Enhancing the Balance Sheet Management Function at Financial Institutions
Behavioral Models

Association Française des Gestionnaires Actif-Passif (AFGAP)

Cayetano Gea-Carrasco
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Moody’s Analytics
Moody’s Analytics: Separation Policy

Moody’s Analytics is a subsidiary of Moody’s Corporation and a separate legal entity from Moody’s Investors Service, Inc. (which is a global provider of credit ratings and research covering debt instruments and securities). Moody’s Investors Service does not share non-public information received from issuers as part of the ratings process with Moody’s Analytics. Further, Moody’s Corporation prohibits any ratings personnel from providing consulting services on behalf of Moody’s Analytics.
Motivation & Regulatory Backdrop
Regulatory Emphasis on Active Liquidity Management around the World

Basel: “… the maintenance of a sufficient cushion of high quality liquid assets to meet contingent liquidity needs…”

FSA: “A Contingency Funding Plan should set out a firm’s strategy for addressing liquidity shortfalls in stressed conditions…”

Fed: “… a cushion of liquid assets, and a formal well-developed contingency funding plan (CFP) as primary tools for measuring and managing liquidity risk…”
Responses to an International Survey that Covered 38 Large banks from Nine Countries show that many Liquidity & Balance Sheet Management Practices were Largely Deficient

“The most striking example of poor practice was that some banks failed to attribute liquidity costs to assets and conversely liquidity credits to liabilities for some business activities due to poor Fund Transfer Pricing Models and policies”

“Banks’ liquidity cushions were too small to withstand prolonged market disruptions and were comprised of assets that were thought to be more liquid than they actually were”

“Some of the banks that were surveyed treated liquidity as a free good, completely ignoring the costs, benefits and risks of liquidity”

“Banks that participated in the survey also applied insufficient haircuts to many of the traded assets they held. These banks clearly underestimated the likelihood of a market disruption, and the extent to which market liquidity could evaporate”

“Liquidity cushions were not linked to stress-testing outcomes, and scenario analyses were not severe enough to account for prolonged market-wide disruptions”

“In one form or another, all banks that participated in the survey are enhancing the way they manage contingent liquidity risk and their balance sheet models”

* Source: BIS
Increasing Basel 3 Liquidity Requirements are becoming a Constraint for Financial Institutions

The Liquidity Coverage Ratio (LCR) reflects a bank’s ability to convert high-quality, unencumbered liquid assets to cash to offset projected cash flows during a one-month period.

The Net Stable Funding Ratio (NSFR) requires banks to maintain enough funding that is expected to be stable to cover potential uses of funds over a one-year period.

“Banks will be required to calculate and report these projected outflows based on a scenario set by supervisors and regulators that will incorporate conditions similar to those experienced during the 2007-2008 crisis.”

* Source: Moody’s Analytics
Liquidity Sources are Scarce and Expensive: You should Model and Manage Them

“Global banks are facing a €4 trillion of cash outflows that should be reduce in the next years in order to be profitable. A lower revenue base, tighter regulation and stubbornly high staff costs would push down average return on equity to 7% by 2013”

“Banks are to shrink their balance sheets by another $1tn or up to 7% globally within the next two years due to higher funding costs and increased regulatory pressure to bolster capital”

“Banks should adjust their funding and liquidity structure by increasing retail deposits by €215bn. However, accelerating the growth in the deposit base is easier said than done: deposit growth trend is negative in Europe and US from 2006 to nowadays”

“The cost of acquiring new retail deposits is high, with current deposit margins already low if not in negative territory (i.e. some banks are losing money in deposits due to the higher funding cost – average loss of 120 bps in 2011 and increasing)”

“On customer deposits, given the amounts required by institutions, analysts expect the average cost of acquiring term deposits to be as expensive as in the wholesale markets at an estimated 221bp”

“Retail deposit spreads will remain under pressure in the next years as a result of increased competition and regulation, especially in countries where the market is more fragmented and bank funding remains stretched (i.e. Spain, Italy, US, Germany and the UK)”

* Source: Financial Times, Moody’s Analytics, JP Morgan
Case Study: Countrywide Taps Backup Lines as a Source of Funding Liquidity

Aug 16, 2007
Countrywide draws on $11.5bn syndicated credit facility

Jul 1, 2008
Bank of America completes acquisition of Countrywide
3

Behavioral Models
## Behavioral Models: Economic Guidance

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets and Liabilities Funding Profile</td>
<td>• Banks’ assets and liabilities are often maturity-mismatched, with long-term assets funded through short-term liabilities</td>
</tr>
<tr>
<td>Funding Planning</td>
<td>• During periods of distressed liquidity conditions, the bank may face elevated funding costs and more stringent haircuts as it refinances its short-term funding</td>
</tr>
<tr>
<td>Liquidity Stress Testing</td>
<td>• At the same time, the bank’s borrowers may increase their use of bank funds, forcing the bank to raise additional funds</td>
</tr>
<tr>
<td>Liquidity Buffers</td>
<td>• What amount of liquid assets should a financial institution hold in order to absorb potential losses due to adverse funding conditions?</td>
</tr>
<tr>
<td>Business-Driven</td>
<td>• How should a financial institution account for these dynamics when originating loans or when calculating a fund transfer price?</td>
</tr>
</tbody>
</table>
Liquidity Stress Testing: Characterizing the “Perfect Storm” for Determining the Balance Sheet’s Resilience

- **Credit Migration**
  - A significant downgrade of the institution’s public credit rating

- **Deposits Run-Off**
  - A partial loss of deposits

- **Unsecured Funding**
  - A loss of unsecured wholesale funding

- **Secured Funding**
  - A significant increase in secured funding haircuts

- **Collateral Haircuts**
  - Increases in derivative collateral calls
Behavior of Non-maturing Liabilities

- Deposits of different categories are modeled as an econometric system of deposit rates and balances, which explicitly account for the relationships between deposit balances, deposit rates, as well as macro-economic factors.

- A system of equations is statistically produced, based on balance sheet’s specific historical data, to quantify past behaviors. The equations are used to forecast future total balances, estimates lifes, deposit rates, and retained balances.

- The framework also quantifies and breaks down the core and the volatile balance contribution to the balance sheet volatility. Decay profiles for the core balances will be computed during the analysis as well as volatility of deposits from historical balance variations by incorporating the volatility of factors in the analytics.

*Chart represents average life estimates for a sample of deposit data under different interest rates shocks, measured in basis points.*
Deposits Model – Forecasting Average Life & Retention Ratios help Institutions to Manage Liquidity and Funding Needs

Retention Ratios - 5 Months Forecasted

Deposits Average Life Estimates - Stress Test
Behavior of Revolving Credit Facilities

- Our research* studies indicate a strong relationship between the credit quality of borrowers and their credit line drawdown behavior.

- Defaulted borrowers draw down their lines heavily when approaching defaults. Non-defaulted borrowers have significantly lower usage. Borrowers with high credit risk tend to draw down the lines more.

- Both the draw-down amount and commitment amount decrease during the economic downturns.

- We also document that usage is related to the collateral type, commitment size and bank internal ratings. The findings suggest banks monitor lines with larger commitment size, no collateral, and worse internal ratings more closely.

*Moody’s Analytics has created the Credit Research Database, which is a middle-market database covering financial statement, loan accounting system data, and default data of middle-market borrowers from 23 countries around the world.
Usage Model – Middle Market lines have higher UGD than Public Firms

Lack of granularity on the usage measurements can have a material effect on liquidity buffers and funding: higher usage implies higher funding needs and therefore higher liquidity risk.

Usage models help institutions to overcome data limitations, granularity problems, and facilitate the empirical validation of their internal usage assumptions for regulatory purposes.

* Results based on Moody’s Analytics Usage Model (“Measuring the EAD of Middle Market Credit Lines”, Jing Zhang, Moody’s Analytics)
** UGD: The percentage of the exposure that is expected to be drawn in the event of default
Behavior of Prepayments Dynamics

- Borrower prepayment assumptions can have a **material effect on liquidity and interest rate risk measures**

- Moody’s Analytics advocates two complementary approaches to prepayment modeling and estimation:
  
  a. **Analytic prepayment models**, which model the prepayment decision of the borrower as a state-dependent rational exercise as a function of both interest rates and credit quality
  
  b. **Econometric prepayment models**, which describe borrowers’ prepayment propensity as a function of a set of explanatory factors, capturing borrower specific information, seasonal variation, market rates, and macroeconomic factors

*The chart represents Moody’s Analytics multi-dimensional lattice valuation model (jointly interest rates and credit quality dynamics)*
Prepayment Model – Prepayment results in Loss of Potential Income & Asset-Liability Mismatch

<table>
<thead>
<tr>
<th>Contractual Prepayment Penalty (bps)</th>
<th>Refinancing Cost (bps)</th>
<th>Option Spread (bps)</th>
<th>Expected Life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>38</td>
<td>0.3</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>20.5</td>
<td>0.44</td>
</tr>
<tr>
<td>70</td>
<td>0</td>
<td>13</td>
<td>0.72</td>
</tr>
<tr>
<td>0</td>
<td>40</td>
<td>7.7</td>
<td>2.29</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
<td>0</td>
<td>2.99</td>
</tr>
<tr>
<td>70</td>
<td>40</td>
<td>0</td>
<td>2.99</td>
</tr>
</tbody>
</table>

*Results based on Moody’s Analytics Prepayment Model for a Term Loan with Prepayment Optionality, 3 years duration. Charts compare the net stock (assets minus liabilities) for a sample balance sheet using two different prepayment assumptions.*
Liquidity Cost & FTP Allocation

- Funds transfer pricing (FTP) is an increasingly central component of asset-liability management, as it facilitates risk transfer, profitability measurement, capital allocation, and business unit incentive alignment.

- The components include a credit spread, which compensates the financial institution for bearing credit risk associated with the exposure, as well as an option spread, which is a premium that compensates the bank for any embedded options in the contract (e.g. prepayment option).

- The funding liquidity spread, which is the expected cost of funds required to support the exposure to its remaining life, and the contingent liquidity spread, which relates to the cost of maintaining a sufficient cushion of high quality liquid assets to meet sudden or unexpected obligation.

*The chart represents a schematic illustration of the components of an FTP.*
### Liquidity Cost Model – Incorporating Contingent Liquidity Costs in Funds Transfer Pricing for Funding Planning

**Base Case:** \( \lambda = 0.5, \) Corr(Bank, Borrower) = 16.5%

- **Commercial Margin**
  - Credit Spread 201bps

- **Reference Rate**

- **Contractual Fee = 300bps**
  - Funding Liquidity Spread 32bps
  - Contingent Liquidity Spread 20bps

- **FTP = 253bps**

**Stressed Scenario:** \( \lambda = 0.9, \) Corr(Bank, Borrower) = 33%

- **Credit Spread** 261bps

- **Funding Liquidity Spread** 32bps

- **Contingent Liquidity Spread** 33bps

- **Reference Rate**

- **Contractual Fee = 300bps**

- **FTP = 326bps**

*Results based on Moody’s Analytics Liquidity Cost Model for a line of credit (bank PD 20bps/annual, borrower PD 1.2%/annual, LGD 50%)*
Assessing and Pricing Contingent Liquidity
## Computing Break-Even Spread in a One-Period Model: No Funding Costs

<table>
<thead>
<tr>
<th>Borrower Credit State</th>
<th>Net Cash Flow to Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Default</td>
<td>( r^*_{\text{Borrower}} )</td>
</tr>
<tr>
<td>Default</td>
<td>(- \text{LGD}_{\text{Borrower}})</td>
</tr>
</tbody>
</table>

### Break-even rate:

\[
r^*_{\text{Borrower}} = \frac{PD^Q_{\text{Borrower}} \cdot \text{LGD}_{\text{Borrower}}}{1 - PD^Q_{\text{Borrower}}}
\]
Computing Break-Even Spread in a One-Period Model: What if the Bank Faces Funding Costs?

<table>
<thead>
<tr>
<th>Borrower Credit State</th>
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<tbody>
<tr>
<td>No-Default</td>
<td>( r_{\text{Borrower}} - r_{\text{Bank}} )</td>
</tr>
<tr>
<td>Default</td>
<td>(-LGD_{\text{Borrower}} - r_{\text{Bank}})</td>
</tr>
</tbody>
</table>

Break-even rate: \( r'_{\text{Borrower}} = \frac{r_{\text{Bank}}}{1 - PD_Q^{\text{Borrower}}} + \frac{PD_Q^{\text{Borrower}} \cdot LGD_{\text{Borrower}}}{1 - PD_Q^{\text{Borrower}}} \)

Expected Life of loan

Funding Liquidity Spread

Credit Spread

Expected Life of loan
Calculating Funding Liquidity Cost Components for a Prepayable Loan

\[ r_{\text{Borrower}} \approx \text{CreditSpread} + \text{OptionSpread} + \frac{r_{\text{Bank}} \cdot \text{TimeToMaturity}}{\text{ExpectedLife}} \]

1. A credit spread is calculated based on contractual terms and borrower risk inputs (PD, LGD, etc).

2. An option spread is calculated using a lattice methodology, based on the credit migration of the borrower, incorporating any prepayment fees or frictions.

3. A funding liquidity cost is calculated based on the bank cost of funds and the expected life of the loan.
Short-Term Cost of Collateralized Funding Within a Structural Model of Default

\[
\tilde{r}_{t_1}^{Bank} \approx - \frac{1}{t_2 - t_1} \log \left[ 1 - N \left( N^{-1} \left( PD_{t_1,t_2}^{Bank} \right) + \lambda_1 \sqrt{RSQ_{Bank} \cdot (t_2 - t_1)} \right) \cdot LGD_{t_1} \right]
\]

- Probability of bank default between \( t_1 \) and \( t_2 \)
- Market risk premium

\[
\tilde{LGD}_{t_1} \approx QPD_{t_1,t_2}^{Colateral} \cdot LGD_{Colateral}
\]

Risk-adjusted collateral default probability, given the bank defaults

Access to capital markets may be limited

- A systemic event may result in severely hampering funding access

\[
1_{\text{Markets Functioning}} = 1_{\bar{\lambda} \leq \lambda_{\text{Shutdown}}}
\]
Contingent Liquidity Risk: Motivation

Question

- What amount of liquid assets should your bank hold in order to absorb potential losses due to adverse funding conditions?

A bank invests in a variety of assets

- Extends backup lines of credit to a pool of borrowers: the future credit quality of them is **uncertain**
- Fully-funded instruments with varying degrees of liquidity: the future liquidity is **uncertain**

The bank funds the credit lines using a combination of long-term funds (a liquidity buffer), short-term collateralized debt, and possibly asset sales

- The degree to which assets can be collateralized is **uncertain**
- The market price of the assets is **uncertain**

The bank’s funding costs, due in part to the value of the collateral, and the borrowers’ line usage are correlated

- The future correlation behavior is **uncertain**
- Borrowers’ future demand for liquidity (line utilization) is **uncertain**

Availability of short-term funds is limited in severe market conditions

- The duration of the adverse funding conditions is **uncertain**
- The future funding needs are **uncertain**
## Measuring Bank Losses

<table>
<thead>
<tr>
<th>Time</th>
<th>Bank Funding Spread</th>
<th>Borrower Line Usage</th>
<th>Net Cash Flow to Bank at End of Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_0$</td>
<td>$r_0^{\text{Bank}}$</td>
<td>Usage$_0$</td>
<td>$\text{Usage}_0 (r_1^{\text{Borrower}} - r_0^{\text{Bank}}) - r_L \cdot L$</td>
</tr>
<tr>
<td>$t_1$</td>
<td>$r_1^{\sim \text{Bank}}$</td>
<td>Usage$_1$</td>
<td>$\text{Usage}_1 (r_1^{\text{Borrower}} - r_1^{\sim \text{Bank}}) - r_L \cdot L$</td>
</tr>
</tbody>
</table>

To absorb losses with 99.9% confidence, $L$ has to satisfy

$$\Pr\left\{\text{Usage}_1 (r_1^{\text{Borrower}} - r_1^{\sim \text{Bank}}) - r_L \cdot L \geq -L\right\} \geq 99.9\%$$
Contingent Liquidity: Joint Dynamics

- Bank borrowing cost
- Bank Funding Decision: Borrow or Sell
- Haircut/Asset Sale
- Market Risk Premium
- Collateral Asset Credit Migration
- Bank Gains/Losses
- Borrower Usage
- Borrower Credit Migration
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How to Enhance your Balance Sheet Management Function
Borrower prepayment assumptions can have a material effect on liquidity and interest rate risk measures and are key to perform liquidity stress testing.

Best practice is to model liabilities by explicitly accounting for the relationships between deposit balances, deposit rates, currency effects, as well as macro-economic factors.

How should one determine the proper maturity for exposures that have short contractual maturity, from a few days to a few weeks and properly account for the liquidity and credit risk?

How should one estimate the proper usage for revolving credit facilities and properly account for the liquidity and credit risk?
Quantifying Banks Assets Value Dynamics

Bank Asset Value and Credit Market Risk Premium

- Correlations between bank asset returns and innovations in risk premium are elevated during crisis periods.

![Graph showing Banking Index Asset Value and Market Price of Risk over time from March 2002 to March 2011. The graph indicates that during crisis periods, the correlations between bank asset returns and innovations in risk premium are elevated.]

Moody’s Analytics Enterprise Risk Management Solutions

Liquidity & Balance Sheet Management Practice
Quantifying a Crisis Period Value

Market Risk Premium Significantly Higher in Crisis Periods

- The crisis period is characterized as the 95th percentile of the empirical density estimate
Measuring Haircuts

A Reliable and Consistent Haircut Level

- The counterparty link to the collateral tends to be ignored altogether in portfolio management; it should be modeled properly.

<table>
<thead>
<tr>
<th>Counterparty</th>
<th>Collateral ID</th>
<th>Baseline Scenario</th>
<th>Stress Testing Scenario (Collateral -3 Notch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Target Probability</td>
<td>Target Probability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90%</td>
<td>95%</td>
</tr>
<tr>
<td>1</td>
<td>C1</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>2</td>
<td>C2</td>
<td>5%</td>
<td>9%</td>
</tr>
</tbody>
</table>
Measuring Correlations, Migrations, and Usage

**Asset Correlations**
- Estimated using GCorr™ Global Correlation Model

**Credit Migration**
- Obtained from Moody’s Analytics’ Distance-to-Default Dynamics model

**Credit Line Utilization**
- Estimate a credit quality contingent PD-usage mapping using Moody’s Analytics Credit Research Database (CRD™)

### Middle Market and Public Firms Usage Models

- **Frequency**
- **Usage Given Default**
  - SME UGD
  - Public...

### Model Factors Matrix

- **Corporate Country Factors**
  - 49 x 49
- **Corporate Industry Factors**
  - 61 x 49
- **US CRE MSA Factors**
  - 73 x 49
- **US CRE Property Type Factors**
  - 5 x 49
- **US Retail State Factors**
  - 51 x 49
- **US Retail Product Type Factors**
  - 6 x 49
Quantifying Portfolio Characteristics

Bank Characteristics
- Cost of long-term debt: 1.5%
- Maturity of short-term debt: one year
- 1-year default probability: 50 bps
- RSQ: 60%

Collateral Asset Characteristics
- No. of homogeneous assets: 40
- Maturity of assets: two years
- 1-year default probability: 80 bps
- Coupon rate: 3%
- RSQ: 40%

Borrower Characteristics
- No. of homogeneous borrowers: 80
- Maturity of credit line: two years
- Contractual usage fee: 3%
- 1-year default probability: 2%
- RSQ: 25%
Quantifying Liquidity Buffers

Liquidity Buffers Size as a Fraction of Total Asset Value

- The size of the buffer is a function of the liquidity of the collateral, asset type, and counterparty.

- corr(bank, revolver) = 36%, assets collateralizable
- corr(bank, revolver) = 36%, assets liquid
- corr(bank, revolver) = 36%, assets illiquid
- corr(bank, revolver) = 56%, assets illiquid
Quantifying Fund Transfer Pricing

**Base Case Scenario**
- Market Sharpe Ratio = 0.5, \( \text{Corr(Bank,Borrower)} = 16.5\% \)

- Contractual Fee = 300bps
- FTP = 253bps
- Reference Rate
- Contingent Liquidity Spread 20bps
- Funding Liquidity Spread 32bps
- Credit Spread 201bps
- Commercial Margin

**Stress Scenario**
- Market Sharpe Ratio = 0.9, \( \text{Corr(Bank,Borrower)} = 33\% \)

- Contractual Fee = 300bps
- FTP = 326bps
- Reference Rate
- Contingent Liquidity Spread 33bps
- Funding Liquidity Spread 32bps
- Credit Spread 261bps
- Commercial Margin
Conclusions
Conclusions

- Liquidity has become a **scarce and expensive resource**, and institutions are starting to measure, allocate liquidity efficiently by improving their Fund Transfer Pricing frameworks.

- The regulators identified “ineffective” **liquidity management** as a key characteristic of the crisis and highlighted the lack of attention that liquidity risk received relative to other risks prior to the crisis.

- Responses to an international survey that covered more than 35 large banks from nine countries show that **many liquidity management practices were largely deficient**.

- A central aspect of the new Basel 3 regulation involves **accurate measurement of the liquidity profile of the balance sheet** under different scenarios.

- This, in turn, relies on a **comprehensive characterization of behaviors** of both assets and liabilities and **liquidity contingency** buffers.

- As a consequence, a large number of institutions are **enhancing the balance sheet management function** by improving the sophistication of their liquidity models, workflows and policies, ALM systems, and integration between the credit and liquidity management function.