BofAML Multi Asset Strategy Index (MAST)

Primer

Bank of America Merrill Lynch

07 February 2019

MAST – The BofAML Multi Asset Strategy Index

BofAML Research introduced its Multi Asset Strategy Index (MAST) in August of 2008. MAST applies an objective and rules-based asset allocation model that was designed to take advantage of the low correlation structure between equity, fixed income, commodity, and currency assets. Each asset class is represented by a total return index (Bloomberg ticker in parenthesis): Equities: the MSCI Net Total Return Developed World Index (NDDUWI), Fixed Income: the BofAML Global Markets 10-year US Treasury Futures Index (MLT1US10), Commodities: the ICE BofAML Commodity Index eXtra (MLCX03TR), and Currencies: the BofAML Global Markets FX Arbitrage Index (MLHFFX1). The MAST Index back-calculated levels and real-time values are available on Bloomberg under MLMAST1 <Index> and Reuters under .MLMAST1.

Quantitative Cross Asset
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Refer to important disclosures on page 5 to 7.
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Introduction

In our February 2006 report, *Optimal Multi Asset Allocation*, we first highlighted the potential diversification benefits that could be obtained by allocating among assets with low correlation.[1] Building on this research, we introduced the BofAML **M**ulti **A**sset **St**rategy (MAST) Index which is designed to be a liquid, transparent, rules-based, intuitively simple, and diversified multi-asset allocation model. MAST was launched on 5 August 2008 and index levels prior to launch were back-calculated to 30 December 1992. MAST aims to capture attractive risk-adjusted returns by taking advantage of the low correlation between equity, fixed income, commodity, and currency assets. Each asset is represented by a total return index (Bloomberg ticker in parenthesis):[2]

- **Equities**: the MSCI Net Total Return Developed World Index (NDDUWI),
- **Fixed Income**: the BofAML Global Markets 10-year US Treasury Futures Index (MLT1US10)
- **Commodities**: the ICE BofAML Commodity Index eXtra (MLCX03TR) [3]
- **Currencies**: the BofAML Global Markets FX Arbitrage Index (MLHFFX1) [4]

The BofAML Global Markets 10-year USD Treasury Futures Index reflects the total return of a collateralized rolling 10-year USD Treasury Notes Futures position. The futures are listed on the Chicago Board of Trade (CBOT) and the expiring contract is rolled to the next expiration month contract two CBOT business days prior to the last CBOT business day in February, May, August, and November. The collateral is designed to earn interest at the Overnight USD Federal Funds Rate and is reset at the time of the futures roll. The daily closing values of the BofAML Global Markets 10-year USD Treasury Futures Index are computed from the daily settlement values of the underlying listed CBOT treasury futures. The BofAML Global Markets 10-year USD Treasury Futures Index was introduced on 15 May 2008. Index values prior to the date of inception are back-calculated using these nondiscretionary index rules and publicly available CBOT listed futures prices. Treasury futures were used in the index instead of cash bonds in order to enhance liquidity and transparency.

The ICE BofAML eXtra Commodity Index went live on 13 September 2007 and the BofAML Global Markets Foreign Exchange Arbitrage Index on 1 June 2007. For both indices prior history is back-calculated using their current non-discretionary index rules. The MSCI Net Total Return Developed World Index went live 31 December 2000 and prior history is back-calculated by MSCI. In MAST each of the four index components measure total returns. Therefore, the index accounts for equity dividends (excluding withholding taxes) and interest for the futures-based currency, commodity, and fixed income indices. Since the daily MSCI Net Total Return Developed World data are only available starting 31 December 1998, for previous observations we use price return data as a conservative proxy. The MSCI Price Return Developed World Index data also went live 31 December 2000 and prior history is back-calculated by MSCI.

[1] "Optimal Multi Asset Allocation - monetizing the risk reduction that is achieved via diversification", Merrill Lynch Equity Derivatives Research, 3 February 2006.

[2] The Index Sponsor for MLT1US10, MLCX03TR, and MLHFFX1 is BofAML Global Markets and each index is not a BofAML Global Research index.

[3] For further details on the ICE BofAML eXtra Commodity Index 03 please see https://www.theice.com/publicdocs/CommodityIndexMethodology.pdf

[4] For further details on the BofAML Global Markets Foreign Exchange Arbitrage Index please see "Merrill Lynch Foreign Exchange Arbitrage Index", Merrill Lynch Equity Derivatives Research, 1 June 2007.

The MAST asset allocation model

MAST seeks to assign asset weights with the objective to generate the highest possible ***diversification ratio***.[5] The diversification ratio is the ratio of a portfolio's weighted average component volatility to its overall portfolio volatility. Intuitively, a portfolio of lower correlated assets will have greater risk reduction through diversification. In turn, a portfolio of lower correlated assets will have an overall volatility that is lower than its weighted average component volatility (higher diversification ratio).

When all asset Sharpe Ratios are equal, the asset weights that produce the highest possible diversification ratio will also generate the portfolio with the highest possible Sharpe Ratio. We show this in the next section.

Review of the Modern Portfolio Theory (MPT)

According to MPT, an efficient set of portfolios (the efficient frontier) can be traced out by determining the weights that yield the maximum expected portfolio return for a given level of portfolio target risk. Formally,

Maximize $$\hat{r}_p = \sum_{i=1}^{N} w_i \hat{r}_i \quad (1)$$

Subject to $$\hat{\sigma}_p = \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \hat{\sigma}_i \hat{\sigma}_j \hat{\rho}_{ij}} = \sigma_{Target} \quad (2)$$

And such that $$\sum_{i=1}^{N} w_i = 1 \text{ and } w_i \geq 0 \forall i \quad (3)$$

where $\hat{r}_p$ is the expected portfolio return, w_i is the weight of each portfolio component, and $\hat{r}_i$ is the expected return of each portfolio component, N is the total number of components in the portfolio, $\hat{\sigma}_p$ is the expected portfolio risk, $\hat{\sigma}_i$ and $\hat{\sigma}_j$ are the expected risk for each portfolio component, $\hat{\rho}_{ij}$ is the pairwise correlation between components, and σ_{Target} is a given level of portfolio target risk. Assuming the minimum risk portfolio has a return greater than the risk free rate, then, along the efficient frontier, a set of weights exist such that portfolio Sharpe Ratio is maximized:

$$\max_w \left(\frac{\hat{r}_p - r_f}{\hat{\sigma}_p}\right) \quad (4)$$

and rewriting equations in matrix notation (1) and (2)

$$\hat{r}_p = w' \cdot \hat{r}\ ,\quad \hat{\sigma}_p = \sqrt{w' \cdot \Sigma \cdot w}\ ,\quad \mathbf{1}' \cdot w = 1 \quad (5)$$

where r_f is the risk free rate, w is an Nx1 vector of weights for each component, $\hat{r}$ is the Nx1 vector of expected returns for each component, Σ is the NxN expected variance-covariance matrix for the components, and $\mathbf{1}$ is the Nx1 vector of ones.

Now let's assume Sharpe Ratios are identical for each of the underlying assets. Using the equal Sharpe Ratio assumption, the expected return vector can be expressed as:

$$\hat{r} = S\hat{\sigma} + r_f \quad (6)$$

where $\hat{\sigma}$ is an Nx1 vector of expected component risks, r_f is the risk free rate, and S is the Sharpe Ratio for each component. The expected portfolio return can then be represented as:

$$\hat{r}_p = w' \cdot (S\hat{\sigma}) + r_f \quad (7)$$

And now substituting equation (6) back into equation (4), the Sharpe Ratio maximization problem becomes:

$$\max_w \left(\frac{Sw'\hat{\sigma}}{\sqrt{w'\Sigma w}}\right) \quad (8)$$

[5] In 2008, Choueifaty and Coignard introduced the Diversification Ratio (DR) as the proper measure of diversification. See "Toward Maximum Diversification", Choueifaty, Yves and Yves Coignard, 2008.

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And such that $\sum_{i=1}^{N} w_i = 1$ and $w_i \geq 0 \forall i$ (3)

where $\hat{r}_p$ is the expected portfolio return, w_i is the weight of each portfolio component, and $\hat{r}_i$ is the expected return of each portfolio component, N is the total number of components in the portfolio, $\hat{\sigma}_p$ is the expected portfolio risk, $\hat{\sigma}_i$ and $\hat{\sigma}_j$ are the expected risk for each portfolio component, $\hat{\rho}_{ij}$ is the pairwise correlation between components, and σ_{Target} is a given level of portfolio target risk. Assuming the minimum risk portfolio has a return greater than the risk free rate, then, along the efficient frontier, a set of weights exist such that portfolio Sharpe Ratio is maximized:

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Looking closely at equation (8), the numerator represents the weighted average component volatility of the portfolio and the denominator represents the portfolio volatility which is therefore the ***diversification ratio***. By assuming equal component Sharpe Ratios, the weights that maximize the portfolio Sharpe Ratio are also the weights that maximize the diversification ratio.

Notably, the choice of optimal weights in equation (8) is independent of expected returns for each component. Instead, the optimal weights are a function of expected component risk and correlation. Solving equation (8) gives optimal weights w^* such that

$$w^* = \frac{\Sigma^{-1}\hat{\sigma}}{\mathbf{1}'\Sigma^{-1}\hat{\sigma}} \quad (9)$$

MAST index mechanics

The MAST Index values are calculated only on days when both closing prices are available for all index components and the U.S., U.K., and Japan equity markets are open.

The latter provision is made to identify days of maximum liquidity for the MSCI Net Total Return Developed World Index.

MAST is rebalanced semiannually. The weights are determined on the last index calculation day in May and November according to the asset allocation model outlined in the prior section. The required expected component standard deviations and correlations are calculated from daily closing levels of the four index components over the index calculation days from (and including) the weight determination day two years prior to (and including) the current weight determination day. Using these daily closing levels, each component's daily log return is calculated. The square root of the variance of each component's daily log returns is the expected component risk. The covariance is between each component pair's daily log returns is also calculated and along with the component's variance of daily log returns makes up the variance-covariance matrix.

The MAST weights are implemented on the second index calculation day in June and December, namely two index calculation days following the weight determination date. The weights are translated into index units such that the newly rebalanced MAST Index has the desired weight values and matches the MAST value that would be obtained prior to the rebalance. These share units are held constant through the next weight implementation date.

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The MAST performance prior to 5 Aug 2008 is based exclusively on back-calculated data and reflects the application of the index methodology as if the index had been in existence at that time. Back-calculated index performance is hypothetical and for illustrative purposes only and does not represent actual investment performance. Index performance returns do not reflect transaction costs and fees and other investment expenses such as advisory or management fees. Indices are unmanaged and it is not possible to invest in an index directly. Past performance is not an indication of future results. The MAST index is owned and maintained by BofA Merrill Lynch Global Research and is subject to change and may be discontinued. In addition, we may cease to publish on the index or any of its applications. Changes to MAST methodology and/or any termination will be announced in advance in a published BofAML published research report. Well-known substitutes are available for the underlying components within the MAST index and a fallback plan has been created in the event that a component is no longer available. Recreating the MAST index with substitute components leads to relatively consistent performance to the original index. More information on component substitutes is available upon request. This primer will also be updated or republished to reflect any methodology changes.

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