Liquidity Buffer Risk Management

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Liquidity Buffer Management

- A bond portfolio can be used as collateral to borrow from other banks and from the BCE.
- The liquidity buffer a banks decides to have over a given period depends on its business activity, its risk appetite and regulatory constraints.
- Given the amount of the buffer, two problems have to be managed:
  1. **Liquidity Generation Capacity** (**LGC**): how much the bond portfolio is able to generate liquidity in the future over a given period (*e.g.*: one year). Once determined that, the bank can also decide which is the volume of the portfolio to hold.
  2. **Cost of the buffer**: which is the cost to hold the portfolio as a liquidity buffer. This cost should be transferred to clients when pricing contracts and charging for the total costs of the liquidity.

Term Structure of **LGC**

- The main tool to monitor the **LGC** is to build a term structure of minimum liquidity that can be generated in the future of the chosen period at a given confidence level (*e.g.*:
- To build the terms structure, we operate the following procedure:
  1. Divide the period in a number of M sub-periods;
  2. At the end of each sub-period t_m compute the minimum value of the portfolio;
  3. Include the hair-cut either according the approach outlined above or according some predefined rules (*e.g.*: ECB hair-cuts)

Interest Rate and Default Probability Modelling

- The minimum value of the portfolio is computed in a VaR-like fashion, by modelling the risk-free interest rate and the default probabilities.
- The risk-free interest rate is modelled by a short-rate CIR model and a deterministic function:

$$r_t = x_t + \psi(t)$$

- For each bond issuer i we assume that the default intensity is the sum of three separate components:

$$\lambda_i^D(t) = \lambda_i^I(t) + p_i \lambda^C(t) + \phi_i(t)$$

- $\lambda_i^I(t)$ is an idiosyncratic factor specific to each issuer.
- $\lambda^C(t)$ is a common factor affecting each issuer according to the parameter p_i, which produces a default's dependence similar to correlation.
- $\psi(t)$ and $\phi_i(t)$ are deterministic functions that assure a perfect match between the data and the model.
- The CIR evolution for a variable y_t is:

$$dy_y = \kappa^y[\theta^y - y_t]dt + \sigma^y \sqrt{y_t} dz_t$$

ECB Haircuts

Haircut schedule for assets eligible for use as collateral in Eurosystem market operations

Levels of valuation haircuts applied to eligible marketable assets											
		Liquidity categories									
Credit quality	*Residual maturity (years)*	Category I		Category II		Category III		Category IV		Category V
		fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	
Steps 1 and 2 (AAA to A-)	0-1	0.5	0.5	1.0	1.0	1.5	1.5	6.5	6.5	16
	1-3	1.5	1.5	2.5	2.5	3.0	3.0	8.5	9.0	
	3-5	2.5	3.0	3.5	4.0	5.0	5.5	11.0	11.5	
	5-7	3.0	3.5	4.5	5.0	6.5	7.5	12.5	13.5	
	7-10	4.0	4.5	5.5	6.5	8.5	9.5	14.0	15.5	
	>10	5.5	8.5	7.5	12.0	11.0	16.5	17.0	22.5	
		Liquidity categories								
Credit quality	*Residual maturity (years)*	Category I		Category II		Category III		Category IV		Category V
		fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	fixed coupon	zero coupon	
Step 3 (BBB+ to BBB-)	0-1	5.5	5.5	6.0	6.0	8.0	8.0	15.0	15.0	Not eligible
	1-3	6.5	6.5	10.5	11.5	18.0	19.5	27.5	29.5	
	3-5	7.5	8.0	15.5	17.0	25.5	28.0	36.5	39.5	
	5-7	8.0	8.5	18.0	20.5	28.0	31.5	38.5	43.0	
	7-10	9.0	9.5	19.5	22.5	29.0	33.5	39.0	44.5	
	>10	10.5	13.5	20.0	29.0	29.5	38.0	39.5	46.0	

An Approach to Model ECB Haircuts

- Haircuts set by ECB depend on the rating of the bond issuer, which basically follow with some delay the default probability implied from the market quotes.
- We map the rating against the **PD** levels and then compute the expected haircut.
- For example, Category I bonds (Treasury bonds) have two possible haircuts given the residual maturity (Steps 1 and 2). If the rating falls below BBB- they are no more eligible (Step 3).
- We decide the **PD**-rating conversion as:
    - $\mathbf{PD}(t_m, t_m + 1Y) \leq 1.5\% \; -> $ haircut is for a Step 1 rating hc_1;
    - $1.5\% \leq \mathbf{PD}(t_m, t_m + 1Y) \leq 5.0\% \; -> $ haircut is for a Step 2 rating hc_2;
    - $\mathbf{PD}(t_m, t_m + 1Y) \geq 5.0\% \; -> $haircut is 100%, *i.e.*: the bond is no more eligible;
- The expected haircut is:

$$
\begin{aligned}
h(t_m) =& hc_1 \Pr[\mathbf{PD}(t_m, t_m + 1Y) \leq 1.5\%] + hc_2 \Pr[1.5\% \leq \mathbf{PD}(t_m, t_m + 1) \leq 5\%] \\
&+ 100\% \Pr[\mathbf{PD}(t_m, t_m + 1) \geq 5\%]
\end{aligned}
$$

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Funding the Liquidity Buffer

- As a very general rule, the bond portfolio included in the liquidity buffer has to be funded at long term otherwise the very notion of liquidity buffer is lost.
- If the liquidity buffer is meant to cover a period of one year, the funding must have a longer maturity, *e.g.*: two years.
- The factors to determine the liquidity buffer's costs are:
    1. Target **LGC**: the buffer must guarantee a target level of liquidity over the chosen period (*e.g.*: 1 year);
    2. Expected return of the buffer: it is the expected amount of interests paid by the bonds in the portfolio. The default must be included in the analysis, since if the issuer goes bankrupt the bank does not receive any other payment. The price variations do not have to be included, since the bonds are not meant to be sold but to be held over the period.

Known Liquidity Buffer Costs

- Assume we are in $t = 0$ and that there are N eligible bonds available with prices $\{B_1, B_2, ..., B_N\}$, each paying a fixed yearly coupon $\{c_1, c_2, ..., c_N\}$.
- Given the target $\mathbf{LGC}^T$, assume that the amount of eligible bonds to hold in the buffer is $\{x_1, x_2, ..., x_N\}$ for a total value of:

$$V = \sum_{i=1}^{N} x_i B_i$$

- The amount V has to be funded with long term debt and the bank pays a total yearly funding interest of f, so that the funding costs are

$$\mathbf{FC} = fV$$

- The expected total for next year is:

$$y = \frac{\sum_{i=1}^{N} x_i c_i [1 - \mathbf{PD}_i(0, 1Y)]}{V}$$

- The liquidity buffer cost over 1-year period is:

$$\mathbf{LBC}(0, 1Y) = (f - y)V$$

Expected Liquidity Buffer Costs

- For periods beyond the first one, liquidity buffer costs can only be computed under a certain number of assumptions.
- Funding spreads over the risk-free rate need to be extrapolated. Expected and unexpected funding spreads can be considered (for example by means of Iason's dynamic funding spread model).
- For the bond portfolio, a given quality of the portfolio has to be assumed, so as to infer the expected amounts needed given the target **LGC**.
- From the level of the interest rates and of the credit spreads, the expected yield of the buffer has to be computed.
- The expected **LBC** can be determined and charged within the total fund transfer price.

A Practical Example

The bank sets as its target $\mathbf{LGC}^T = 2.50$, so that the bonds in the portfolio have to be bought for 1.049 each to make sure that the buffer is sufficient at 99% confidence level. The expected yield over the period of 1 year of the portfolio is 5.20%, determined as shown on the right-hand side.
Assuming that the bank funds the portfolio at a yearly total cost of $\mathbf{FC} = 5.65\%$, the cost of the liquidity buffer **LBC** is derived straightforward.

	Bond1	Bond2	Bond3
$\mathbf{PD}(0, 1Y)$	1.5%	2.0%	4.0%
Exp. Yield	4.93%	4.90%	5.76%

$$\mathbf{LBC} = 1.049 \times [5.20\% - 5.65\%] = 0.47\%$$

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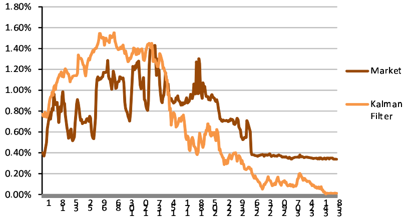
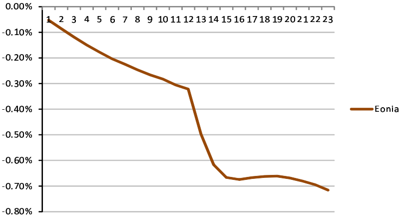
The Risk-Free Interest Rate: Data and Calibration

For the risk-free interest rate, we consider a series of zero-coupon bonds obtained by bootstrapping the data from the Eonia swaps in the period 31/12/2010 - 25/05/2012. Calibration is performed by a Maximum Likelihood jointly with a Kalman filter to account for the instantaneous rate latent variable.

Calibrated parameters are below. On the right column, the market historical instantaneous rate (Eonia O/N) vs the Kalman estimate, and the functions $\psi(t)$ to perfect fit the market data on the last date (25/05/2012).

κ^r	0.08178
θ^r	6.23%
σ^r	10.1%





Treasury Bonds' Data

We consider a portfolio of 20 bonds, issued by Italy, Germany, France, Spain, over the period from 31/12/2010 to 25/05/2012. Bonds are considered from their issue date on, if it falls after the start of the period.

ITA	Issue date	Maturity	Coupon
1	28/03/2011	01/04/2014	3.00%
2	14/03/2012	01/03/2015	2.50%
3	01/01/2012	01/05/2017	4.75%
4	30/12/2010	01/03/2019	4.50%
5	26/08/2011	01/03/2022	5.00%

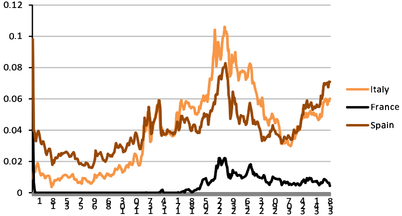
FRA	Issue date	Maturity	Coupon
1	17/04/2012	25/09/2014	0.75%
2	30/12/2010	15/01/2015	2.50%
3	02/02/2012	25/02/2017	1.75%
4	30/12/2010	25/10/2018	4.25%
5	31/01/2012	25/04/2022	3.00%

GER	Issue date	Maturity	Coupon
1	22/05/2012	13/06/2014	0.00%
2	30/12/2010	10/04/2015	2.25%
3	08/05/2011	07/04/2017	0.50%
4	30/12/2010	04/07/2019	3.50%
5	10/04/2012	04/07/2022	1.75%

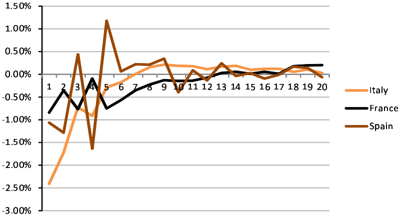
SPA	Issue date	Maturity	Coupon
1	05/04/2011	30/04/2014	3.40%
2	10/01/2012	30/07/2015	4.00%
3	31/08/2011	31/10/2016	4.25%
4	30/12/2010	30/07/2019	4.60%
5	11/11/2011	31/01/2022	5.85%

Calibration of the Default Intensities

The intensities of default are calibrated to the time series of bonds' prices. German bonds imply no default risk but a liquidity premium that makes their yields lower than the risk-free yield. We show the calibrated data, the instantaneous default intensities estimated by Kalman filter and the functions $\phi(t)$.



κ^r	0.0465
θ^C	1.1257%
θ^{ITA}	11.477%
θ^{FRA}	4.974%
θ^{SPA}	11.835%
σ^C	6.634%
p_{ITA}	0.883
p_{FRA}	0.668
p_{SPA}	0.867



Calibration of the Default Intensities

Comparison of the market and model prices on the reference date we chose to compute the **LGC** term structure (25/05/2012).

Bond	MKT	Model	Model + ϕ
ITA1	98.913	97.675	98.913
ITA2	95.585	95.112	95.585
ITA3	99.128	99.392	99.128
ITA4	95.637	96.139	95.637
ITA5	95.703	95.717	95.703
FRA1	100.725	99.563	100.725
FRA2	105.088	103.881	105.088
FRA3	101.893	101.467	101.893
FRA4	114.858	114.704	114.858
FRA5	104.253	105.426	104.253
SPA1	98.403	97.041	98.403
SPA2	96.848	96.577	96.848
SPA3	94.982	95.392	94.982
SPA4	92.278	92.582	92.278

Bond Specific Liquidity Parameters

The residual part of the bonds' prices that is not explained by the interest rate and by the default spread, is due to a liquidity parameter. This is calibrated for each bond to obtain a perfect match with the market data. For German bonds the difference between market and model prices implies a liquidity premium. For other issuers liquidity premiums are negligible, consistently with the fact they are benchmark bonds for the relevant maturities.

Bond	Liquidity
ITA1	0.00024%
ITA2	0.00046%
ITA3	0.00050%
ITA4	0.00016%
ITA5	0.00036%
GER1	-0.2300%
GER2	-0.2400%
GER3	-0.2200%
GER4	-0.1300%
GER5	-0.0200%

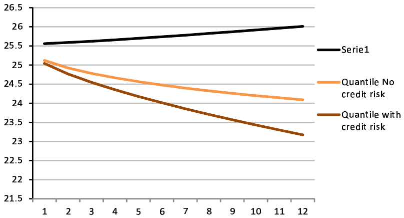
Bond	Liquidity
FRA1	-0.00330%
FRA2	0.00068%
FRA3	-0.00073%
FRA4	-0.00023%
FRA5	0.00021%
SPA1	-0.00150%
SPA2	-0.00049%
SPA3	-0.00056%
SPA4	-0.00037%
SPA5	-0.00030%

LGC Term Structure w/o German Bonds

We compute the **LGC** term structure for a portfolio of 30Mln Euro, equally distributed amongst the 15 bonds of Italy, France, Spain, over a period of 1 year with monthly sub-periods

The triggers for the ECB haircuts are set at $\mathbf{PD}(t_m, t_m + 1Y) \leq 5\%$ and $\mathbf{PD}(t_m, t_m + 1Y) \leq 15\%$.

Months	Expected	99 Quantile (No credit risk)	99 Quantile (with credit risk)
1	25.57201	25.22845	25.04041
2	25.58902	24.92103	24.76522
3	25.62103	24.77742	24.54403
4	25.65802	24.66381	24.35302
5	25.69643	24.56342	24.17601
6	25.73764	24.47584	24.01164
7	25.77862	24.39485	23.85445
8	25.82421	24.32443	23.70802
9	25.87022	24.25904	23.56684
10	25.91480	24.19682	23.42922
11	25.96383	24.14281	23.29986
12	26.00984	24.08900	23.17124

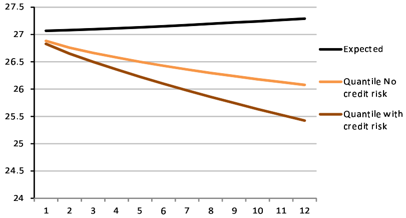


LGC Term Structure w. German Bonds

We compute the **LGC** term structure for a portfolio of 30Mln Euro, equally distributed amongst 20 bonds of Italy, France, Spain, and Germany, over a period of 1 year with monthly sub-periods

The triggers for the ECB haircuts are set at $\mathbf{PD}(t_m, t_m + 1Y) \leq 5\%$ and $\mathbf{PD}(t_m, t_m + 1Y) \leq 15\%$.

Months	Expected	99 Quantile (No credit risk)	99 Quantile (with credit risk)
1	27.06810	26.88225	26.82705
2	27.08100	26.75835	26.64825
3	27.09510	26.66235	26.49720
4	27.11295	26.57790	26.35800
5	27.13065	26.49855	26.22375
6	27.15105	26.42625	26.09685
7	27.17130	26.35770	25.97355
8	27.19530	26.29620	25.85775
9	27.21915	26.23785	25.74480
10	27.24045	26.17965	25.63230
11	27.26670	26.12880	25.52715
12	27.29040	26.07765	25.42200



Term Structure of Expected Haircut

In the table below the term structure of expected ECB haircuts when triggers are set at $\mathbf{PD}(t_m, t_m + 1Y) \leq 5\%$ and $\mathbf{PD}(t_m, t_m + 1Y) \leq 7.5\%$.

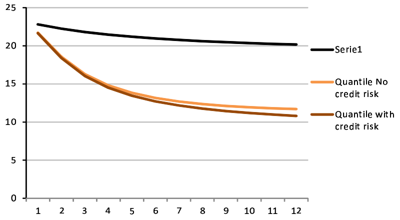
	Months											
Bonds	1	2	3	4	5	6	7	8	9	10	11	12
ITA1	6.50%	6.47%	6.40%	6.31%	6.23%	6.16%	6.09%	6.03%	5.98%	5.93%	5.89%	5.85%
ITA2	6.50%	6.47%	6.40%	6.31%	6.23%	6.16%	6.09%	6.03%	5.98%	5.93%	5.89%	5.85%
ITA3	8.00%	7.97%	7.90%	7.81%	7.73%	7.66%	7.59%	7.53%	7.48%	7.43%	7.39%	7.35%
ITA4	8.50%	8.47%	8.40%	8.31%	8.23%	8.16%	8.09%	8.03%	7.98%	7.93%	7.89%	7.85%
ITA5	9.50%	9.47%	9.40%	9.31%	9.23%	9.16%	9.09%	9.03%	8.98%	8.93%	8.89%	8.85%
GER1	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
GER2	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
GER3	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
GER4	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
GER5	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%
FRA1	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
FRA2	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
FRA3	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
FRA4	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
FRA5	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%
SPA1	6.50%	6.50%	6.50%	6.49%	6.48%	6.46%	6.44%	6.42%	6.39%	6.37%	6.34%	6.32%
SPA2	8.00%	8.00%	8.00%	7.99%	7.98%	7.96%	7.94%	7.92%	7.89%	7.87%	7.84%	7.82%
SPA3	8.00%	8.00%	8.00%	7.99%	7.98%	7.96%	7.94%	7.92%	7.89%	7.87%	7.84%	7.82%
SPA4	9.50%	9.50%	9.50%	9.49%	9.48%	9.46%	9.44%	9.42%	9.39%	9.37%	9.34%	9.32%
SPA5	9.50%	9.50%	9.50%	9.49%	9.48%	9.46%	9.44%	9.42%	9.39%	9.37%	9.34%	9.32%

LGC Term Structure w/o German Bonds (Higher Haircuts)

We compute the **LGC** term structure for a portfolio of 30Mln Euro, equally distributed amongst the 15 bonds of Italy, France, Spain, over a period of 1 year with monthly sub-periods

The triggers for the ECB haircuts are set at $\mathbf{PD}(t_m, t_m + 1Y) \leq 5\%$ and $\mathbf{PD}(t_m, t_m + 1Y) \leq 7.5\%$.

Months	Expected	99 Quantile (No credit risk)	99 Quantile (with credit risk)
1	22.80062	21.71160	21.63640
2	22.23483	18.56026	18.41004
3	21.80344	16.26536	16.04026
4	21.46225	14.79120	14.49136
5	21.18428	13.81924	13.44480
6	20.95726	13.15816	12.70932
7	20.76644	12.69220	12.16910
8	20.60703	12.35930	11.76210
9	20.47102	12.11618	11.44510
10	20.35043	11.93390	11.18904
11	20.24884	11.80152	10.98316
12	20.15706	11.70114	10.80942

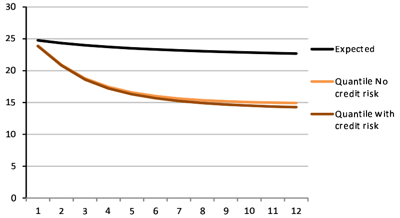


LGC Term Structure w. German Bonds (Higher Haircuts)

We compute the **LGC** term structure for a portfolio of 30Mln Euro, equally distributed amongst 20 bonds of Italy, France, Spain, and Germany, over a period of 1 year with monthly sub-periods

The triggers for the ECB haircuts are set at $\mathbf{PD}(t_m, t_m + 1Y) \leq 5\%$ and $\mathbf{PD}(t_m, t_m + 1Y) \leq 7.5\%$.

Months	Expected	99 Quantile (No credit risk)	99 Quantile (with credit risk)
1	24.76590	23.89580	23.84085
2	24.33135	20.91510	20.80500
3	23.99750	18.77520	18.80500
4	23.73195	17.43195	17.21205
5	23.51385	16.57100	16.29630
6	23.33415	16.00425	15.67485
7	23.18190	15.62085	15.23670
8	23.05335	15.35930	14.92073
9	22.94295	15.18015	14.68715
10	22.84410	15.05520	14.50793
11	22.76010	14.97459	14.37302
12	22.68315	14.92092	14.26521



Term Structure of Expected Haircut

In the table below the term structure of expected ECB haircuts when triggers are set at $\mathbf{PD}(t_m, t_m + 1Y) \leq 5\%$ and $\mathbf{PD}(t_m, t_m + 1Y) \leq 7.5\%$.

	Months											
Bond	1	2	3	4	5	6	7	8	9	10	11	12
ITA1	6.88%	9.46%	12.68%	15.64%	18.19%	20.39%	22.29%	23.95%	25.41%	26.71%	27.87%	28.92%
ITA2	6.88%	9.46%	12.68%	15.64%	18.19%	20.39%	22.29%	23.95%	25.41%	26.71%	27.87%	28.92%
ITA3	8.37%	10.91%	14.08%	16.99%	19.50%	21.66%	23.53%	25.16%	26.60%	27.87%	29.02%	30.05%
ITA4	8.87%	11.40%	14.55%	17.44%	19.94%	22.09%	23.95%	25.57%	26.99%	28.26%	29.40%	30.43%
ITA5	9.87%	12.37%	15.48%	18.34%	20.81%	22.94%	24.77%	26.37%	27.79%	29.04%	30.17%	31.18%
GER1	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
GER2	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
GER3	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
GER4	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
GER5	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%	5.50%
FRA1	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
FRA2	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
FRA3	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
FRA4	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
FRA5	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%
SPA1	39.66%	44.15%	46.30%	47.66%	48.62%	49.35%	49.93%	50.41%	50.81%	51.16%	51.46%	51.73%
SPA2	40.62%	45.05%	47.17%	48.50%	49.44%	50.16%	50.73%	51.20%	51.60%	51.94%	52.24%	52.50%
SPA3	40.62%	45.05%	47.17%	48.50%	49.44%	50.16%	50.73%	51.20%	51.60%	51.94%	52.24%	52.50%
SPA4	41.59%	45.94%	48.03%	49.34%	50.26%	50.97%	51.54%	52.00%	52.39%	52.72%	53.02%	53.27%
SPA5	41.59%	45.94%	48.03%	49.34%	50.26%	50.97%	51.54%	52.00%	52.39%	52.72%	53.02%	53.27%

About Iason

Iason is a company created by market practitioners, financial quants and programmers with valuable experience achieved in dealing rooms of financial institutions.
Iason offers a unique blend of skills and expertise in the understanding of financial markets, in the pricing of complex financial instruments and in the measuring and the management of banking risks. The company's structure is very flexible and grants a fully bespoke service to our Clients.
Iason believes that the ability to develop new quantitative finance approaches through research as well as to apply those approaches in practice, is critical to innovation in risk management and derivatives pricing. It brings into all the areas of the risk management a new and fresh approach based on the balance between rigour and efficiency Iason's people aimed at when working in the dealing rooms.
Besides tailor made services, Iason offers software applications to calculate and monitor credit VaR and counterparty VaR, fund transfer pricing and loan pricing, liquidity-at-risk.