# Muni Excess Return Model

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## Introduction

Muni market has several features that distinguish it from other asset classes and makes it somewhat difficult to use standard quantitative tools. The most important features of muni market are:

* Tax-exempt status of most municipal securities
* A particular structure of issuance, meaning that practically all bonds with maturities longer than 10 years are callable
* A risk-free AAA MMD reference curve (its specific features we discuss below)

The latter feature implies that excess return for muni securities is not defined as a return over Treasury. Muni excess return (ER) model is built to forecast 3-month security-wise return in excess of non-callable muni AAA curve. This curve is derived from a callable AAA curve provided by Municipal Market Data (MMD) company (owned by Thompson-Reuters). The MMD curve is used by muni market participants as a standard risk-free reference curve. The exact methodology used for the curve construction is proprietary, the following quoting conventions are used:

* For each maturity the quoted rate is the yield of a semi-annual 5% coupon AAA bond
* For maturities 10 year and shorter, the quoted rate is the yield of a noncallable bond of the same maturity.
* For maturities of longer than 10 years, the quoted rate is the yield to worst of a bond of the same maturity and callable in 10 years.

It is quite apparent that AAA MMD curve does not allow for computation of risk free discount factors beyond 10 years and therefore is not directly usable within option-adjusted (OA) framework. To derive a non-callable risk-free par coupon curve, we use Kalotay analytics engine. With the given volatility, Kalotay engine adjusts the callable curve using implied option value, hence producing non-callable curve.

The muni ER model covers Barclay (Bloomberg) muni and muni HY indices, currently about 55,000 securities, and all AB holdings, totaling to about 70,000. All security indicative data (coupon, maturity, call schedule, etc.) is provided by Bloomberg. Security prices are provided by IDC pricing service. All security analytics (OAS,OAD, KRDs, etc.) are generated by overnight batch that utilizes Kalotay analytics libraries. Data starts in March, 2007.

## Model Framework

We assume that expected excess return for any muni bond of credit *r* and duration *d* from time t to t+3 months has the following structure:

(1)

where

* is the carry component of the return, equals to OAS minus adjustment term. We discuss the adjustment term in detail latter.
* is expected spread change.
* Beta coefficients are obtained through a pooled ridged regression as follows:

where is 3 month forward excess return of *j*-th bond in the index at time , where time spans all available data points.

* is a deviation of current OAS attributed to duration *d* and credit *r* to its 2-year historical average.
* is the OAS that is attributed to duration *d* and credit rating *r*, see OAS attribution model.
* is the mispricing component of a bond’s OAS, see OAS attribution model.

Essentially, the expected excess return is driven by 2 components: OAS carry and expected change in OAS. The latter part consists of 2 factors: reversion of mispricing to zero and reversion of credit-duration OAS to its 2-year average. Both components, as well as the adjustment term of OAS carry are derived using OAS attribution model. We discuss it in the following section.

## OAS Attribution Model

The purpose of OAS attribution model is to assign a spread value to all market factors that drive muni securities pricing. This is achieved through running a cross-sectional gam model each day for a union of muni and muni HY indices. The model has a following general form:

(2)

where is the OAS of *i*-th bond in the index and is, in general, a non-linear function of a factor representing OAS value of that factor. The remaining residual part of the OAS is not explained by any factor and is considered to be caused by mispricing. Let’s consider each of the factor in the OAS attribution model separately.

### Credit-Duration

Credit-duration factor is constructed by fitting a two-dimensional smooth surface to a collection of observations: ) - credit rating and OAD of *i*-th bond, for all index bonds. Surface fitting algorithm is a thin plate spine, which is a default spline method for t() object of R gam() function. Figure 1 shows a sample fit of credit-duration surface. Note, that credit rating that is used for construction of credit-duration surface is not a published rating but an underlying rating (rating of issuer only) and does not include possible credit-enhancement. It allows to estimate a value of credit enhancement separately (see section Insurance).

Credit rating data comes from two sources. First, all held securities are rated internally by AB muni team. Second, if internal rating is not available then it’s the average of underlying rating provided by Moody and S&P agencies.

Figure . Sample Credit-duration OAS attribution surface (2018-05-16)

### State

State factor is collection of dummy variable where each factor representing a separate state takes a value of 1 for that state and 0 otherwise. The factor takes into account only high credit securities of each state (AA and higher). This is done to isolate state specific price drivers that are not related to credit. For example, it captures extra demand in high tax states, which is driven by higher tax advantage of holding tax-free muni securities. Figure 2 shows a sample OAS attribution for 25 states with highest amount outstanding.

Figure . OAS attribution for 25 states with highest outstanding debt (2018-05-16).

### Sector

Sector factor captures differences between various muni sectors. Sectors are defined internally by AB muni desk. Most of the sectors cover revenue bonds representing different industries, such as Electric Utility or Health Care. Non-revenue bonds are covered by two sectors: State G.O. and Local G.O. Sector factor is defined by a collection of dummy variables similar to the State factor. Figure 3 shows sample attribution muni sectors.

Figure . Sample OAS attribution for sectors (2018-05-16)

### Deminimis Tax

Deminimis tax factor reflects the deminimis rule that is used for muni securities. This rule makes a muni investor pay regular income tax on capital gains if a security is bought below certain price (deminimis threshold). Hence, the security pricing experiences an extra pressure once it gets closer to deminimis threshold, reflecting the possibility of future reduction of after tax revenue. To capture this effect, we compute estimated deminimis tax impact in spread space:



where is expectation of dollar value of the future tax:



is marginal tax rate, applied in case the bond is subject to deminimis rule.

is a fraction of assumed holding period (3 years) relative to maturity. If maturity is less than 3 years, then it’s held to maturity.

is deminimis basis price, 100 for bonds issued at par or above par; for bond issued at discount (OID), the basis price is the current price of the bond maturing in *M* at issue yield:

, *C* is the bond’s coupon.

is the deminimis threshold, if the bond is bought below that price, it is subject to deminimis tax.

is normal PDF with *µ* = 0 and σ = 0.02, implying 200 bps of annual spread volatility.

Summarizing, the formula above represent an expectation of deminimis tax that an investor has to pay if the bond is bought in 1 year and is held for the next 3 years (or till maturity, if shorter than 3 years)

Deminimis tax impact is computed separately for IG and HY. Figure 4 provides an example of OAS attribution for deminimis tax factor.

Figure . Sample OAS attribution for deminimis tax (2018-05-16)

Note, that Kalotay OA analytics does account for deminimis tax on the tree, reducing after tax cash flows if tax is applicable. In theory, that should lead to redundancy of an extra deminimis tax factor. Indeed, comparing to Point based analytics, OAS attribution for EDTI is reduced for Kalotay analytics. However, due to model simplifications and possible mismatch between market and model assumptions, the factor is still significant. Note also, that the expected shape for EDTI attribution functions is a monotonically increasing function, which holds for IG securities. On the other hand, HY bonds pricing may be influenced by other market forces that are not currently captured by the model and may distort EDTI attribution. In particular, in presence of a high credit risk, investors prefer low dollar price bonds, expecting higher recovery rates, thus providing extra support for this market segment.

### AMT

Some muni securities are not fully free from federal taxes and are subject to AMT tax. Naturally, they trade cheap to regular muni securities. AMT factor is used to capture that effect. We separate all securities subject to AMT into 3 buckets based on duration, see Figure 5. During model calibration, each bucket is represented by a dummy variable.

Figure . Sample AMT factor attribution (2018-05-16)

To avoid discontinuity in OAS attribution in case of a security transition from one bucket to another, the buckets’ attribution is assigned to respective middle points of 0..5 and 5..15 buckets and to 20 year for the long bucket. The final AMT OAS attribution for all intermediate points is obtained by linear interpolation/constant extrapolation, see Figure 5.

### Zero coupon

Zero coupon bonds are traded cheap to coupon bonds on muni market. This is handled in same way as AMT facto: we use 3 duration buckets to calibrate the model and linear interpolation to remove discontinuity between buckets, see Figure 6.

Figure . Sample OAS attribution for zero coupon factor (2018-05-16)

### Extension risk

This factor is used to capture the fact that muni market participants avoid holding securities with a potential of significant change of duration, in particular, an increase of duration. That may be related to extra cost of duration hedging of this type of securities relative to bonds with stable duration. To model this observation, we use ratio of OAD to duration till maturity. Thus, the factor is changing between 0 and 1, with smaller values indicating a higher extension risk, see Figure 7.

Figure . Sample OAS attribution for extension risk (2018-05-16)

### Credit enhancement

Muni securities have various types of credit enhancement. One of the commonly used one is the insurance of muni issues by insurance companies. There are several companies that provide insurance to muni issuers. Value of the insurance is a function of creditworthiness of both the issuer and the insurance company. To capture this value, we use a set of dummy variables representing buckets of securities according to underlying credit rating and the insurance company. Currently, there are 9 insurance companies on the market for each of them there are 5 buckets by underlying credit: AAA, AA, A, BBB and HY. Only the buckets with 5 or more securities are used. The attribution value is capped at 0, since the value can not be negative, thus the spread impact can not be greater than 0. Figure 8 provides OAS attribution for selected insurance companies.

Figure . Sample OAS attribution for credit enhancement (2018-05-16)

### Mispricing

Some of all factors’ attributions constitutes a fair value OAS, inferred from the current market prices. The remaining part that is not explained by any factor is considered to be caused by mispricing and is expected to be removed from the market and therefore is used as factor in expected return model.

Mispricing OAS is also used to compute a correction term for spread carry component of expected return. The idea of the correction term is to make internally consistent model assumptions for carry term and spread change term. Carry term represents the return if spread stays constant. On the other hand, spread change term expects that some of the spread will be removed. So, if it is removed, it can not be earned as a part of the carry term, except one extreme case if mispricing is removed at the last day of 3 month period. In reality only partial mispricing reversion happens over 3 month. Also, timing of this reversion is uncertain and probably uniformly distributed over 3 month period. Given all these observations, the correction term is assumed to be 10% of mispricing OAS, which is based on back testing of expected return model.

## Model Performance

To measure model performance we run a monthly out of sample backtest: each month end expected excess return is generated based on the as of date available data, the whole index is subdivided into 5 groups based on the expected ER, from q1 with the highest return to q5 with the lowest return. Figure 9 presents cumulative return of each group over past few years.

Figure .Cumulative Kalotay quantiles excess return performance