MEMORANDUM

To:         Liquidity Risk Management Programs Proposal File

From:       Amanda Hollander Wagner
            Senior Counsel, Division of Investment Management

Date:       December 21, 2015

Re:         Meeting with Representatives of Bloomberg

On December 17, 2015, Sarah ten Siethoff (Assistant Director, IM), Melissa Gainor (Senior Special Counsel, IM), Kathleen Joaquin (Senior Financial Analyst, IM), Thoreau Bartmann (Branch Chief, IM), and Amanda Wagner (Senior Counsel, IM) met with the following representatives of Bloomberg:

- Ronnie Taylor, Regulatory & Evaluated Pricing Strategy, Enterprise Solutions;
- Stefano Pasquali, Global Head of Liquidity Research, Regulatory & Accounting Products;
- Krishna Nadella, Americas Head of Regulatory Sales and Institutional Pricing Services; and
- Chris Casey, Regulatory Product Manager.

Among other things, the participants discussed the Commission’s proposal on liquidity risk management programs and swing pricing.
LQA-LIQUIDITY ASSESSMENT

LIQUIDITY RISK AND MARKET IMPACT. ESTIMATING LIQUIDITY USING PRICE UNCERTAINTY AND MACHINE LEARNING. A FIXED INCOME CASE STUDY.

(HIGHLY CONFIDENTIAL, FOR DISCUSSION PURPOSE ONLY)

Stefano Pasquali Global Head of Liquidity Research Enterprise Solutions, Bloomberg

JAN 2015
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**PREMISE**

**MARKET NEEDS**

- Regulatory requirements
- Risk management functions and systemic risk
- Trading/investment support

**THE PROBLEM**

- There is no industry-standard definition of liquidity
- Liquidity is difficult to estimate due to lack of data and transparency
- Bid-ask spread is an inadequate approach relied on by the market and academia

**THE SOLUTION**

- We developed a proxy that addresses market demands leveraging Bloomberg data, analytics and pricing
- **Our methodology is based on machine learning.** We approach the problem from a systemic risk perspective “melting” together relevant factors that can influence liquidity
- Uncertainty in the data is factored into the calibration

**THE PRODUCT**

- The Liquidity Assessment Tool (LQA) helps measure market depth and liquidity of securities for the purposes of regulatory reporting, risk and pre/post trade analysis.
- It provides information, based on a machine learning approach, such as the probability of selling a specific volume at a specific price, the expected cost of liquidation and expected maximum volume and expected days to liquidate a specific volume (given a maximum market impact).
- The tool also provides the level of uncertainty for each of these returns.
LIQUIDITY MODEL OVERVIEW

The overall model is based on THREE components:

Market Impact model
- Market Impact model derived from literature
- We estimate price shift from a fair value (equilibrium) given a specific volume
- In the proposed framework the calibration can be extended to every asset class

Machine Learning Engine
- Problem: A lack of trade data gives < 100% coverage
- Solution: Cluster Analysis is used to identify comparable assets
- We also leverage NON-traditional information

Market Normalization Factor
- We want the model to react to market conditions
- We measure the quality of information in the market (Entropy)
- New concept of market indices

- Definition: “PROBABILITY OF LIQUIDATING A GIVEN VOLUME AT A FAIR VALUE PRICE OR BETTER”
- Illiquidity (low probability of SELL) can be driven by
  - illiquidity of the bond (high cost of liquidation)
  - high uncertainty in the estimation due to poor market observation or low cluster quality

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# Model Inputs and Outputs

## Inputs

### General Inputs
- $V$ = Trade Volume
- $P$ = Reference (fair value) Price
- $S$ = Bid/Ask Spread
- $\sigma$ = Price Volatility over period $\Delta T$ (i.e. 2 months for Corp)
- $F_2$ = Turn over in period $\Delta T$ (i.e. 2 months for Corp)
- $F_3$ = Average daily volume
- $N$ = Average daily number of trades
- $R$ = Participation Rate

### Asset Class Specific Inputs
- Fixed Income: Duration ($D$), Coupon ($C$), AMT ($M$), etc.
- Equity: Fundamentals
- Other asset class ....

### Novel Inputs
- News Sentiment Index
- Accessibility Index (function of holder type)
- Other specific features for different asset classes

## Outputs

### Liquidity Assessment (LQA)
- $\Phi$ = Probability of Selling volume ($V$) at Price ($P$) or worse
- $I_V$ = Market Impact selling custom volume ($V$)
- $V_{MAX}$ = Given max Market Impact ($I_{max}$), max Volume can be sold
- $T$ = Given max Market Impact ($I_{max}$), days to liquidate custom volume ($V$)
- $L$ = Synthetic Liquidity Score (*)
- $\Gamma$ = Cluster Quality Index (*)
- $\Theta$ = Cluster Migration Rate (*)

### Prudent Valuation (PRUVAL)
- $P_{MPU}$ = Market Prudent Price
- $\Delta CC_{AVA}$ = Close Out cost AVA
- $\Delta MPU_{AVA}$ = Market Price Uncertainty AVA
- $\Delta CP_{AVA}$ = Concentrated position AVA
- $\Delta C_{AVA}$ = Combined AVA

### Margin Period of Risk (MPR)
- Under Test (Q2 2015, details in the appendix)

### HQLA: Active and sizable market
- Under Test

### Volker: RENDT
- Under Test

(*) input overridable with client assumption

(**) available in Q2 2015
• Price impact for selling 1% of AMT is -0.307 (USD) with uncertainty (st.dev.) of 0.210. The probability of execution at the bid is 47.61%.
• The max volume can be executed, with market impact not bigger than 0.31%, is 8.70 MM (USD).
• Given max volume and accepted market impact, the time to liquidation is 1.15 days (under linearity assumption in this release).
### REPORT EXPLANATION

**Security features**

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<th>Date</th>
<th>5/9/2014</th>
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<tr>
<td>Snapshot Time</td>
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<tr>
<td>Duration</td>
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<td>Coupon</td>
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<td>Age</td>
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<td>AMT Outstanding</td>
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<td>Price</td>
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<tr>
<td>Contrib Std</td>
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<tr>
<td>% of Market Data</td>
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<td>BA Spread</td>
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<tr>
<td>Sum Trade Vol. of past 2 months</td>
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<tr>
<td>Country of Risk</td>
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<tr>
<td>Currency</td>
<td>USD</td>
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</table>

- **Reference date**
- **Other summary data**
- % of fair value coming from direct marker observation
- Standard deviation of observations
- Fair value bid-ask spread
- Sum of trades volume in the last 2 months (if available)

### Cluster composition order in by similarity with the target asset.

<table>
<thead>
<tr>
<th>Security</th>
<th>Issuer</th>
<th>Sector</th>
<th>Weight</th>
<th>Yield</th>
<th>BA Spread</th>
<th>AMT Outstanding</th>
<th>Duration</th>
<th>CPN</th>
<th>Rating</th>
<th>Country</th>
<th>2m P std</th>
<th>Score</th>
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<tr>
<td>COE2592190</td>
<td>BM CORP</td>
<td>Technology</td>
<td>100.00%</td>
<td>3.02</td>
<td>0.37</td>
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<td>7.67</td>
<td>1.88</td>
<td>AA-</td>
<td>US</td>
<td>0.60</td>
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<tr>
<td>COE7607116</td>
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<td>NULL</td>
<td>92.23%</td>
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<td>8.02</td>
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<td>US</td>
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<td>10</td>
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<td>3.63</td>
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<td>5.73</td>
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<td>US</td>
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<td>1.63</td>
<td>AA-</td>
<td>US</td>
<td>0.60</td>
<td>9</td>
</tr>
</tbody>
</table>

- **New Price**: Predicted price.
- **Impact**: Difference between new and ask price.
- **Uncertainty**: Standard Deviation of the distribution of the Impact.
- **Probability of selling at fair value bid or higher for different volumes**
- **N of days to liquidation**: This is the number of days that it would take to sell a specific volume at simulated maximum accepted market impact ($0.31 in this case). In this version with linearity assumption.

### Probability Density Function

- PDF around the equilibrium price
- PDF around trade prices for different volumes

### Distances in Cluster (no of member 5)

- (BLUE are from the same issuer)
- Price impact for selling 1% of AMT is -0.403 (EUR) with uncertainty (st.dev.) of 0.374. The probability of execution at the bid is 17.27%.
- The max volume can be executed, with market impact not bigger than 0.05%, is 1.12 MM (EUR).
- Given max volume and accepted market impact, the time to liquidation is 22.35 days (under linearity assumption in this release).
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