Methodology for Determining the Parameters Used in Margins Calculation for Fixed Income Instruments

Manual

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London Stock Exchange Group

Contents

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Foreword

This document describes the methodology used to determine the parameters used for Initial Margin Calculation for cash and repo contracts on government bonds and for cash contracts on corporate bonds traded on markets where CC&G is about to intervene as Central Counterparty.

The document is preceded by an executive summary followed by a detailed description of the methodology, containing the underlying assumptions and the applicative details. The document ends with a description of the margin parameters update and modification procedure.

Executive Summary

The document describes the methodology from a conceptual standpoint beginning with the intrinsic characteristics of bonds which do not allow the determination of margin parameters directly from historical price series of traded bonds, as it is to the contrary possible with equities. This description is then followed by an overview on the various methodologies (so-called "cashflow mappings") that may be used to associate bond price fluctuations with variations of easily manageable risk factors, such as rates along the zero coupon curve.

Then a description is provided about the zero coupon curve splitting into several Vertices[1]. For each Vertex a Margin Interval is determined in the usual manner, that is a value such to comprise at least a predetermined percentage (99.80%) of the actual two-day yield fluctuations. Once the Margin Interval in Terms of Yield has been determined, the application of the formulas linking price, yield and duration, allows to determine a Margin Interval in Terms of Percentage Bond Price Variation.

In order to identify the Duration Classes, it is necessary to examine correlations between zero coupon bond prices on the 45 Vertices along the curve. Paragraph 2-1-4**Error! eference source not found.** shows how yield time series can be converted in bond price time series.

Once the above mentioned operations have been achieved, it is possible to build up Duration Classes. As shown in paragraph 2-1-5**Error! Reference source not found.**,

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[1] We have 41 vertices for the italian Government bond curve and 45 vertices for the Euro ZCB curve.

uration classes are defined as sets of Vertices whose reciprocal correlations (identified by an index, denominated “D/U” or “div-undiv”) are above a predetermined level (generally 0.80). It must be mentioned that this approach may be followed in the central part of the curve, whereas in the “peripheral” parts, a case-by-case approach must be followed.

Once duration classes have been defined, Offset Factors may be defined for positions of opposite sign belonging to the same Duration Class (Intra–Class Offset Factor) or to different duration Classes (Inter–Class Offset Factor).

Paragraphs 2-1-7 and 2-1-8 describe the conservative approach used to define the Intra– and Inter–Class Offset Factors; the latter being applied according to a priority sorting criterion .

In further detail, the Intra–Class Offset Factor is set equal to the lowest correlation registered between Vertices comprised in the Class. Correspondingly, the Inter–Class Offset Factor is set equal to the lowest correlation registered between the two Classes. Regarding the priority sorting, it has been decided to follow a conservative criterion. Therefore the low correlations registered in the short term part of the curve are applied first and only afterwards the higher correlations registered in the medium-long term part of the curve.

All others parameters having been determined, paragraph 2-1-**Error! Reference source ot found.** shows how the Margin Interval is determined for each duration Class. For this purpose the Margin Interval in terms of Percentage Bond Price Variations determined for each Vertex, are considered. The Margin Interval for each duration Class is set equal to the highest Margin Interval in Terms of Percentage Bond Price Variations for each Vertex comprised in the Duration Class.

Description of the Methodology

1.1. Peculiarities of Fixed Income Securities

In order to determine the largest price variation for a fixed income security, its main peculiarities must be recalled.

1.1.1. The pull to par phenomenon

Whereas the price of an equity instrument may be assumed to follow a random walk and therefore it is not possible to determine *a priori* which will be the price of a given stock at a given future date, the price of a bond converges to the parity at maturity (so–called “*pull to par phenomenon*”).

1.1.2. The roll down phenomenon

The volatility of a stock is a function of the square root[2] of the time interval on which it is measured, that volatility over a time horizon of *n* days is equal to $\sqrt{n}$ times the one-day volatility: $\sigma_{ng} = \sqrt{n}\sigma_{1g}$. To the opposite the volatility of a bond converges to zero as the time to maturity decreases (so–called “*roll down phenomenon*”).

The above mentioned phenomena preclude the recourse to analysis of price variations of the bond itself since the price variation patterns of a bond having a certain time to maturity τ is completely unrelated to the price variation patterns of the same bond at a different point in time in which its time to maturity was τ +t.

a) Cashflow Mappings Methodology

In order to measure the risk of a bond is therefore necessary to use analytical instruments that may indicate the functional relationships of the bond price with the risk factors to which it is exposed; such task may be fulfilled by mapping the cashflows produced by the bond.

The simplest and most immediate type of mapping is the principal mapping, in which the bond risk is associated with the time to maturity of its principal payment

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[2] The apparently anti-intuitive relation linking volatility to the square root of time derives from the following considerations: The two-day return of a security is equal to: $\ln\left(\frac{P_{t+2}}{P_t}\right)$, which, using the properties of logarithms may be written as: $\ln\left(\frac{P_{t+2}}{P_t}\right) = \ln\left(\frac{P_{t+2}}{P_{t+1}}\right) + \ln\left(\frac{P_{t+1}}{P_t}\right)$. That is the two-day return is the sum of the two one-day returns. The two-day standard deviation σ_{t+2} is equal to: $\sigma_{t+2} = \sqrt{\sigma_{t+1}^2 + \sigma_t^2 + 2\sigma_{t+2}\sigma_{t+1}\rho_{t+2,t+1}}$. Under the assumption that returns follow a random walk, the correlation term $\rho_{t+2,t+1}$ is equal to zero. If moreover it is assumed that returns are identically distributed across time (*independent and identically distributed returns*), then $\sigma_{t+1} = \sigma_t$ and therefore $\sigma_{t+2} = \sqrt{\sigma_{t+1}^2 + \sigma_t^2} = \sqrt{2}\sigma_t$.

only, without considering any other information regarding the other characteristics of the bond, in other words, not taking into consideration the coupons paid by the bond during its life. A more advanced type of mapping is the duration mapping, in which the risk is associated with the bond duration[3], a quantity that allows bond with coupons to transform into an equipollent zero–coupon bond, allowing thus the comparison between bonds with different coupon rates and between bonds with coupon and zeroes.

It is worth mentioning that both principal mapping and duration mapping identify a single risk factor for each bond, respectively equal to the zero–coupon yield for maturity equal to the time to maturity of the bond and to the zero–coupon yield for maturity equal to the bond duration. Both methodologies consider as fungible the cash flows originated by the same bond at different points in time and do not consider, within the same bond, the imperfect correlation of yields along the curve.

A more advanced type of mapping, the so-called "cashflow mapping" allows to keep into account also the decorrelation along the zero–coupon curve, as it takes into consideration the risk of each single future cash flow produced by the bond, discounted at the proper rate.

The margin parameters calculation methodology adopted by CC&G is based on Duration mapping for non indexed Italian government bonds and on Principal mapping for other government bonds and corporate bonds.

2.0 Methodologies for determining Margin Parameters

2.1. Government Bonds

This section describes the methodology used to determine the parameters adopted in the Initial Margin calculation for cash and repo contracts on government.

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[3] The *duration D* is equal to the weighted average of the maturities t_i of the various cash flows CF_i, using as weights the present values (discounted at rate *y*) of the amounts due; *k* is the number of coupon per year. $D = \frac{1}{k}\sum_{i=1}^{n}\frac{CF_i(1+y)^{-t_i}t_i}{CF_i(1+y)^{-t_i}}$.

2.1.1. Main parameters

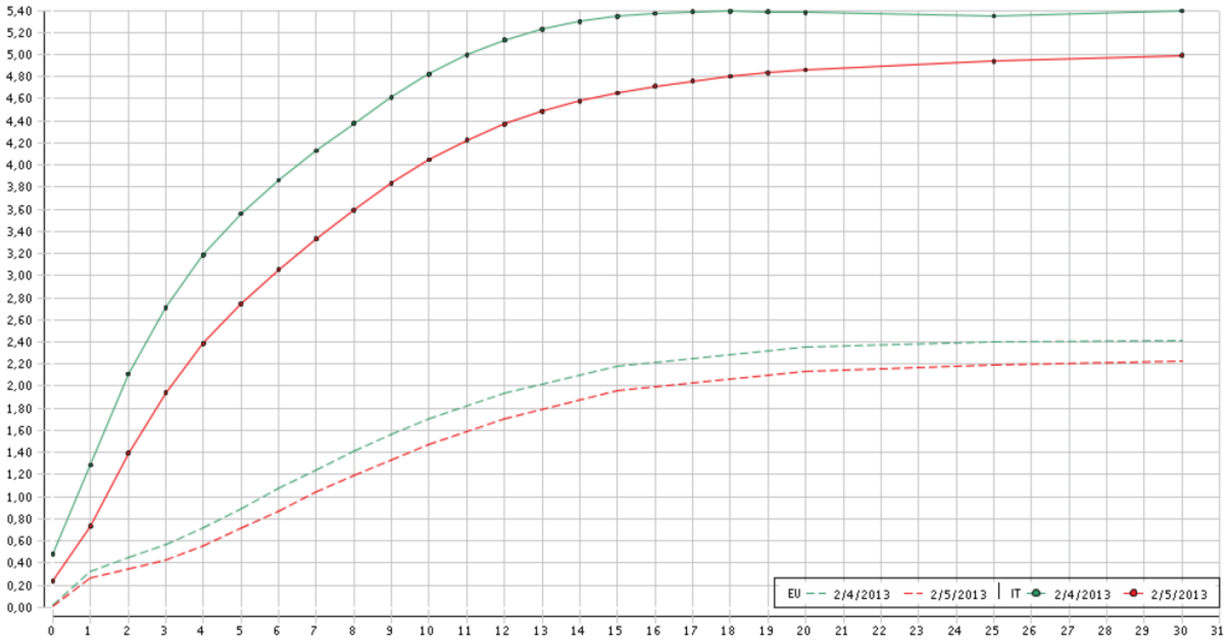
The following paragraphs aim at describing the below parameters:

1. Bracket and number of duration classes
2. Margin Intervals for each class (Government Bonds)
3. Intra-Class Offset Factor (COF_k)
4. Inter–Class Offset Factor ($XOF_{h,k}$)
5. Margin Interval for Corporate Bonds
6. Intra–Class Offset Factor for corporate bond

2.1.2. Margin Interval Calculation

In order to evaluate with the highest accuracy the possible variations of risk factors, CC&G has divided the Italian sovereign zero–coupon curve in 41 Vertices[4] x_i, ranging from 3 months to 30 years, and the Euro zero–coupon curve in 45 Vertices x_i, ranging from TN to 30 years as shown in Figure 1.

Figure 1: Italian government zcb yield curve and Euro zcb yield curve



[4] Obtained by linear interpolation from the original 25 vertices, in order to make a homogeneous comparison with Euro zcb curve.

For each Vertex x_i (both for Euro and sovereign zero-coupon curve) the yield variations for different holding periods are calculated and for each scenario (one, two or three days fluctuations) the Margin Interval in Terms of Yield is determined[5] and set equal to such a value as to supply a fixed Coverage Level (see next paragraph) compared to the whole set of n-days yield variations $\Delta y = y_{t+n} - y_t$ actually observed on various time horizons.

The coverage level has been fixed to give more weight to the most recent fluctuations with respect to the older ones.

2.1.3. Defining Coverage Level

Level of coverage and, consequentially, Margin Intervals are defined by applying the "**Sovereign Risk Framework**" (SRF) that basically consists in:

- a "**Predictive Model**", based on dynamic market indicators, to detect early warnings of the progressive deterioration of Sovereign creditworthiness
- a "**Toolbox**" structured in order to gradually build the CCP level of protection against Sovereign Risk

For each Band/Riskiness Level, the SRF foresees the application of the following "Toolbox" that includes different coverage levels for one, two, three, four and five days yield variations of the vertices of the Specific Sovereign Curve since the introduction of the Euro (January 2nd, 1999). Conservatively the comparison with the European zero coupon bond curve is also taken into account, whenever applicable.

Generally, the coverage levels applied to longer time brackets are lower than those applied to shorter ones in order to limit the impact on margin levels of price variations occurred in a distant past.

2.1.4. Determining Proposed Margin Interval for each vertex of the curve

After defining the appropriate coverage level as from the "toolbox", the methodology adopted leads to the identification of a Margin Interval for each vertex, according the following steps:

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[5] Calculating also the first four moments of the yield variation distribution (average, standard deviation, skewness and kurtosis).

1) Identification, for each vertex of the curve (both for government and euro curve), of the corresponding Margin Interval for each time bracket (separately for each holding period considered)[6],

2) Determination, for each vertex of the curve (both for government and euro zcb curve), of the Proposed Margin Interval (in terms of yield) as the highest Margin Interval of each time bracket (separately for each holding period),

3) Determination, for each vertex of the curve (both for government and euro curve) separately for each holding period, of the proposed Margin Interval in terms of price by multiplying the Margin Interval in terms of yield times the Modified Duration,

4) Determination, for each vertex of the curve (both for government and euro curve) of the Proposed Margin Interval (in terms of price) as the highest Proposed Margin Interval in all the holding periods considered in the analysis,

5) Determination, for each vertex of the curve, of the Proposed Margin Interval (in terms of price) as the highest amount between the Proposed Margin Interval calculated on Euro Zcb curve and on the Sovereign Zcb curve,

6) The Proposed Mathematic Margin Interval for the "special" Class of BTPi is equal to the highest Margin Interval among all BTPi.

7) The Proposed Mathematic Margin Interval for the "special" Class of CCTs is equal to the highest Margin Interval among all CCTs[7].

2.1.5. Defining the Duration Classes

The brackets and the number of "ordinary" Classes are defined in order to maximize the correlations among all the vertices in the Classes, except for inflation linked bonds (BTPi) and for Floating Rate Bonds (CCT) that, regardless of their Duration, are instead allocated in a "specific" Class (respectively Class XII and XIII).

In order to determine the correlations between price variations of the zero–coupon bonds for each vertex x_i along the curve yield figures are converted into price figures[8] .

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[6] At this step, Magin interval is defined as the average value between the first observation to be included and the first observation to be excluded.

[7] The only lookback period applied to CCTs is 18 months.

[8] For money market maturities, zero–coupon prices are obtained using the formula: $P_t = \frac{1}{(1+y_t)^n}$, where n is the number of years to maturity; for maturities greater than one year the continuously compounding is used $P_t = e^{y_t n}$.

For each pair of vertices x_i, x_j CC&G determines the complement to the ratio (so-called "div-undiv" or "D/U") between the "diversified VaR" and the "non-diversified VaR" for positions of opposite sign. In other words, the D/U measures the actual benefit in terms of risk reduction arising from positions of opposite sign (and same countervalue) on different vertices, deducted the lack of correlation between the two Vertices.

The diversified VaR is equal to the portfolio standard deviation $\sigma_p = \sqrt{W_a^2\sigma_a^2 + W_b^2\sigma_b^2 \mp 2W_aW_b\sigma_a\sigma_b\rho_{ab}}$ comprising instruments *a* and *b* with relative weightings respectively equal to W_a and W_b and having a correlation ρ_{ab}. Assuming the relative weights equal to 1 and –1 (positions of opposite sign) the result is:

$\sigma_p = \sqrt{\sigma_a^2 + \sigma_b^2 - 2\sigma_a\sigma_b\rho_{ab}}$.

The Undiversified VaR is equal to the portfolio standard deviation σ_p calculated assuming a perfect correlation, that is ρ_{ab}=1; in case of relative weights equal to 1 and –1 (therefore *ρab*-1) the result is: $\sigma_p = \sqrt{\sigma_a^2 + \sigma_b^2 + \sigma_a\sigma_b} = \sqrt{(\sigma_a + \sigma_b)^2} = |\sigma_a + \sigma_b|$.

The actual diversification benefit between positions of opposite sign is assumed equal to:

$$div - undiv = 1 - \frac{Diversified\ VaR}{Undiversified\ VaR} = 1 - \frac{\sqrt{\sigma_a^2 + \sigma_b^2 - 2\sigma_a\sigma_b\rho_{ab}}}{|\sigma_a + \sigma_b|}$$

Duration Classes shall comprise high correlated Vertices, generally those Vertices whose “div-undiv” are above 0,80. In other words, Classes will be the set of Vertices whose reciprocal “div-undiv” are generally higher than or equal to 0,80.

$$C_k = \left\{x \middle| x \in C, div - undiv(x_i\ x_j) \geq \Phi; \forall x_i, x_j \in C_k\right\}$$

Whereas *C* is the zero–coupon curve, *x* a generic Vertex, C_k is the generic Duration Class *and* Φ is approximately near to 0,80.

Conservatively the comparison with the correlations of the European blended curve is also taken into account, whenever applicable.

Table 2.1. D*iv-undiv-* example 1

01-mag-15		3Y6M	3Y9M	4Y	4Y3M	4Y6M	4Y9M	5Y	5Y3M	5Y6M	5Y9M	6Y	6Y3M	6Y6M	6Y9M
3Y6M	1 day		0,94	0,88	0,85	0,81	0,77	0,76	0,72	0,71	0,69	0,65	0,65	0,65	0,64
	2 days		0,95	0,90	0,87	0,83	0,80	0,78	0,75	0,73	0,71	0,68	0,67	0,66	0,65
	3 days		0,95	0,90	0,88	0,84	0,81	0,79	0,76	0,74	0,72	0,69	0,68	0,67	0,65
3Y9M	1 day	0,94		0,92	0,89	0,85	0,80	0,79	0,75	0,74	0,71	0,68	0,68	0,68	0,67
	2 days	0,95		0,94	0,91	0,87	0,83	0,81	0,78	0,77	0,74	0,71	0,70	0,69	0,68
	3 days	0,95		0,94	0,92	0,88	0,84	0,82	0,79	0,78	0,75	0,72	0,71	0,70	0,69
4Y	1 day	0,88	0,92		0,94	0,87	0,82	0,81	0,77	0,76	0,74	0,70	0,70	0,70	0,69
	2 days	0,90	0,94		0,95	0,90	0,86	0,84	0,80	0,79	0,77	0,74	0,73	0,72	0,71
	3 days	0,90	0,94		0,96	0,91	0,87	0,85	0,82	0,80	0,78	0,75	0,74	0,73	0,71
4Y3M	1 day	0,85	0,89	0,94		0,92	0,88	0,85	0,82	0,80	0,77	0,72	0,73	0,73	0,71
	2 days	0,87	0,91	0,95		0,94	0,90	0,88	0,85	0,83	0,80	0,76	0,76	0,75	0,73
	3 days	0,88	0,92	0,96		0,95	0,91	0,89	0,86	0,84	0,81	0,78	0,77	0,76	0,74
4Y6M	1 day	0,81	0,85	0,87	0,92		0,92	0,90	0,87	0,84	0,79	0,74	0,75	0,75	0,74
	2 days	0,83	0,87	0,90	0,94		0,94	0,92	0,89	0,87	0,83	0,78	0,78	0,78	0,76
	3 days	0,84	0,88	0,91	0,95		0,95	0,93	0,90	0,87	0,84	0,80	0,80	0,79	0,77
4Y9M	1 day	0,77	0,80	0,82	0,88	0,92		0,90	0,91	0,86	0,81	0,75	0,76	0,76	0,75
	2 days	0,80	0,83	0,86	0,90	0,94		0,93	0,92	0,89	0,84	0,80	0,80	0,79	0,78
	3 days	0,81	0,84	0,87	0,91	0,95		0,94	0,93	0,90	0,86	0,82	0,81	0,80	0,79
5Y	1 day	0,76	0,79	0,81	0,85	0,90	0,90		0,90	0,88	0,83	0,77	0,79	0,80	0,79
	2 days	0,78	0,81	0,84	0,88	0,92	0,93		0,93	0,90	0,86	0,82	0,82	0,82	0,81
	3 days	0,79	0,82	0,85	0,89	0,93	0,94		0,94	0,92	0,88	0,84	0,84	0,83	0,82
5Y3M	1 day	0,72	0,75	0,77	0,82	0,87	0,91	0,90		0,93	0,86	0,80	0,81	0,82	0,80
	2 days	0,75	0,78	0,80	0,85	0,89	0,92	0,93		0,94	0,89	0,85	0,85	0,84	0,83
	3 days	0,76	0,79	0,82	0,86	0,90	0,93	0,94		0,95	0,91	0,87	0,86	0,86	0,84
5Y6M	1 day	0,71	0,74	0,76	0,80	0,84	0,86	0,88	0,93		0,92	0,87	0,87	0,86	0,84
	2 days	0,73	0,77	0,79	0,83	0,87	0,89	0,90	0,94		0,94	0,90	0,89	0,88	0,86
	3 days	0,74	0,78	0,80	0,84	0,87	0,90	0,92	0,95		0,95	0,91	0,90	0,89	0,87
5Y9M	1 day	0,69	0,71	0,74	0,77	0,79	0,81	0,83	0,86	0,92		0,93	0,93	0,89	0,85
	2 days	0,71	0,74	0,77	0,80	0,83	0,84	0,86	0,89	0,94		0,94	0,94	0,91	0,88
	3 days	0,72	0,75	0,78	0,81	0,84	0,86	0,88	0,91	0,95		0,95	0,94	0,92	0,89
6Y	1 day	0,65	0,68	0,70	0,72	0,74	0,75	0,77	0,80	0,87	0,93		0,96	0,90	0,85
	2 days	0,68	0,71	0,74	0,76	0,78	0,80	0,82	0,85	0,90	0,94		0,96	0,92	0,88
	3 days	0,69	0,72	0,75	0,78	0,80	0,82	0,84	0,87	0,91	0,95		0,97	0,93	0,90
6Y3M	1 day	0,65	0,68	0,70	0,73	0,75	0,76	0,79	0,81	0,87	0,93	0,96		0,93	0,89
	2 days	0,67	0,70	0,73	0,76	0,78	0,80	0,82	0,85	0,89	0,94	0,96		0,95	0,91
	3 days	0,68	0,71	0,74	0,77	0,80	0,81	0,84	0,86	0,90	0,94	0,97		0,96	0,92
6Y6M	1 day	0,65	0,68	0,70	0,73	0,75	0,76	0,80	0,82	0,86	0,89	0,90	0,93		0,94
	2 days	0,66	0,69	0,72	0,75	0,78	0,79	0,82	0,84	0,88	0,91	0,92	0,95		0,96
	3 days	0,67	0,70	0,73	0,76	0,79	0,80	0,83	0,86	0,89	0,92	0,93	0,96		0,96
6Y9M	1 day	0,64	0,67	0,69	0,71	0,74	0,75	0,79	0,80	0,84	0,85	0,85	0,89	0,94	
	2 days	0,65	0,68	0,71	0,73	0,76	0,78	0,81	0,83	0,86	0,88	0,88	0,91	0,96	
	3 days	0,65	0,69	0,71	0,74	0,77	0,79	0,82	0,84	0,87	0,89	0,90	0,92	0,96	
7Y	1 day	0,62	0,65	0,67	0,69	0,73	0,74	0,77	0,78	0,80	0,81	0,80	0,84	0,90	0,94
	2 days	0,63	0,66	0,69	0,71	0,74	0,76	0,79	0,81	0,83	0,84	0,84	0,88	0,92	0,96
	3 days	0,64	0,67	0,70	0,72	0,75	0,77	0,80	0,82	0,84	0,85	0,86	0,89	0,93	0,96

Table 2.1 shows how the *div-undiv,* for maturities comprised between 3 years and six months and 4 years and 9 months, are generally near to 0,80, as well as for maturities comprised between 5 years and 7 years.

In the "peripheral" parts of the curve - in particular in the short term part (see Table 2.2) where jumps are more frequent given the higher sensitivity to monetary policy decisions - a case-by-case evaluation[9] is required.

9 It must be also mentioned that breaking up the zero–coupon curve in too many Classes is not desirable. Experience has shown insofar that the number of Classes is best being kept between 10 and 15.

Table 2.2. D*iv-undiv-* example 2

01-mag-15		TN	1W	1M	2M	3M	6M	9M	1Y	1Y3M	1Y6M	1Y9M	2Y
TN	1 day		0,28	0,08	0,04	0,03	0,01	0,01	0,01	0,01	0,00	0,00	0,00
	2 days		0,31	0,09	0,05	0,03	0,01	0,01	0,01	0,01	0,00	0,00	0,00
	3 days		0,27	0,08	0,04	0,03	0,01	0,01	0,01	0,00	0,00	0,00	0,00
1W	1 day	0,28		0,28	0,16	0,11	0,06	0,04	0,03	0,03	0,02	0,02	0,01
	2 days	0,31		0,30	0,17	0,12	0,06	0,04	0,03	0,02	0,02	0,02	0,01
	3 days	0,27		0,35	0,19	0,14	0,07	0,04	0,03	0,03	0,02	0,02	0,01
1M	1 day	0,08	0,28		0,37	0,29	0,16	0,12	0,10	0,08	0,07	0,06	0,05
	2 days	0,09	0,30		0.40	0,32	0,17	0,12	0,09	0,08	0,06	0,05	0,04
	3 days	0,08	0,35		0.51	0,40	0,22	0,14	0,11	0,09	0,07	0,06	0,05
2M	1 day	0,04	0,16	0,37		0.47	0,29	0,21	0,17	0,15	0,13	0,11	0,09
	2 days	0,05	0,17	0.40		0.51	0,31	0,21	0,17	0,14	0,12	0,10	0,08
	3 days	0,04	0,19	0.51		0.62	0,39	0,27	0,21	0,17	0,14	0,11	0,10
3M	1 day	0,03	0,11	0,29	0.47		0,37	0,28	0,24	0,21	0,18	0,15	0,13
	2 days	0,03	0,12	0,32	0.51		0,40	0,29	0,24	0,20	0,17	0,14	0,12
	3 days	0,03	0,14	0,40	0.62		0.51	0,37	0,29	0,24	0,20	0,17	0,14
6M	1 day	0,01	0,06	0,16	0,29	0,37		0.55	0.49	0.44	0,37	0,32	0,28
	2 days	0,01	0,06	0,17	0,31	0,40		0.56	0.49	0.43	0,36	0,30	0,26
	3 days	0,01	0,07	0,22	0,39	0.51		0.64	0.55	0.48	0.40	0,34	0,29
9M	1 day	0,01	0,04	0,12	0,21	0,28	0.55		0.72	0.65	0.55	0.46	0,37
	2 days	0,01	0,04	0,12	0,21	0,29	0.56		0.73	0.65	0.55	0.46	0,37
	3 days	0,01	0,04	0,14	0,27	0,37	0.64		0.78	0.70	0.60	0.51	0.42
1Y	1 day	0,01	0,03	0,10	0,17	0,24	0.49	0.72		0,82	0.69	0.57	0.46
	2 days	0,01	0,03	0,09	0,17	0,24	0.49	0.73		0,82	0.70	0.59	0.49
	3 days	0,01	0,03	0,11	0,21	0,29	0.55	0.78		0,83	0.71	0.60	0.51
1Y3M	1 day	0,01	0,03	0,08	0,15	0,21	0.44	0.65	0,82		0,83	0.70	0.58
	2 days	0,01	0,02	0,08	0,14	0,20	0.43	0.65	0,82		0,84	0.73	0.61
	3 days	0,00	0,03	0,09	0,17	0,24	0.48	0.70	0,83		0,85	0.74	0.63
1Y6M	1 day	0,00	0,02	0,07	0,13	0,18	0,37	0.55	0.69	0,83		0,84	0.69
	2 days	0,00	0,02	0,06	0,12	0,17	0,36	0.55	0.70	0,84		0,86	0.72
	3 days	0,00	0,02	0,07	0,14	0,20	0.40	0.60	0.71	0,85		0,86	0.74
1Y9M	1 day	0,00	0,02	0,06	0,11	0,15	0,32	0.46	0.57	0.70	0,84		0.80
	2 days	0,00	0,02	0,05	0,10	0,14	0,30	0.46	0.59	0.73	0,86		0,83
	3 days	0,00	0,02	0,06	0,11	0,17	0,34	0.51	0.60	0.74	0,86		0,85
2Y	1 day	0,00	0,01	0,05	0,09	0,13	0,28	0,37	0.46	0.58	0.69	0.80	
	2 days	0,00	0,01	0,04	0,08	0,12	0,26	0,37	0.49	0.61	0.72	0,83	
	3 days	0,00	0,01	0,05	0,10	0,14	0,29	0.42	0.51	0.63	0.74	0,85	

2.1.6. Determining the Margin Interval for Each Duration Class

The Proposed Mathematic Margin Interval for each Duration Class is set – as shown in Table 2 – as the largest Margin Interval in Terms of Price of all the Vertices comprised in the Class, rounded – where advisable – to the 0,05% above. The Proposed Mathematic Margin Interval for the Class *XII* (BTPi) and XIII (CCT) is equal to the highest Margin Interval among all the specific instruments.

In order to mitigate procyclicality, CC&G applies the required 25% buffer, only to those instruments whose time series are shorter than 10 years.

Table 2.3. Determination of the Proposed Margin Interval for each class – Example

Class	I			II		III		IV		V		
Expiry	TN	1W	1M	2M	3M	6M	9M	1Y	1Y3M	1Y6M	1Y9M	2Y
Duration	0,00	0,02	0,08	0,17	0,25	0,50	0,75	1,00	1,25	1,50	1,75	2,00
Yield	0,272	0,289	0,312	0,570	0,782	1.079	1.052	1.113	1.221	1.337	1.476	1.695
Modified Duration	0,00	0,02	0,08	0,17	0,25	0,49	0,74	0,99	1,23	1,48	1,72	1,97
1 D Margin Interval (Yield)	0,87	0,45	0,39	0,35	0,37	0,31	0,28	0,26	0,27	0,28	0,28	0,27
1 D Margin Interval (Price)	0,00%	0,01%	0,03%	0,06%	0,09%	0,15%	0,21%	0,26%	0,34%	0,41%	0,48%	0,53%
2 D Margin Interval (Yield)	0,97	0,62	0,42	0,41	0,45	0,70	0,61	0,49	0,45	0,43	0,40	0,38
2 D Margin Interval (Price)	0,00%	0,01%	0,03%	0,07%	0,11%	0,35%	0,45%	0,48%	0,56%	0,63%	0,69%	0,74%
3 D Margin Interval (Yield)	0,81	0,46	0,37	0,40	0,37	0,40	0,35	0,38	0,40	0,37	0,37	0,38
3 D Margin Interval (Price)	0,00%	0,01%	0,03%	0,07%	0,09%	0,20%	0,26%	0,38%	0,49%	0,55%	0,63%	0,74%
4 D Margin Interval (Yield)	0,70	0,55	0,32	0,31	0,35	0,37	0,38	0,39	0,41	0,42	0,39	0,38
4 D Margin Interval (Price)	0,00%	0,01%	0,03%	0,07%	0,07%	0,24%	0,25%	0,34%	0,42%	0,47%	0,57%	0,74%
5 D Margin Interval (Yield)	0,71	0,52	0,33	0,33	0,37	0,40	0,37	0,39	0,40	0,40	0,36	0,38
5 D Margin Interval (Price)	0,00%	0,01%	0,03%	0,07%	0,08%	0,25%	0,25%	0,38%	0,46%	0,50%	0,62%	0,74%
Proposed Margin Interval (Math)	0,05%			0,15%		0,54%		0,60%		0,75%		
Applied Margin Interval	0,70%			1,00%		1,10%		1,20%		1,30%		

Applied Margin Interval *is the Margin Interval in force at the date of the calculation (which is the result of previous margin calculations and of parameters change).*

A back test is performed daily on the actual price variations of the bonds included in the margins procedure, in order to verify the ex post performance of the risk parameter settings compared to the observed market data.

In particular, the back test compares the price variation of each bond with the Margin Interval applied to the Class in which the Bond is included and, in case the price variation results higher than the Margin Interval, a breach is counted.

The coverage level obtained in the back test is then calculated in order to verify the adequacy of the Margin Interval calculated on the analysis of the volatility on the vertices of the Italian zero coupon bond curve (for further details concerning margin parameters review see paragraph 2.2.3).

2.1.7. Determining the Intra-Class Offset Factor COFk

In order to take into account correlation between long and short positions of bonds within the same class of duration, offset factors are applied to reduce positions.

Once Duration Classes have been determined according to the aforesaid procedure, for each Class C_k the Intra–Class Offset Factor COF_k is determined.

As a general rule, COF_k is equal to the smallest *div-undiv* between pairs of Vertices comprised in the Class:

$$COF_k = \{x | x \in C_k, \min\lfloor div - undiv(x_i\ x_j)\rfloor \quad ; \forall x_i, x_j \in C_k\}$$

Prudentially COF_k is rounded to the lower 5% (e. g.: 0,68 is rounded to 0,65).

Typically COF_k will be found at the extreme of the secondary diagonal where the *div-undiv* between the two farthest Vertices in the Class is calculated, as it can be seen in Table 2.2.

2.1.8. Determining the Inter–Class Offset Factor XOFh,k

In order to take into account correlation between long and short positions of bonds included in the different classes of duration (highly correlated positions), offset factors are applied to reduce positions.

The Inter–Class Offset Factor $XOF_{h,k}$ between two classes C_h and C_k is determined according to the same criterion. It is assumed equal to the lowest *div-undiv* between Vertices belonging to two separate Classes. Only those Classes whose lowest *div-undiv* is higher of a threshold value Ψ are eligible for Inter–Class Offsetting.

$$XOF_{h,k} = \{x_h | x_h \in C_h, x_k | x_k \in C_k, min[div - undiv(x_k\ x_l)] \geq \Psi, \forall x_k \in C_k, \forall x_l \in C_k, C_h \cap C_k = \emptyset; min[div - undiv(x_k\ x_l)]\}$$

Table 2.1 provides an example of how $XOF_{h,k}$ is determined between two Duration Classes. In the central part of the zero–coupon curve Ψ is approximately set at 0,35-0,40, also with the aim of keeping the priority matrix reasonably manageable.

Once more, in the "peripheral" parts of the curve, in particular in the short term part (see Table 2.2) Ψ must be necessarily evaluated on a case-by-case basis.

Experience has shown insofar that the number of $XOF_{h,k}$ is better kept below 30, in order to ensure a more efficient operational management of margin parameters.

2.1.9. Priorities in Applying the Inter–Class Offset Factors XOFh,k

The correlation between Vertices – and therefore between Duration Classes – grows with the time to maturity, as shown in Figure 3 (1 year figures). Prudentially the first $XOF_{h,k}$'s applied are the smallest ones measured between the low Duration Classes and only subsequently the higher $XOF_{h,k}$'s between higher Duration Classes are applied.

Figure 3. Correlation among all pairs of vertices -Example

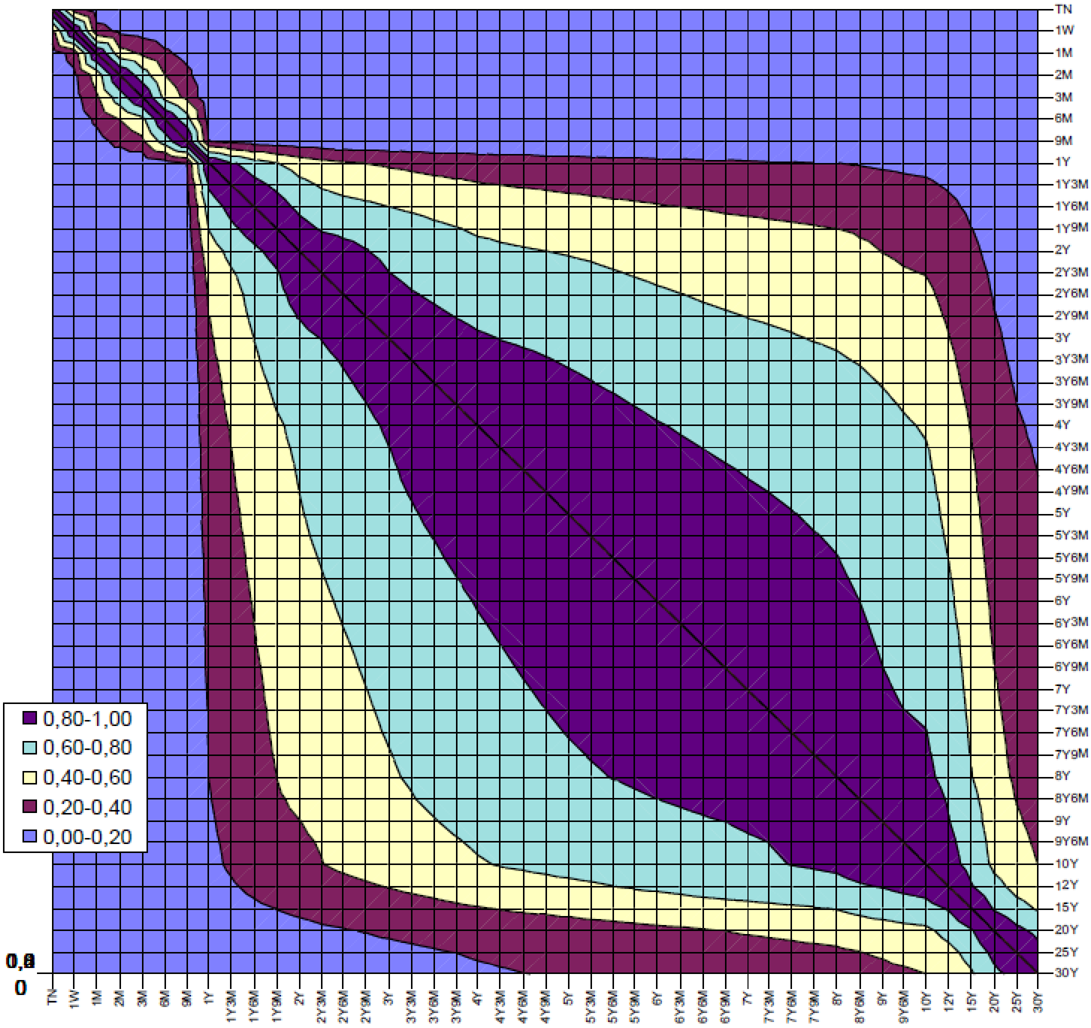

Figure 4: Priority and Intra / Inter Class offset - Example

Class	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I Priority	5% 1												
II Priority		35% 2	20% 14										
III Priority		20% 14	50% 3	40% 15									
IV Priority			40% 15	75% 4	35% 16	25% 17							
V Priority				35% 16	65% 5	40% 18	25% 19						
VI Priority				25% 17	40% 18	70% 6	50% 20	35% 21	25% 22				
VII Priority					25% 19	50% 20	75% 7	55% 23	40% 24	25% 25			
VIII Priority						35% 21	55% 23	75% 8	55% 26	40% 27			
IX Priority						25% 22	40% 24	55% 26	75% 9	55% 28	25% 29		
X Priority							25% 25	40% 27	55% 28	70% 10	35% 30		
XI Priority									25% 29	35% 30	55% 11		
XII Priority												15% 12	
XIII Priority													10% 13

2.2. Corporate Bonds

2.2.1. Classes specifications

To distinguish between the margin parameters applied to government bonds and the margin parameters applied to corporate Bonds, a different set of classes has been implemented.

Due to the reduced liquidity of corporate bonds, a less granular classes structure has been adopted for these instruments.

Therefore, 5 classes have been identified taking into consideration the maturities on the medium and long term (3,5,7,10 and 10 years +).

2.2.2. Intra–Class and Inter-Class Offset Factors

Corporate bonds price takes in account the *risk free* rates shape and the single issuer financial condition, considering the specific *pay-off* for each corporate bond. As a consequence, is not possible *a priori* to determine a correlation between the corporate bonds prices fluctuations related to the corporate bonds Classes.

In order to take into account of the part related to the ZCB curve shape, an Intra-Class Offset Factor (conservatively set at maximum value equal to the lower value calculated for ZCB curve) may be applied to each corporate bonds class, subject to Internal Risk Committee approval. No Inter-Class Offset Factor is applied.

Figure 5 provides an example of Duration Classes and corresponding Margin Intervals separately for government bonds and corporate bonds.

Figure 5: Duration Classes and Margin Intervals – Example

Government bonds

Class	Duration	Unità	Intervallo del margine
I	(0-1]	months	0,15%
II	(1-3]	months	0,35%
III	(0,25-0,75]	years	0,85%
IV	(0,75-1,25]	years	1,50%
V	(1,25-2]	years	2,40%
VI	(2-3,25]	years	3,55%
VII	(3,25-4,75]	years	4,90%
VIII	(4,75-7]	years	6,35%
IX	(7-10]	years	7,60%
X	(10-15]	years	8,35%
XI	(15-30]	years	23,20%
XII	BTPi	BTPi	12,15%
XIII	CCT	CCT	3,45%

Corporate bonds

Classe	Vita residua	Unità
XXXI	(0-3]	years
XXXII	(3-5]	years
XXXIII	(5-7]	years
XXXIV	(7-10]	years
XXXV	>10	years

Classe	Intervallo del margine
XXXI	9,00%
XXXII	11,00%
XXXIII	13,00%
XXXIV	17,00%
XXXV	30,00%

2.2.3. Procedures for Margin Parameters Review

Margin parameters are monitored and - if necessary - modified, basing on the periodic back test results and, in general, on the market conditions and volatility trends.

Parameters for Italian government bonds shall be agreed with LCH.Clearnet SA before entering into force.