# Algorithmic Market Making

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## Symbology Glossary

1. Tight Skew: $\alpha_T$

2. Loose Skew: $\alpha_L$

3. Tight Width: $\omega_T$

4. Loose Width: $\omega_L$

5. Algorithmically generated Ideal Mid Cash Price: $\Pi_{Ideal}$

6. Position: $P$ (expressed in cumulative net position per unit under consideration – firm/desk/trader)

7. Position Pivot: $P_{Pivot}$. Dimensionless ontological view of the scaling position metric – roughly equivalent to the Reynolds' number of market making position units. Expressed in currency units.

8. Risk: $R$ (expressed in cumulative net risk per unit under consideration – firm/desk/trader)

9. Risk Pivot: $R_{Pivot}$. Dimensionless ontological view of the scaling risk metric – roughly equivalent to the Reynolds' number of market making risk units. Expressed in PV01 currency units.

## Framework Glossary

1. Equilibrium quantity: Quantity that only changes with the macro drivers/factors, and not the technical factors. Typically stable, but jumpy and undergoes changes when drivers shift – and introduces perturbations on the disequilibrium quantities.
2. Disequilibrium quantity: Quantity that changes with the technical, transient factors.

## Width/Skew/Size Estimation Models

1. Tight Models:
   - Tight models estimate the market making quantities on a trader/firm/desk independent manner.
   - They estimate the "secular" market making parameters – width, skew, and size for either the Market Making Outputs or the Axe Outputs – estimate them based on classes of input parameters.
   - For each input parameter class, the following are needed:
        a. A proxy that serves as a quantitative estimate of the desired parameter class.
        b. Segmentation of the proxy over the sub-classified parameter set.
2. Input Class => Risk Profile:
   - Captures all the cumulative risk components => the credit/solvency, market, and liquidity risk behind the issue.
   - Proxy => CDS Spread, rating, bond basis
   - Sub-classification => Issue, issuer, and sector.
3. Input Class => Liquidity:
   - Captures the frequency and volume of the trade flow of a given issue, and the ease of getting in and getting out at the given side.
   - Proxy:
        i. Aggregated periodic (e.g., daily) volume for each side (buy/sell).
        ii. Aggregated periodic (e.g., daily) notional for each side (buy/sell).
   - Sub-classification => Issue, issuer, sector, and the instrument universe.

4. <u>Firm/Desk/Trader level parameters</u>: These provide aggregated controls for trading.

   - Net Position => vital metric for inventory control.
   - Risk limits => to control/manage exposure to specific granules – issue, issuer, tenor, sector, unit etc:

5. <u>Monitor Mobility</u>: Certain measures such as PV01 based risk, inventory, etc: are more easily human-monitored, so they are done daily. Others (such as tenor 01s) are less easily monitored, so they are done infrequently.

## Market Making System SKU

1. Intra day Curve Generation Scheme
2. Mid Price Estimation Models
   
       i. Accommodate different mid price estimation models, and their respective parameters

3. Algorithmic Quote Construction => used for generating venue/ECN independent width/skew/size [composed of tight/loose components]. Broadly speaking achieves the following:

       i. Specific parameters to control skew for targeted alpha generation strategies

       ii. Accommodate different width and size estimation models, and their respective parameters

       iii. Venue-independent base quote synthesis/construction

       iv. Circuit breaker heuristics

       v. Policy driven/policy enforcement/policy control applied at this level

4. Quote Management: Publishing/tailoring the constructed quote towards specific venues (possibly with order routing applied at this stage).

       i. Venue specific rules (and thereby external vendor incorporations, like Broadway etc☺ at this stage.

## Market Making Parameter Types

1. Model Parameters: Parameters for generation of algorithmic generation of width, skew, and size.
2. Quote Generation Control Parameters
3. Quote Heuristics Control
4. Quote Management Control

## Intra-day Pricing Curve Generation Schemes

1. Issue Benchmark Bonds: The following set of threshold criteria are used to determine the issuer specific benchmark bonds:

    ii. Threshold of daily TRACE volume/number of trades

    iii. Threshold of outstanding notional

    iv. Only senior obligations

    v. Some combination of the following threshold of the ratios:

$$\frac{CUMULATIVEDAILYISSUETRACEVOLUME}{OUTSTANDINGNOTIONAL}$$

$$\frac{CUMULATIVEDAILYISSUETRACEVOLUME}{CUMULATIVEDAILYISSUERTRACEVOLUME}$$

2. Benchmark bonds basis tracking: Track the bid side and ask side credit basis of the benchmark bonds from each TRACE print, using EMA VWAP/TWAP from the intra-day rates/credit curves. This will be the attempt to estimate the mid credit basis for the, and it is generally well behaved.

• Need to find a way to accommodate the institutional closing CDS mid marks and the benchmark bonds into the credit curve construction – these are highly valid points.

3. Intra-day credit curve generation inputs: Need a way to generate the credit curve from

    i. The CDS marks

      ii.   The basis-adjusted benchmark bonds

     iii.   It always needs to be used in conjunction with tension splines.

     iv.   Also need intra-day TRACE series to update the basis (direct or EMA) – will use this to establish the intra-day relationship between the CDS nodes and the TRACE cut-off threshold).

4. <u>Intra-day credit curve updating</u>:

     a.   Use the relationship grid between CDS 5Y, the off-tenors, and the benchmark bonds

     b.   Any change in any of them automatically re-adjusts using the set relationships.

     c.   CDS Curves are trader set; bond basis are EMA'd from the TRACE series using the prior credit curve

     d.   Relationships are either reviewed daily EOD

5. <u>Live updating of bond prices</u>: Use the live curve (either pure CDS, or a mixture of CDS/bond instruments) to extract the basis of each print, and then EMA that to generate the bond live prices.

## Mid Price Models

   i.   <u>Definition</u>: Computed theoretical mid-price, as to where the next print should be – assuming zero transaction costs, zero position/risk constraints, and infinite liquidity. Mid Price is an ***Equilibrium Quantity***.

  ii.   <u>Estimation parameters</u>: Typical mid price estimation parameters are: the IR curve, the survival curve, and the recovery curve. The other possible drivers are: funding curve – typically for long position, and repo curve – typically for shorts.

## Width Models

1. <u>Tight Width</u>: Computed theoretical width, after accounting for the issue liquidity and the issue riskiness. Tight width is the first in the set of disequilibrium quantities. Tight width is:

    a. Proportional to issue risk (combination of credit and market risk – not counter party risk).
    b. Inversely proportional to liquidity

## Skew Models

1. <u>Tight Skew</u>: This measure how far the last print has been OFF from the theoretical mid price. Thus Tight Skew is representative of the alpha potential – for a theoretical mid price that chases the print in a sequence, the tight skew is zero.
2. <u>Tight Bid Skew and Tight Ask Skew</u>: This is an alternative SKU – instead of tight width and tight skew cognitive view, tight bid/ask skew parameters are determined only from their corresponding liquidity and flow metrics (i.e., bid/ask liquidity metrics).
3. <u>Loose Skew</u>: Simply put, loose skew is:

$$\alpha_L = \max\left( \frac{P}{P_{Pivot}}, \frac{R}{R_{Pivot}} \right)$$

4. <u>Heuristic Checks on Loose Skew</u>: Following checks applied to round out quoting:
    1. Ceiling/floor applied
    2. Maximum cutoff for width
    3. Best right skew – bid becomes ask.
    4. Best left skew – ask becomes bid.

## Size Models

1. <u>Tight bid size/tight ask size</u>: Basically, tight size is inversely proportional to tight width, to within normalized bounds.

## Heuristics Control

1. <u>Can Buy/Can Short</u>: Can But/Can Short => whether the bid/ask stays within the LONGABLE/SHORTABLE cutoff.
2. <u>ECN Threshold Cross</u>: Check to see if there is a cross between the published bid/ask and a given ECN's bid/ask.

## Published Market Quote Picture

1. Bid/Ask Sizes: Truncated to their appropriate rounding.

2. Bid Price: $\Pi_{Ideal} - \frac{1}{2}\omega_L\alpha_L$

3. Ask Price: $\Pi_{Ideal} + \frac{1}{2}\omega_L\alpha_L$

4. Bid/Ask Prices rounded downward/upward to their appropriate increments.