A Framework to Consistently Monitor Funding Costs and Transfer Them into Pricing

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The Funding and the Banking Activity

Funding costs and funding transfer rates have been examined in the past, and generally the analysis (often implicitly) assumed that:

- the financial institution was able to finance its credit intermediation activity at lower rates than those earned on the activities, thus generating interest margin profits (and implying banks' better than clients' creditworthiness)
- (partly) financing at short term activities with long term maturities was not a risky activity in practice;
- liquidity in the market was abundant so that the choice of the funding mix was determined with almost no constraints.

The Funding and the Banking Activity

The turbulence in the financial markets, starting in the 2007, made these assumptions no more realistic:

- financial institutions are no more able to always raise funds at less expensive conditions than their clients;
- the volatility of the spreads over interbank market rates (*e.g.*: Libor) dramatically increased, so that financing long term activities with short term debt, even partially, is riskier than before;
- as a consequence of the first two points, the funding mix is subject to constraints so as to abate the average funding cost and make the credit intermediation activity still profitable.

Banking has become, in some cases, a loosing business according to past schemes, e.g.: long term loans were (are...) often priced with funding cost equal to marginal cost on the same expiry. Currently such approach would reject in theory some possible investments, depending on general market and bank specific conditions.

Towards a New Approach to Compute Funding Costs

Since banks are still doing their business, that means that they are starting considering the financing activity with new criteria:

- the funding cost has to take into account all possible funding sources available: on some of them, such as demand and saving deposits, the bank's bargaining power is still relatively strong and the cost paid can be abated;
- the funding mix has to be considering under a dynamic rather than static perspective: this makes possible the building of funding curves that account for the (expected) average funding costs on short term liabilities also for longer maturities, by assuming the continuity of the banking activity and of the roll-over of the liabilities;
- the risks inherent to the liabilities' rolling (*refunding risks*) have to be consistently measured and accounted for so as to allocate an amount of Economic Capital and to correctly include them into the investments' pricing.

Towards a New Approach to Compute Funding Costs

What we propose a possible approach complying with these criteria. Schematically it can be sketched as follows:

1. A funding curve for all the single available sources has to be built up to a given expiry, even longer than the source's average duration, by projecting the future costs based on market (*e.g.*: Libor) forward rates and specific spreads over them;
2. A weighted average funding curve is then calculated and it determines the average (and expected) cost born to finance a given investment;
3. The unexpected funding costs due to the uncertainty related to the liabilities' rolling activity is measured by a VaR-like methodology, thus identifying an unexpected maximum cost for each expiry at a given level of confidence;
4. The unexpected costs imply a given amount of Economic Capital to be allocated and its remuneration has to be included in the pricing of the investments, such as a loan.

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Bank's Profit and Loss

If we indicate with $\pi = (e - r_f)$ the risk premium demanded by the equity holders, the fair rate i_1^* that should be applied on a loan of amount A_1 is:

$$i_1^* A_1 = \underbrace{\bar{r}L}_{fu} + \underbrace{SA_1}_{cs} + \underbrace{(\pi + \varepsilon r_f)E}_{cc} \qquad (1)$$

where $\bar{r}$ is the average cost paid on all liabilities $L = A_1$. The three components of the rate requested on the investment are:

- *fu*, the funding cost,
- *cs*, the credit spread,
- *cc* the cost of capital to partially finance the investment and to cover the unexpected credit and market losses.

We have to include in *cc all* unexpected losses, not only credit and market, but also related to funding as we show below.

An Overview of the Framework with an Example

Assume the bank has three funding sources:

- the interbank deposit market, allowing to borrow from (but also to lend to) other banks via time deposits, usually expiring up to one year;
- the CDs' (Certificates of Deposit) market, allowing to raise funds from retail customers at good levels compared to other sources;
- the issuance of bonds, allowing a medium-term funding (five years), typically selling bonds to investors

We assume

- a yearly refunding schedule for the interbank deposits;
- for the CD's market the refunding schedule is on a two year basis;
- the bonds are issued on a five-year basis.

We model the term structure of Libor rates by a CIR model. In this renowned model (in its basic form) the term structure of interest rates is driven by one stochastic factor.

Deterministic Spread of the Funding Sources

In the first case we examine, we make the following assumptions:

- it is possible to determine the cost of each funding source as the Libor rate for the relevant maturity plus a deterministic, though time dependent, spread that is known;
- it is possible today to define the entire funding curve for each source, up to a given expiry t_N, though this source entails a refunding schedule because on average it has a much smaller duration than the total period running from 0 to t_N;

Deterministic Spread of the Funding Sources

Under the deterministic spread assumption, refunding is not a risk since the Treasury department can lock-in the future cost implicit in the curves by static or dynamic strategies involving swaps, FRA's, euro-futures, all having a Libor rate as underlying, to hedge the exposures at the refunding dates.

Example

The CD's with an average maturity of two years have to be re-sold each two years. It is possible, under the hypothesis above, to hedge the exposures generated by the re-selling of CD's, thus locking in the funding cost up to a maturity of, say, 20 years.

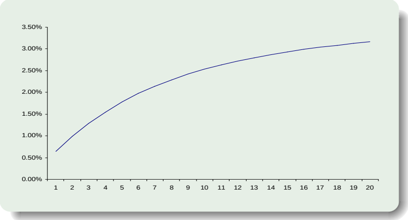
Libor, Funding and FTP Curves

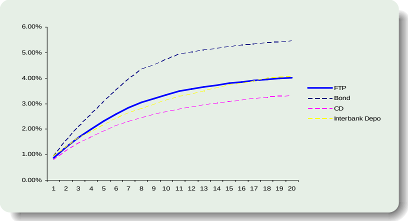
Zero-rates *Libor curve*: this is the basic building-block to produce the curve for all the funding sources, by adding the relevant spread for each expiry. The curves for the three sources are derived once the (deterministic) term structures of the spreads are give

In the interbank deposit market, for example, the zero-spread term structure starts with 0.30% for the one-year expiry and increases up to 90% for the 20-year expiry.

The *funding curve* is the weighted average (for each expiry) of the zero-rates of the three sources. The weights are given by the actual or targeted funding mix.

Depo	CD	Bond
20.00%	50.00%	30.00%





Moving to Stochastic Funding Costs

The assumption of deterministic, though time dependent, spreads is too naive and it is not acceptable in practice:

- spreads are stochastic as well as the Libor rates, and they are a function of the (perceived) bank's default risk and recovery ratios on bank's bankruptcy, which depends on the type of instrument;
- with stochastic spreads, we cannot anymore assume that the funding curve is determined up to an expiry t_N, since the average life of the instruments underlying the different funding sources imply a refunding risk, which can be defined as the greater-than-expected costs to be paid when rolling over a given funding source on its maturities;
- in fact we cannot simply lock in the cost implicit in the Libor curve and the spread curves by setting up a hedging strategy for all future refunding exposures (we can hedge the Libor risk, but it is almost impossible to hedge the spread risk: bank cannot sell CDS on its own credit).

Stochastic Funding Costs' Setting

In a stochastic environment we have to:

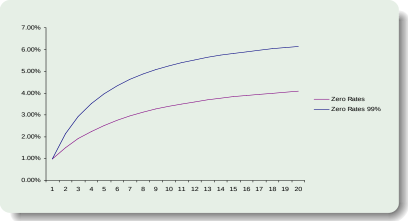
- introduce a stochastic model for the different spreads, describing their evolution in time;
- build the spread curves by the chosen model, after its fitting to current market prices;
- consider the curves thus derived as expected funding costs for each funding source and hence we can build also an average bank's funding curve;
- take into account the fact that the spreads may be different from the (implied) average, possibly higher than that, on the refunding dates and this imply a higher cost to be borne by the bank.

Stochastic Funding Costs' Setting

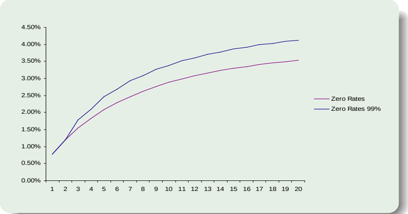
- Basically we may experience future spreads higher than the forward spreads implied in the curve;
- the higher cost can be considered an *unexpected funding cost* that has to be measured according to a VaR-like approach;
- as all unexpected costs, the higher funding cost has to be covered eventually by an amount of economic capital, in the same way as an amount of economic capital is provided for to cover unexpected credit and market losses;
- on the other hand, the expected funding costs is included into the pricing of the bank's products by using the expected funding curves.

Funding Curves: Expected and Maximum Levels

The interbank deposit market: we derive the maximum zero-rates (minimum discount factors with a confidence level $cl = 99\%$), with a stochastic model for the spreads and we compare them with the expected zero-rate term structure: since the refunding schedule is yearly, the maximum term structure is smooth and similar in shape to the expected one.

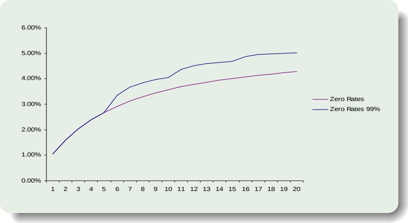


The same approach is used to derive the expected and maximum level of the zero-rate curve for the CD market. The maximum level curve appears less regular than the interbank deposit's case.

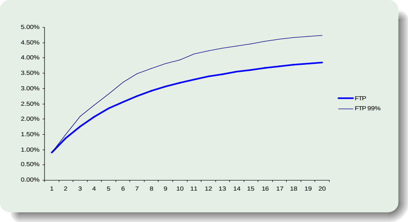


Funding Curves: Expected and Maximum Levels

As it easy to notice, the distance from the expected curve is much smaller for the issued bonds, since they have a refunding schedule on a five year basis, which allows for a fixing of the funding costs for longer periods than the two year basis for the CD's and one year basis for the interbank deposits. The shape of the maximum zero-rates for the bonds is the most irregular, since it changes only each five years.



The term structures of expected and maximum zero-rates and minimum discount factors for the *funding curve* can be easily computed as a weighted average of the corresponding term structures of the three funding sources.



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Including Funding Cost in Loans' Pricing

- The *funding curve* can be used to discount the cash flows related to a loan (or to any other asset bought by the bank) so as to include into the pricing the average liquidity cost borne by the bank.
- The difference between the stochastic and deterministic spread *funding curve* lies in that in the latter case we have a curve of settled funding costs for each maturity which can be locked in at any future date, whereas in the former case we have a curve of funding costs that cannot be locked in with any hedging strategy, so that at any future date the curve implies only the **expected** cost to raise funds.
- We have to take into account both the expected and the unexpected costs, and hence to post a suitable amount of *economic capital* to cover the latter.
- Expected (forward) *funding curve* are used to discount cash flows and thus to consider expected liquidity costs.
- Maximum (99% confidence level) curves are used to compute the *economic capital* to cover the unexpected liquidity costs.

Example of Fixed Rate Bullet Loans' Pricing

The expected and maximum (99% confidence level) zero coupon bonds and rates are shown beside.
Weights for each funding source are sown in the table below.

Depo	CD	Bond
20.00%	50.00%	30.00%

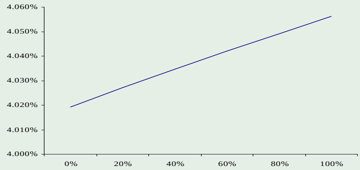
Expiry	$P^F(0, T)$	ZC Rate	$P^F_{99\%}(0, T)$	ZC Rates 99%
1	0.991052	0.90%	0.991052	0.90%
2	0.972832	1.38%	0.970389	1.50%
3	0.948503	1.76%	0.939380	2.08%
4	0.920200	2.08%	0.906206	2.46%
5	0.889421	2.34%	0.868478	2.82%
6	0.857238	2.57%	0.825297	3.20%
7	0.824427	2.76%	0.783906	3.48%
8	0.791549	2.92%	0.746677	3.65%
9	0.759006	3.06%	0.709187	3.82%
10	0.727082	3.19%	0.674930	3.93%
11	0.695972	3.29%	0.635407	4.12%
12	0.665804	3.39%	0.601965	4.23%
13	0.636660	3.47%	0.569701	4.33%
14	0.608583	3.55%	0.540906	4.39%
15	0.581593	3.61%	0.512333	4.46%
16	0.555690	3.67%	0.482882	4.55%
17	0.530862	3.73%	0.455763	4.62%
18	0.507086	3.77%	0.432124	4.66%
19	0.484335	3.82%	0.408959	4.71%
20	0.462576	3.85%	0.388238	4.73%

Example of Fixed Rate Bullet Loans' Pricing

The fair fixed rate of a 20-year expiry loan (the funding curves are those showed above). The amount is $A_1 = 100$, the economic capital is remunerated with a premium of 5% over the risk free rate. With a zero capital investment ($\varepsilon = f = 0$) the fair rate is $i_1^* = 4.019\%$; it can be compared with the fair rate with no refunding risk, which is $\widehat{i_1^*} = 3.729\%$, so that the spread due to the economic capital for refunding risks accounts for $i_1^* - \widehat{i_1^*} = 0.29\%$.

The figure shows the fair rate as a function of percentage ε of the economic capital invested in the loan. One may note how the rate is linearly increasing with the percentage of economic capital invested, although the difference between the no investment and the full investment is rather small.

ε	i_1^*	Diff.
0%	4.019%	0.290%
20%	4.027%	0.298%
40%	4.035%	0.305%
60%	4.042%	0.313%
80%	4.049%	0.320%
100%	4.056%	0.327%



Simulation of Distressed Periods

The framework outlined is suitable to conduct simulations for distressed market's or bank's conditions.

An example is given in the table beside, where we assume that starting from the fourth year the bank may resort mainly to interbank money market, with a sharp decline of the weight for bonds.

Exp.	P^F	ZC R	$P^F_{99\%}$	ZC R 99%	Wgt Depo	Wgt CD	Wgt Bond
1	0.991052	0.90%	0.991052	0.90%	20.00%	50.00%	30.00%
2	0.972832	1.38%	0.970389	1.50%	20.00%	50.00%	30.00%
3	0.948503	1.76%	0.939379	2.08%	20.00%	50.00%	30.00%
4	0.921207	2.05%	0.898118	2.69%	40.00%	50.00%	10.00%
5	0.890723	2.31%	0.857439	3.08%	40.00%	50.00%	10.00%
6	0.858813	2.54%	0.815945	3.39%	40.00%	50.00%	10.00%
7	0.826249	2.73%	0.773896	3.66%	40.00%	50.00%	10.00%
8	0.793593	2.89%	0.735150	3.85%	40.00%	50.00%	10.00%
9	0.761247	3.03%	0.695926	4.03%	40.00%	50.00%	10.00%
10	0.729496	3.15%	0.659987	4.16%	40.00%	50.00%	10.00%
11	0.698536	3.26%	0.622248	4.31%	40.00%	50.00%	10.00%
12	0.668499	3.36%	0.588765	4.41%	40.00%	50.00%	10.00%
13	0.639465	3.44%	0.555782	4.52%	40.00%	50.00%	10.00%
14	0.611482	3.51%	0.526080	4.59%	40.00%	50.00%	10.00%
15	0.584570	3.58%	0.496615	4.67%	40.00%	50.00%	10.00%
16	0.558730	3.64%	0.468824	4.73%	40.00%	50.00%	10.00%
17	0.533951	3.69%	0.441981	4.80%	40.00%	50.00%	10.00%
18	0.510213	3.74%	0.418093	4.84%	40.00%	50.00%	10.00%
19	0.487488	3.78%	0.394519	4.90%	40.00%	50.00%	10.00%
20	0.465746	3.82%	0.373383	4.93%	40.00%	50.00%	10.00%

Economic Capital for Funding Risk

The Economic Capital for the unexpected funding costs not only has to be included into the pricing, but it can be also monitored for the existing deals.
Monitoring unexpected funding costs mitigates the impact of distressed periods on:

- funding policies;
- on-going activity;
- profitability;

The table shows the Economic Capital required at inception by the loan in the example (notional = 100). It shows also how the Economic Capital at inception would change if the weights of each funding source modifies after the fourth year, as in the distressed condition above.

Exp. **FC**	10.21

The **FC** is equal to the difference between the NPV of the loan obtained with the risk-free curve and the NPV obtained with the funding curve.

Wgt Depo	Wgt CD	Wgt Bond	**EC**
20.00%	50.00%	30.00%	7.43385
40.00%*	50.00%*	10.00%*	9.23631

* Weights after the fourth year. For the first three years the weights are the same as in the first row.

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Funding Costs and ALM: Relationship between **DVA** and **FC**

Assume we have a marked-to-the-market balance sheet.
At time 0, the bank closes a loan contract with a lender (*e.g.*: an institutional investor) which is not charging any funding cost when setting the fair amount to lend. The amount is deposited in a bank account D_2, also risk-free to avoid immaterial complications at the moment. The balance sheet at time 0 looks like as follows:

Assets	**Liabilities**
$D_1 = E$	$L = Ke^{-rT}$
$D_2 = Ke^{-(r+s_B)T}$	$-\mathbf{DVA}(0)$
	E

where
$-\mathbf{DVA}(0) = \mathbf{FC}(0) = -e^{-rT}K(1 - e^{-s_B T})$
assuming that the $\text{L}_{\text{GD}} = 100\%$, so that the instantaneous spread s_B equals the instantaneus probability of default.

Funding Costs and ALM: Relationship between **DVA** and **FC**

The **DVA** is not a reduction in the value of the liabilities due to the credit risk of the borrower, but it is actually the present value of the costs (or losses, if you wish) that the borrower has to pay due to the fact that he/she is not a risk-free economic operator. For raising funds, this cost is the **FC**.
Being a cost, has to be moved in the balance sheet to reduction of the value of the net equity, rather than of the risk-free present value of the debt, so that the balance sheet should read as:

Assets	Liabilities
$D_1 = E$	$L = Ke^{-rT}$
$D_2 = Ke^{-(r+s_B)T}$	
	E
	$-\mathbf{DVA}(0) = -\mathbf{FC}(0)$

The assets and liabilities are still balancing but now we have a completely different picture of the balance sheet, since the deal produces a P&L at inception: a loss equal to the
$\mathbf{DVA} = \mathbf{FC}$.

Funding Costs and ALM: Buying an Asset

When buying and asset A (*e.g.*: lending money to a customer) the bank has to charge the **FC** it pays if the business activity has to be profitable.

So, assuming that the bank has enough bargaining power, the asset will be bought paying $Ke^{-(r+s_B)T}$. Revaluing this at the risk free rate will produce a profit equal to **FC**, so that the balance sheet is:

Assets	Liabilities
$D_1 = E$	$L = Ke^{-rT}$
$A = Ke^{-rT}$	
	E
	$-\mathbf{DVA}(0) = -\mathbf{FC}(0)$
	$+\mathbf{FC}(0)$

Funding Costs and ALM: Buying an Asset

When finding costs are stochastic, then the bank has to charge also the remuneration for the **EC** for the unexpected funding costs when buying an asset.
The profit earned $+\pi\mathbf{EC}(0)$ is a compensation for the reserve used to cover future unexpected costs related to the funding.

Assets	Liabilities
$D_1 = E$	$L = Ke^{-rT}$
$A = Ke^{-rT}$	
	$E - \mathbf{EC}(0)$
	$+\mathbf{EC}(0)$
	$-\mathbf{DVA}(0) = -\mathbf{FC}(0)$
	$+\mathbf{FC}(0)$
	$+\pi\mathbf{EC}(0)$

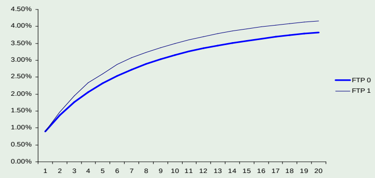
Funding Costs and ALM: Monitoring

We go back to the loan we have priced above.

Assume that suddenly the spreads paid by the bank over its funding sources rise. The new funding curve will shift upward, by we have to consider the fact that the funding has been locked for:

- 1 year on interbank deposits;
- 2 years on CDs;
- 5 years on bonds.

The new funding curve is shown in the figure. In the table below there is the comparison between the first and the updated expected **FC** after the increase in the spreads. This difference, if actually occurring, can be covered with the **EC**.



	Starting	Updated
Expected **FC**	10.21194	14.42253

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Transferring Funds to Treasury Department

- The Treasury department should be remunerated for the average costs it bears for funding the bank activity, whereas the unexpected losses due to the refunding should be charged to the bank and covered by the economic capital provided for it;
- when a Commercial Unit transfer funds to the central Treasury, it should receive from the latter the corresponding flows, with opposite sign, so as to fulfill the contract obligations with its retail customers;
- the branch will have a zero profit/loss (without considering any possible margin) and the cost related to the funding is entirely born by the Treasury department;
- the average cost paid, originated by all the funding sources, will be then charged to the Commercial Units requiring funds for investments, such as loans.

The bank has more bargaining power on some funding sources (*e.g.*: related to retail customers) w.r.t. others (*e.g.*: bonds issued). It can act on the funding mix, by setting the less expensive one and by diverting the commercial units to sell products whose weight is lower than targeted, from those whose weight is higher.

Transferring Funds to Treasury Department

One possible solution to incentive Commercial Units is the following. Assume that the target average funding rate is given by:

$$\bar{r}^* = \sum_{j=1}^{J} w_j^* r_j \qquad (2)$$

where w_j^* is the targeted weight for the funding source j. If the Commercial Unit, when raising funds and transferring them to the Treasury, is given back the amount:

$$\widetilde{r}_j = \max[\frac{w_j^*}{w_j} r_j, r_j] \qquad (3)$$

then we have that the funding **PL** is split amongst all the Commercial Units accordingly to the distance of the actual weight for a given funding source from its targeted value:

- if the source is under-weighted ($w_j^* > w_j$), then the interests transferred from the Treasury will be higher than the interest that the Unit has to pay: $\widetilde{r}_j > r_j$ and it will earn a profit;
- when the source is overweighted ($w_j^* < w_j$), there should be no incentive so that the interests paid is r_j.

About Iason

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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, and to apply them in practice, is critical to innovation in risk management and pricing. It constantly strives to bring into all the areas of the risk management a new and fresh approach based on the balance between rigour and efficiency which its people aimed at when working in the dealing rooms.

Besides tailor made services, Iason develops software applications to calculate and monitor credit VaR and conterparty VaR, fund transfer pricing and loan pricing, liquidity-at-risk.