no. of breaches | 3 | 5 | 4 |
| Coverage ratio | 99.82% | 99.70% | 99.76% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* USD – 2 Day / Up Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **USD – 2Y** | **USD – 5Y** | **USD – 10Y** |
| No. of days in back-testing window | 1,649 | 1,649 | 1,649 |
| Total no. of breaches | 5 | 7 | 4 |
| Coverage ratio | 99.70% | 99.58% | 99.76% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* USD – 2 Day / Down Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **USD – 2Y** | **USD – 5Y** | **USD – 10Y** |
| No. of days in back-testing window | 1,649 | 1,649 | 1,649 |
| Total no. of breaches | 5 | 3 | 5 |
| Coverage ratio | 99.70% | 99.82% | 99.70% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* GBP – 1 Day / Up Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **GBP – 2Y** | **GBP – 5Y** | **GBP – 10Y** |
| No. of days in back-testing window | 1,650 | 1,650 | 1,650 |
| Total no. of breaches | 5 | 10 | 7 |
| Coverage ratio | 99.70% | 99.39% | 99.58% |
| Passed Kupiec test? | TRUE | FALSE | TRUE |

* GBP – 1 Day / Down Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **GBP – 2Y** | **GBP – 5Y** | **GBP – 10Y** |
| No. of days in back-testing window | 1,650 | 1,650 | 1,650 |
| Total no. of breaches | 5 | 8 | 5 |
| Coverage ratio | 99.70% | 99.52% | 99.70% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

* GBP – 2 Day / Up Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **GBP – 2Y** | **GBP – 5Y** | **GBP – 10Y** |
| No. of days in back-testing window | 1,649 | 1,649 | 1,649 |
| Total no. of breaches | 8 | 10 | 8 |
| Coverage ratio | 99.51% | 99.39% | 99.51% |
| Passed Kupiec test? | TRUE | FALSE | TRUE |

* GBP – 2 Day / Down Breaches

|  |  |  |  |
| --- | --- | --- | --- |
|  | **GBP – 2Y** | **GBP – 5Y** | **GBP – 10Y** |
| No. of days in back-testing window | 1,649 | 1,649 | 1,649 |
| Total no. of breaches | 5 | 9 | 8 |
| Coverage ratio | 99.70% | 99.45% | 99.51% |
| Passed Kupiec test? | TRUE | TRUE | TRUE |

Appendix 4 - Price Alignment Interest & Potential Implications of Convexity Bias

At the MRMC meeting on 1st July 2014 – at which the DSF proposal was first presented and discussed – and the subsequent ERCO meeting on 22nd July 2014 various references were made to a piece of analysis (originally undertaken in December 2013) on the potential implications of convexity bias in relation to the LSEDM DSF. This is reproduced below.

Introduction

Without the compensating effect of Price Alignment Interest (PAI) – i.e. as exists on all the OTC IRS cleared by LCHC – the price-based DSF contracts being launched on the LSEDM will exhibit a pricing bias versus the underlying forward-starting swap. This is caused by convexity issues arising from the future’s daily variation margining process.

As described in section 4.3 above, each DSF contract will be modelled in harmony with the forward pricing approach adopted in respect of the STIR and government bond futures that are currently cleared into the Listed Rates default fund (i.e. as part of the existing NLX service). Specifically, each DSF contract will be priced in accordance with the relevant underlying forward-starting IRS discounted on a standard OIS basis. As a result, the aforementioned convexity bias will be ignored in the pricing and corresponding IM models for the DSF.

Although there is no precedent (within LCHC) for modelling convexity bias in respect of deliverable interest rate futures – specifically, it is ignored in the Listed Rates government bond future model used for NLX’s Long Gilt, Euro-Schatz, Euro-Bobl and Euro-Bund contracts – it was nevertheless considered prudent to conduct some analysis to estimate the potential effect of representing each DSF contract as an equivalent forward-starting swap and hence ignoring convexity bias.

Work Undertaken

In order to generate some preliminary estimates of the likely impact of representing each DSF contract as an equivalent forward-starting swap and hence ignoring convexity bias – specifically as regards theoretical (instantaneous) valuation differences and the potential for revaluation misstatement across a 5-day HVAR observation period – the following work was undertaken:

* A Normal mean-reverting interest rate model was built, with calibration parameters as follows:
  + 2,000 Monte Carlo simulations using a suitable (antithetic variates) variance reduction technique
  + Volatility range = 50 basis points - 200 basis points i.e. as measured in absolute / Normal terms
  + Mean-reversion level = 3%
  + Constant forward swap rate = 3%
  + DSF fixed rate range = 2% - 4%
* This model was used to estimate a theoretical convexity adjustment (in basis points) for a range of (a) DSF contract specifications (i.e. by assuming various expiry dates and underlying swap tenors), (b) volatility levels and (c) degrees of moneyness
* Having established the key market data driver of the theoretical convexity adjustment, a suitable 99.7% 5-day historical move was applied to the corresponding model parameter in order the estimate the potential for revaluation misstatement under the IM methodology

In addition, some of the results obtained above were benchmarked against similar pieces of independent external analysis for the purposes of highlighting the generally conservative nature of the underlying modelling approach, itself a result of various approximations made in order to facilitate a relatively rapid implementation.

It should also be noted that this piece of work was undertaken when it was proposed to clear the LSEDM DSF contracts into the SwapClear default fund. Hence the analysis was performed using an assumption of a 5-day close-out period (with an equivalent HVAR observation period).

Results

As far as instantaneous valuation differences are concerned, these are summarised in the tables below (which show each relevant theoretical convexity adjustment in basis points):









Given that each LSEDM DSF contract will never have a time to expiry greater than 3.5 months (which follows from the fact that the second “back” contract will only be listed 2 weeks prior to the expiry of the current “front” contract) the results reproduced above are based on the 3-month expiry. These show that the convexity adjustment is fairly negligible in most cases, with only the 30-year contract generating a valuation difference of greater than 0.6 basis points versus the equivalent forward-starting swap.

For the 6-month expiry the theoretical convexity adjustments are somewhat higher, reaching a maximum of 13.4bps (a figure that corresponds to the 3-month equivalent of 4.1bps for the 30-year contract, as per the bottom table above).

It should be noted that, by way of comparison, the paper entitled “Swap Futures in HJM One-Factor Model” by Gary J. Kennedy cites the following convexity adjustments using a flat 3% yield curve and a volatility of 1.5%:



These estimates compare to the following convexity adjustments generated above:



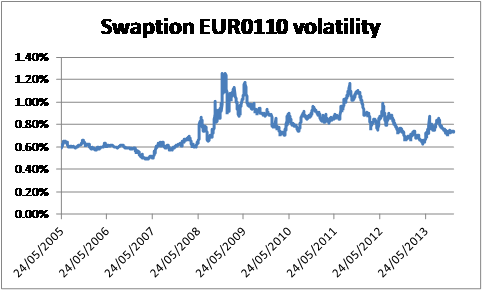
As alluded to above, these show that the LCHC model (as it currently stands) generates conservative results in that it tends to overstate the size of the convexity bias when compared to a more sophisticated model that was built without severe time constraints and the necessary approximations inherent in such a rapid piece of development work.

It is also clear from the main piece of analysis above that the theoretical convexity adjustment is far more sensitive to the underlying volatility assumption than it is to moneyness. Therefore, for the purposes of estimating the potential for revaluation misstatement under the 5-day HVAR IM methodology, a history of European swaption volatility levels (specifically for a 1-year expiry on a 10-year EUR-denominated swap) was obtained from Bloomberg and this was used to compute a 99.7% worst-case 5-day move. This was then used in the above model to estimate a potential revaluation misstatement over the chosen (5-day) HVAR horizon for IM.

The results of this exercise show quite clearly that despite the underlying model being somewhat conservative, the 99.7% worst-case 5-day change in theoretical convexity bias at various levels of moneyness are negligible for all combinations of expiry date and underlying swap tenor apart from the 6-month expiry on the 30-year swap, although for this combination the change is still less than a single basis point:



The swaption volatility time series downloaded from Bloomberg is shown below for information:



Conclusion

The analysis undertaken shows that not only are the instantaneous convexity adjustments generally small, but the potential for revaluation misstatement over a 5-day HVAR period (i.e. in line with the existing IM methodology for SwapClear) is negligible, specifically less than a basis point for all examined combinations of expiry date, underlying swap tenor and moneyness.

Moreover, given that the assumed close-out period and corresponding HVAR observation period for Listed Rates is 2 days (as opposed to 5 days for SwapClear) the potential for revaluation misstatement is likely to be even smaller than that shown above.

In turn, this suggests that the proposal to use a forward-starting IRS pricing / risk representation for the LSEDM DSF is not unreasonable.