Funds Transfer Pricing and Risk-Adjusted Performance Measurement
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This paper discusses the challenges inherent in funds transfer pricing and risk-adjusted performance measurement. SAS has responded to these challenges by delivering an integrated risk offering – SAS® Risk Management for Banking – that can meet the immediate requirements banks are looking for while providing a framework to support future business needs.

Funds transfer pricing has been used by banks for many decades. Today, it is a central component in banks for:

- Achieving centralization of risks – i.e., clear branch risks (such as interest rate risk) that are most efficiently managed centrally.

- Measuring ex-ante performance of traditional banking book items, such as loans, mortgages and deposits.

A loan or deposit clearing of interest rate risk is achieved through the funds transfer price, defined as the matched maturity funding rate plus a mark-up for business costs. In effect, this is an interest rate swap agreement between the loan branch and the clearing center, and the price of the swap is usually null.

For ex-ante performance evaluation of branches, the assigned funds transfer rate is used to measure a net interest margin vs. the transfer rate. The difference between the transfer rate and the actual funding is managed on residual terms by Treasury. This assignment of a matching funding asset or liability to a corresponding branch liability or asset also achieves balanced balance sheets for branches; therefore, each branch becomes a consistent performance measurement unit.

In practice, risks other than interest rate risk, such as credit and operational risks, are also part of the transfer pricing. For example, clearing branch credit risk that is the size of the risk spread added to the funds transfer price should be related to the cost of clearing the risk. While such risk spreads may be available for traded assets, the risk spread for nontraded, traditional balance sheet items has to be defined internally. The clearing of credit risk from branches and centralization to Treasury may seem a natural step as the efficient hedging of credit risk requires a portfolio perspective. However, there are also drawbacks to clearing branches’ credit risks. Most notably, the clearing of the credit risk essentially removes the branch incentive to actually manage the credit issued locally by the branch.
A complex issue in funds transfer pricing is how to measure funds transfer prices when future cash flows are uncertain. This is the case for most deposits where consumers can withdraw their funds at any point in time, and hence the branch has in effect issued a withdrawal option on the account. Other examples include loans with prepayment and associated caps and floors. Since the funds transfer rate should represent the actual cost of matched maturity funds, a bank cannot ignore incorporating the additional cost for embedded options in branch products. If they do, then incentives to issue embedded products that raise the interest rate paid by consumers, such as floors and embedded call options, increase.

Moreover, since the funds transfer price is not adjusted accordingly, there is no indication on what spread on the consumer rate is needed for the branch to achieve profitability.

In ex-ante performance measurement, the spread between the consumer rate and the funds transfer price is an indication of the prospective future economic value generated by a particular contract or portfolio. Of course, for a contract or portfolio to make a positive contribution to ex-ante returns, the economic value should be positive. For contracts with a positive economic value, banks rank the economic value based on risk adjusting. The general idea is that for two contracts with the same economic value, one would prefer the one with the least risk. In risk-adjusted performance measurement, one compares the economic value generated by further dividing by the risk – thereby obtaining a risk-adjusted measure of ex-ante performance. As we shall discuss below, the risk measure used in risk-adjusted performance should be the risk contribution of the contract to the portfolio.

2 The bank’s equity holders’ expected return on equity gives an indication of the threshold that needs to be satisfied in order for the contract to contribute to improving the bank’s expected return.
Funds Transfer Pricing and Risk-Adjusted Performance Measurement

Techniques for Funds Transfer Pricing

Basic funds transfer pricing focuses on assigning a clearing rate that is consistent with the asset or liability maturity. Figure 1 shows a situation where the interbank cost of funding curve is used to generate a fixed-term deposit funds transfer rate that is consistent with the maturity of the funds. The net transfer rate for the branch is obtained as the difference between the funds transfer rate and the consumer funds rate.

![Figure 1: Fixed-term deposit funding cost and net transfer rate using the interbank curve as the funding curve.](image)

Another example is the calculation of the funds transfer rate and the net transfer rate for a bullet payment loan. Figure 2 displays the bullet loan funding rate on the interbank curve together with the actual duration of the bank’s funding pool – which is significantly shorter than the loan duration. The loan is attributed the funds transfer rate consistent with the loan duration and the interbank rate, yielding a positive spread between the loan paying rate and the funds transfer rate. The residual spread – i.e., that between the funds transfer rate and the actual duration of funding – is managed by Treasury.

![Figure 2: Bullet loan funding cost, branch net margin and Treasury-managed residual spread.](image)

3 The interbank curve is the bank cost of funding with other banks using short-term money market instruments, forward rate agreements, etc. On a longer term, the funding curve is usually composed of the cost of the bank’s long-term bond funding.

4 In practice, one may decompose the total margin (i.e., the net transfer rate) into different sources, such as: a) branch margin vs. funds transfer rate; b) matched maturity liability funding vs. transfer rate; c) net transfer rate between the synthetic matched maturity funding for the branch and the actual funding. These decompositions are, in effect, achieved by calculating both branch asset margin and synthetic liabilities margin. As the calculations of the funds transfer rate and margin for the synthetic liability portions (b) and (c) do not differ from the funds transfer rate calculations for actual liabilities or the branch margin, it is sufficient to focus on the calculation of funds transfer rates for branch margins and actual liabilities.
In these two simple cases, there was only one payment, which allowed us to define the funds transfer rate as the funding rate that is applicable at cash flow maturity. If there’s a loan with several payments until maturity, it is clear that the funds transfer rate cannot be the funding rate at maturity. In particular, all cash flows from the loan must be accounted for, as they need to be funded accordingly. Taking into account all cash flows, and weighting by the relevant funding rate, we get the funds transfer rate (FTP):

\[ FTP = \frac{\sum_{t=1}^{T} CF(t) \times f(t)}{\sum_{t=1}^{T} CF(t)} \]

where \( CF(t) \) is the cash flow at time \( t, t=1, \ldots, T \), and \( f(t) \) is the funding rate at \( t \). This method of assigning funds transfer rates to a contract is usually called the “exact” method, as it computes the funding using all cash flows of the contract. Another method is to calculate the duration of the contract and then assign the funding rate corresponding to the duration to the contract. However, the duration approach is only an approximation and requires the same amount of computations as the exact method, as both approaches require that contract cash flows be computed. Therefore, the exact method is often used in practice. Table 1 calculates funds transfer rates for a mortgage and a loan using the exact method. The funding curve used in the calculation is displayed in Table 2.

Table 1: Calculation of funds transfer rates for a mortgage and a loan.

<table>
<thead>
<tr>
<th>Contract Type</th>
<th>Interest Payment Frequency</th>
<th>Amortization Type/Amount</th>
<th>Notional Amount</th>
<th>Maturity Term</th>
<th>Funds Transfer Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortgage</td>
<td>Biannual</td>
<td>Annuity</td>
<td>100,000</td>
<td>5.5 Years</td>
<td>0.026307</td>
</tr>
<tr>
<td>Loan</td>
<td>Quarterly</td>
<td>30,000</td>
<td>1,900,000</td>
<td>12,5 Years</td>
<td>0.039661</td>
</tr>
</tbody>
</table>

Table 2: The funding curve used in calculation of funds transfer rates.

<table>
<thead>
<tr>
<th>Maturity Date</th>
<th>Funding Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Month</td>
<td>0.0215</td>
</tr>
<tr>
<td>3 Months</td>
<td>0.0222</td>
</tr>
<tr>
<td>9 Months</td>
<td>0.0244</td>
</tr>
<tr>
<td>1 Year</td>
<td>0.0254</td>
</tr>
<tr>
<td>3 Years</td>
<td>0.0331</td>
</tr>
<tr>
<td>4 Years</td>
<td>0.0362</td>
</tr>
<tr>
<td>5 Years</td>
<td>0.0388</td>
</tr>
<tr>
<td>7 Years</td>
<td>0.0424</td>
</tr>
<tr>
<td>9 Years</td>
<td>0.0446</td>
</tr>
<tr>
<td>10 Years</td>
<td>0.0455</td>
</tr>
<tr>
<td>15 Years</td>
<td>0.0452</td>
</tr>
</tbody>
</table>

Having calculated the funds transfer price for a particular asset or liability, the actual transfer amount is then simply calculated as the funds transfer price times the notional amount.
Clearing Credit Risk and Other Risks with Funds Transfer Pricing

For traded assets with credit risk, the cost of clearing default risk is the corresponding credit default swap premium; hence the markup on the transfer price is determined by the market in which the credit trades. By clearing credit risk, the obtained interest margin is now split on three levels:

a. Actual spread (using actual duration of funding).

b. Funds transfer pricing adjusted margin.

c. Risk-adjusted margin for credit risk.

Figure 3 displays the case of clearing credit risk using the credit default swap curve. The credit default swap curve is added to the interbank funding curve to obtain a new funding rate that includes the effect of clearing the default risk. The economic value-added spread is now taken as the loan paying rate minus the total funding cost – inclusive of credit risk.

![Figure 3: The credit risk clearing for a loan by adding the default risk clearing cost to the funds transfer rate.](image)

In order to clear traded credit risk, the total transactions between the branch and the Treasury are: a) the interest rate swap, and b) the Treasury-issued credit default swap to the branch.

While the above clearing works for traded credits and credits that can at least be mapped approximately to traded credits, a large part of the banking book items with credit risk do not have a market – i.e., there is no given market price of credit. While securitizations on banking book items may provide some information on the price of default risk, it is generally difficult to extract such information from the underlying pools.
In the case of nontraded credits, the cost of funds for credit must therefore be generated internally. Ideally, one has available estimates of expected credit losses as well as allocated risk or capital. In the cost of capital approach to funding costs, one splits the funding into two parts: One part is the risk-free funding and the other part is the risky funding. Specifically, denoting the base transfer rate by \( FTP \), expected credit loss by \( EL \), return on equity capital by \( E \) and contract allocated credit risk capital by \( w \), we have that:

\[
FTP \text{ Risk} = FTP \times (1 - w) + E \times w + EL
\]

Here, \( FTP \text{ Risk} \) is the total funds transfer price that is allocated to the credit. The funding is effectively split up in two parts: risk-free interbank funding and risky equity funding. The split between the two is decided by the allocated credit risk capital for the contract; since equity funding is usually much more expensive than interbank funding, \( FTP \text{ Risk} \) is increasing in allocated credit risk capital (i.e., risk).

Table 3 displays the calculation of \( FTP \text{ Risk} \) for the mortgage in Table 2 above. The calculation is also split up in the effect from only credit risk capital and only expected losses (i.e., spread). The calculation uses the funding curve in Table 2 as well as an expected loss curve, an allocated capital curve and a cost of equity funding curve. These latter curves are displayed in Table 4.

**Table 3: Funds transfer pricing for credit risk for the mortgage in Table 2.**

<table>
<thead>
<tr>
<th>Contract Type</th>
<th>Funds Transfer Rate (FTP)</th>
<th>Funds Transfer Rate with Credit Risk Capital</th>
<th>Funds Transfer Rate with Expected Losses (Spread)</th>
<th>Total Funds Transfer Rate for Credit Risk (FTP RISK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortgage</td>
<td>0.026307</td>
<td>0.0280169</td>
<td>0.0491221</td>
<td>0.049293</td>
</tr>
</tbody>
</table>

**Table 4: The expected loss curve, the allocated capital curve and the cost of equity funding curve for the mortgage in Table 3.**

<table>
<thead>
<tr>
<th>Maturity Term</th>
<th>Expected Loss</th>
<th>Allocated Capital</th>
<th>Cost of Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Year</td>
<td>0.02081</td>
<td>0.001</td>
<td>0.080</td>
</tr>
<tr>
<td>3 Years</td>
<td>.</td>
<td>.</td>
<td>0.085</td>
</tr>
<tr>
<td>5 Years</td>
<td>0.02150</td>
<td>0.005</td>
<td>0.093</td>
</tr>
<tr>
<td>10 Years</td>
<td>.</td>
<td>0.010</td>
<td>0.100</td>
</tr>
<tr>
<td>20 Years</td>
<td>0.02219</td>
<td>.</td>
<td>0.110</td>
</tr>
</tbody>
</table>
The process of adding other nontraded, risky charges follows the same approach as for credit risk (i.e., we can interpret $w$ as the total economic capital allocated and $\text{EL}$ as the total expected losses). Other charges, such as operations and business costs, are generally treated as fixed additions to FTP (risk). See Dev and Rao (2006, Chapter 4) for a discussion of different methods of expense allocations to funds transfer prices.

A key issue when using FTP Risk as the vehicle for calculating funds transfer prices to branches is that the allocated capital, $w$, should be a so-called Euler risk contribution. This is because branch pricing incentives will then be consistent with local portfolio optimization. See Tasche (1999) and Skoglund and Chen (2009) for a discussion of Euler risk contributions. In Tasche’s work, the Euler risk contributions are shown to be the only risk allocation that is consistent with risk-adjusted performance optimization.

### Funds Transfer Pricing with Uncertain Cash Flows

For many assets and liabilities, the future cash flows are not known. For example, demand deposits have no assigned maturity; loans may have prepayment options; bonds may be called by the issuer and/or put by the holder; and a loan may have a cap or floor on the rate. In these situations, the funds transfer price needs to incorporate the uncertainty due to these unknown cash flow streams. This inclusion is important in order to distribute the right pricing and valuation incentives for these products to the branches.

To price these embedded options, one can generally consider two different approaches: They are the financial engineering approach and the statistical model approach. In the financial engineering approach, the embedded option is formulated as a market-priced embedded option. The option is valued using a market model for the short rate (such as the Hull-White) and the implied model parameters are extracted from similar market instruments. Finally, the funds transfer price is adjusted with the embedded option value using a so-called option-adjusted spread. In the statistical model approach, a model of behavior is formulated (e.g., a prepayment model or a model of deposit volume). The cash flows are evaluated under the model and the funds transfer spread needed for the uncertainty is calculated.
Financial Engineering Approach to Valuation of Embedded Options

In the financial engineering approach the embedded options are American in nature, such as:

a. Early withdrawal of deposits.

b. Early prepayment features.

Embedded options can be viewed as bond or loan and option packages. For example, in a callable bond the issuer has the right to repurchase the bond cash flows at a pre-specified price. This corresponds to: 1) selling the option-free bond; and 2) buying a call option on the bond.

The value of the bond or loan is the traditional value minus the call value. For a putable bond, the holder has right to sell back the bond at the pre-specified price. It corresponds to: 1) buying the option-free bond or loan; and 2) buying an option to sell the bond (put option). The value is the bond value plus the put value.

The valuation of the American embedded call or put option relies on a model for the interest rate. The standard market model uses either the Hull-White model (Hull and White, 1994, 1996)

$$dr = (b(t) - ar)dt + cdz$$

or the Black-Karasinski model (Black and Karasinski, 1991)

$$d \log r = (b(t) - a \log r)dt + cdz.$$  

Here $r$ is the short rate of interest, and $b$ and $a$ are constants where $a$ is the mean reversion rate. These models are so-called no arbitrage models, where the current term structure of interest rates is an input to the model. Having specified the model for the interest rate, $r$, the next step is to value the embedded American option. Hull and White (1994, 1996) specify a trinomial tree approach to solving for the option value. In particular for the Hull-White model, the first step is to consider a tree for the discretized process

$$dr^* = -ar^*dt + cdz$$

and then convert the tree into a tree for the full model by translating

$$\alpha(t) = r - r^*.$$  

Using this tree, the bond prices consistent with the current term structure can be calculated and the bond price lattice can be solved backward to obtain the option price consistent with the term structure.
For embedded cap and floor rates to a re-pricing bond or loan, these are consistently valued using the classical Black commodity options model (Black, 1976) for European options. The cap and floor options for each re-pricing term are referred to as caplets and floorlets respectively, and the option value is the sum of the value of all the caplets and floorlets.

Having calculated the embedded option value, the next step is to define the markup on the funds transfer price due to the embedded option. The concept of option adjusted spread (OAS) is used in this context. The OAS for a callable bond is defined as the fixed spread that when added to the set of spot (forward) rates used in valuation gives a callable bond value consistent with the noncallable bond value. In practice, this means we have to solve numerically for the OAS using the given value of the bond or loan without embedded options and the embedded option value(s). Having obtained the OAS, we can now add this to the funds transfer price as

\[
\text{FTP Risk} = \text{FTP} \times (1 - w) + E \times w + EL + \text{OAS}
\]

The obtained FTP Risk incorporates into the funds transfer price the effect of nontraded risk as well as any market-priced embedded options.

Table 5 displays the option adjusted spreads obtained from a floating rate note with embedded American call and cap and floor. The table displays the obtained cap and floor OAS and embedded call OAS with different assumptions on the call strike level. The cap and floor levels are set to 10 percent and 0.1 percent respectively, and the cap and floor valuation is done using the Black model with volatility curves for the caplets and floorlets respectively. The American embedded-call options are valued using the Hull-White trinomial tree with the Hull-White model parameters set to \(\alpha = 0.01\), \(\beta = 0.12\), and \(\gamma = 0.1\). The option-adjusted spread is obtained by numerically solving for the fixed spread that would make an investor indifferent between the plain floating rate note and the floating rate note with the embedded optionality.

For reference, Table 6 displays the index curve for re-pricing the floating rate note as well as the volatility curves used to price the caplets and floorlets.

Table 5: Option-adjusted spreads for caps and floors, and American embedded call options using different call strikes.

<table>
<thead>
<tr>
<th>Bond Maturity Term</th>
<th>Embedded Call Maturity Term</th>
<th>Interest Payment Frequency</th>
<th>Strike Percent of Notional</th>
<th>Call Option OAS</th>
<th>Capfloor OAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Years</td>
<td>10 Years</td>
<td>Year</td>
<td>100</td>
<td>0.00560</td>
<td>0.00123</td>
</tr>
<tr>
<td>14 Years</td>
<td>10 Years</td>
<td>Year</td>
<td>89</td>
<td>0.01334</td>
<td>0.00123</td>
</tr>
<tr>
<td>14 Years</td>
<td>10 Years</td>
<td>Year</td>
<td>70</td>
<td>0.03130</td>
<td>0.00123</td>
</tr>
</tbody>
</table>

5 Assuming forward rates are lognormal, see Hull (2006, pp. 619-622).
6 The strike price is a quote strike price. That is, it includes accrued interest.
Having derived a funds transfer pricing model, incorporating the effect of market-priced embedded options, one may consider applying this model to consumer-embedded options as well (e.g., prepayment options). However, when applying this model to nontraded risks, there are several issues that need to be considered.

Firstly, consumers may not act as rational market players in the sense that embedded options are not exercised even when beneficial. This is referred to as customer irrationality, and a prime example is that all consumers who should rationally prepay at a certain time don’t. Moreover, sometimes consumers prepay when they shouldn’t. This phenomena is observed in McConnell and Singh (1994), Stanton (1995), Levin (2001) and, Levin and Davidson (2005). Secondly, when applying the OAS model to consumer options, it is not clear what model parameters (e.g., implied volatility) should be used.

To solve the first problem of handling the appearing irrationality of consumers vs. market participants, one may consider consumers as rational; however, they exercise their options subject to transaction costs. An example of a transaction cost is the effort it takes for a consumer to actually prepay the loan or withdraw the funds, and place the funds in another account. Arguably, most consumers will not take action unless the cost of transactions is covered by the gain in exercising the embedded option. Also, one may argue that consumers don’t follow markets continuously and the decision to exercise a prepayment option may happen only when the consumer realizes that there is considerable gain in doing so.
The approach taken to model consumer-embedded options in the financial engineering framework introduces a so-called subjective strike model – capturing the fact that consumers have transaction costs for exercising their options. In the subjective strike model, the embedded option strike is adjusted by the consumer’s transaction costs – leading to a higher strike value and hence a larger gain in the value of re-financing – or fund withdrawal is required for most consumers to act. In this consumer adjustment to the financial engineering model, the transaction costs represent the sensitivity of consumers to exercise their options and these sensitivities are derived from historical data analysis on classifications of consumers based on product type, region, age, income, etc.\(^7\)

For prepayments, we can formulate the subjective strike model as borrowers refinance as soon as the present value of the loan is above the notional adjusted by the transaction costs. In this setting, a loan has not been refinanced if the present value has not exceeded the notional adjusted by the transaction costs. Moreover, a refinancing occurs if and only if it is the first time that the present value of the loan exceeds the notional adjusted by the borrower’s transaction costs. Note that this path dependency captures the phenomena of burnout in prepayments (i.e., pools of loans that have already experienced large exposure to refinancing opportunities tend to have lower prepayment rates, other things being equal). This is because borrowers that are sensitive to refinancing opportunities prepay rapidly as soon as it is profitable. After a period of low refinancing rates, only the least sensitive borrowers still remain in the pool and prepayment rates decay. Formulated in terms of the transaction costs approach, this means that after the borrowers with low transaction costs have already left the pool, only the borrowers with high transaction costs remain.

While the financial engineering approach to valuation of consumer-embedded options has several drawbacks, such as the difficulty to estimate consumer transaction costs and option-implied parameters such as volatility, it also has several advantages. Specifically, one of the main advantages with analyzing customer behavior in the context of rational, no arbitrage pricing is that the usual hedge techniques applied by fixed-income traders are applicable. Indeed a consequence of replacing the rational strike price with the estimated irrational strike price is that from the perspective of the fixed-income trader, the implicit option-embedded bonds held by customers may be analyzed and hedged as any fixed-income portfolio with embedded options. Also, the approach allows for an idiosyncratic valuation of customer optionality.

\(^7\) When estimating transaction costs on historical data, there is generally a truncation effect in that for some consumers the gain in exercising was never high enough. That is, their true transaction costs may not have been observed.
Statistical Model Approach to Valuation of Embedded Options

In statistical model or scenario-based approaches to valuation of consumer options, the consumer behavior is described using the model and the cash flows of the contract are evaluated under the model. In contrast to the financial engineering approach, which may allow idiosyncratic valuation, these statistical models rely upon large pools and the notion of the law of large numbers to derive behavioral statistics. Traditionally two types of statistical models have been used. These are prepayment models and volume models for deposits and facilities.

Prepayment models specify the prepayment rate of a pool of loans, conditional on pool characteristics such as loan age, product type and the refinancing incentive. In the model, it is beneficial to prepay if it is cheaper to refinance a new loan. Hence, prepayment should be expected when offered loan rates drop below the paying rate. However, just as in the case of the financial engineering approach, all borrowers don’t refinance even if it would be beneficial for them. Therefore, the prepayment rate is not discrete 0 percent or 100 percent, but instead increases smoothly with the spread between the paying rate and the current refinancing rate.

In practice, the simple conditional prepayment rate model (CPR) is used; however, more complex regression-based models with explanatory variables are also possible. In the case of simple conditional prepayment rates, the funds transfer price is calculated as for a standard loan – though with accelerated prepayment rates acting on the contractual rate of amortization. The difference between the funds transfer rate obtained with the contractual amortization and the accelerated amortization rate is the funds transfer spread for the prepayment risk. Table 7 displays a sample conditional prepayment curve.

Table 7: An example conditional prepayment curve.

<table>
<thead>
<tr>
<th>Term</th>
<th>Prepayment Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Year</td>
<td>0,03</td>
</tr>
<tr>
<td>2 Years</td>
<td>0,06</td>
</tr>
<tr>
<td>5 Years</td>
<td>0,08</td>
</tr>
<tr>
<td>10 Years</td>
<td>0,08</td>
</tr>
</tbody>
</table>

Similar to prepayment models, deposit volume models aim to capture the consumer’s decisions to withdraw and place funds in the bank account. The willingness to withdraw funds is expected to decrease with the increased relative performance of other funds (e.g., equity and other bank accounts). As for prepayment, all consumers typically don’t withdraw all funds and place in alternative fund sources even if it would be beneficial to them. Common models used to describe deposit volume are regression models, with logarithmic volume change being explained by key variables.
Funds Transfer Pricing and Risk-Adjusted Performance Measurement

For example, interest rates, GDP and seasonal terms could be considered as explanatory factors. Another type of model used frequently in practice is the core and non-core deposit model, which specifies a portfolio runoff amortization scenario for the core part (see Dev and Rao, 2006, Chapter 8). Approaches to valuation and cash flow generation for deposits have been extensively studied in the literature (Selvaggio, 1996; and Jarrow and Van Deventer, 1998). In these approaches, the value of the deposit funding increases with the spread between the funding rate, \( r_f \), and the deposit rate, \( r_d \), volume, \( V \), and time, \( t \). For example, Jarrow and Van Deventer specify the deposit present value (PV) on a time interval \([0,T]\) as

\[
PV(T) = \int_{0}^{T} E \left( V(t, v) \left[ r_f(t, v) - r_d(t, v) \right] d(t, v) \right)
\]

where \( d(t) \) is a discount factor and \( v \) is a particular scenario realization.

Having specified a model for the prepayment rate or the deposit volume, the next step is to evaluate the cash flows under the model. Recall here that the funds transfer price is completely defined from the cash flows of the asset or liability. Therefore, the expected funds transfer price may be derived from a set of cash flow scenarios, which are in turn derived from the model of prepayment or deposit volume. While this approach captures the expected funds transfer price, it is sometimes practice to compute the funds transfer price for deposits and prepayment loans using a single plausible scenario for the volume and prepayment rate. This practice is similar to the market practice of computing expected cash flows for re-pricing instruments using the forward curve at re-pricing times. In this approach, the funds transfer rate under a specific scenario becomes

\[
FTP \text{ Risk}(s) = FTP(s) \times (1 - w) + E \times w + EL + OA\$
\]

where \( FTP(s) \) indicates that the FTP Risk(s) is conditional on a scenario for deposit volume or a vector of prepayment rates.

Table 8 calculates the funds transfer rate for a deposit with an associated volume schedule, as well as a rule for administered deposit rate. The deposit is re-priced quarterly based on the underlying reference market rate and the administrative rules. The deposit volume schedule, expressed as a factor on the current volume, and the administrative rule for the deposit rate are given in Tables 9 and 10, respectively. The funding curve used is the same as in Table 2.

**Table 8: Funds transfer rate for a deposit with a scenario for the volume.**

<table>
<thead>
<tr>
<th>Contract Type</th>
<th>Interest Payment Frequency</th>
<th>Current Volume</th>
<th>Funds Transfer Rate (FTP(s))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposit</td>
<td>Biannual</td>
<td>85,432,890</td>
<td>(0.0245391)</td>
</tr>
</tbody>
</table>
Table 9: Deposit volume scenario used to calculate deposit funds transfer rate. The deposit volume factor acts as a multiplier on the current volume.

<table>
<thead>
<tr>
<th>Term</th>
<th>Deposit Volume Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 Years</td>
<td>0.9</td>
</tr>
<tr>
<td>1 Year</td>
<td>0.85</td>
</tr>
<tr>
<td>3 Years</td>
<td>0.6</td>
</tr>
<tr>
<td>5 Years</td>
<td>0.45</td>
</tr>
<tr>
<td>10 Years</td>
<td>0.2</td>
</tr>
<tr>
<td>11 Years</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 10: Administrative rate rules for the deposit.

<table>
<thead>
<tr>
<th>Market Rate</th>
<th>Administrative Deposit Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.01</td>
<td>0</td>
</tr>
<tr>
<td>&lt;0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>&lt;0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>&lt;0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>&lt;0.10</td>
<td>0.6</td>
</tr>
<tr>
<td>&lt;0.15</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Risk-Adjusted Performance with Funds Transfer Prices

In evaluation of the ex-ante performance of an asset or liability, the funds transfer price serves as an estimate of the expected costs associated with the asset or liability. Hence, the funds transfer price is closely related to the contribution margin calculated in business economics. That is, the consumer-paying rate minus the funds transfer price can be referred to as a contribution margin.8

In this context, the contribution margin is often referred to as the economic value. There is typically also one significant difference between the classical contribution margin concept as used in business economics and the economic value. Specifically, the economic value concept based on funds transfer price is an expected margin and is in general truly only ex-ante. It is therefore important to consider the potential deviation of the economic value ex-post. The ex-ante estimate is an expectation that this potential deviation can be measured by considering the size of the pools of assets or liabilities for which the risk components of the funds transfer price has been estimated; the larger the pool of assets and liabilities, the less the potential deviation.

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8 As explained in footnote 4, the contribution margin can be decomposed as: a) branch margin vs. funds transfer rate; b) margin from the matched maturity actual fund cost vs. transfer rate; and, finally, c) net transfer rate between the matched maturity funding rate and actual funding base funds transfer rate. We assume for simplicity of exposition that the base funds transfer rate is the funds transfer rate of the actual funding base and, hence, the net rate represents the total margin from branch, matched maturity funding and actual funding.
The economic value (EV), for paying rate $R$,

$$EV = R - FTP\ Risk(s)$$

should generally be positive for an asset or liability to be expected to contribute to the bank’s profitability. However, one may want to rank different EVs based on their risk. In general, for two assets with the same EV, one prefers to acquire the asset with the least risk or capital (contribution). The concept of risk-adjusted return on capital (RAROC) compares the EV to the capital (contribution) for a certain asset and ranks the assets accordingly. Specifically,

$$RAROC = \frac{EV}{w} = \frac{R - FTP\ Risk(s)}{w}$$

where above, $w$, is the allocated capital. It is notable that many banks define a threshold for RAROC that every new asset’s RAROC is expected to be above. The threshold, $Q$, is usually defined so that it is consistent with the equity holders expected returns on the bank stock. In this case any asset with a RAROC higher than the bank threshold, $Q$, contributes positively to meeting investors’ expected returns.

Table 10 displays the economic value and the one-year RAROC of the credit-risky mortgage in Table 3. The one-year RAROC is obtained by dividing the economic value by the capital allocated at a one-year horizon in Table 4. The customer paying rate is assumed to be 5.5 percent.

<table>
<thead>
<tr>
<th>FTP Risk</th>
<th>Customer Rate</th>
<th>Economic Value</th>
<th>RAROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.049293</td>
<td>0.0550</td>
<td>0.0057</td>
<td>5.707</td>
</tr>
</tbody>
</table>
Conclusion

Funds transfer pricing is key in banks striving to centralize risk and manage risk-adjusted performance. The funds transfer price is also a key component in the pricing of traditional balance sheet items, such as loans and deposits.

While traditional transfer pricing of interest rate risk is a core component in models for asset and liability management, the transfer pricing of credit and other risks – such as liquidity risk and volatility risk of uncertain cash flows – is equally important. In particular, accurate measurement and management of risk-adjusted performance, as well as distribution of the correct incentives for value creation, is dependent on banks’ abilities to measure all the risks associated with the financial exposures.

This white paper has presented practical approaches to calculating both traditional and risk-based funds transfer prices, and has demonstrated how to integrate funds transfer prices in the management of risk-adjusted performance.

About SAS® Risk Management for Banking

SAS Risk Management for Banking has been designed as a comprehensive and integrated suite of quantitative risk management applications, combining market risk, credit risk, asset and liability management, and firmwide risks into one solution. The solution leverages the underlying SAS 9.2 platform and the SAS Business Analytics Framework, providing users with a flexible and modular approach to risk management. Users can start with one of the predefined workflows and then customize or extend the functionality to meet ever-changing risk and business needs. The introduction of SAS Risk Management for Banking will take the industry's standards to a higher paradigm of analytics, data integration and risk reporting.


