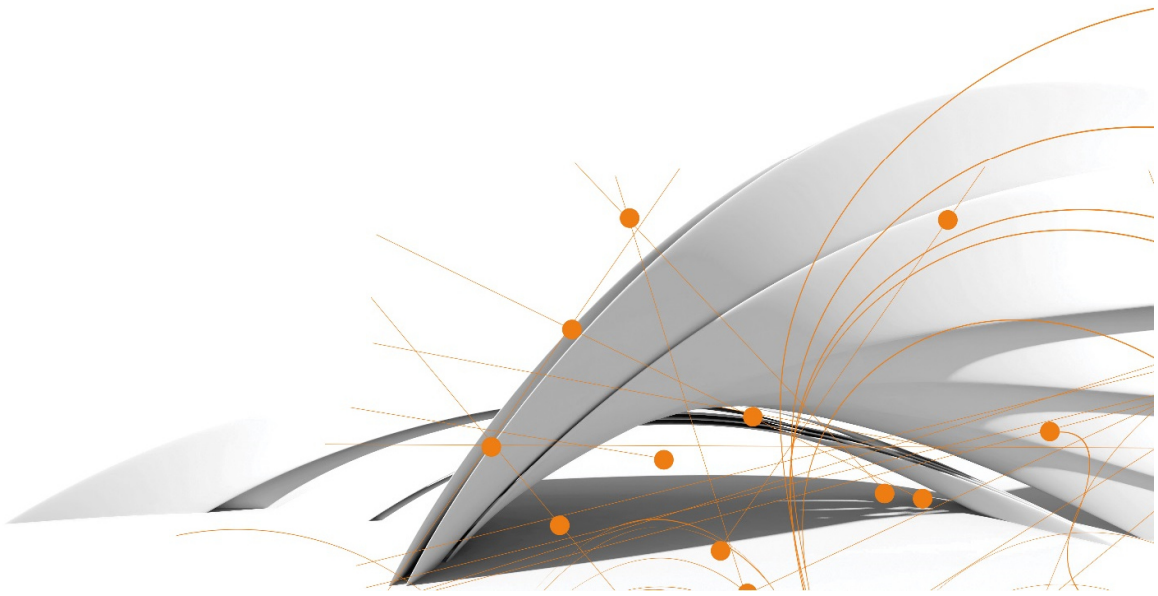
TOBAM*
CORE INVESTMENTS

To be or not to be predictable? About Sharpe Ratios hierarchy, cross-asset allocation and Maximum Diversification®

May 2019



TOBAM launched its first Anti-Benchmark® equity strategy in 2006, applied the Maximum Diversification® approach to fixed income in 2014 and then expanded the offering of the firm again with the application of TOBAM's patented investment process in a multi-asset context. This required specific research on the different issues that arise from quantitative cross-asset allocation, which ultimately lead TOBAM to offer investors the Anti-Benchmark® Multi-Asset strategy.

Traditionally, with regards to cross-asset allocation, the critical question lies around the percentage allocated to equity. Given, that in the past, equity markets have demonstrated higher returns and higher volatility than fixed income markets, the decision of equity allocation will dominate both risk and return, in a simple binary way – either equity did well, or it didn't. This explains why multi-asset allocation is usually evaluated by risk-adjusted returns, the Sharpe ratio being one of these measures.

One of the properties of the Most Diversified Portfolio® is the maximization of the Sharpe ratio whenever risk is equally rewarded across all assets - though this hypothesis is not needed to deliver superior returns vs. market cap-weighted portfolios.

In this dashboard, we will look into this assumption and empirically verify that risk is equally rewarded across all assets, and thus deduce that maximizing diversification is a logical portfolio construction technique for cross-asset investments.

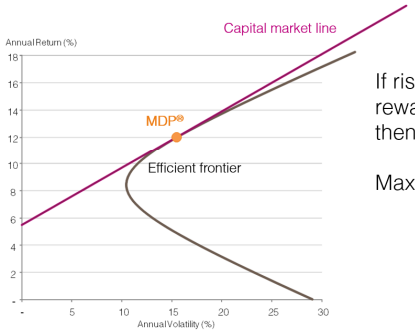
To be or not to be predictable? About Sharpe Ratios hierarchy, cross-asset allocation and Maximum Diversification®

Liquid, easily substituted, investments should, by arbitrage, yield the same return for each unit of risk invested in. While different asset classes are exposed to different types of risk (economic growth, financial stress, inflation, etc.), investors, by rebalancing their portfolios, are expected to apply the law of one price[1] across markets. In layman's terms investors are deemed to be rational investors and will invest in the asset which contributes the highest return for the same level of risk.

The Most Diversified Portfolio® is known to be mean-variance efficient under the "weakest assumption" ex-ante, i.e. the absence of an ability to predict risk-adjusted returns, in other words, precisely when expected risk-adjusted returns are equal across all assets of the universe (Choueifaty et al., 2013). Figure 1 illustrates the exact mechanism of this optimality.

Figure 1: Optimality of the Most Diversified Portfolio®

The Sharpe Portfolio under the weakest assumption



If risk is homogeneously rewarded across the universe, then:

Max DR(P)

$\Leftrightarrow$ Max $\frac{(w_1\sigma_1 + w_2\sigma_2 + \ldots + w_n\sigma_n)}{\sigma_P}$

$\Leftrightarrow$ Max $\frac{ER(P)}{\sigma_P}$

$\Leftrightarrow$ Max Sharpe Ratio

Source: TOBAM. The capital market line developed by Markovitz in the CAPM theory, represents portfolios that optimally combine risk and return. It reflects the expected return of a portfolio consisting of all possible proportions between the market portfolio and a risk-free asset. The market portfolio is completely diversified, carries only systematic risk and its expected return is equal to the expected

1. *The law of one price is the economic theory that states the **price** of an identical security, commodity or asset traded anywhere should have the same price regardless of location when currency exchange rates are taken into consideration, if it is traded in a free market with no trade restrictions.*

market return as a whole. Portfolios that fall on the capital market line (CML), in theory, optimize the risk/return relationship, thereby maximizing performance.

For the mean-variance efficiency property of the Most Diversified Portfolio® to hold in a multi-asset context, where discrepancies between asset classes risk are frequent, the risk-adjusted return must be homogenous across asset classes as well as within asset classes.

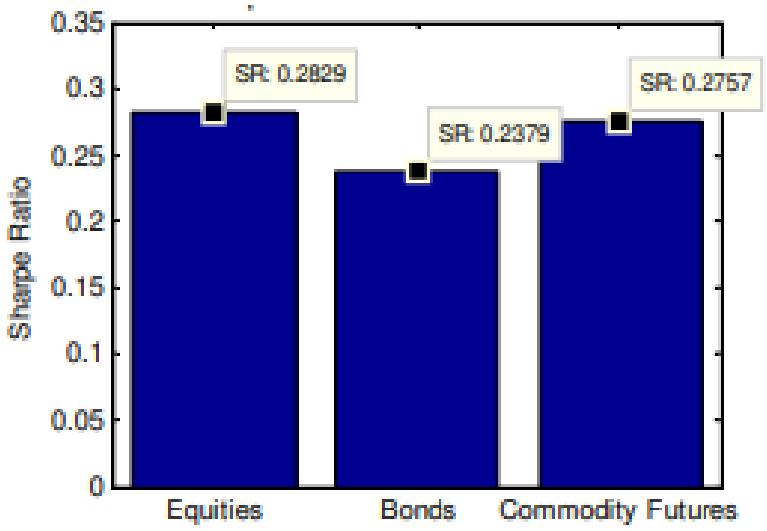
In the first section of this dashboard, we analyse empirical results at the asset class level to confirm that this assumption of homogeneous risk/return profile across asset classes is not rejected by empirical analysis. In the second section, we continue our investigation by looking at the empirical behaviours within and between asset classes at the security level.

1. Sharpe ratios between asset classes

This first section will look into the hierarchy of Sharpe ratios at the asset class level, with the aim to see whether the long-term asset returns can be used to draw conclusions on relative risk-adjusted returns. We draw here on a prolific body of research and, since this is not the focus of TOBAM's philosophy, will keep this section brief.

This topic has been investigated in academic and practitioner's literature. For instance, Figure 2 below from Partridge and Croce, 2012, plots Sharpe ratios between asset classes over the long term, from 1958 to 2011:

Figure 2: Sharpe Ratios across asset classes - 1958 – 2011



Source: Risk Parity for the Long Run (2012 – Partridge & Croce)

The Sharpe ratios shown here are very close, and can be considered as equal given the margins of error associated with long run estimates. There has been extensive research showing that long-run behaviour of equities and bonds is difficult to quantify with precision and that statistics pose numerous economic questions, see for instance Mehra–Prescott (1984), Pastor and Stambaugh

(2012) or Weil (1989). In particular, expected returns are particularly sensitive to the chosen assumptions, with an equity premium varying from 4% to 8% depending on the articles.

Given these limitations, looking at the hierarchy of Sharpe ratios at asset class levels still gives a first approximation on the subject of risk/return. The relevant information for constructing the MDP® however, are statistics on the remuneration of risk at the security level that we will show next.

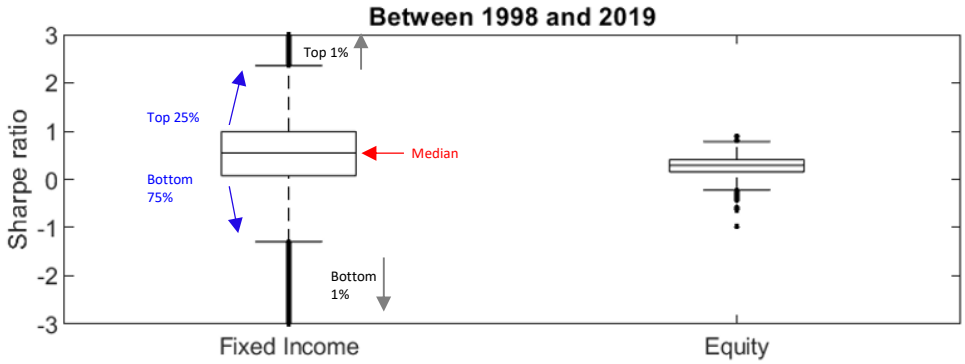
2. Risk-adjusted returns for individual bonds and stocks

Section 2 of this dashboard looks into the risk/reward profile at the single asset level to determine if the assumption that risk is equally rewarded across all assets is supported, or at least not rejected, by empirical analysis.

Over a 20-year sample, we computed the risk-adjusted returns for the stocks in the MSCI, and the corporate bonds in the BofA ML Corporate US index (Figure 3). We use box plots to sum up the distribution of the Sharpe ratios. The outer edges of each box are the first and third quartiles of the distribution while the median is the straight line bisecting the box. The outside dotted lines go up to 3 standard deviations, comprising of 98% of the distribution.

Over that period (from 1998 to 2019), notably with the global finance crisis included, Sharpe ratios have been relatively low (below 0.5 on average).

Figure 3: Sharpe ratios for bonds and equities (1998 to 2019)



Source: TOBAM, Bloomberg. Calculations from January 1998 to February 2019

Over the whole period, the median stock Sharpe ratio has been approximately 0.3, while for bonds the median Sharpe ratio has been 0.45. At first glance, the difference seems a little larger than the small one observed at the asset class level in the long run in the previous section.

The question when building a portfolio, however, is whether the differences observed in the past are stable and somehow an indicator of what will happen in the future.

We will proceed in two steps to verify this:

- First, we **split the universe into two equal periods**, from 1998 to 2008, and from 2008 to 2019 and observe if any pattern observed in the first period (Figure 4), remains relevant in the second period (Figure 5).

Sharpe ratios for bonds and equities

Figure 4: From 1998 to 2008

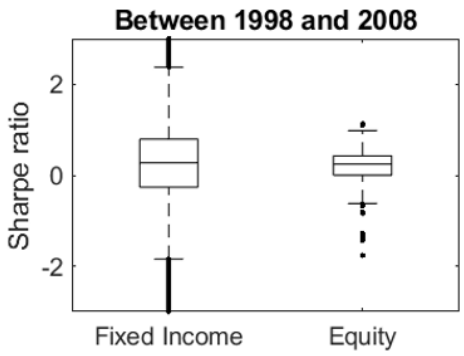
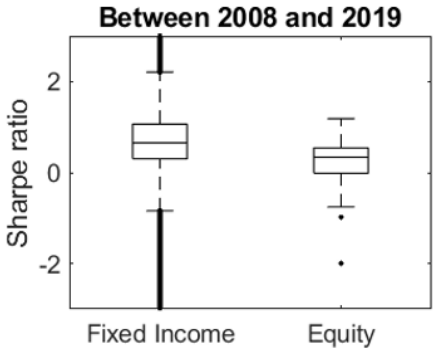


Figure 5: From 2008 to 2019

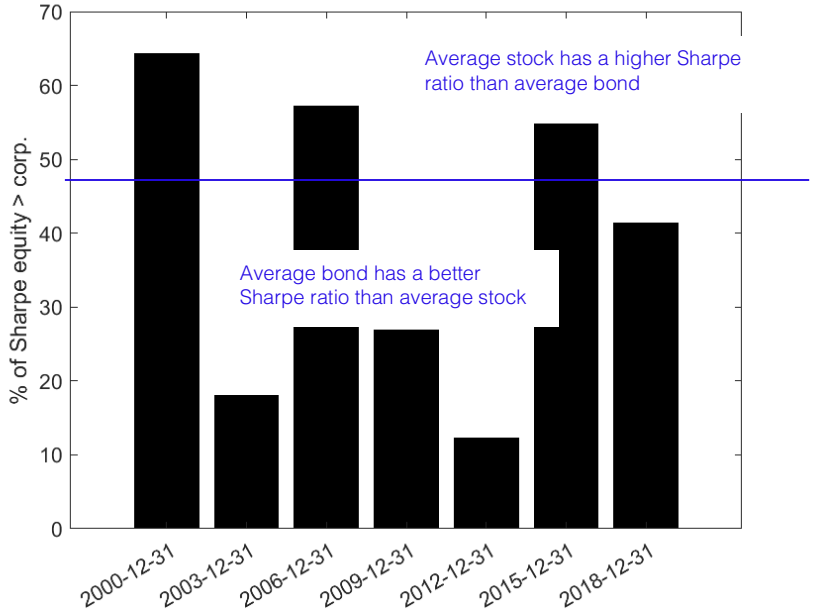


Source: TOBAM, Bloomberg. Calculations from January 1998 to February 2019

These two charts show that the difference is not consistent from one period to another. Over the ten years preceding the global financial crisis, equity Sharpe ratios exceeded bonds', while this relationship was reversed over the next ten years, which included quantitative easing and near zero interest rates.

- Second, we verify the stability of Sharpe ratios hierarchy between bonds and equity by looking at sub-periods of 3 years, and the share of individual stocks that over-perform individual corporate bonds over each identical 3-year sub-period. The reason for looking at 3-year period, is to match common practices in the fund industry when calculating Sharpe ratios. We split the sample into non-overlapping 3-year periods to perform individual comparisons.

Figure 6: Comparison of individual stocks and corporate bonds' Sharpe ratios on non-overlapping 3-year periods



Source: TOBAM and Bloomberg. Data calculations from January 1998 to February 2019.

The results are unstable: there is no persistent over or under-performance, of one asset class over another when examining the Sharpe ratios at the security level. In particular, the pattern doesn't seem to be predictable, and it would be difficult to make informed bets as to whether a bond or a stock will yield a better risk-adjusted return in the future.

3. Consequences for the Most Diversified Portfolio®

Though, in the long run, the Sharpe ratios across asset classes are comparable, they are less so over shorter investment cycles, when looking at individual stocks and bonds. It is still not possible, however, to predict for which assets the risk will be best remunerated in advance: the hierarchy of Sharpe ratio remains unknown in advance (ex-ante), and the Sharpe ratios largely overlap both within and across asset classes.

TOBAM's investment process involves maximizing diversification from a 100% bottom up perspective, and is agnostic as to macro-economic scenarios or future returns. In the absence of the capability to determine which asset class will outperform in a given period (as demonstrated empirically in section 1 and 2), we believe that the Maximum Diversification® approach is particularly well suited to a multi asset construction process. Indeed, the Most Diversified Portfolio® is the one which, given the uncertainty, maximizes the Sharpe ratio. This methodology has been applied to the Anti-Benchmark Multi-Asset strategy since its launch in December 2016.

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For more information

TOBAM is an asset management company offering innovative investment capabilities designed to increase diversification. Its mission is to provide rational and professional solutions to long term investors in the context of efficient markets.

The Maximum Diversification® approach, TOBAM's flagship investment process founded in 2006, is supported by original, patented research and a mathematical definition of diversification and provides clients with diversified core exposure, in both the equity and fixed income markets.

In line with its mission statement and commitment to diversification, TOBAM also launched a separate activity on cryptocurrencies in 2017.

TOBAM currently manages US$10 billion (at March 29, 2019). TOBAM's team is composed of 53 professionals.

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