

---

# Morningstar Portfolio Risk Scoring Methodology

---

## Morningstar Inc.

July 2022

### Contents

1	Overview
3	The Systematic Risk Spectrum
6	Calculating an MPRS
7	Analyzing a Portfolio
9	Base Risk Score
17	Morningstar Portfolio Risk Score
21	Mapping to Risk Comfort/Bands
23	Use Cases/Examples
31	Conclusion

---

Thomas Idzorek, CFA  
Chief Investment Officer—Retirement,  
Morningstar Investment Management LLC  
Thomas.Idzorek@morningstar.com

Paul Kaplan, Ph.D., CFA  
Director of Research, Canada,  
Morningstar Research, Inc.  
Paul.Kaplan@morningstar.com

Shawn Brayman, Chartered FP, MES  
Director of Financial Planning Methodology,  
Morningstar Research, Inc.  
Shawn.Brayman@morningstar.com

## Overview

The Morningstar Portfolio Risk Score, or MPRS, assesses risk and diversification to help investors, financial professionals, and those who oversee large groups of financial professionals to:

- ▶ better understand where a portfolio or investment lies on a well-defined, transparent, and independent risk spectrum,
- ▶ to test the portfolio's level of diversification versus an independent standard (Morningstar Target Allocation Indexes) and,
- ▶ to understand the underlying contributors to the risk in a portfolio.

It is designed to help assess whether the riskiness of the portfolio matches the risk profile of an investor. It has optimal value when combined with the Morningstar Risk Profiler and the personalized Risk Comfort Range of an investor but can be mapped to static investment policy bands and risk profilers that are independent from Morningstar. The Portfolio Risk Score enables investors to be matched with suitable portfolios that align with their respective risk profile.

At the heart of the system is a risk-scoring engine that is capable of automatically analyzing millions of portfolios and assigning a numeric risk score in which diversified asset-allocation portfolios typically receive a score ranging from 0 to 100. MPRS is highly correlated with the level of equity/risky assets, where 0 represents a cash portfolio and 100 represents a well-diversified 100% equity portfolio. Highly concentrated portfolios and asset-class-specific portfolios (such as, a small growth fund, a sector fund, a country-specific fund) will typically receive scores above 100, indicating higher levels of risk. Scores above 100 indicate high levels of risk and are probably not suitable to represent a complete investor portfolio. The score is based on the portfolio's relationship to an extended risk spectrum based on the Morningstar Target Allocation Index family.

The indexes of the Morningstar® Target Allocation Index Family, or MTAI, maintain a fixed level of equity exposure and are aligned with the Morningstar Category classifications for asset-allocation funds in each country. Each MTAI is an index of indexes. The underlying index weights are derived from eligible open-end funds in Morningstar's fund holdings data and therefore reflect the collective wisdom of the numerous asset managers producing asset-allocation funds in the relevant categories. While one cannot invest directly in the Morningstar Target Allocation Index Family, we believe the asset allocations embedded in these indexes represent appropriate asset-allocation portfolios for a wide variety of investors.

Separate Target Allocation Index Families are maintained for the United States, Canada, Australia, New Zealand, the United Kingdom, and Europe, supporting the release of MPRS in those markets. Note that in Canada, Fund Categories are determined by the Canadian Investment Funds Standards Committee, or CIFSC, rather than Morningstar.

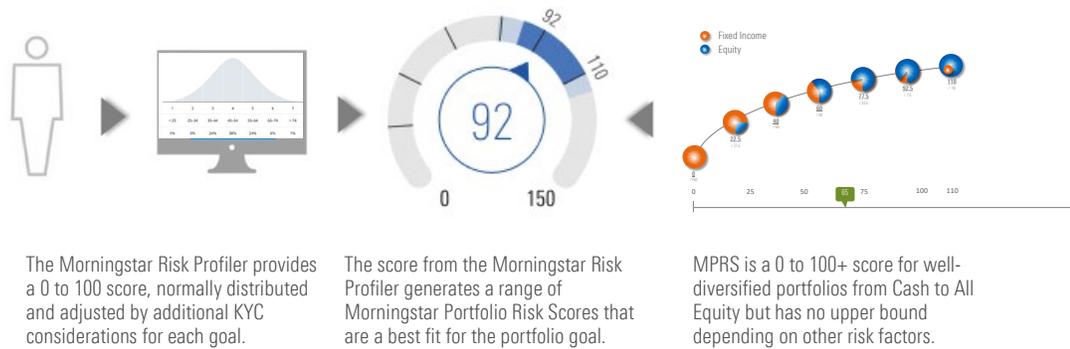
For a portfolio to be suitable, the MPRS should correspond closely with the investor's Risk Comfort Range, but the source of the risk must also be considered. For example, two portfolios with an MPRS of

---

80, where one is well structured with 80% equity and the other is poorly constructed with 40% equity and significant idiosyncratic or allocation misfit risk, are far from the same for client suitability. We have introduced a decomposition of MPRS on multiple levels to clarify the source of the risk. We also have surfaced the Alignment Score, which measures the risk resulting from any variance from the benchmark, concentration risk, and idiosyncratic risks within the portfolio/investment, measured on the same scale as MPRS itself.

While no system can guarantee portfolio quality nor ensure against losses, it can serve as an additional due-diligence tool for investors, financial professionals, compliance officers monitoring a large number of portfolios (or funds), and for regulators. The Morningstar Risk Ecosystem is depicted in Exhibit 1.

**Exhibit 1** Morningstar Risk Profiler and Portfolio Risk-Scoring Systems — The Advice Flow



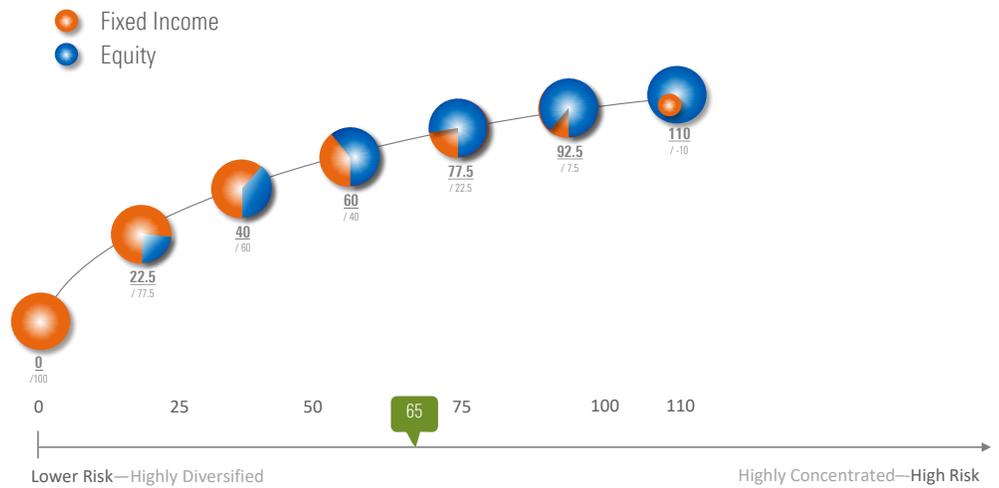
Source: Morningstar.

This document explains the methodology behind the MPRS (the right panel of Exhibit 1 above) for evaluating portfolios and determining if they align well with the asset allocations of the Morningstar Target Allocation Indexes.

### The Systematic Risk Spectrum

Portfolios have varying degrees of risk exposures, and the volatility present in the market evolves through time. The following graphic illustrates a stylized risk/expected return frontier. Moving from left to right along the systematic risk spectrum, we move from low risk to high risk. The far-left mix typically consists of all cash while the far-right asset-allocation mix represents a slightly levered, diversified all-equity mix. This systematic risk spectrum is based on the completely transparent Morningstar® Target Allocation Index Family and is depicted in Exhibit 2. The Morningstar Categories that serve as the anchor points vary across the different markets--U.S., Canada, the United Kingdom, and Europe--but in all cases result in a base risk spectrum ranging from 0 (lowest risk/cash) to 110 (110% equity).

**Exhibit 2** Systematic Risk Spectrum



Source: Morningstar

Portfolios/investments with a risk score greater than 110 may represent good investments but have risk that we believe exceeds that of a well-diversified equity portfolio and, as such, would generally not be suitable to represent a complete portfolio for most investors.<sup>1</sup>

### Morningstar® Target Allocation Indexes

In the United States, the United Kingdom, Australia, and New Zealand, Morningstar classifies target allocation funds using a five-category risk-based system.<sup>2</sup> Exhibit 3 presents the five categories in each of these markets.

<sup>1</sup> Here we refer to an equity portfolio that is well-diversified in terms of the characteristics of its holdings, rather than the inclusion of other asset classes.

<sup>2</sup> Morningstar uses a different system in Canada and in the eurozone, which we discuss later in this document.

**Exhibit 3** Morningstar Target Allocation Categories

Market	Category #1	Category #2	Category #3	Category #4	Category #5
United States	Very Conservative 15% to 30% Equity	Conservative 30% to 50%	Moderate 50% to 70%	Aggressive 70% to 85% Equity	Very Aggressive 85%+ Equity
United Kingdom	Cautious 0% to 20% equity	Moderately Cautious 20% to 40%	Moderate 40% to 60%	Moderately Adventurous 60% to 80%	Adventurous 80% to 100%
Australia	Multisector Conservative 0% to 20% equity	Multisector Moderate 20% to 40%	Multisector Balanced 40% to 60%	Multisector Growth 60% to 80%	Multisector Aggressive 80% to 100%
New Zealand	Multisector Conservative 0% to 20% equity	Multisector Moderate 20% to 40%	Multisector Balanced 40% to 60%	Multisector Growth 60% to 80%	Multisector Aggressive 80% to 100%

Source: Morningstar.

For each family of target allocation categories, Morningstar creates a corresponding family of multi-asset-class indexes, the Morningstar Target Allocation Indexes, or TAIs. The equity/fixed income split of each index is at the midpoint of the range for the target allocation category it represents. Each year, Morningstar calculates the sub-asset-class weights from the average weights of the funds in the category.<sup>3</sup> Exhibits 5, 6, 7, and 8 in the main text present the allocations of the five Target Allocation Indexes for the United States, the United Kingdom, Australia, and New Zealand, respectively. We label the five target allocation indexes TAI #1, TAI #2, TAI #3, TAI #4, and TAI #5, respectively. Note how the equity allocations of the target allocation indexes differ between the United States and the United Kingdom. This is due to differences in how the target allocation categories are defined in the two markets.

See Exhibit 4 for the names of the Target Allocation Indexes and security IDs, or Seclds, that Morningstar uses to identify them in its database. To save space, the names are abbreviated without the prefix "Morningstar" and the suffixes that indicate return type and currency. In the same way, these tables also show the abbreviated names and Seclds of the constituent indexes. (Here, return type is shown for hedged returns.) Note that while the abbreviated name of the index for Emerging Markets is the same for the U.S. and the U.K., the Seclds differ, reflecting the difference in currency. The Seclds of the Target Allocation Indexes can be used to obtain the weights and Seclds of the constituent indexes and their weights.

For the purpose of calculating the risk score, we add two additional Target Allocation Indexes to TAI #1, ..., TAI #5. To represent extremely low-risk portfolios, we add TAI #0, which is 100% cash. To represent extremely high-risk portfolios, we add TAI #6, which is 110% equity. We create TAI #6 from TAI #5 by uniformly increasing all the equity allocations to make them 110%, setting all the bond allocations to 0%, and setting the cash allocation to negative 10%.

<sup>3</sup> The target-risk indexes are reconstituted annually and rebalanced monthly.

**Exhibit 4** Morningstar Target Allocation Categories

<b>United States</b>		<b>United Kingdom</b>	
US Con Tgt Alloc	F000015CBX	UK Cau Tgt Alloc	F000015CBH
US Mod Con Tgt Alloc	F000015CC0	UK Mod Caut Tgt Alloc	F000015CBI
US Mod Tgt Alloc	F000015CBZ	UK Mod Tgt Alloc NR GBP	F000015CBK
US Mod Agg Tgt Alloc	F000015CC2	UK Mod Adv Tgt Alloc	F000015CBJ
US Agg Tgt Alloc	F000015CC1	UK Adv Tgt Alloc	F000015CBM
US Market	XIUSA0010V	UK Equity UK	F00000T63K
DM xUS	F00000S00	DM Europe xUK	F00000T00J
EM	F00000SNZ	DM xEurope	F000014VUA
US Core Bd	F0000119FA	EM Equity EM	F00000VN8X
Gbl xUS Core Bd GR Hdg	F000011P2G	UK Bonds UK Core Bd	F000011COA
US Cash	F0000113F1	Gbl xUK Core Bd GR Hdg	F000011P0T
		UK Cash	F00001130D
<b>Australia</b>		<b>New Zealand</b>	
AUS Con Tgt Alloc	F0000174LC	NZ Con Tgt Alloc	F0000174LG
AUS Mod Tgt Alloc	F0000174LE	NZ Con Tgt Alloc	F0000174LI
AUS Balance Tgt Alloc	F0000174LD	NZ Balance Tgt Alloc	F0000174LH
AUS Growth Tgt Alloc	F0000174LF	NZ Growth Tgt Alloc	F0000174LJ
AUS Agg Tgt Alloc	F0000174LB	NZ Agg Tgt Alloc	F0000174LA
Australia GR AUD	F00000T5UB	AU NZ 50/50 GR NZD	F0000103Q3
Gbl xAus NR AUD	F00000YXXC	Gbl xAus NR NZD	F0000165E8
Gbl xAus NR Hdg AUD	F0000165EC	New Zealand Real Est GR NZD	F0000103RF
Australia REIT GR AUD	F00000XPJQ		F000015YN8
Gbl Mkts xAus REIT NR AUD	F000015YMQ	Gbl Mkts xAus REIT NR NZD	F000014YLC
AU Core Bd GR AUD	F000011BLN	NZ Trsy Bd GR NZD	F000014YL2
Gbl xAU Core Bd GR Hdg AUD	F000011OVS	Gbl Core Bd GR Hdg NZD	F000014YL8
AU Cash GR AUD	F000011430	NZ Cash GR NZD	
<b>Canada</b>		<b>Europe</b>	
<u>Local Categories</u>		<u>Local Categories</u>	
Balanced Can FI Tgt Alloc	F000015CBS	EU Cau Tgt Alloc	F000015CBL
Can Neut Tgt Alloc	F000015CBT	EU Mod Tgt Alloc	F000015CBN
Can Equity Tgt Alloc	F000015CBU	EU Agg Tgt Alloc	F000015CBO
<u>Global Categories</u>		<u>Global Categories</u>	
Can FI Gbl Tgt Alloc	F000015CBW	EU Cau Gbl Tgt Alloc	F000015CBP
Can Neu Gbl Tgt Alloc	F000015CBV	EU Mod Gbl Tgt Alloc	F000015CBQ
Can Eq Gbl Tgt Alloc	F000015CBY	EU Agg Gbl Tgt Alloc	F000015CBR
Canada	F00000T5V0	DM Europe	F00000T5WI
US Market	F00000ZXLX	DM xEurope	F000014VU7
DM xNA	F00000VN70	EM NR EUR	F00000VN8W
EM	F00000VN8U	EZN Core Bd	F000011C1Z
Can Core Bd	F000011Y00	Gbl xEZN Core Bd GR H	F0000110YD
Gbl xCan Core Bd GR Hdg	F000011YDT	EUR Cash	F0000113JL
Can Cash	F000011Y0U		

Source: Morningstar.

## Calculating Morningstar Portfolio Risk Score

### Identifying a Portfolio

The process for calculating an MPRS begins by identifying the investments—mutual funds, ETFs, individual securities, and so on—in the portfolio. When deployed for home office analytics and monitoring, portfolios are typically identified using information from the Morningstar system or a template using Morningstar's unique security identification system. When deployed for direct use by a financial professional (or an individual investor), these users can leverage existing client portfolios or model portfolios or upload them using an import feature. Alternatively, they can analyze portfolios on the fly by entering portfolio positions.

The MPRS can also be calculated for managed investment products such as open-end mutual funds, ETFs, CITs, separately managed accounts, variable annuity subaccounts, segregated funds, and pooled funds.

The automated analysis of a portfolio is dependent on Morningstar having at least 24 months (preferably 48 months) of trailing returns for the current constituents (mutual funds, ETFs, individual securities, and so on) of a portfolio. In general, for a portfolio to receive a Morningstar Portfolio Risk Score, the scoring engine requires Security IDs for 100% of the portfolio.

There are checks in place to determine whether the portfolio to be scored contains a sufficient returns history. If an insufficient history exists, we would not be confident in the score and would not score the portfolio/fund in question. For funds or ETFs, the process is to simply score anything with more than 24 months' worth of return history and utilize proxy data based on the category average returns to fill in missing return history (to the extent that the less than 24 months' worth of actual history falls short of 48 months of actual return history).

For a client (bespoke) portfolio, we use a special process to determine whether to score the portfolio or not. Since there may be several constituents in a client portfolio, to determine whether to score or not, we multiply the weight of each constituent in the portfolio by the number of actual months of return history it has. The portfolio will be scored if the weighted sum meets or exceeds 24 months and not scored if it is less than 24 months. For portfolios that will be scored, the constituents that are missing return history will use proxy data based on the category average for each constituent to the extent that their individual returns history is less than 48 months. The constituents' return histories are then rolled up into a composite return history for the portfolio for 48 months, which is the return history ultimately used for the subsequent analysis.

Some examples of what this might mean for a bespoke portfolio are:

- A custom portfolio with five constituents where each constituent has exactly 24 months of return history would have the remaining history proxied based on category averages for each of the constituents and would be scored.
- A custom portfolio with 50% of the portfolio held in one holding with a full 48 months of return history and other constituents with one month of history would be scored. The constituents with one month of returns would have 47 months of return history based on their respective category averages.

## Methodology for Analyzing a Portfolio

The MPRS Scoring System uses a hybrid holdings-based/returns-based-style analysis approach to evaluate a portfolio's level of risk and diversification. Once the holdings (individual securities or pooled investment vehicles) of a portfolio are identified, a custom return composite is constructed based on the current holdings. If the portfolio is a single security or fund, the return composite is simply the returns of the security or funds. This custom holdings-based return composite is then analyzed using returns-based-style analysis as put forth in Sharpe [1988, 1992].

Sharpe's returns-based-style analysis, a specialized multi-factor model, enables investors to determine a portfolio's effective asset mix using nothing more than historical returns and the historical returns of a broad set of asset class indexes. The method described by Sharpe is a powerful and popular tool for determining the behavior (investment style) of portfolios and evaluating their performance. More formally, return-based-style analysis takes the form:

$$r_{p,t} = x_1 a_{1,t} + x_2 a_{2,t} + \dots + x_K a_{K,t} + e_t \quad (1)$$

Where

$r_{p,t}$  is the return of the portfolio for  $t = 1, 2, \dots, T$ ;  $T$  being the number of months, which is usually 48  
 $c_1, \dots, c_K$  are the asset class coefficients for  $k = 1, 2, \dots, K$ ;  $K$  being the number of asset class indexes  
 $a_{1,t}, \dots, a_{K,t}$  are the period  $t$  returns for the  $K$  asset class indexes; and,  
 $e_t$  is the excess return at time  $t$  (for example, the portion of the return that is not explained by the returns of the  $K$  asset classes).

Returns-based-style analysis determines the asset class coefficients ( $x_1, \dots, x_K$ ) that minimize the variance of the excess return series ( $e_t$ ), typically subject to  $x_k \geq 0$  for  $k = 1, 2, \dots, K$ , and  $x_1 + x_2, \dots, x_K = 1$ . In other words, the values of the individual coefficients, or exposures, to the  $K$  asset classes are equal to or greater than 0 and sum to 1. These asset class exposures form what is referred to as the effective asset allocation of the portfolio.

### Post-RBSA Regression

We use the RBSA results to form a custom benchmark for the portfolio. The returns on this benchmark are given by:

$$r_{b,t} = x_1 a_{1,t} + x_2 a_{2,t} + \dots + x_K a_{K,t} \quad (2)$$

Where

$r_{b,t}$  is the return of the benchmark for  $t = 1, 2, \dots, T$

We then regress the benchmark returns on the portfolio returns:

$$r_{p,t} = \alpha + \beta r_{b,t} + u_t \quad (3)$$

Where  $u_t$  is the residual term of the regression.

We use three results from this regression in the calculation of the risk score:

- 1)  $\beta$ . We use the estimated beta coefficient in the calculation of the systematic risk of the portfolio (for well-diversified portfolios, beta is close to 1).
- 2) The standard error of the regression (estimate of the standard deviation of  $u$ ), which we denote  $\sigma_u$ . This is our estimate of unsystematic/idiosyncratic risk.

- 3)  $R^2$ . The goodness-of-fit measure. We use this to determine the degree of confidence in the RBSA model and to set a floor for the Portfolio Risk Score.

### Base Risk Score

The next step to calculate the MPRS is the Base Risk Score. The Base Risk Score only considers systematic risk.

The main output from the RBSA is the effective asset mix or effective asset allocation of the portfolio. This is the  $K$ -element vector of weights on the asset class indexes included in the RBSA analysis, which we denote  $\vec{x}_p$ .

Within a given country/region, we use the longest possible common period of asset index returns to estimate the  $K \times K$  covariance matrix of asset class returns, which we denote  $\mathbf{V}$ . We calculate the systematic risk of the portfolio as follows:

$$\sigma_S = |\beta| \sqrt{\vec{x}_p' \mathbf{V} \vec{x}_p} \quad (4)$$

$\beta$  being the slope coefficient in equation 3.

We calculate the variance for each of the Morningstar® Target Allocation Indexes in the given family, and, when appropriate, various asset mixes based on the corresponding index family. As depicted above in Exhibit 2, within a given country/region we identify seven anchor points, in which the equity exposure of these seven points corresponds directly to the Base Risk Score and range from 0 to 110.

Let:

$\vec{x}_j^{TAI}$	= the $K$ -element vector of asset class weights for Target Allocation Index # $j$
$(\sigma_j^{TAI})^2$	= the variance of Target Allocation Index # $j$
$\widehat{RS}_j^{TAI}$	= the Base Risk Score of Target Allocation Index # $j$ = percentage of $\vec{x}_j^{TAI}$ . This is its equity allocation
$\widehat{RS}_p$	= the Risk Score of the portfolio

The variance of Target Allocation Index # $j$  is:

$$(\sigma_j^{TAI})^2 = \vec{x}_j^{TAI'} \mathbf{V} \vec{x}_j^{TAI} \quad (5)$$

The last row of Exhibits 5, 6, 7, and 8 give the Base Risk Scores for the U.S., U.K., Australia, and New Zealand TAI, respectively, which are their equity allocations. As we discuss below, the Base Risk Scores of the U.S. TAIs are also the Base Risk Scores for the Canadian TAIs; Base Risk Scores of the U.K. TAIs are Base Risk Scores in all other markets.

If  $\sigma_S > \sigma_6^{TAI}$ , we set the Base Risk Score of the portfolio to the base risk score of Target Allocation Index #6 so that  $\widehat{RS}_p = \widehat{RS}_6^{TAI} = 110$ . Similarly, if  $\sigma_S < \sigma_0^{TAI}$ , we set  $\widehat{RS}_p = \widehat{RS}_0^{TAI} = 0$ . For values of  $\sigma_S$  between  $\sigma_0^{TAI}$  and  $\sigma_6^{TAI}$ , we find the consecutive pair of Target Allocation Indexes, # $j$  and # $(j+1)$  such that:

$$\sigma_j^{TAI} \leq \sigma_S \leq \sigma_{j+1}^{TAI}$$

We seek a linear combination of the consecutive Target Allocation Indexes so that it has the same variance as the portfolio. Let  $\theta$  be the weight on Target Allocation Index  $\#(j+1)$  so that  $1-\theta$  is the weight on Target Allocation Index  $\#j$ . To calculate the base risk score, we solve the following equation for  $\theta$ :

$$\left( (1-\theta)\vec{x}_j^{TRJ} + \theta\vec{x}_{j+1}^{TRJ} \right)' \mathbf{V} \left( (1-\theta)\vec{x}_j^{TRJ} + \theta\vec{x}_{j+1}^{TRJ} \right) = \sigma_S^2 \quad (6)$$

This is a quadratic equation, so it can be solved with the quadratic formula. The coefficients for the quadratic formula are:

$$a = (\vec{x}_{j+1}^{TAI} - \vec{x}_j^{TAI})' \mathbf{V} (\vec{x}_{j+1}^{TAI} - \vec{x}_j^{TAI}) \quad (7a)$$

$$b = 2\vec{x}_j^{TAI}' \mathbf{V} (\vec{x}_{j+1}^{TAI} - \vec{x}_j^{TAI}) \quad (7b)$$

$$c = \vec{x}_j^{TAI}' \mathbf{V} \vec{x}_j^{TAI} - \sigma_S^2 \quad (7c)$$

Applying the quadratic formula, we have:

$$\theta = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (8)$$

The Base Risk Score of the portfolio is:

$$\widehat{RS}_p = (1-\theta)\widehat{RS}_j^{TAI} + \theta\widehat{RS}_{j+1}^{TAI} \quad (9)$$

When we discuss calculating the base risk score for the Canadian and eurozone markets below, it will be helpful to define a Base Risk Score function. For this function, we define the matrix of the set of seven Target Allocation Indexes (each column being a Target Allocation Index allocation) as  $\mathbf{X}^{TAI}$ . The Risk Score Function,  $\widehat{RS}(\cdot; \cdot)$  is:

$$\widehat{RS}(\vec{x}_p, \beta; \mathbf{X}^{TAI}) = \widehat{RS}_p \text{ using } \mathbf{X}^{TAI} \quad (10)$$

### Alignment Measure

Another useful measure is the Alignment Measure,  $AM_p$ , which measures how well aligned the asset mix is with the set of TAls, as represented by the blended pair of TAls in the calculation of the Base Risk Score. The Alignment Measure is basically the distance between the asset mix of the portfolio and the blended pair of TAls. Let  $\vec{x}_B$  denote the vector of asset class weights that result from the calculation of the Base Risk Score. We have:

$$\vec{x}_B = \begin{cases} \vec{x}_0^{TAI}, & \text{if } \sigma_S < \sigma_0^{TAI} \\ (1-\theta)\vec{x}_j^{TAI} + \theta\vec{x}_{j+1}^{TAI}, & \text{if } \sigma_0^{TAI} \leq \sigma_S \\ \vec{x}_6^{TAI}, & \text{if } \sigma_S > \sigma_0^{TAI} \end{cases} \quad (11)$$

The Alignment Measure is:

$$AM_p = \sqrt{(\beta\vec{x}_p - \vec{x}_B)' \mathbf{V} (\beta\vec{x}_p - \vec{x}_B)} \quad (12)$$

Like the Base Risk Score, the Alignment Measure can also be expressed as a function:

$$AM(\vec{x}_P, \beta; X^{TAI}) = AM_P \text{ using } X^{TAI} \quad (13)$$

**Exhibit 5** Morningstar United States Target Allocation Index Family

Asset Classes	Left Extension Target Allocation	Morningstar® US Conservative		Morningstar® US Moderately		Morningstar® US Aggressive		Right Extension Target Allocation
		Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	
		Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	
US Equities	0.0%	17.5%	29.0%	47.5%	55.0%	68.5%	81.5%	
Developed ex US Equity	0.0%	5.0%	9.0%	10.0%	17.5%	19.0%	22.6%	
Emerging Markets Equity	0.0%	0.0%	2.0%	2.5%	5.0%	5.0%	5.9%	
US Bonds	0.0%	59.0%	45.5%	30.5%	15.5%	4.0%	0.0%	
Global Bonds ex US	0.0%	12.5%	9.5%	4.0%	3.0%	0.5%	0.0%	
Cash	100.0%	6.0%	5.0%	5.5%	4.0%	3.0%	-10.0%	
Total Equity Weight	0.0%	22.5%	40.0%	60.0%	77.5%	92.5%	110.0%	
Total Fixed Income Weight	100.0%	77.5%	60.0%	40.0%	22.5%	7.5%	-10.0%	
<b>Portfolio Risk Score</b>	<b>0</b>	<b>22.5</b>	<b>40</b>	<b>60</b>	<b>77.5</b>	<b>92.5</b>	<b>110</b>	

Source: Morningstar.

**Exhibit 6** Morningstar United Kingdom Target Allocation Index Family

Asset Classes	Left Extension Target Allocation	Morningstar® UK Cautious		Morningstar® UK Moderately		Morningstar® UK Adventurous		Right Extension Target Allocation
		Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	
		Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	
UK Equity	0.0%	3.5%	9.5%	15.0%	22.0%	24.5%	29.9%	
Dev. Europe Equity ex UK	0.0%	1.5%	4.5%	7.5%	9.5%	12.0%	14.7%	
Dev. Equity ex Europe	0.0%	5.0%	13.5%	24.0%	33.0%	44.0%	53.8%	
Emerging Market Equity	0.0%	0.0%	2.5%	3.5%	5.5%	9.5%	11.6%	
UK Bonds	0.0%	28.0%	19.0%	13.5%	8.0%	1.5%	0.0%	
Global Bonds ex UK	0.0%	49.0%	39.5%	27.0%	13.5%	4.0%	0.0%	
Cash	100.0%	13.0%	11.5%	9.5%	8.5%	4.5%	-10.0%	
Total Equity Weight	0.0%	10.0%	30.0%	50.0%	70.0%	90.0%	110.0%	
Total Fixed Income Weight	100.0%	90.0%	70.0%	50.0%	30.0%	10.0%	-10.0%	
<b>Portfolio Risk Score</b>	<b>0</b>	<b>10</b>	<b>30</b>	<b>50</b>	<b>70</b>	<b>90</b>	<b>110</b>	

Source: Morningstar.

**Exhibit 7** Morningstar Australia Target Allocation Index Family

Asset Classes	Left Extension Target Allocation	Morningstar® Australia Conservative		Morningstar® Australia Moderate		Morningstar® Australia Balanced		Morningstar® Australia Growth		Right Extension Target Allocation
		Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	
		Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	Target Allocation	Index <sup>SM</sup>	
AU Equity	0.0%	6.5%	11.5%	20.0%	30.0%	36.5%	44.6%			
Intl Equity Unhdgd	0.0%	2.0%	10.0%	17.5%	23.5%	33.5%	40.9%			
Intl Equity Hdgd	0.0%	0.5%	4.0%	7.5%	10.0%	14.0%	17.1%			
AU Prop	0.0%	1.0%	2.5%	2.5%	3.5%	2.5%	3.1%			
Intl Prop Hdgd	0.0%	0.0%	2.0%	2.5%	3.0%	3.5%	4.3%			
Dom Fixed Inc	0.0%	54.0%	34.5%	24.5%	13.5%	3.0%	0.0%			
Intl Fixed Inc Hdgd	0.0%	6.0%	16.0%	14.0%	8.0%	2.5%	0.0%			
Cash	100.0%	30.0%	19.5%	11.5%	8.5%	4.5%	-10.0%			
Total Equity Weight	0.0%	10.0%	30.0%	50.0%	70.0%	90.0%	110.0%			
Total Fixed Income Weight	100.0%	90.0%	70.0%	50.0%	30.0%	10.0%	-10.0%			
<b>Morningstar Portfolio Risk Score</b>	<b>0</b>	<b>10</b>	<b>30</b>	<b>50</b>	<b>70</b>	<b>90</b>	<b>110</b>			

Source: Morningstar.

**Exhibit 8** Morningstar New Zealand Target Allocation Index Family

Asset Classes	Left Extension Target Allocation	Morningstar® New Zealand					Right Extension Target Allocation
		Morningstar® Conservative Target Allocation Index <sup>SM</sup>	Morningstar® New Zealand Moderate Target Allocation Index <sup>SM</sup>	Morningstar® New Zealand Balanced Target Allocation Index <sup>SM</sup>	Morningstar® New Zealand Growth Target Allocation Index <sup>SM</sup>	Morningstar® New Zealand Aggressive Target Allocation Index <sup>SM</sup>	
AU+NZ Equity	0.0%	3.5%	11.0%	15.0%	22.0%	22.0%	26.9%
Intl Equity	0.0%	6.5%	15.5%	31.5%	42.5%	61.5%	75.2%
NZ Prop	0.0%	0.0%	2.0%	1.5%	3.0%	3.0%	3.7%
Intl Prop	0.0%	0.0%	1.5%	2.0%	2.5%	3.5%	4.3%
NZ Fixed Inc	0.0%	25.5%	28.5%	16.0%	10.0%	2.0%	0.0%
Intl Fixed Inc Hdgd	0.0%	39.0%	23.0%	23.0%	12.0%	3.0%	0.0%
Cash	100.0%	25.5%	18.5%	11.0%	8.0%	5.0%	-10.0%
Total Equity Weight	0.0%	10.0%	30.0%	50.0%	70.0%	90.0%	110.0%
Total Fixed Income Weight	100.0%	90.0%	70.0%	50.0%	30.0%	10.0%	-10.0%
<b>Morningstar Portfolio Risk Score</b>	<b>0</b>	<b>10</b>	<b>30</b>	<b>50</b>	<b>70</b>	<b>90</b>	<b>110</b>

Source: Morningstar.

**Canada and the Eurozone**

Recall that we defined the Risk Score Function and the Alignment Measure Function as functions of: 1) the asset-allocation vector of the portfolio in question  $\vec{x}_P$ , and 2) the matrix of target allocation indexes,  $\mathbf{X}^{TAI}$ . However, for Canada and the eurozone, we have two sets of target allocation indexes. Hence, we need to take both sets of target allocation indexes into account when calculating the Risk Score and the Alignment Measure. Let  $\mathbf{X}_L^{TAI}$  and  $\mathbf{X}_G^{TAI}$  be the matrices of target allocation indexes for the Local and Global biases, respectively. To calculate the Risk Score and the Alignment Measure for Canada and the eurozone, we take the linear combination of  $\mathbf{X}_L^{TAI}$  and  $\mathbf{X}_G^{TAI}$  that minimizes the Alignment Measure. We introduce an additional variable,  $\lambda_P$ , which we call the Global Tilt, defined as follows:

$$\lambda_P = \arg \min_{0 \leq \lambda \leq 1} AM(\vec{x}_P; (1 - \lambda)\mathbf{X}_L^{TAI} + \lambda\mathbf{X}_G^{TAI}) \quad (14)$$

We can then calculate the Base Risk Score as follows:

$$\widehat{RS}_P = \widehat{RS}(\vec{x}_P, \beta; (1 - \lambda_P)\mathbf{X}_L^{TAI} + \lambda_P\mathbf{X}_G^{TAI}) \quad (15)$$

*Target Allocation Indexes for Canada and the Eurozone*

The number of categories and the equity ranges of each category is not standardized throughout the world. For target allocation funds in Canada and the eurozone, rather than having five categories, Morningstar has two sets of three each.<sup>4</sup> The two sets are local (for funds that have a strong home country bias), and global (for funds that are more geographically balanced.) Within each of these sets, there are indexes for conservative, moderate, and aggressive levels of risk. Exhibits 9 and 11 display the asset mixes for Canadian and eurozone indexes, respectively.

From each market (Canada and the eurozone) and for each set of three indexes (local and global), we derive TAI #1, TAI #2, ..., TAI #5. As explained below, we use both sets of TAI #1, TAI #2, ..., TRI #5 to calculate the Risk Score and the Alignment Score.

The derivation of TAI #1, TAI #2, ..., TAI #5 differ between Canada and the eurozone, so we describe them separately.

<sup>4</sup> In Canada, Morningstar does not define fund categories. Rather, they are defined by the industrywide Canadian Investment Funds Standard Committee, or CIFSC, of which Morningstar is a member.

### Canada

For Canada, we form a set of target allocation indexes that align with those of the U.S. in that their equity allocations are the same as those shown in Exhibit 5. Let  $\vec{x}_q^R$  denote asset mix of the category index with regional bias  $R$  (Local or Global) with equity allocation (and therefore Risk Score)  $q$  percent. Since TAI #1 for the U.S. is 22.5% and the equity allocation of the first category index for Canada is also 22.5%, we set

$$\vec{x}_1^{TAI,R} = \vec{x}_{22.5}^R \quad (16)$$

Note that we have added  $R$  to the superscript of the Target Allocation Index allocation vector to show that the calculation is for each set of regionally biased Target Allocation Indexes.

TAI #2 should have an equity allocation of 40%. Since this falls between the equity allocations of the first two category indexes of 22.5 and 50, respectively, we calculate TAI #2 by interpolation:

$$\vec{x}_2^{TAI,R} = \frac{50-40}{50-22.5} \vec{x}_{22.5}^R + \frac{40-22.5}{50-22.5} \vec{x}_{50}^R \quad (17)$$

Similarly, TAI #3 should have an equity allocation of 60%. Since this falls between the equity allocations of the second and third category indexes of 50 and 75, respectively, we calculate TAI #3 by interpolation:

$$\vec{x}_3^{TAI,R} = \frac{75-60}{75-50} \vec{x}_{50}^R + \frac{60-50}{75-50} \vec{x}_{75}^R \quad (18)$$

The equity allocation of TAI #4 should be 77.5%. Since this is greater than the equity allocation of the third category index (75%), we cannot use interpolation. Instead, we reallocated between the equity and fixed-income allocations of the third category index (75% equity). To show how we do this, we need to introduce some new notation. For an allocation vector  $\vec{x}$ ,  $\vec{x}\langle EQ \rangle$  and  $\vec{x}\langle FI \rangle$  denote the equity and fixed-income sub-vectors, respectively, so that:

$$\vec{x} = \begin{bmatrix} \vec{x}\langle EQ \rangle \\ \vec{x}\langle FI \rangle \end{bmatrix}$$

We derive TAI #4 from the third category index (equity allocation 75%) by reallocating the equity and fixed-income allocations of the category index to bring the equity allocation of TAI #4 to 77.5%:

$$\vec{x}_4^{TAI,R} = \begin{bmatrix} \frac{77.5}{75} \vec{x}_{75}^R\langle EQ \rangle \\ \frac{22.5}{25} \vec{x}_{75}^R\langle FI \rangle \end{bmatrix} \quad (19)$$

We also derive TAI #5 from the third category index (equity allocation 75%) by reallocating the equity and fixed-income allocations of the category index to bring the equity allocation of TAI #5 to 92.5%:

$$\vec{x}_5^{TAI,R} = \begin{bmatrix} \frac{92.5}{75} \vec{x}_{75}^R\langle EQ \rangle \\ \frac{7.5}{25} \vec{x}_{75}^R\langle FI \rangle \end{bmatrix} \quad (20)$$

As with all markets, TAI #0 is 100% cash and TAI #6 is 110% equity, no bonds, and negative 10% cash. For Canada, TAI #6 is derived from TAI #5 in the same manner as it is for the U.S.

Exhibit 10 shows the derived target allocation indexes (Anchor Points) for Canada with both the Local and Global biases.

### Exhibit 9 Morningstar Canada Target Allocation Index Family

Asset Classes	Domestic			Global		
	Morningstar® Canadian Fixed Income Balanced Target Allocation	Morningstar® Canadian Neutral Balanced Target	Morningstar® Canadian Equity Balanced Target	Morningstar® Global Fixed Income Balanced Target Allocation	Morningstar® Global Neutral Balanced Target	Morningstar® Global Equity Balanced Target
	Index <sup>SM</sup>	Allocation Index <sup>SM</sup>	Allocation Index <sup>SM</sup>	Index <sup>SM</sup>	Allocation Index <sup>SM</sup>	Allocation Index <sup>SM</sup>
Canadian Equity	10.0%	31.5%	49.5%	6.5%	12.5%	19.5%
US Equity	7.5%	13.0%	17.5%	10.0%	22.5%	30.5%
DM x NA Equity	5.0%	5.5%	6.5%	6.0%	12.5%	20.0%
Emerging Markets Equity	0.0%	0.0%	1.5%	0.0%	2.5%	5.0%
CA Bonds	54.5%	34.0%	17.5%	42.5%	23.5%	12.0%
Global Bonds ex Canada	16.0%	10.5%	3.5%	28.5%	20.5%	8.5%
Cash	7.0%	5.5%	4.0%	6.5%	6.0%	4.5%
Total Equity Weight	22.5%	50.0%	75.0%	22.5%	50.0%	75.0%
Total Fixed Income Weight	77.5%	50.0%	25.0%	77.5%	50.0%	25.0%
<b>Portfolio Risk Score</b>	<b>22.5</b>	<b>50</b>	<b>75</b>	<b>22.5</b>	<b>50</b>	<b>75</b>

Source: Morningstar.

While the published indexes in Exhibit 9 are well-suited for benchmarking funds in the corresponding categories, to create something akin to global consistency for the risk scoring system across countries/regions, we translate each of these into seven corresponding anchor points as depicted in Exhibit 10.

### Exhibit 10 Canadian Target Allocation Anchor Points

Asset Classes	Canadian Anchor Points With Domestic Home Bias						
	Anchor Point 0	Anchor Point 1	Anchor Point 2	Anchor Point 3	Anchor Point 4	Anchor Point 5	Anchor Point 6
Canadian Equity	0.0%	10.0%	23.7%	38.7%	51.2%	61.1%	72.6%
US Equity	0.0%	7.5%	11.0%	14.8%	18.1%	21.6%	25.7%
DM x NA Equity	0.0%	5.0%	5.3%	5.9%	6.7%	8.0%	9.5%
Emerging Markets Equity	0.0%	0.0%	0.0%	0.6%	1.6%	1.9%	2.2%
Canadian Bonds	0.0%	54.5%	41.5%	27.4%	15.8%	5.3%	0.0%
Global Bonds ex Canada	0.0%	16.0%	12.5%	7.7%	3.2%	1.1%	0.0%
Cash	100.0%	7.0%	6.0%	4.9%	3.6%	1.2%	-10.0%
Total Equity Weight	0.0%	22.5%	40.0%	60.0%	77.5%	92.5%	110.0%
Total Fixed Income Weight	100.0%	77.5%	60.0%	40.0%	22.5%	7.5%	-10.0%
<b>Portfolio Risk Score</b>	<b>0</b>	<b>22.5</b>	<b>40</b>	<b>60</b>	<b>77.5</b>	<b>92.5</b>	<b>110</b>

Asset Classes	Canadian Anchor Points With Global Bias						
	Anchor Point 0	Anchor Point 1	Anchor Point 2	Anchor Point 3	Anchor Point 4	Anchor Point 5	Anchor Point 6
CA Equity	0.0%	6.5%	10.3%	15.3%	20.2%	24.1%	28.6%
US Equity	0.0%	10.0%	18.0%	25.7%	31.5%	37.6%	44.7%
DM x NA Equity	0.0%	6.0%	10.1%	15.5%	20.7%	24.7%	29.3%
EM Equity	0.0%	0.0%	1.6%	3.5%	5.2%	6.2%	7.3%
CA Bonds	0.0%	42.5%	30.4%	18.9%	10.8%	3.6%	0.0%
Non-CA Bonds	0.0%	28.5%	23.4%	15.7%	7.7%	2.6%	0.0%
Cash	100.0%	6.5%	6.2%	5.4%	4.1%	1.4%	-10.0%
Total Equity Weight	0.0%	22.5%	40.0%	60.0%	77.5%	92.5%	110.0%
Total Fixed Income Weight	100.0%	77.5%	60.0%	40.0%	22.5%	7.5%	-10.0%
<b>Portfolio Risk Score</b>	<b>0</b>	<b>22.5</b>	<b>40</b>	<b>60</b>	<b>77.5</b>	<b>92.5</b>	<b>110</b>

Source: Morningstar.

When applied to Canadian funds and portfolios, the Base Risk Score is based on the relationship of a portfolio's effective asset allocation to these anchor points, both because of the blend of two adjacent Anchor Points and the blend of Domestic and Global Bias.

### The Eurozone

As with Canada, the published European indexes, shown in Exhibit 11, are well-suited for benchmarking funds in the corresponding categories. From these, we form a set of target allocation indexes that align with those of the U.K. in that their equity allocations are the same as those shown in Exhibit 6.

Since the equity allocation of TAI #1 is 10%, which is lower than the equity allocation of the first category index (25%), we derive TAI #1 by reallocating between the equity and fixed-income allocations of the first category index:

$$\vec{x}_1^{TAI,R} = \begin{bmatrix} \frac{10}{17.5} \vec{x}_{25}^R(EQ) \\ \frac{90}{82.5} \vec{x}_{25}^R(FI) \end{bmatrix} \quad (21)$$

Since the equity allocation of TRI #2 is 30%, which falls between the equity allocations of the first and second category indexes (17.5 and 50%, respectively), we derived TRI #2 from these category indexes by interpolation:

$$\vec{x}_2^{TAI,R} = \frac{50-30}{50-17.5} \vec{x}_{17.5}^R + \frac{30-17.5}{50-17.5} \vec{x}_{50}^R \quad (22)$$

Since the equity allocation of TAI #3 is the same as that of the second category index (50%), we equate them:

$$\vec{x}_3^{TAI,R} = \vec{x}_{50}^R \quad (23)$$

Since the equity allocation of TAI #4 is 70%, which falls between the equity allocations of the second and third category indexes (50 and 82.5%, respectively), we derived TRI #4 from these category indexes by interpolation:

$$\vec{x}_4^{TAI,R} = \frac{82.5-70}{82.5-50} \vec{x}_{50}^R + \frac{70-50}{82.5-50} \vec{x}_{82.5}^R \quad (24)$$

Since the equity allocation of TAI #5 is 90%, which is greater than the equity allocation of the third category index (82.5%), we derive TAI #5 by reallocating between the equity and fixed-income allocations of the third category index:

$$\vec{x}_5^{TAI,R} = \begin{bmatrix} \frac{90}{82.5} \vec{x}_{82.5}^R(EQ) \\ \frac{10}{17.5} \vec{x}_{82.5}^R(FI) \end{bmatrix} \quad (25)$$

As with all markets, TAI #0 is 100% cash and TAI #6 is 110% equity, no bonds, and negative 10% cash. For the eurozone, TAI #6 is derived from TAI #5 in the same manner as it is for the U.K.

Exhibit 12 shows the derived target allocation indexes for the eurozone with both Local and Global biases.

**Exhibit 11** Morningstar Euro Target Allocation Index Family

Asset Classes	Local Categories			Global Categories		
	Morningstar® Euro Cautious	Morningstar® Euro Moderate	Morningstar® Euro Aggressive	Morningstar® Euro Cautious	Morningstar® Euro Moderate	Morningstar® Euro Aggressive
	Target Allocation Index <sup>SM</sup>	Target Allocation Index <sup>SM</sup>	Target Allocation Index <sup>SM</sup>	Global Target Allocation Index <sup>SM</sup>	Global Target Allocation Index <sup>SM</sup>	Global Target Allocation Index <sup>SM</sup>
Developed European Equity	13.5%	40.0%	66.0%	8.0%	19.5%	32.0%
Global Equity x Europe Equity	4.0%	10.0%	14.5%	9.5%	26.5%	43.5%
Emerging Market Equity	0.0%	0.0%	2.0%	0.0%	4.0%	7.0%
European Bonds	48.5%	30.0%	8.5%	35.5%	19.0%	5.0%
Global x European Bonds	21.5%	11.0%	3.5%	34.5%	22.0%	7.0%
Cash	12.5%	9.0%	5.5%	12.5%	9.0%	5.5%
Total Equity Weight	17.5%	50.0%	82.5%	17.5%	50.0%	82.5%
Total Fixed Income Weight	82.5%	50.0%	17.5%	82.5%	50.0%	17.5%
Portfolio Risk Score	<b>17.5</b>	<b>50</b>	<b>82.5</b>	<b>17.5</b>	<b>50</b>	<b>82.5</b>

Source: Morningstar.

**Exhibit 12** Euro Target Allocation Anchor Points

Asset Classes	Euro Anchor Points With Local (Euro) Bias						
	Anchor Point 0	Anchor Point 1	Anchor Point 2	Anchor Point 3	Anchor Point 4	Anchor Point 5	Anchor Point 6
Developed European Equity	0.0%	7.7%	23.7%	40.0%	56.0%	72.0%	88.0%
Global Equity x Europe Equity	0.0%	2.3%	6.3%	10.0%	12.8%	15.8%	19.3%
Emerging Market Equity	0.0%	0.0%	0.0%	0.0%	1.2%	2.2%	2.7%
European Bonds	0.0%	52.9%	41.4%	30.0%	16.8%	4.9%	0.0%
Global x European Bonds	0.0%	23.5%	17.5%	11.0%	6.4%	2.0%	0.0%
Cash	100.0%	13.6%	11.2%	9.0%	6.8%	3.1%	-10.0%
Total Equity Weight	0.0%	10.0%	30.0%	50.0%	70.0%	90.0%	110.0%
Total Fixed Income Weight	100.0%	90.0%	70.0%	50.0%	30.0%	10.0%	-10.0%
<b>Portfolio Risk Score</b>	<b>0</b>	<b>10</b>	<b>30</b>	<b>50</b>	<b>70</b>	<b>90</b>	<b>110</b>

Asset Classes	Euro Anchor Points With Global Bias						
	Anchor Point 0	Anchor Point 1	Anchor Point 2	Anchor Point 3	Anchor Point 4	Anchor Point 5	Anchor Point 6
Developed European Equity	0.0%	4.6%	12.4%	19.5%	27.2%	34.9%	42.7%
Global Equity x Europe Equity	0.0%	5.4%	16.0%	26.5%	37.0%	47.5%	58.0%
Emerging Market Equity	0.0%	0.0%	1.5%	4.0%	5.8%	7.6%	9.3%
European Bonds	0.0%	38.7%	29.2%	19.0%	10.4%	2.9%	0.0%
Global x European Bonds	0.0%	37.6%	29.7%	22.0%	12.8%	4.0%	0.0%
Cash	100.0%	13.6%	11.2%	9.0%	6.8%	3.1%	-10.0%
Total Equity Weight	0.0%	10.0%	30.0%	50.0%	70.0%	90.0%	110.0%
Total Fixed Income Weight	100.0%	90.0%	70.0%	50.0%	30.0%	10.0%	-10.0%
<b>Portfolio Risk Score</b>	<b>0</b>	<b>10</b>	<b>30</b>	<b>50</b>	<b>70</b>	<b>90</b>	<b>110</b>

Source: Morningstar.

### The Morningstar Portfolio Risk Score

The MPRS takes unsystematic/idiosyncratic risk into account. To do this, we combine systematic risk and unsystematic risk to arrive at the total risk of the portfolio. We divide this by the standard deviation of the blended portfolio of the anchor points formed when we calculate the Base Risk Score. This ratio measures how much leverage we need to apply to the blended portfolio of the anchor points to get to a levered portfolio that has the same standard deviation as the portfolio being scored. The MPRS is this leverage ratio times the Base Risk Score.

Mathematically, the total risk of the portfolio is:

$$\sigma_P = \sqrt{\sigma_S^2 + \sigma_u^2} \quad (26)$$

The risk of the blended benchmark is:

$$\sigma_B = \sqrt{\vec{x}_B' \mathbf{V} \vec{x}_B} \quad (27)$$

The leverage ratio is:

$$L_P = \frac{\sigma_P}{\sigma_B} \quad (28)$$

MPRS is:

$$RS_P = L_P \cdot \widehat{RS}_P \quad (29)$$

### R<sup>2</sup>-Based Floor

RBSA is only useful if the asset class index returns sufficiently explain the returns on the portfolio. The goodness-of-fit, or R<sup>2</sup>, statistic from the post-RBSA regression in equation (3) measures how well an RBSA model works.

A low R<sup>2</sup> indicates that there are other factors in the portfolio at play besides the asset class returns. Since MPRS is based on asset class exposures, a low R<sup>2</sup> indicates that risk score is not an appropriate way to assess the risk of the portfolio.

We use the R<sup>2</sup> from the post-RBSA regression to set a floor on the value of MPRS. To report MPRS, we require that it be at least 100(1-M×R<sup>2</sup>), where M is a parameter that we currently set to 3.

If the asset mix of the portfolio came about through either: 1) holding-based analysis, or 2) by specifying the asset mix apart from any actual investments, R<sup>2</sup> can be taken to be 100%.

### Decompositions of the Morningstar Portfolio Risk Score

There are six components of Morningstar Portfolio Risk Score that are calculated to provide three decompositions of the MPRS. Each component is a fraction of the total risk in units of MPRS. The six components are:

- ▶ **Blended Anchor Risk** (also known as Blended Benchmark Risk): This is the risk of the asset allocation of the Blended Anchor Benchmark. By design, the Blended Anchor Risk is generally the same as the Allocation Risk of the product/portfolio being measured.<sup>5</sup>
- ▶ **Misfit Risk**: This is the allocation risk that results from the difference between the allocation of the product/portfolio and the allocation of the Blended Anchor.
- ▶ **Covariance of Blended Anchors and Misfit** (also known as Covariance of Blended Benchmark and Misfit): This is the covariance of the Blended Anchors and the difference between the allocation of the product/portfolio and the allocation of the Blended Anchors.
- ▶ **Asset-Allocation Risk** (also known as Systematic Risk and Market Risk): This is represented by the Base Risk Score in the calculation and is the asset-allocation risk of the product/portfolio being measured. When the Base Risk Score is less than 110, this is identical to Blended Anchor Risk.
- ▶ **Residual Risk** (also known as Unsystematic Risk and Idiosyncratic Risk): This is the risk from the products in the portfolio resulting from concentration risk (such as undiversified stock holdings) or from active management risk within those products.
- ▶ **Active Risk** (Alignment Score): This is the risk resulting from Misfit Risk (asset allocation diverging from the benchmark) and the Residual Risk from concentration or active management.

The Alignment Score is one of six components that we use to decompose the Risk Score. Exhibit 13 presents the full list with the formulas for calculating them.

#### Exhibit 13: Components of the Risk Score

Component	Formula
Blended Benchmark Risk	$\frac{\sigma_B^2}{\sigma_P^2} RS_P$
Misfit Risk	$\frac{AM_P^2}{\sigma_P^2} RS_P$
Covariance of Blended Benchmark & Misfit	$\frac{\vec{x}_B' \mathbf{V} (\beta \vec{x}_P - \vec{x}_B)}{\sigma_P^2} RS_P$
Asset-Allocation Risk	$\frac{\sigma_S^2}{\sigma_P^2} RS_P$
Residual Risk	$\frac{\sigma_U^2}{\sigma_P^2} RS_P$
Active Risk (Alignment Score)	$AS_P$

Source: Morningstar.

Exhibit 14 shows how these components can be used in three alternative decompositions of the Morningstar Portfolio Risk Score. Exhibit 15 shows the risk decompositions for a sample EFT.

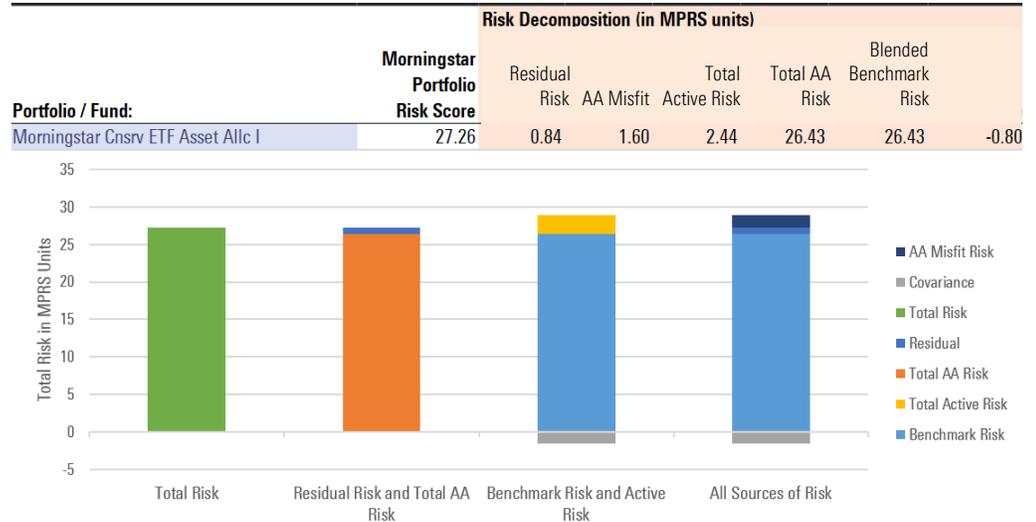
<sup>5</sup> They can differ if the Base Risk Score is 110.

**Exhibit 14** Decompositions of the Morningstar Portfolio Risk Score

Total Asset Allocation & Residual Risk	All Sources of Risk	Benchmark & Active Risk
Asset-Allocation Risk	Blended Anchor Risk	Active Risk (Alignment Score)
	2×Covariance of Blended Anchor & Misfit	
Residual Risk	Misfit Risk	

Source: Morningstar.

**Exhibit 15** Risk Decompositions for the Morningstar Conservative ETF Allocation Index



Source: Morningstar.

**The Alignment Score**

The Alignment Score measures active risk as a fraction of total risk in units of the Risk Score:

$$AS_p = \frac{AM_p^2 + \sigma_u^2}{\sigma_p^2} RS_p \tag{30}$$

The Alignment Score can be represented with text as shown in Exhibit 16.

**Exhibit 16:** Textual Representation of the Alignment Score

Range	Text
$0 \leq AS_p \leq 4$	Excellent
$4 < AS_p \leq 8$	Good
$8 < AS_p \leq 12$	Mediocre
$12 < AS_p \leq 16$	Poor
$AS_p > 16$	Very Poor

Source: Morningstar.

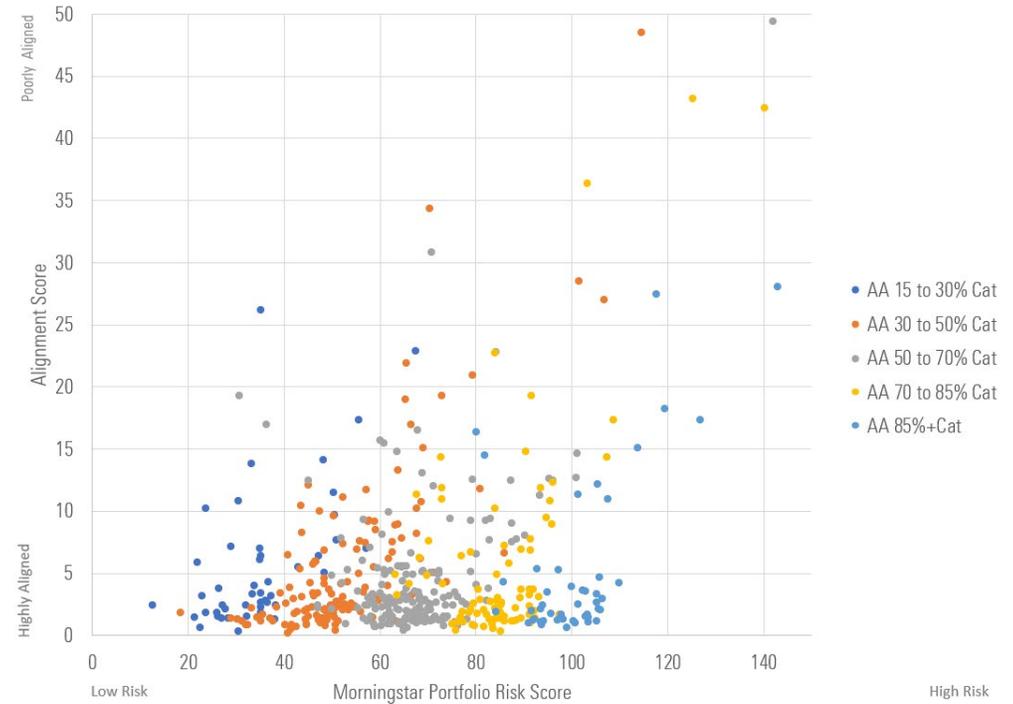
We highlight the Alignment Score as the key outcome of the risk decomposition. Active risk is the combination of asset-allocation misfit risk and unsystematic risk. The Alignment Score measures active



risk as a fraction of total risk in units of the Morningstar Portfolio Risk Score. As Exhibit 16 shows, it can be mapped to text.

We illustrate the different degrees of alignment in Exhibit 17. Notice that there are a number of funds with Excellent and Good alignment, but there are also a number of asset-allocation funds with varying degrees of poor alignment.

**Exhibit 17:** Morningstar Portfolio Risk Score vs. Alignment Score--U.S. Allocation Funds



Source: Morningstar.

For a fund to be suitable, having the right portfolio risk score only reflects one dimension of suitability. It is best to use the Morningstar Portfolio Risk Score and the Alignment Score together to form a more-complete assessment of suitability.

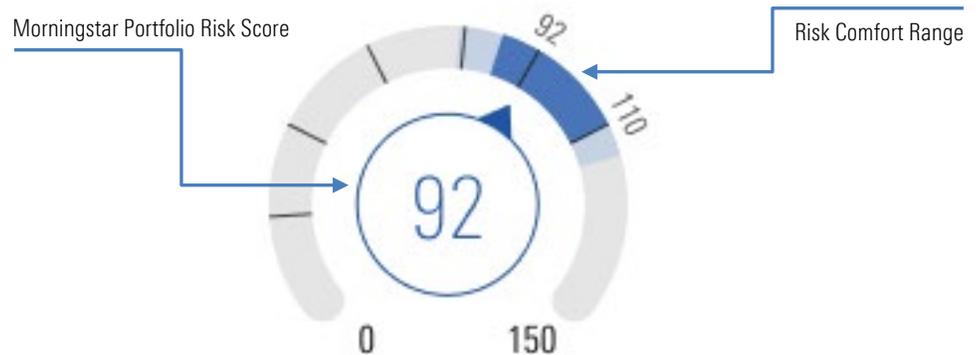
Notice that in Exhibit 17 the Alignment Score is not a statement about the appropriateness of the risk level of a portfolio. Rather, it is about having a reasonably diversified asset allocation, where the reasonable diversified asset allocations are based on the Category average exposures embedded in the Morningstar® Target Allocation Index Family, and not having too much unsystematic risk. Thus, it reflects the collective wisdom of the professional asset managers.

As a side note, in Exhibit 17 we have color-coded the funds based on their respective Category. From the color-coding, one can see that funds tend to cluster in the equity range associated with the Category; however, there are some interesting outliers. Notice the yellow dot from the 70% to 85% Equity Category with a Morningstar Portfolio Risk Score of 140--upon further investigation it was revealed that this fund had the highest exposure within the Category to Emerging-Markets Equity, thus, causing it to behave in a riskier manner than the other funds in the Category.

### Mapping to Risk-Comfort Range or Custom Risk Bands

Exhibit 18 illustrates what the advisor/financial representative and client would jointly see in the expression of the Risk Comfort Range. Here it is presented in the orientation of the current or proposed portfolio with an MPRS of 92, in relation to the person's Risk Comfort Range of 85-110. The Risk Comfort Range was determined as the range of 85-110 based on a Suitability Score of 80. The MPRS (92) falls within the bounds of the Risk Comfort Range

**Exhibit 18** UK Risk Comfort Range of 85-110 (Suitability Score of 80) and MPRS of 92



Source: Morningstar.

Risk Comfort Range is a crucial concept, as it diverges from most legacy solutions that simplified systems to categorize investors and products into static investment policy bands. Investors are grouped together in these bands, and products and portfolios are rated to be appropriate for people in a specific band or higher. As an example, money market funds may be rated a 1, fixed income a 2, allocation funds a 3, large-cap developed equity a 4, and emerging-markets and small-cap funds a 5. If a client is placed in Band 3, they can be recommended products from Band 1, 2 or 3—but not from higher-risk bands.

The products and portfolios are themselves scored using the MPRS on a scale from 0 (cash) to 100 (well-diversified 100% equity portfolio with no idiosyncratic risk), to whatever is appropriate above this based on the risk of the portfolio. Asset-allocation funds in almost all markets never seem to exceed 125 (although we did see a number of funds that appear miscategorized with higher scores), while a portfolio composed of one or two stocks might have a score in excess of 500.

The Risk Comfort Range introduces a tailored band for a client where the range is a good fit for them. This addresses issues with legacy systems where a client may be at the high end of Band 3 but still not allowed access to Band 4 products. This means that a portfolio or product may fall in the Risk Comfort Range of investors that, as an example, were historically in the high end of Band 3 and the lower end of Band 4.

The Risk Comfort Range is instrumental in providing more-tailored personal advice to investors and a more-versatile ability to apply investment solutions. Advisors can blend adjacent preconstructed portfolios for an investor arriving at a best-fit solution from a risk-profiling perspective.

Many users of MPRS may have a more traditional banding structure where clients are grouped in one of a limited number of fixed bands. This is a common practice as it is easily administered (for example, my client is conservative so I sell them conservative products). In this case it is straightforward for a firm to simply set an MPRS range for each of these bands, such as:

- ▶ Very Conservative: MPRS < 30
- ▶ Conservative: MPRS 30 to < 50
- ▶ Moderate: MPRS 50 to < 70
- ▶ Aggressive: MPRS 70 to < 85
- ▶ Very Aggressive: MPRS 85 or more

## Use Cases/Examples

### Empirical Analysis

A companion document to this methodology document is the Morningstar Portfolio Risk Scoring-- Empirical Analysis. Within this document we perform a bulk scoring of all of the open-end mutual funds in the six major markets:

- United States
- Canada
- United Kingdom
- Europe
- Australia
- New Zealand

The analysis shows all major mutual fund categories with 20 or more mutual funds in the category. It displays the distribution of MPRS scores with the score of fifth, 25th, 50th, 75th, and 95th percentiles.

The second schedule for each country is the distribution of the Alignment Scores. We would be expecting to see lower Alignment Scores on asset-allocation funds that properly diversified than on more-concentrated sector or geographic funds.

The third analysis is an out-of-sample back-test where we calculate the MPRS Scores for all funds in each of the six country universes as of July 2017 and again as of July 2021. The two period tests utilize different period TAIs in addition to the period of the representative indexes and the returns of the individual products. We look at each marketplace to confirm the stability or correlation of the two period MPRS scores.

These were found to be:

- United States      94.25
- Canada              89.64
- United Kingdom    85.64
- Europe              89.23
- Australia            92.11
- New Zealand        94.13

### Measuring Alignment Score vs. Home Office Models

Here we consider another common use case: namely when there are home office models. While the Morningstar Portfolio Risk Score should always be calculated relative to the Morningstar Target Allocation Indexes, it may be of interest to calculate the Alignment Score relative to both the Morningstar Target Allocation Indexes and the Home Office Models, as we discussed earlier. Calculating the Alignment Score relative to the Morningstar Target Allocation Indexes serves as an independent check of diversification and may be of particular interest to end investors/clients. For Home Offices with their own Home Office Models, the degree to which financial-professional-created portfolios align with those models is of particular interest.

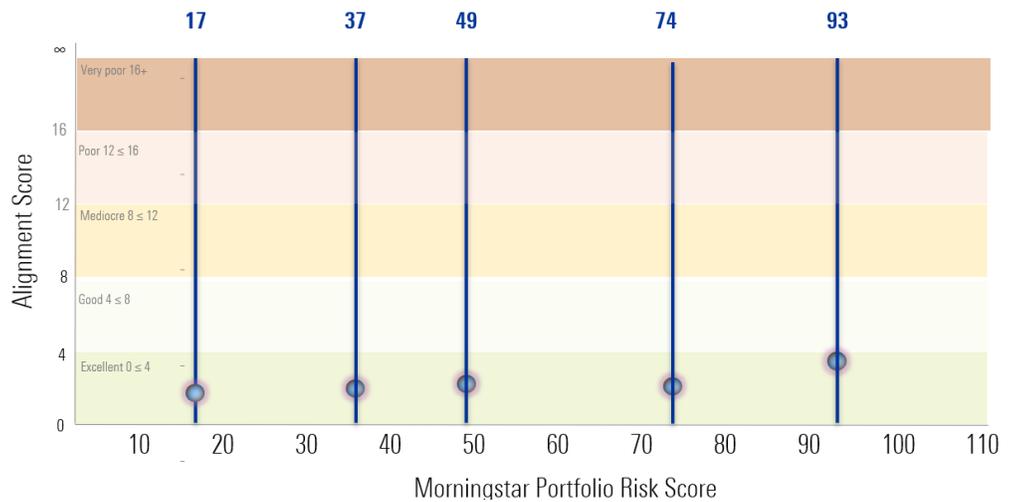
To decompose MPRS using a Home Office Model, run RBSA and the post-RBSA regression to form a vector of asset class weights by multiplying the RBSA-weights by the beta of the post-RBSA regression and use this vector in place of  $\vec{x}_B$ .

### Monitoring the Entire Book of Business

There are several use cases that can leverage the Morningstar Portfolio Risk Scoring System. In this example, we demonstrate how the home office or chief compliance officer could use this system to a) monitor the quality of the thousands of financial-professional-created portfolios built by hundreds of the firm's financial professionals, and b) identify portfolios with a risk score that does not match the target risk level as determined by the firm's risk-profiling system. In this example, the firm in question uses a non-Morningstar-created Risk Tolerance Questionnaire that maps investors to one of five home office-created asset-allocation models.

Exhibit 19 illustrates where the firm's five asset-allocation models plot on the Morningstar Portfolio Risk Score spectrum (the horizontal axis). From an asset-allocation misfit perspective, the firm's models are extremely well-aligned with the independent asset allocations from the Morningstar Target Allocation Indexes. A fundamental design issue is that the MPRS scores of the head office models are identical to the MPRS that would be published in Morningstar data and tools like Morningstar Direct.

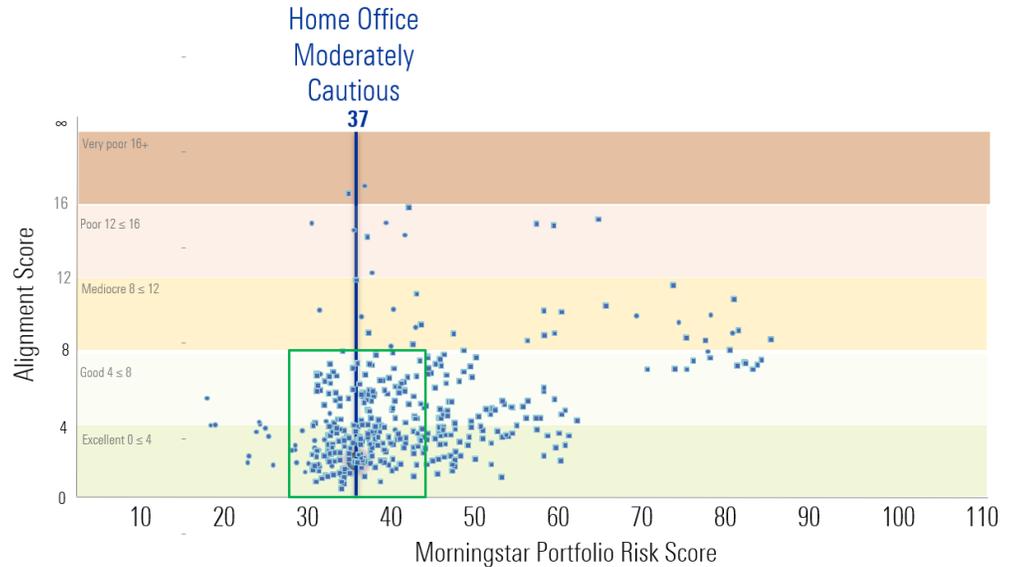
**Exhibit 19** Five Home Office Models



Source: Morningstar.

In Exhibit 20, we focus on all of the client portfolios of the firm in which the Risk Profile on file is listed as Moderately Cautious.

**Exhibit 20** All Financial-Professional-Created Portfolio in Which Risk Profile = Moderately Cautious



Source: Morningstar.

In Exhibit 20, the green box identifies portfolios with a Portfolio Risk Score that is within 10 risk score units of the target risk level of 37 and have Excellent or Good Alignment Scores. In this example, 89% of the portfolios are in the green box, indicating that from a suitability perspective they look good from both a Portfolio Risk Score and Alignment Score perspective. There may be good reasons that a portfolio's risk doesn't match the target risk score level as determined by the firm's risk-profiling system, but from a home office oversight perspective, this allows the Home Office to quickly identify potential areas of concern. In this example, there are 19 portfolios that have an acceptable risk score; however, they have concerning Alignment Scores. All the portfolios outside of the green box are concerning from a suitability perspective and arguably the further they are from that box, the more concerning they are.

From a monitoring dashboard perspective, one can quickly identify different offices (branches) or specific financial professionals in which there are consistently large risk mismatches or asset allocations with potential quality issues based on a lack of Alignment. Filtering based on account balance allows the home office or the advisor to focus on the potentially most egregious portfolios in which there is a potential suitability issue.

**Sample Portfolios Scored With MPRS**

To better understand the application of MPRS on a portfolio and the underlying securities, we present sample portfolios from some different countries.

**Sample United States Portfolio**

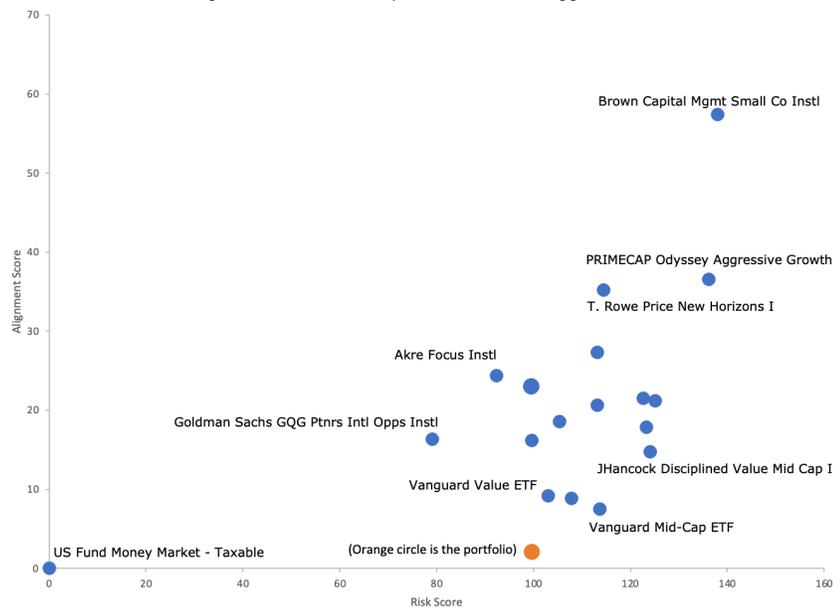
In Exhibit 21, we show an aggressive portfolio followed by a graphical representation of the constituents of the portfolio and the overall portfolio MPRS and Alignment Score in Exhibit 22.

**Exhibit 21** Sample United States Portfolio

Name	SecId	Morningstar Category	Base Currency	Port. Weight	Risk Score	Active Risk (Alignment Score)
Vanguard Value ETF	FEUSA04AC4	US Fund Large Value	US Dollar	13.67%	103.04	9.15
Vanguard Russell 1000 Value ETF	F00000J3KG	US Fund Large Value	US Dollar	9.50%	107.89	8.87
Artisan International Value Instl	FOUSA05KBM	US Fund Foreign Large Blend	US Dollar	9.22%	125.16	21.17
JHancock Disciplined Value Mid Cap I	FOUSA00HVB	US Fund Mid-Cap Value	US Dollar	8.47%	124.06	14.74
JHancock International Growth I	FOUSA05GD5	US Fund Foreign Large Growth	US Dollar	6.77%	99.69	16.18
Akre Focus Instl	F000003Y6K	US Fund Large Growth	US Dollar	6.18%	92.41	24.38
T. Rowe Price Blue Chip Growth I	F00000WMWX	US Fund Large Growth	US Dollar	5.78%	105.35	18.56
JPMorgan Small Cap Equity I	FOUSA00L2F	US Fund Small Blend	US Dollar	4.96%	123.33	17.85
Edgewood Growth Instl	FOUSA05H9Y	US Fund Large Growth	US Dollar	4.91%	99.52	22.97
PRIMECAP Odyssey Aggressive Growth	FOUSA05B5A	US Fund Mid-Cap Growth	US Dollar	4.74%	136.23	36.58
Vanguard Mid-Cap ETF	FEUSA04AC2	US Fund Mid-Cap Blend	US Dollar	4.04%	113.72	7.51
Goldman Sachs GQG Ptnrs Intl Opps Instl	F00000XRZ4	US Fund Foreign Large Growth	US Dollar	3.88%	79.09	16.34
Artisan International Small-Mid Instl	F00000WVG1	US Fund Foreign Small/Mid Growth	US Dollar	3.77%	113.12	20.64
T. Rowe Price New Horizons I	F00000VWMX	US Fund Mid-Cap Growth	US Dollar	3.74%	114.42	35.17
Brown Capital Mgmt Small Co Instl	F00000MQJ0	US Fund Small Growth	US Dollar	3.49%	137.93	57.39
iShares MSCI EAFE Value ETF	FEUSA04ADQ	US Fund Foreign Large Value	US Dollar	3.06%	122.61	21.54
Brown Capital Mgmt Intl Sm Co Instl	F00000VB3W	US Fund Foreign Small/Mid Growth	US Dollar	2.84%	113.18	27.33
Goldman Sachs FS Treasury Intms Instl	FMUSA0010W	US Fund Money Market - Taxable	US Dollar	0.98%	0.00	0.00
<b>Portfolio</b>			<b>US Dollar</b>	<b>100.00%</b>	<b>99.65</b>	<b>2.08</b>
			<b>Weighted Average</b>		<b>110.38</b>	<b>19.19</b>
			<b>Diversification Benefit</b>		<b>10.72</b>	<b>17.11</b>

Source: Morningstar.

**Exhibit 22** MPRS and Alignment Score of Sample United States Aggressive Portfolio and Constituents



Source: Morningstar.

Although we do not publish scores for individual stocks or bonds because of their very high idiosyncratic risk, we have shown their scores in this illustration. Any security that has a representative return history can be included in the overall portfolio score. Notice that in this portfolio, the weighted average MPRS is 110.38, while the MPRS of the aggregate portfolio is 99.65. Similarly, the Alignment Score on individual holdings can be significant, with a weighted average of 19.19 while the Alignment Score is 2.08 for the overall portfolio.

### Sample Canadian Portfolio

The sample Canadian portfolio is composed of some individual funds, ETFs, and stocks. Notice the very high Alignment Scores for the Marijuana or Blockchain ETFs and individual stocks like Shopify, where the unique risk of the investment far outweighs the market risk.

**Exhibit 23** Sample Moderately Aggressive Canadian Portfolio

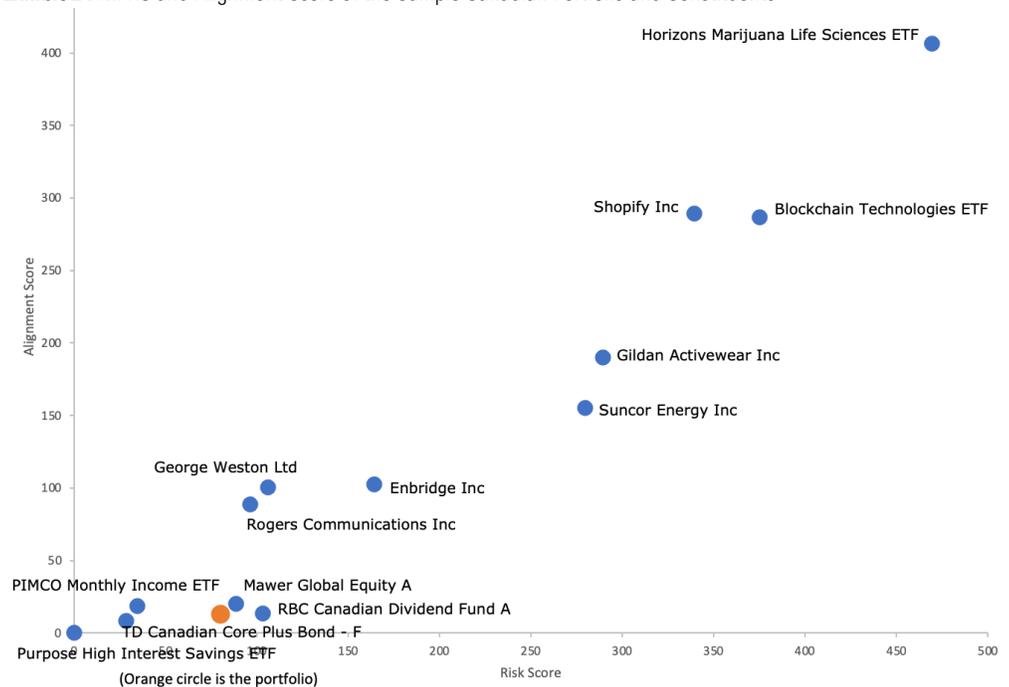
Name	SecId	Morningstar Category	Base Currency	Weight	Risk Score	Alignment Score
RBC Canadian Dividend Fund A	FOCAN0507X	Canada Fund Canadian Dividend & Income Equity	Canadian Dollar	15.00%	103.52	13.61
Mawer Global Equity A	F000005HZL	Canada Fund Global Equity	Canadian Dollar	15.00%	88.91	20.08
Horizons Marijuana Life Sciences ETF	0P0001B2RT	Canada Fund Sector Equity	US Dollar	5.00%	469.37	406.31
Blockchain Technologies ETF	F00001030Q	Canada Fund Sector Equity	Canadian Dollar	5.00%	375.22	286.49
TD Canadian Core Plus Bond - F	FOCAN071SD	Canada Fund Canadian Fixed Income	Canadian Dollar	20.00%	28.46	8.29
PIMCO Monthly Income ETF	F00000ZIR3	Canada Fund Global Fixed Income	Canadian Dollar	15.00%	34.63	18.65
Purpose High Interest Savings ETF	F00000QK0A	Canada Fund Canadian Money Market	Canadian Dollar	5.00%	0.00	0.00
Shopify Inc	0P000162RX	none	Canadian Dollar	3.33%	339.55	289.25
Enbridge Inc	0P0000681O	none	Canadian Dollar	3.33%	164.36	102.44
Suncor Energy Inc	0P0000688T	none	Canadian Dollar	3.33%	279.63	155.15
Rogers Communications Inc	0P0000687M	none	Canadian Dollar	3.33%	96.50	88.57
George Weston Ltd	0P00005ROR	none	Canadian Dollar	3.33%	106.34	100.57
Gildan Activewear Inc	0P0000682L	none	Canadian Dollar	3.33%	289.55	189.88
<b>Portfolio</b>			<b>Canadian Dollar</b>	<b>100.00%</b>	<b>80.22</b>	<b>13.04</b>
				<b>Weighted Average</b>	<b>124.49</b>	
				<b>Diversification Benefit</b>	<b>44.28</b>	

Source: Morningstar.

Notice that the overall MPRS for the portfolio is 80.22 while the weighted average of the MPRS for the individual products comes to 124.49. This illustrates the diversification benefit of the aggregate portfolio, which reduces concentration risk (having all their money in Shopify) and the benefits of the asset allocation.

Exhibit 24 is a graphical representation of the MPRS and Alignment Scores of the various securities in the portfolio and the portfolio itself, which appears as the orange dot.

**Exhibit 24** MPRS and Alignment Score of the Sample Canadian Portfolio and Constituents

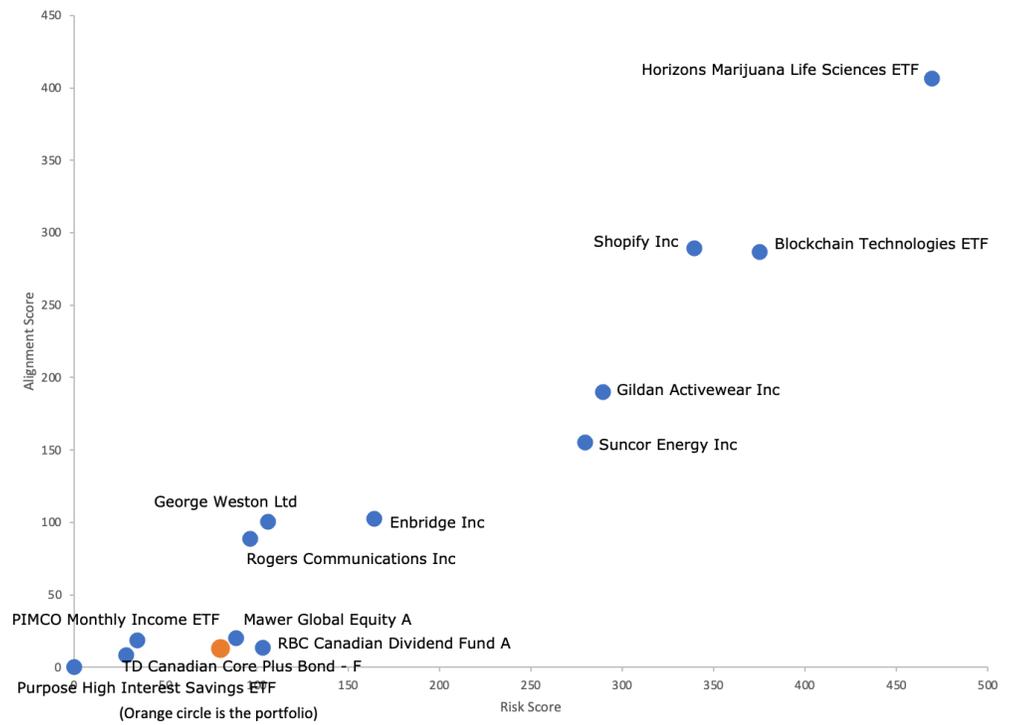


Source: Morningstar.

### Sample UK Portfolio

In Exhibit 25 we show a traditional moderate portfolio provided by Morningstar Investment Management in the U.K. This portfolio includes currency diversification and a few low allocations to several concentrated funds.

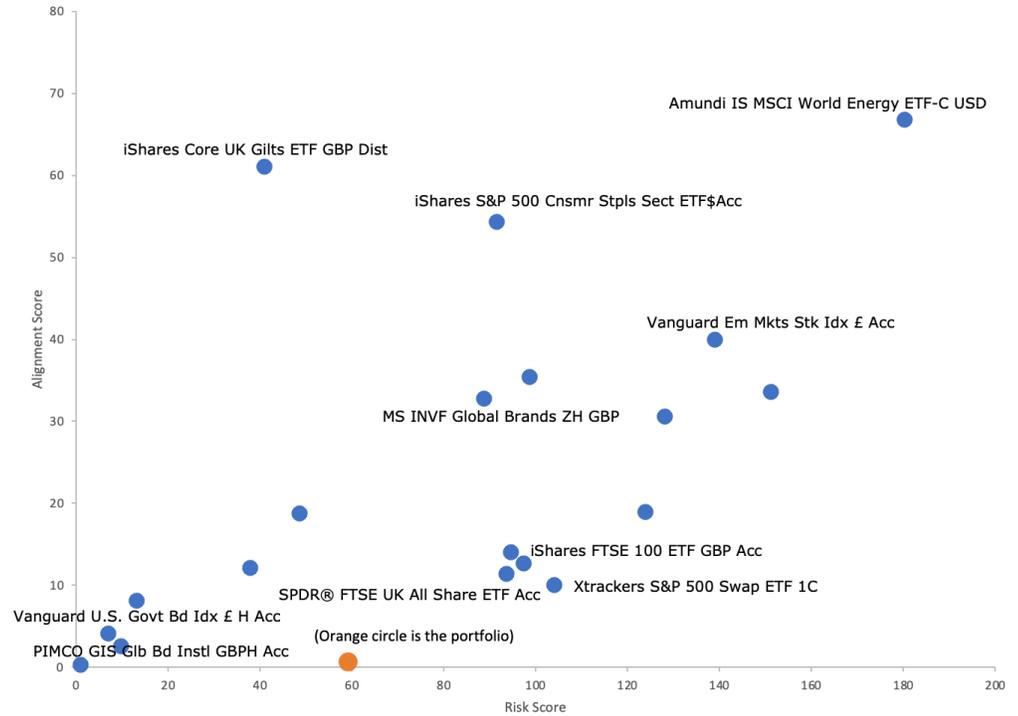
**Exhibit 25** Sample UK Moderate Portfolio



Source: Morningstar.

The result from this well-diversified portfolio is the weighted MPRS scores of all the holdings (75.72) is reduced in the portfolio to an overall MPRS of 59.18. Notice as well that the overall Alignment Score of the portfolio is 0.64, indicating very little unsystematic risk.

**Exhibit 26** MPRS and Alignment Score of Sample Moderate U.K. Portfolio and Constituents



Source: Morningstar.

**Sample Australia Portfolio**

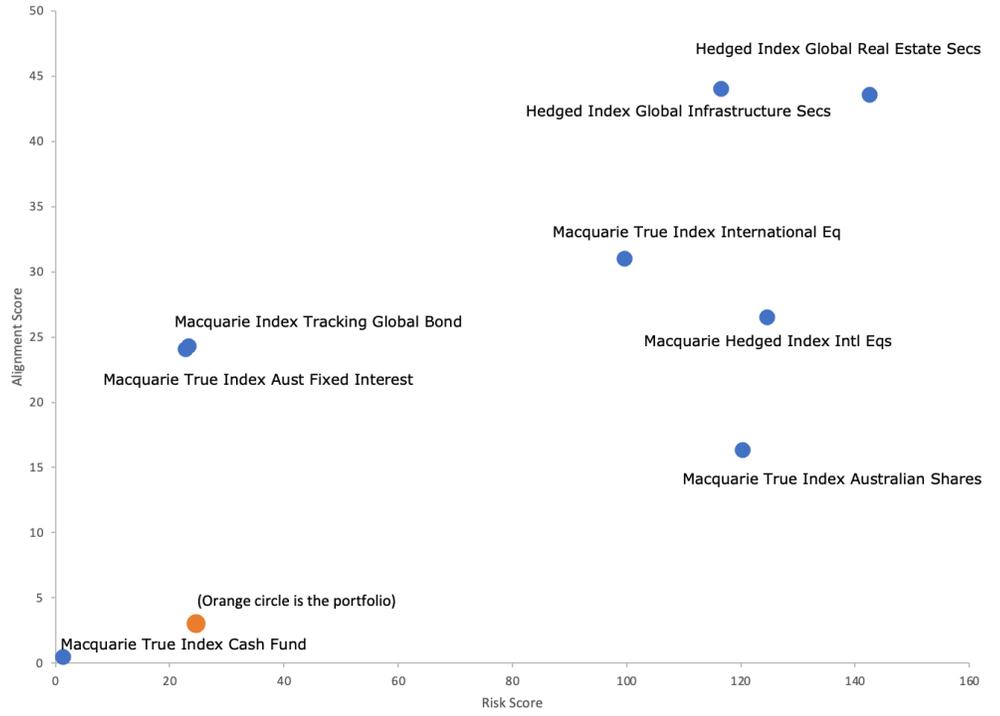
In Exhibit 27, we show a conservative portfolio provided for Australia. Exhibit 28 is a graphical representation of the MPRS and Alignment Scores of the various securities in the portfolio and the portfolio itself, which appears as the orange dot.

**Exhibit 27** Sample Conservative Australian Portfolio

Name	SecId	Morningstar Category	Base Currency	Port. Weight	Risk Score	Active Risk (Alignment Score)
Macquarie True Index Aust Fixed Interest	F0AUS05COF	Australia Fund Bonds - Australia	Australian Dollar	38.80%	22.73	24.06
Macquarie Index Tracking Global Bond	F0AUS05COG	Australia Fund Bonds - Global	Australian Dollar	38.80%	23.38	24.28
Macquarie True Index Australian Shares	F0AUS05DV6	Australia Fund Equity Australia Large Blend	Australian Dollar	9.20%	120.32	16.35
Macquarie Hedged Index Intl Eqs	F0000150O7	Australia Fund Equity World - Currency Hedged	Australian Dollar	4.10%	124.63	26.50
Macquarie True Index International Eqs	F0000044W0	Australia Fund Equity World Large Blend	Australian Dollar	3.10%	99.59	31.03
Hedged Index Global Infrastructure Secs	F00000TIOC	Australia Fund Equity Global Infrastructure - Curr	Australian Dollar	3.00%	116.57	44.05
Hedged Index Global Real Estate Secs	F00000TIOD	Australia Fund Equity Global Real Estate	Australian Dollar	2.00%	142.50	43.60
Macquarie True Index Cash Fund	F00000U3L1	Australia Fund Australian Cash	Australian Dollar	1.00%	1.40	0.44
<b>Portfolio</b>			<b>Australian Dollar</b>	<b>100.00%</b>	<b>24.60</b>	<b>3.00</b>
				<b>Weighted Average</b>	43.52	24.51
				<b>Diversification Benefit</b>	18.92	21.51

Source: Morningstar.

**Exhibit 28** Visual Representation of Sample Conservative Australian Portfolio and Components



Source: Morningstar.

## Conclusion

Financial professionals and those who oversee groups of financial professionals have a duty to make sure the portfolios they are using are well-diversified and that they are assigning individuals to an appropriate risk-based portfolio. With the creation of the Morningstar Portfolio Risk Score there is an objective and rigorous way for financial professionals (and individuals) to compare their portfolios to a series of transparent, well-diversified asset-allocation benchmarks developed from a leading authority on asset allocation.

This system enables investors, financial professionals, compliance personnel, and regulators to assess risk (using a risk score) relative to a family of published Asset Allocation Indexes, in which the indexes have been used to create an intuitive risk spectrum. The system accounts for total risk, systematic risk, idiosyncratic risk, and active asset-allocation risk and is calibrated in such a way that it automatically adjusts to changing volatility levels in the overall market.

The Morningstar Portfolio Risk Score enables investors to be matched with portfolios that align with their risk profile as well as measure the risk of concentrated portfolios. There is an objective score published and calculated by Morningstar, plus there is the ability to frame the risk decomposition based on company-specific benchmarks. ■■■

## References

Sharpe, William F. 1988. "Determining a Fund's Effective Asset Mix." *Investment Management Review*, December, P. 59.

Sharpe, William F. 1992. "Asset Allocation: Management Style and Performance Measurement." *The Journal of Portfolio Management*, Winter, P. 7.



22 West Washington Street  
Chicago, IL 60602 USA

©2022 Morningstar. All Rights Reserved. Unless otherwise provided in a separate agreement, you may use this report only in the country in which its original distributor is based. The information, data, analyses, and opinions presented herein do not constitute investment advice; are provided solely for informational purposes and therefore are not an offer to buy or sell a security; and are not warranted to be correct, complete, or accurate. The opinions expressed are as of the date written and are subject to change without notice. Except as otherwise required by law, Morningstar shall not be responsible for any trading decisions, damages, or other losses resulting from, or related to, the information, data, analyses, or opinions or their use. The information contained herein is the proprietary property of Morningstar and may not be reproduced, in whole or in part, or used in any manner, without the prior written consent of Morningstar. To license the research, call +1 312 696-6869.