MORNINGSTAR®

Morningstar Portfolio Risk Score
Methodology

Morningstar Analytics
Oct. 25, 2024

Contents

Overview

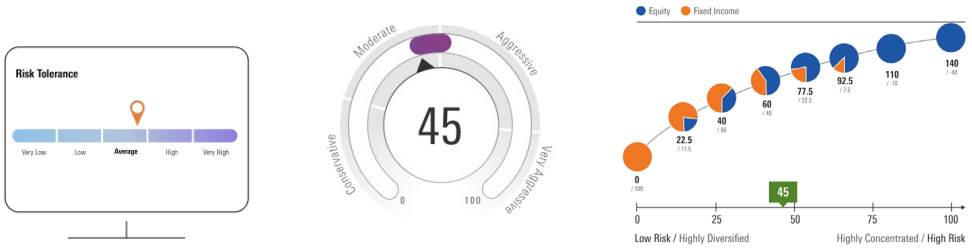
The Morningstar Portfolio Risk Score is a single number that represents the expected risk of a portfolio, and can be used by investors, financial professionals, and those who oversee large groups of financial professionals to assess whether the riskiness of the portfolio matches the risk profile of an investor. It has optimal value when combined with the Morningstar Risk Profiler and the personalized Risk Comfort Range of an investor. 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 80 and highly concentrated portfolios and asset-class-specific portfolios (such as a small-growth fund, a sector fund, or a country-specific fund) will typically receive scores between 80 and 100. Scores above 100 indicate elevated to extreme 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, provide consistent measures of risk by asset-class exposures to Morningstar building-block indexes and are aligned with the Morningstar Category classifications for asset-allocation funds. 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.

While no system can guarantee portfolio quality nor ensure against losses, MPRS 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 System – The Advice Flow



The Morningstar Risk Profiler provides a risk tolerance score that can be adjusted by additional KYC considerations for each goal.

The score from the Morningstar Risk Profiler generates a range of Morningstar Portfolio Risk Scores that are a best fit for the portfolio goal.

MPRS scores the risk of a portfolio using our holdings-based Risk Model, and our multi-asset Target Allocation Indexes to define risk ranges.

Source: Morningstar.

This document explains the methodology behind the Portfolio Risk Score (the right panel of Exhibit 1) and demonstrates its application.

Return Volatility-Based Risk Scores

The Portfolio Risk Scores are calculated based on the estimated volatility of fund returns. These volatility estimates are primarily generated using holdings-based factor exposure estimates coming from the Morningstar Risk Model's holdings-based style analysis or holdings-and-returns-based style analysis, or HaRBSA, methodologies. As a secondary option, volatility estimates may also be generated using Sharpe's returns-based style analysis, or RBSA, for portfolios with insufficient risk model coverage.

Volatility is widely understood as a measure of risk. Exhibits 10 and 11 in Appendix A show that risk is generally higher for funds with style tilts and for funds with higher equity weights in the allocation.

Another popular approach of measuring the level of risk in a portfolio is by how much growth assets, typically equities, are in the portfolio. For example, a 60/40 equity/fixed-income portfolio is typically classified as moderate and an 80/20 portfolio as aggressive. This approach excels in its simplicity and interpretability but requires the classification of assets classes. Moreover, the percentage of growth assets allocation may not accurately capture the risk of the portfolio across different market conditions as shown in Exhibit 12 in Appendix A. The volatility of S&P 500 in 2022 is almost twice the volatility in 2017, indicating that the same allocation to growth assets can have vastly different risk levels depending on the market.

Unlike the asset-allocation-based approach, a volatility-based scoring approach is not prone to ambiguous classification of growth assets and can incorporate diverse and nontraditional investment types (for example, alternatives) that do not fall neatly into an asset-allocation approach. A potential concern of a volatility-based scoring system is the stability of the score, which could vary significantly as market condition changes.

To ensure the stability of volatility-based scores while retaining the benefits of an asset-allocation-based approach, portfolios are scored based on their volatility relative to the Morningstar Target Allocation Indexes. The indexes work as anchor points that measure the overall market condition and allow us to retain the connection to the traditional allocation views and risk classification.

Morningstar® Target Allocation Indexes

For each family of target allocation categories, Morningstar creates a corresponding family of multi-asset-class indexes, the Morningstar Target Allocation Indexes, or TAIs. Each year, Morningstar calculates the sub-asset-class weights from the average weights of the funds in the category. Exhibit 2 presents the equity/fixed-income split of the five TAIs (and two additional extensions) in the US market. The two extensions represent the high-risk and the extreme-risk portfolios by uniformly increasing the equity allocations in the Aggressive TAI to a total of 110% and 140% and setting the cash allocation to negative 10% and negative 40%, respectively. For the purposes of MPRS calculation, two distinct TAI mappings are currently supported covering all the MPRS calculation regions – US (which is used for US calculations and all other regions besides UK) and UK.

Exhibit 2 Morningstar US Target Asset Allocation Indexes

Asset Class	Conservative	Moderate Conservative	Moderate	Moderate Aggressive	Aggressive	Aggressive Extension 1	Aggressive Extension 2
US Equity	16.5%	28.5%	47.0%	55.0%	68.5%	81.5%	103.7%
DM xUS Equity	5.0%	9.5%	10.5%	18.0%	19.5%	23.2%	29.5%
EM Equity	1.0%	2.0%	2.5%	4.5%	4.5%	5.4%	6.8%
US Core Bond	58.5%	45.0%	30.5%	15.5%	4.0%	0.0%	0.0%
Global Core Bond ex US	11.5%	9.5%	4.5%	2.5%	0.5%	0.0%	0.0%
Cash	7.5%	5.5%	5.0%	4.5%	3.0%	-10.0%	-40.0%

Source: Morningstar.

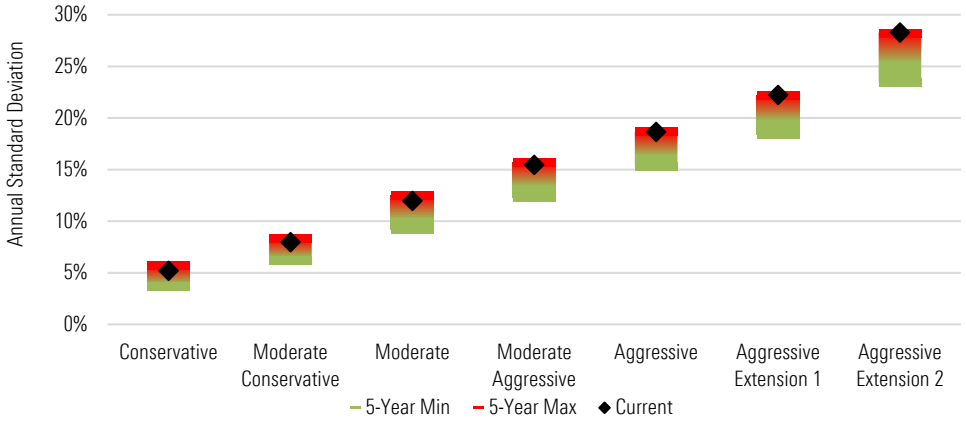
Exhibit 3 Morningstar UK Target Asset Allocation Indexes

Asset Class	Cautious	Moderate Cautious	Moderate	Moderate Adventurous	Adventurous	Adventurous Extension 1	Adventurous Extension 2
UK Equity	3.0%	7.5%	13.0%	19.0%	20.0%	24.4%	31.1%
DM xEU Equity	7.0%	16.0%	26.5%	36.0%	50.0%	61.1%	77.8%
DEU xUK Equity	0.0%	4.5%	7.5%	10.0%	12.5%	15.3%	19.4%
EM Equity	0.0%	2.0%	3.0%	5.0%	7.5%	9.2%	11.7%
UK Core Bond	22.5%	18.5%	13.0%	8.0%	1.5%	0.0%	0.0%
Global xUK Core Bond	57.0%	42.0%	29.5%	15.0%	4.5%	0.0%	0.0%
Cash	10.5%	9.5%	7.5%	7.0%	4.0%	-10.0%	-40.0%

Source: Morningstar.

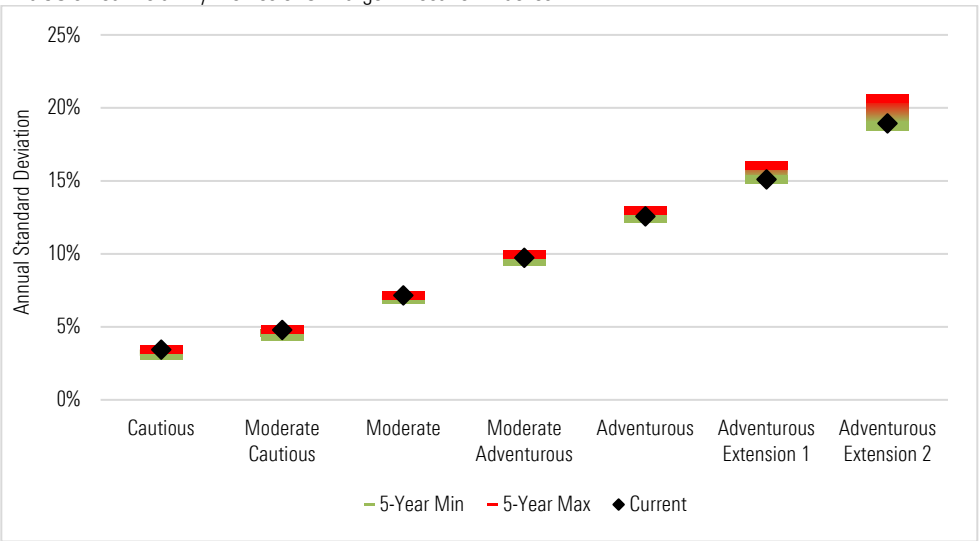
To ensure that the risk scores are stable over time and not clustered around 15% to 20% volatility range, the risk scores are anchored to the risk bands that are derived from the long-term risk profiles of the TAIs for each calculation region, as shown in Exhibits 2 and 3. The risk bands then facilitate the interpretation of risk scores so that the portfolio can be gauged against the individual's risk-comfort range.

Exhibit 4 5-Year Volatility Profiles of US Target Allocation Indexes



Source: Morningstar.

Exhibit 5 5-Year Volatility Profiles of UK Target Allocation Indexes



Identify Modeling Approach

The Morningstar Portfolio Risk Score uses a consistent methodology to translate a portfolio's level of risk into an overall score. To determine the portfolio's risk estimate, the Portfolio Risk Score system selects between a holdings-based methodology supported by Morningstar's Risk Model, or HBSA, and a returns-based methodology using a returns-based-style analysis approach, or RBSA. Between these two approaches, we can cover virtually the entire managed product, stock, and fixed-income universes and client portfolios that hold combinations of these assets. Depending on the information we have about a portfolio, we will select the appropriate methodology to use, with preference given to the holdings-based methodology.

Identifying a Portfolio

The process for calculating a Portfolio Risk Score begins by identifying the investments—mutual funds, exchange-traded funds, 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 Portfolio Risk Score can also be calculated for managed investment products such as open-end mutual funds, exchange-traded funds, unit investment trusts, US separately managed accounts, model portfolios, variable-annuity/variable-life subaccounts, segregated funds, UK closed-end funds and pooled funds, as well as certain nonmanaged investments like structured products.

The automated analysis of an investment or portfolio is dependent on Morningstar having at least 80% risk model coverage to be eligible for the HBSA methodology, or sufficient returns data (outlined below) to be eligible for the RBSA methodology. In order to maintain the highest standards of quality, certain holdings-based risk model coverage has been determined to be ineligible for purposes of MPRS calculation on a category-by-category basis. Refer to Appendix D for more information.

For managed products like funds or ETFs, the process is to score anything with more than 80% risk model coverage. For managed products without sufficient risk model coverage, we require at least 24 months of return history to be eligible for the RBSA approach. We will automatically use proxy return data based on the managed product's category average returns to fill in missing return history up to the required 48 months. For individual securities, the security is covered via the holdings-based approach provided it falls within the risk model coverage universe. No return history is required in these cases.

For a client (bespoke) portfolio, we use a special process to determine whether to score the portfolio and the approach for the risk estimate. Since there may be many constituents in a client portfolio, we need to examine our coverage of the constituents to determine whether to score or not.

The client portfolio will be scored by the HBSA approach if the weighted sum of each portfolio holding's risk model coverage weight is at least 80%. Upon insufficient risk model coverage data, the returns-based approach will be invoked.

For a returns-based approach, we have a 50% threshold on the amount of real (non-proxied) return data to ensure that the aggregated return is meaningfully driven by the holdings, not approximated by the category average, and is fully representative of the overall portfolio. To do so, we check for a percentage of real return data as following.

$$\%\ of\ real\ return = (\%\ of\ return\ overall) \times (1 - \%\ of\ proxied\ return)$$

Some scenarios of how a risk score approach (HBSA vs. RBSA) is selected for a bespoke portfolio are described in Exhibits 6 and 7:

Exhibit 6: HBSA Scenario: The Overall Risk Model Coverage Is at Least 80%

	Weight	Risk Model Coverage
Holding 1	10%	70%
Holding 2	15%	75%
Holding 3	15%	80%
Holding 4	30%	95%
Holding 5	30%	100%
Weighted Sum		**88.8% (≥ 80%)**

Holdings Coverage = 10%×70% + 15%×75% + 15%×80% + 30%×95% + 30%×100% = 88.8%

Exhibit 7: RBSA Scenario: The Percentage of Real Return Data Is More Than 50%

	Weight	Risk Model Coverage	Non-Proxied Return (Months)	Proxied Return (Months)	Overall (Non-Proxied + Proxied) (Months)
Holding 1	10%	20%	45	0	45
Holding 2	15%	25%	12	36	48
Holding 3	15%	65%	35	13	48
Holding 4	30%	75%	10	38	48
Holding 5	30%	100%	48	0	48
Weighted Sum		**68% (< 80%)**			**60.6% (>50%)**

$$\%\ of\ real\ return = \left(10\% \times \frac{45}{48} + 15\% \times \frac{48}{48} + 15\% \times \frac{48}{48} + 30\% \times \frac{48}{48} + 30\% \times \frac{48}{48}\right) \times \left(1 - \left(10\% \times \frac{0}{45} + 15\% \times \frac{36}{48} + 15\% \times \frac{13}{48} + 30\% \times \frac{38}{48} + 30\% \times \frac{0}{48}\right)\right) = 60.6\%$$

Volatility Estimate of Portfolio Returns

The risk score engine takes the volatility estimate and translates it to a risk score. The first step to calculate the Portfolio Risk Score is to estimate the systematic and idiosyncratic risk of a security and portfolio. The volatility estimate is calculated from either the HBSA approach using Morningstar's Risk Model or an RBSA approach.

Volatility Estimate by Morningstar Risk Model HBSA Approach

With at least 80% risk model coverage, the system uses the outputs from Morningstar's Risk Model to estimate the portfolio's systematic and idiosyncratic risk. Morningstar Risk Model identifies the systematic drivers of security returns, which are commonly referred to as factors. These factors include style, sector, region, and currency for equities; duration, spread, and credit for fixed income. It then uses the relationship among these factors and securities' factor exposures to estimate the systematic risk of a portfolio. This relationship among factors is captured by the factor variance-covariance matrix, and the Risk Model supports a variety of methods to forecast the co-movement. For the purpose of generating risk scores, we use an empirically derived long-horizon sample variance-covariance matrix. In addition to factor premiums, the Risk Model also produces residual terms for individual security, which represents the returns not explained by the systematic factors. We model the factor co-movement over a 20-year window, stock residual volatility using an enhanced exponentially weighted moving (EWM) standard deviation over a four-year window with a two-year half-life and a bond residual volatility using a simple standard deviation over a 65-day window with a 20-day minimum window. For more details about the volatility forecasting models for a variance-covariance matrix and residual volatility, please refer to the Risk Model Methodology document.

If the portfolio holdings coverage is less than 80% but more than 30%, portfolio currency is USD and the portfolio is in the eligible categories, its exposure data may be enhanced by HaRBSA (Holdings-and-Returns Based Style Analysis) and incorporated into the volatility estimate. Please refer to the Appendix D of the Risk Model Methodology document for more details.

Prior to estimating the portfolio risk, the portfolio and TAI factor exposures are scaled in such a way that the uncovered portion of the portfolio is assumed to have the same level of risk as the covered portion of the portfolio. For example, for an equity-only portfolio with 90% risk model coverage, we multiply the equity factor exposure for the portfolio by a factor of 100/90 to cover the missing 10%. For multi-asset portfolios, our equity coverage is typically good, and any missing coverage is assumed to be fixed-income related. That is, for a 60/40 (60% equity and 40% fixed income) multi-asset portfolio with 90% risk model coverage, we multiply the fixed-income factor exposure by a factor of 40/30 to cover the missing 10%.

This is a more conservative way to estimate the overall portfolio risk, because if the exposures of the missing portion of the portfolio are assumed to be zero (essentially equivalent to cash) it will underestimate the overall risk of the portfolio.

In addition to the risk assessment based on the total portfolio volatility, what can provide an additional dimension of risk is measuring how much of that total risk is unexplained by the risk factors and is instead specific to an individual security or a portfolio. Given that the fundamental factors of the risk model can effectively capture most of the systematic risk, high idiosyncratic risk indicates a possible lack of diversification and a higher likelihood of extreme left-tail events. This is especially important when assessing risk for individual stocks because our stock universe shows a median annualized idiosyncratic risk of 37% whereas it is only 2.4% for portfolios, which could lead to significant drawdowns and more

frequent left-tail events when held individually as a portfolio. Therefore, for the MPRS calculation only, the residual variance is scaled up by an empirically determined multiplier of 2 to recognize that there is potentially additional risk that can emerge from the idiosyncratic risk.

A portfolio's variance at time t, V_t^P, is modeled as:

$$(\sigma_s^P)^2 = (\vec{x}_t^P)^T \boldsymbol{F_t} \vec{x}_t^P \quad \text{(H-1)}$$

$$(\sigma_u^P)^2 = (\vec{w}_t^P)^T \Delta_{\boldsymbol{t}} \vec{w}_t^P \quad \text{(H-2)}$$

$$V_t^P = m_s(\sigma_s^P)^2 + m_u(\sigma_u^P)^2 \quad \text{(H-3)}$$

Where

$\vec{x}_t^P$ = the m-element vector of the portfolio's exposures to the m Risk Model factors
$\vec{w}_t^P$ = the n-element vector of the portfolio's holdings weights where n is the number of securities in the portfolio
$\boldsymbol{F_t}$ = the m x m factor premium covariance matrix estimate
$\Delta_{\boldsymbol{t}}$ = the n x n diagonal matrix with residual variance estimates along its diagonal
σ_s^P = the systematic risk
σ_u^P = the idiosyncratic risk
m_s = a scaling multiplier of 1 for systematic variance
m_u = s scaling multiplier of 2 for residual variance

Volatility Estimate by Returns-Based Style Analysis Approach

For investments and portfolios with insufficient risk model coverage, the system uses a returns-based-style analysis approach to estimate a security, fund, or portfolio's asset allocation. If the portfolio is a single security or fund, the system will analyze the time series of returns of the security or fund. For portfolios with multiple securities or funds, a custom time series of returns is constructed based on the current holdings and weights. Either way that it is determined, the time series of returns is analyzed using returns-based-style analysis as put forth in Sharpe [1988, 1992].

Sharpe's returns-based-style analysis, a specialized multifactor 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, returns-based-style analysis takes the form:

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

Where

$r_{p,t}$ = the return of the portfolio for t = 1, 2,…T; T being the number of months, which is usually 48
$c_1, \ldots, c_K$ = the asset-class coefficients for k = 1, 2,…,K; K being the number of asset-class indexes
$a_{1,t}, \ldots, a_{K,t}$ = are the period t returns for the K asset-class indexes
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 ($x, \ldots, x_K$) that minimize the variance of the excess return series (e_t), typically subject to $x_k \geq 0$ for k = 1, 2, …, K, and $x_1 + x_2, \ldots, x_K = 1$. 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.

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

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

Where

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

We then regress the benchmark returns on the portfolio returns:

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

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) β. 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 as σ_u. This is our estimate of unsystematic/idiosyncratic risk.
3) R2. The goodness-of-fit measure. We use this to determine the degree of confidence in the returns-based-style analysis model and to set a floor for the Portfolio Risk Score.

For portfolios and securities with insufficient risk model coverage, we use the effective asset mix or effective asset allocation of the portfolio from the returns-based-style analysis. This is the K-element vector of weights on the asset-class indexes included in the returns-based-style analysis, which we denote as $\vec{x}_P$.

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

$$\sigma_S = |\beta| \sqrt{\vec{x}_P{}' \boldsymbol{V} \vec{x}_P} \quad \text{(R-4)}$$

β being the slope coefficient in equation R-3. For the RBSA model, a scaling multiplier of 1.5 was empirically determined to scale up the residual variance. The scaling multiplier here is lower than HBSA because there are fewer factors in the RBSA model, resulting in less systematic risk being captured by the factors, and the scaling multiplier can penalize on the model's lower explanatory power rather than accounting for additional risk that comes from the idiosyncratic risk. Similarly, as shown in equation H-3, we combine this systematic risk with the scaled idiosyncratic risk to calculate the total risk that will ultimately be translated into the risk score.

In the HaRBSA (Holdings and Returns Based Style Analysis) model, the same scaling multiplier of 1.5 is applied because the HaRBSA model is agnostic of the holdings' residual variances, and the portfolio residual variance is estimated via a Bayesian regression.

All of the holdings-based, returns-based and holdings-and-returns-based methodologies follow the same procedures to translate the total volatility estimates into risk scores and anchor them to the long-term risk profiles of TAIs to ensure the stability and consistent risk assessment across all models.

R^2-Based Floor

Returns-based-style analysis is only useful if the asset-class index returns sufficiently explain the returns on the portfolio. The goodness-of-fit, or R^2, statistic from the post-returns-based-style analysis regression in equation (R-3) measures how well a returns-based-style analysis model works. The holdings-based model does not require the post-returns-based-style analysis regression and has no floor value for the Portfolio Risk Score. The goodness-of-fit for the holdings-based model is essentially the risk model coverage, and it is addressed by the 80% threshold and the factor exposure scaling.

A low R^2 indicates that there are other factors in the portfolio at play besides the asset-class returns. Since the Portfolio Risk Score is based on asset-class exposures, a low R^2 indicates that risk score is not an appropriate way to assess the risk of the portfolio.

We use the R^2 from the post-returns-based-style analysis regression to set a floor on the value of the Portfolio Risk Score. To report the Portfolio Risk Score, we require that it be at least $100(1-M\times R^2)$, 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^2 can be taken to be 100%.

Morningstar Portfolio Risk Score

For the US, Canada, Australia, New Zealand, and Europe calculation regions, the frame of reference for mapping the volatilities to risk scores is based on the distribution of US TAI volatility estimates. Exhibits 13 and 14 in Appendix A present the volatility profiles and percentiles of the US TAIs and extensions that provide stable and nonoverlapping anchor points over time. Through series of empirical analysis of volatility distributions, we have determined that the median values of the Moderate Conservative and Moderate Aggressive TAIs can serve as the breakpoints among Conservative, Moderate, and Aggressive risk bands. For Very Aggressive and Extreme risk bands, we use the maximum values of the Aggressive Extension 1 and Aggressive Extension 2 TAIs.

For the UK calculation region, the risk score mapping is based on the distribution of UK TAI volatility estimates using local currency returns, in order to align MPRS with the local UK asset-allocation standards and support the local perspective of UK portfolio advisors. For example, instead of using volatility estimates from the USD risk model and anchoring to the US market, the local RBSA model is used to independently identify what volatility level is considered "cautious" in the UK market. Currently, local-currency risk models are not available for HBSA risk score calculations, and as such, UK securities are excluded from the HBSA calculation universe. As seen in the US calculation region, Exhibit 15 shows that the TAI volatility estimates provide stable anchor points over time, and Exhibit 16 shows the five-year volatility ranges corresponding to each risk band.

In consultation with consuming products and advisor clients, it has been determined that a score of 100 should be considered the upper limit for a client's portfolio, with anything more aggressive than 100 being normally reserved for concentrated or inherently risky investments that are not suitable for clients under normal circumstances. From this upper limit, the volatility of the most aggressive TAI is set to equal a score of 100, with all other scores and breakpoints mapped relative to this maximum value. For the US TAI, a volatility of 28.2% equates to 100; for the UK TAI, a volatility of 20.6% equates to 100. Exhibit 8 shows the volatility ranges and corresponding risk score ranges for all calculation regions.

In addition to the simplified system of three risk categories (conservative, moderate, and aggressive), Appendix B presents a system of five traditional risk categories (conservative, moderately conservative, moderate, moderately aggressive, and aggressive) that provides a more granular classification of risk scores. The same risk score grid is used for consistent mapping between volatilities and risk scores, but the volatility ranges of the "categories" can be different. For purposes of assigning a risk score category to an MPRS score, the conventional rounding is applied to the raw MPRS number. As an example, an MPRS of 23.78 would be considered as 24: "Moderate."

Exhibit 8 Mapping Between Portfolio Annual Volatility and Risk Scores

For the US calculation region:

	Volatility Range (HBSA)	**Volatility Range (RBSA)**	Risk Score Range
Conservative	0.0% ≤ vol < 6.8%	0.0% ≤ vol < 6.5%	0 ≤ RS < 24
Moderate	6.8% ≤ vol < 13.4%	6.5% ≤ vol < 11.6%	24 ≤ RS < 48
Aggressive	13.4% ≤ vol < 22.2%	11.6% ≤ vol < 20.3%	48 ≤ RS < 79
Very Aggressive	22.2% ≤ vol < 28.2%	20.3% ≤ vol < 29.0%	79 ≤ RS < 100
Extreme Risk	28.2% ≤ vol ≤ 50.0%	29.0% ≤ vol ≤ 50.0%	100 ≤ RS ≤ 200

For the Canada, Australia, New Zealand, and Europe calculation regions:

	Volatility Range	Risk Score Range
Conservative	0.0% ≤ vol < 6.8%	0 ≤ RS < 24
Moderate	6.8% ≤ vol < 13.4%	24 ≤ RS < 48
Aggressive	13.4% ≤ vol < 22.2%	48 ≤ RS < 79
Very Aggressive	22.2% ≤ vol < 28.2%	79 ≤ RS < 100
Extreme Risk	28.2% ≤ vol ≤ 50.0%	100 ≤ RS ≤ 200

For the UK calculation region:

	Volatility Range	Risk Score Range
Cautious	0.0% ≤ vol < 4.5%	0 ≤ RS < 22
Moderate	4.5% ≤ vol < 9.7%	22 ≤ RS < 47
Adventurous	9.7% ≤ vol < 16.0%	47 ≤ RS < 78
Very Adventurous	16.0% ≤ vol < 20.6%	78 ≤ RS < 100
Extreme Risk	20.6% ≤ vol ≤ 50.0%	100 ≤ RS ≤ 200

Source: Morningstar.

Based on this volatility to risk score mapping in each risk band, we rank portfolios by volatility. Since percentile ranking can be unstable when the market environment shifts dramatically or securities are removed from or added to the investment universe, we've constructed a grid that is calibrated on an annual basis. Depending on the region and the scoring methodologies, we map the volatilities to scores using three risk score grids based on 1) the HBSA volatility estimates for US, Canada, Australia, New Zealand, and Europe, 2) the USD RBSA volatility estimates for US, and 3) the GBP RBSA volatility estimates for the UK. The RBSA risk score grid was additionally created for the US region to reduce the discrepancy between the HBSA and RBSA scoring methodologies. As shown in Exhibit 8, RBSA volatility ranges have been adjusted so that RBSA scores increase in general, giving more impact on scores between 40 and 80, to be more aligned with HBSA scores. For each risk band, we construct 10,000 equally spaced points that connect volatilities to risk scores. For example, the 5,000th point in the US Conservative risk band is:

$$Volatility = \frac{5000}{10000} \times (6.8\% - 0\%)$$

$$Risk\ Score\ = \frac{5000}{10000} \times (24 - 0)$$

and the 15,000th point in the US Moderate risk band is:

$$Volatility\ =\ 6.8\% + \frac{15000 - 10000}{10000} \times (13.4\% - 6.8\%)$$

$$Risk\ Score\ = 24 + \frac{15000 - 10000}{10000} \times (48 - 24)$$

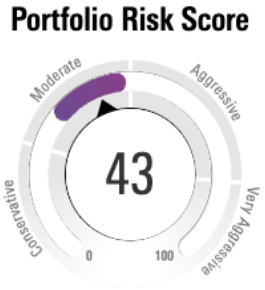
Beyond the 50,000th point in the Extreme risk band, we simply extrapolate points from any two points in the Extreme risk band. The risk band beyond Extreme cannot be reliably predefined because the maximum volatility is unknown until the universe is observed. Risk scores beyond 200 are capped at 500. Using two points in the Extreme risk band (v_1, v_2, rs_1, rs_2), and the portfolio volatility v_p,

$$Risk\ Score\ =\ rs_1 + (rs_2 - rs_1) \times \frac{v_p - v_1}{v_2 - v_1}$$

Mapping to Risk Comfort Range

Exhibit 9 illustrates what the financial professional 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 a Portfolio Risk Score of 43, in relation to the individual's Risk Comfort Range of 34-47. The Risk Comfort Range was determined as the range of 34-47 based on a suitability score of 57. The Portfolio Risk Score (43) falls within the bounds of the Risk Comfort Range.

Exhibit 9 Risk Comfort Range of 34-47 (Suitability Score of 57) and Morningstar Portfolio Risk Score of 43



Source: Morningstar.

Risk Comfort Range is a crucial concept, as it diverges from most legacy solutions that simplified systems to categorize clients and products into static investment policy bands. Clients are grouped 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 bands 1, 2, or 3—but not from higher-risk bands.

The products and portfolios are themselves scored using the Portfolio Risk Score on a scale from 0 to 80 for diversified asset-allocation portfolios, to whatever is appropriate above this, based on the risk of the portfolio. Asset-allocation funds generally score within 80, while a portfolio composed of one or two stocks might have a score in excess of 100.

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 clients who, 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 clients and a more versatile ability to apply investment solutions. Financial professionals can blend adjacent preconstructed portfolios for a client, arriving at a best-fit solution from a risk-profiling perspective.

For more information on the Risk Comfort Range, please refer to the Morningstar Risk Comfort Range Methodology document.

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 volatility-based Morningstar Portfolio Risk Score, there is an objective and rigorous way for financial professionals (and individuals) to clearly understand how portfolio risk is measured, including assessment of nontraditional portfolio constructions that was otherwise challenging in the asset-allocation approach.

This system enables investors, financial professionals, compliance personnel, and regulators to assess risk (using a risk score) relative to the long-term risk profiles of Asset Allocation Indexes, in which the indexes have been used to create an intuitive risk spectrum. The system recalibrates the risk score grid to reflect changing volatility levels in the overall market. Because the risk score engine is powered by the Morningstar Risk Model, it can be further enhanced by the full capabilities of the holdings-based-style analysis such as factor decomposition and in-depth analysis of risk attribution.

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.

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Appendix A: Data

The volatility estimates presented here are from Morningstar Risk Model's HBSA methodology, and the time horizon is one year as of Nov. 30, 2022. The time windows for the forecast calculation are 20 years for the factor covariance matrix and three months for residual variance. The historical returns were used to calculate the realized volatilities in Exhibit 12.

Exhibit 10 Estimated Annual Standard Deviations for the Morningstar Style Box Indexes

	Value	Blend	Growth
Large	21.0%	20.4%	22.0%
Median	22.5%	22.8%	22.9%
Small	24.8%	23.9%	23.9%

Source: Morningstar.

Exhibit 11 Estimated Annual Standard Deviations for the US Morningstar Target Allocation Indexes

Name of TAI	Equity	Fixed Income	Estimated Annual Standard Deviation
Morningstar US Conservative TAI	22.5%	77.5%	5.2%
Morningstar US Moderate Conservative TAI	40.0%	60.0%	8.0%
Morningstar US Moderate TAI	60.0%	40.0%	12.0%
Morningstar US Moderate Aggressive TAI	77.5%	22.5%	15.5%
Morningstar US Aggressive TAI	92.5%	7.5%	18.6%
Morningstar US Aggressive TAI Extended 1	110.0%	0.0%	22.2%
Morningstar US Aggressive TAI Extended 2	140.0%	0.0%	28.3%

Source: Morningstar.

Exhibit 12 Historical Annualized 4-Year Trailing Standard Deviation of S&P 500 Monthly Returns

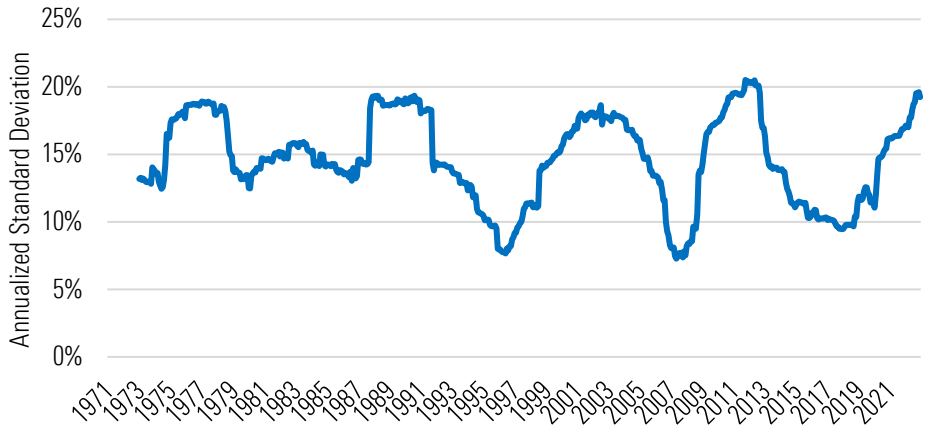

Exhibit 13 5-Year Time Series of US TAI Volatility Estimates

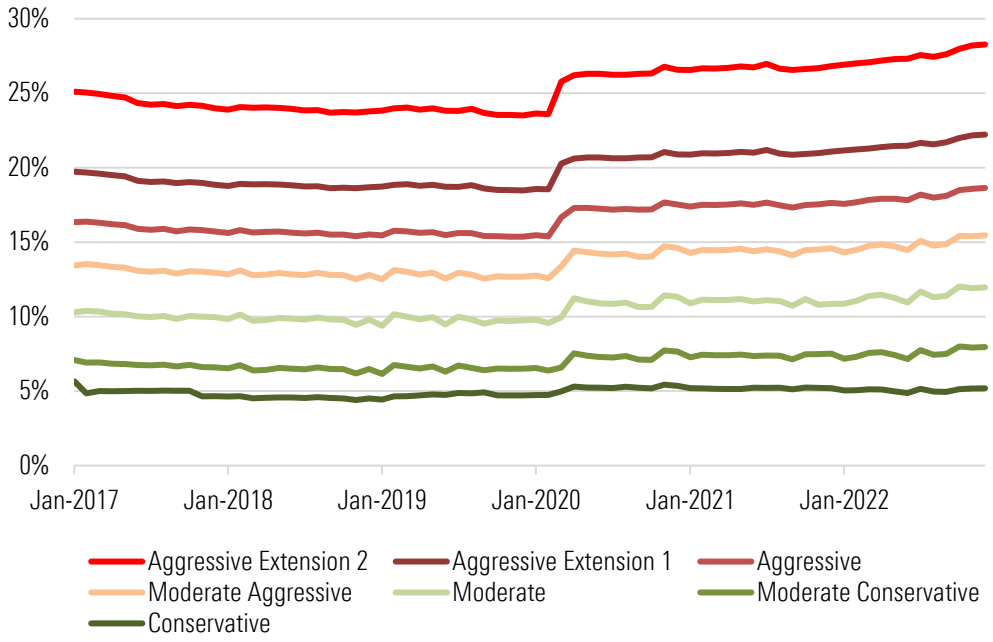

Exhibit 14 5-Year Percentiles of US TAI Volatility Estimates

Percentile	Conservative	Moderate Conservative	Moderate	Moderate Aggressive	Aggressive	Aggressive Extension 1	Aggressive Extension 2
0%	3.6%	6.1%	9.2%	12.3%	15.3%	18.4%	23.4%
10%	4.5%	6.4%	9.7%	12.7%	15.5%	18.6%	23.7%
20%	4.7%	6.5%	9.8%	12.8%	15.6%	18.8%	23.9%
30%	4.7%	6.6%	9.9%	12.9%	15.7%	18.8%	24.0%
40%	4.9%	6.7%	10.0%	13.0%	15.8%	19.0%	24.2%
50%	5.0%	6.8%	10.2%	13.4%	16.3%	19.6%	24.9%
60%	5.0%	7.2%	10.8%	14.2%	17.2%	20.7%	26.3%
70%	5.1%	7.3%	11.0%	14.4%	17.4%	20.9%	26.5%
80%	5.2%	7.4%	11.1%	14.5%	17.6%	21.0%	26.8%
90%	5.2%	7.5%	11.2%	14.6%	17.8%	21.3%	27.1%
100%	5.7%	8.3%	12.4%	15.7%	18.7%	22.2%	28.3%

Source: Morningstar.

Exhibit 15 5-Year Time Series of UK TAI Volatility Estimates

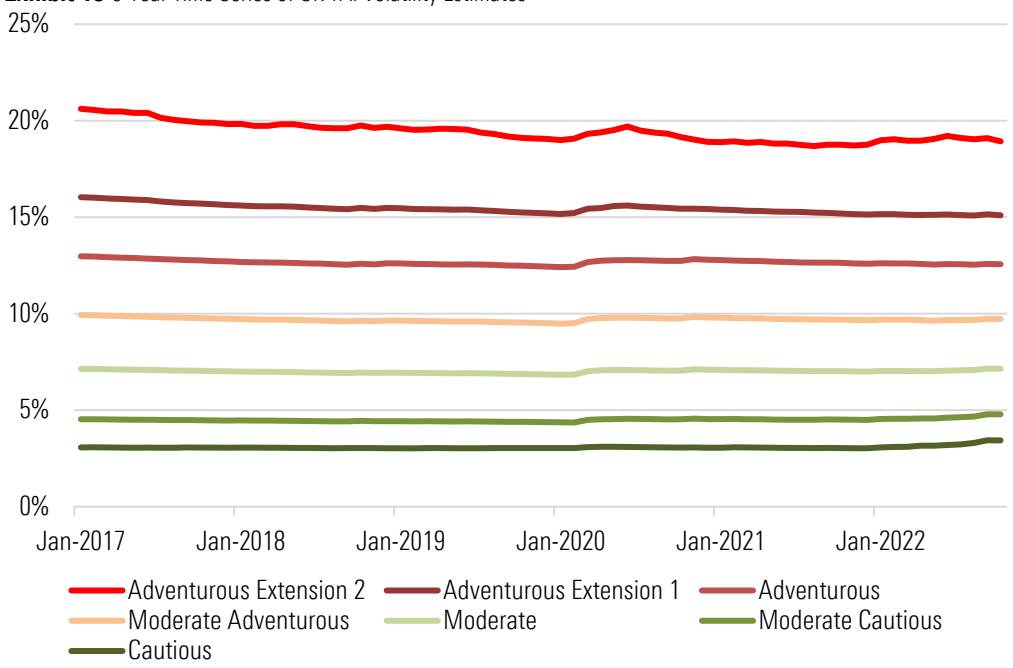

Exhibit 16 5-Year Percentiles of UK TAI Volatility Estimates

Percentile	Cautious	Moderate Cautious	Moderate	Moderate Adventurous	Adventurous	Adventurous Extension 1	Adventurous Extension 2
0%	3.02%	4.36%	6.84%	9.48%	12.42%	15.09%	18.69%
10%	3.03%	4.41%	6.91%	9.59%	12.54%	15.15%	18.82%
20%	3.04%	4.43%	6.93%	9.62%	12.55%	15.20%	18.96%
30%	3.04%	4.45%	6.97%	9.66%	12.58%	15.28%	19.05%
40%	3.05%	4.48%	7.01%	9.68%	12.61%	15.37%	19.14%
50%	3.06%	4.50%	7.03%	9.70%	12.64%	15.42%	19.39%
60%	3.06%	4.51%	7.04%	9.72%	12.67%	15.45%	19.56%
70%	3.07%	4.53%	7.06%	9.76%	12.74%	15.51%	19.65%
80%	3.08%	4.54%	7.08%	9.79%	12.77%	15.59%	19.82%
90%	3.11%	4.56%	7.10%	9.82%	12.83%	15.77%	20.06%
100%	3.44%	4.79%	7.15%	9.93%	12.98%	16.04%	20.62%

Source: Morningstar.

Appendix B: Risk Categories

A risk score can belong to either 3 simplified or 5 traditional risk categories as shown in the table below. Both systems use an identical risk score grid to provide consistent mapping between volatilities and risk scores. For example, a risk score of 25 belongs to the "Moderate" category in the simplified system and the "Moderately Conservative" category in the traditional system.

Exhibit 17 Volatility Range and Risk Score Range for Risk Categories

For the US, Canada, Australia, New Zealand, and Europe calculation regions:

	Simplified 3 Risk Categories (plus 2 Extreme Risk Categories)		Traditional 5 Risk Categories (plus 2 Extreme Risk Categories)	
	Volatility Range	Risk Score Range	Volatility Range	Risk Score Range
Conservative	0% ≤ vol < 6.8%	0 ≤ RS < 24	0% ≤ vol < 5.9%	0 ≤ RS < 21
Moderately Conservative			5.9% ≤ vol < 8.8%	21 ≤ RS < 31
Moderate	6.8% ≤ vol < 13.4%	24 ≤ RS < 48	8.8% ≤ vol < 12.4%	31 ≤ RS < 44
Moderately Aggressive			12.4% ≤ vol < 15.5%	44 ≤ RS < 55
Aggressive	13.4% ≤ vol < 22.2%	48 ≤ RS < 79	15.5% ≤ vol < 22.2%	55 ≤ RS < 79
Very Aggressive	22.2% ≤ vol < 28.2%	79 ≤ RS < 100	22.2% ≤ vol < 28.2%	79 ≤ RS < 100
Extreme Risk	28.2% ≤ vol ≤ 50%	100 ≤ RS ≤ 200	28.2% ≤ vol ≤ 50%	100 ≤ RS ≤ 200

For the UK calculation region:

	Simplified 3 Risk Categories (plus 2 Extreme Risk Categories)		Traditional 5 Risk Categories (plus 2 Extreme Risk Categories)	
	Volatility Range	Risk Score Range	Volatility Range	Risk Score Range
Cautious	0% ≤ vol < 4.5%	0 ≤ RS < 22	0% ≤ vol < 3.9%	0 ≤ RS < 19
Moderately Cautious			3.9% ≤ vol < 5.8%	19 ≤ RS < 28
Moderate	4.5% ≤ vol < 9.7%	22 ≤ RS < 47	5.8% ≤ vol < 8.3%	28 ≤ RS < 40
Moderately Adventurous			8.3% ≤ vol < 11.2%	40 ≤ RS < 54
Adventurous	9.7% ≤ vol < 16.0%	47 ≤ RS < 78	11.2% ≤ vol < 16.0%	54 ≤ RS < 78
Very Adventurous	16.0% ≤ vol < 20.6%	78 ≤ RS < 100	16.0% ≤ vol < 20.6%	78 ≤ RS < 100
Extreme Risk	20.6% ≤ vol ≤ 50%	100 ≤ RS ≤ 200	20.6% ≤ vol ≤ 50%	100 ≤ RS ≤ 200

Appendix C: MPRS for Sample Funds

Exhibit 18 MPRS for Sample Funds in Different Sectors and Regions

Name	SecId	Morningstar Category	Base Currency	Risk Score
Invesco S&P 500 Equal Weight Utilts ETF	F0USA05V5P	US Fund Utilities	USD	70.23
Invesco S&P SmallCap Info Tech ETF	F000005OGX	US Fund Technology	USD	95.88
Dimensional US Targeted Value ETF	F0000162E9	US Fund Small Value	USD	90.30
Vanguard Short-Term Investment-Grade Adm	F0USA00H6E	US Fund Short-Term Bond	USD	8.00
iShares Global REIT ETF	F00000T1FW	US Fund Real Estate	USD	75.30
SPDR Portfolio S&P 500 ETF	FEUSA04AE6	US Fund Large Blend	USD	72.70
iShares US Energy ETF	FEUSA0000T	US Fund Equity Energy	USD	112.24
iShares JP Morgan USD Em Mkts Bd ETF	F0USA06LLM	US Fund Emerging Markets Bond	USD	34.70
SPDR Portfolio Corporate Bond ETF	F00000M8DJ	US Fund Corporate Bond	USD	23.08
SPDR Blmbg Intl Corp Bd ETF	F00000GX0C	US Fund Global Bond	USD	36.34
iShares US Consumer Staples ETF	FEUSA0000S	US Fund Consumer Defensive	USD	63.56
SPDR S&P Telecom ETF	FEUSA04AHG	US Fund Communications	USD	86.12
WisdomTree US Hi Yld Corp Bd	F00000WTHP	US Fund High Yield Bond	USD	26.45
TD Canadian Core Plus Bond - F	F0CAN071SD	Canada Fund Canadian Fixed Income	CAD	21.94
TD High Yield Bond - I	F0CAN05MF4	Canada Fund High Yield Fixed Income	CAD	21.57
iShares MSCI World ETF	F000003V29	Canada Fund Global Equity	CAD	69.81
RBC Global Corporate Bond Fund A	F0CAN05PDI	Canada Fund Global Corporate Fixed Income	CAD	18.43
BMO Mid Corporate Bond ETF	F000005PNY	Canada Fund Canadian Corporate Fixed Income	CAD	16.08
Invesco Canadian Plus Div Cl Ser A	F0CAN070P2	Canada Fund Canadian Dividend & Income Equity	CAD	78.44
Invesco Pure Canadian Equity Cl Ser A	F0CAN05OB7	Canada Fund Canadian Equity	CAD	80.77
TD Canadian Small Cap Equity - F	F0CAN06GXZ	Canada Fund Canadian Small/Mid Cap Equity	CAD	85.20
Invesco Global Real Estate F	F000000R29	Canada Fund Real Estate Equity	CAD	74.49
Mackenzie US Mid Cap Opportunities A	F000015AKN	Canada Fund US Small/Mid Cap Equity	CAD	72.29
Dimensional Global Core Equity AUD Hgd	F0AUS06YSK	Australia Fund Equity World Large Blend	AUD	41.62
Dimensional Global Core Equity AUD Hgd	F000002BMN	Australia Fund Equity World - Currency Hedged	AUD	53.68
Vanguard International Property Secs Idx	F0AUS066H8	Australia Fund Equity Global Real Estate	AUD	53.95
State Street Australian Fixed Inc Idx Tr	F0AUS05E7P	Australia Fund Bonds - Australia	AUD	13.62
UBS Short-Term Fixed Income Fund	F0AUS05C9W	Australia Fund Australian Short Term Fixed Interest	AUD	3.93
iShares JP Morgan USD EmMkts Bd AUDH ETF	F00000WYMH	Australia Fund Bonds - Emerging Market Debt	AUD	36.36
Schroder Australian Equity Fund - PC	F0AUS05F6S	Australia Fund Equity Australia Large Blend	AUD	49.81
BlackRock Australian Share Plus	F0AUS05HH8	Australia Fund Equity Australia Large Growth	AUD	57.76
SPDR MSCI Australia Sel Hi Div Yld ETF	F00000JU4P	Australia Fund Equity Australia Large Value	AUD	54.70
Dimensional UK Smlr Coms Inc	F0GBR04V8L	EAA Fund UK Small-Cap Equity	GBP	101.35
Vanguard FTSE 100 ETF GBP Acc	F00000OC1S	EAA Fund UK Large-Cap Equity	GBP	62.58
L&G Global High Yield Bond I USD Inc	F00000WN33	EAA Fund Global High Yield Bond - GBP Hedged	GBP	44.23
SPDR FTSE UK All Share ETF Acc	F00000NXU8	EAA Fund UK Large-Cap Equity	GBP	65.58
Ninety One GSF UK Alpha I Acc GBP	F00000VAEP	EAA Fund UK Large-Cap Equity	GBP	69.77
iShares Core FTSE 100 ETF GBP Acc	F000005PTT	EAA Fund UK Large-Cap Equity	GBP	62.54
Vanguard FTSE 250 ETF GBP Acc	F000013LQM	EAA Fund UK Mid-Cap Equity	GBP	93.49
Vanguard UK S/T Invm Grd Bd Idx Â£ Acc	F00000PZUV	EAA Fund GBP Corporate Bond - Short Term	GBP	18.72
Vanguard UK Invm Grd Bd Idx £ Acc	F000001W0U	EAA Fund GBP Corporate Bond	GBP	27.69

Source: Morningstar.

Appendix D: Category Exclusion for HBSA

Morningstar reviews the quality of exposure estimates per each asset-class category on a periodic basis and determines whether to allow the use of holdings-based exposure estimates for calculating MPRS. This is meant to maintain the highest standard of quality, as holdings-based exposures in certain categories do not yield accurate volatility forecasts, typically due to issues with the underlying holdings data. This exclusion applies to the use of purely holdings-derived exposures only. If a managed product can be covered under the Morningstar Risk Model HaRBSA methodology, the HaRBSA-derived exposures are eligible for the MPRS calculation, even when the managed product falls into an excluded category as defined below. Refer to Morningstar's Risk Model Methodology for additional information on the HaRBSA methodology.

Exhibit 19 US and Canada Categories Where Holdings-Based Exposures Are Not Included in MPRS Calculations

US Category Name	Category ID	Canada Category Name	Category ID
High Yield Bond	$FOCA$HY$$	Tactical Balanced	CACA000148
Tactical Allocation	$FOCA$TV$$	Alternative Equity Focused	CACA000171
Options Trading	$FOCA$OT$$	Precious Metals Equity	CACA000057
Miscellaneous Region	$FOCA$MQ$$	Preferred Share Fixed Income	CACA000160
Emerging Markets Bond	$FOCA$EB$$	Passive Inverse/Leveraged	CACA000156
Trading—Leveraged Equity	$FOCA$LE$$	Geographic Equity	CACA000154
Energy Limited Partnership	$FOCA$LP$$	Alternative Credit Focused	CACA000172
Long-Short Equity	$FOCA$LO$$	Alternative Multi - Strategy	CACA000173
Derivative Income	$FOCA$DI$$	Alternative Other	CACA000175
Miscellaneous Sector	$FOCA$MR$$	Alternative Market Neutral	CACA000174
Target Maturity	$FOCA$TT$$	Commodity	CACA000155
Equity Precious Metals	$FOCA$SP$$	Miscellaneous - Undisclosed Holdings	CACA000157
Multisector Bond	$FOCA$MU$$	Alternative Private Equity	CACA000176
Nontraditional Bond	$FOCA$NT$$	Global Long/Short Equity	HSTG000006
Preferred Stock	$FOCA$RR$$	Long-Only Debt	HSTG000029
Trading—Inverse Equity	$FOCA$IE$$	Merger Arbitrage	HSTG000027
India Equity	$FOCA$EI$$	Alternative Private Debt	CACA000177
Commodities Broad Basket	$FOCA$BB$$	Alternative Strategies	CACA000126
Global Bond	$FOCA$IB$$	Fund of Funds – Multi-strategy	HSTG000021
Global Bond-USD Hedged	$FOCA$WH$$	Global Real Estate	$FOCA$GR$$
Multi-strategy	$FOCA$MX$$	Long/Short Debt	HSTG000008
Macro Trading	$FOCA$TR$$	Miscellaneous Region	$FOCA$MQ$$

Commodities Focused	$FOCA$CF$$	Retail Venture Capital	CACA000142
Event Driven	$FOCA$ED$$	US Money Market	CACA000067
Digital Assets	$FOCA$DA$$	USD Flexible Bond	EUCA000775
Trading—Leveraged Debt	$FOCA$VD$$		
Trading—Miscellaneous	$FOCA$IS$$		
Options-based	$FOCA$XR$$		
Static Large Blend	$FOCA$5B$$		
Equity Market Neutral	$FOCA$EN$$		
Global Corporate Bond - USD Hedged	EUCA000893		
Global Emerging-Markets Bond	EUCA000586		
Global High-Yield Bond	EUCA000766		
Singapore Equity	EUCA000544		
Static Allocation—50% to 70% Equity	$FOCA$5O$$		
Static Allocation—70% to 85% Equity	$FOCA$5A$$		
Static Short-Term Bond	$FOCA$5T$$		
Systematic Trend	$FOCA$13$$		
Trading—Inverse Debt	$FOCA$ND$$		
Leveraged Net Long	$FOCA$LN$$		
Equity Emerging Markets	AUCA000008		
Bank Loan	$FOCA$BL$$		
Age 19+	$FOCA$A9$$		
Static Intermediate Bond	$FOCA$5I$$		
Target-Enrollment 2024	$FOCA$T5$$		
Target-Enrollment College	$FOCA$T9$$		
Other Bond	EUCA000771		
Target-Enrollment 2018	$FOCA$T7$$		
Stable Value	$FOCA$VL$$		
Convertibles	$FOCA$CV$$		
Global Emerging Markets Bond - EUR Biased	EUCA000764		
Equity World Other	AUCA000026		
Global Corporate Bond - CHF Hedged	EUCA000890		
Global Corporate Bond - EUR Hedged	EUCA000891		
Global High Yield Bond - EUR Hedged	EUCA000854		
Global High Yield Bond - GBP Hedged	EUCA000855		
Japan Large-Cap Equity	EUCA000521		

Multi-alternative	$FOCA$GY$$
Property - Indirect Global	EUCA000541
Sector Equity Precious Metals	EUCA000646
Static Global Bond	$FOCA$5P$$
Trading—Inverse Commodities	$FOCA$IC$$
Trading—Leveraged Commodities	$FOCA$LC$$
US Long/Short Equity	HSTG000001
US Small-Cap Equity	EUCA000530
USD Flexible Bond	EUCA000775
USD High Yield Bond	EUCA000583
USD Inflation-Linked Bond	EUCA000767
Emerging-Markets Local-Currency Bond	$FOCA$XP$$
Age 13-18 Low Equity	$FOCA$53$$
Age 19+ Low Equity	$FOCA$59$$
Age 19+ Medium Equity	$FOCA$51$$
Relative Value Arbitrage	$FOCA$RV$$
Equity World Large Blend	AUCA000027
Global Emerging Markets Bond - Local Currency	EUCA000765
USD Money Market - Short Term	EUCA000832
USD Flexible Allocation	EUCA000746
QDII Fund	PGSZ0BTTTT
Global Corporate Bond - GBP Hedged	EUCA000892
Global Corporate Bond	EUCA000889
Global Bond - USD Hedged	EUCA000763
Global Bond - NOK Hedged	EUCA000882
Global Bond - ILS	EUCA000731
Global Bond - GBP Hedged	EUCA000761
Global Bond - EUR Hedged	EUCA000624
Global Bond - CHF Hedged	EUCA000760
Asia-Pacific ex-Japan Equity	EUCA000501
Asia-Pacific Equity	EUCA000502

Exhibit 20 UK and Europe Categories Where Holdings-Based Exposures Are Not Included in MPRS Calculations

UK Category Name	Category ID	Europe Category Name	Category ID
GBP Corporate Bond	EUCA000692	Global Bond - EUR Hedged	EUCA000624
Global Flexible Bond - GBP Hedged	EUCA000903	Global Bond - USD Hedged	EUCA000763
GBP Diversified Bond	EUCA000604	EUR Corporate Bond	EUCA000690
GBP Inflation-Linked Bond	EUCA000758	EUR High Yield Bond	EUCA000590
GBP Flexible Allocation	EUCA000740	Guaranteed Funds	EUCA000611
GBP High Yield Bond	EUCA000607	EUR Flexible Bond	EUCA000754
GBP Flexible Bond	EUCA000757	Fixed Term Bond	EUCA000888
Global Corporate Bond - GBP Hedged	EUCA000892	Global Emerging Markets Bond - EUR Biased	EUCA000764
Global High Yield Bond - GBP Hedged	EUCA000855	Global Emerging Markets Bond	EUCA000586
Other Bond	EUCA000771	Global High Yield Bond - EUR Hedged	EUCA000854
EUR Corporate Bond	EUCA000690	Global Flexible Bond - EUR Hedged	EUCA000901
Global High Yield Bond	EUCA000766	Global High Yield Bond	EUCA000766
Long/Short Equity - UK	EUCA000809	EUR Bond - Long Term	EUCA000622
EUR Cautious Allocation - Global	EUCA000564	GBP Corporate Bond	EUCA000692
EUR Flexible Allocation	EUCA000864	Global Corporate Bond - EUR Hedged	EUCA000891
EUR High Yield Bond	EUCA000590	Global Corporate Bond - USD Hedged	EUCA000893
Global Corporate Bond	EUCA000889	EUR Money Market	EUCA000591
Global Corporate Bond - USD Hedged	EUCA000893	Global Emerging Markets Corporate Bond	EUCA000878
Global Emerging Markets Bond	EUCA000586	EUR Subordinated Bond	EUCA000922
Global Emerging Markets Bond - EUR Biased	EUCA000764	Long/Short Equity - Europe	EUCA000807
Global Flexible Bond - EUR Hedged	EUCA000901	GBP Diversified Bond	EUCA000604
Global High Yield Bond - CHF Hedged	EUCA000894	Global High Yield Bond - CHF Hedged	EUCA000894
Long/Short Equity - Europe	EUCA000807	Europe Bond	EUCA000594
Other	EUCA000999	Global Emerging Markets Corporate Bond - EUR Biased	EUCA000879
Property - Direct Other	EUCA000540	Global High Yield Bond - GBP Hedged	EUCA000855
Global Inflation-Linked Bond - GBP Hedged	EUCA000860	Greece Equity	EUCA000701
Global Bond - GBP Hedged	EUCA000761	USD Cautious Allocation	EUCA000695
Global Bond - USD Hedged	EUCA000763	Global Flexible Bond - USD Hedged	EUCA000902

Global Inflation-Linked Bond - EUR Hedged	EUCA000859	Macro Trading EUR	EUCA000804
GBP Money Market - Short Term	EUCA000831	Global Bond - GBP Hedged	EUCA000761
EUR Bond - Long Term	EUCA000622	Global Corporate Bond - GBP Hedged	EUCA000892
Global Flexible Bond - USD Hedged	EUCA000902	Global Flexible Bond	EUCA000899
Spain Equity	EUCA000643	Global Flexible Bond - GBP Hedged	EUCA000903
Japan Large-Cap Equity	EUCA000521	Multi-strategy EUR	EUCA000812
Asia-Pacific ex-Japan Equity	EUCA000501	Global Corporate Bond	EUCA000889
Asia-Pacific Equity	EUCA000502	Global Flexible Bond - CHF Hedged	EUCA000900
Property - Indirect Global	EUCA000541	Global Corporate Bond - CHF Hedged	EUCA000890
US Small-Cap Equity	EUCA000530	Equity Market Neutral EUR	EUCA000811
India Equity	EUCA000520	GBP Flexible Allocation	EUCA000740
Japan Small/Mid-Cap Equity	EUCA000522	GBP High Yield Bond	EUCA000607
Sector Equity Healthcare	EUCA000537	SEK Corporate Bond	EUCA000905
Japan Flex-Cap Equity	EUCA000915	Emerging Europe Bond	EUCA000623
UK Large-Cap Growth Equity	EUCA000551	Long/Short Equity - UK	EUCA000809
Sector Equity Precious Metals	EUCA000646	Systematic Trend EUR	EUCA000813
Global Bond	EUCA000759	CHF Aggressive Allocation	EUCA000618
Equity Market Neutral Other	EUCA001005	French PEA Eonia SWAP	EUCA000857
Latin America Equity	EUCA000524	Portugal Equity	EUCA000696
Global Bond - GBP Biased	EUCA000605	SEK Flexible High Yield Bond	EUCA001003
Global Corporate Bond - EUR Hedged	EUCA000891	Convertible Bond - Europe	EUCA000748
Global High Yield Bond - EUR Hedged	EUCA000854	Convertible Bond - Global, CHF Hedged	EUCA000821
Non-Euro Inflation Linked Bond	EUCA000626	EUR Money Market - Short Term	EUCA000830
Asia ex-Japan Small/Mid-Cap Equity	EUCA000907	Emerging Markets Bond	$FOCA$EB$$
Global Bond - EUR Hedged	EUCA000624	Equity Market Neutral Other	EUCA001005
Guaranteed Funds	EUCA000611	GBP Money Market	EUCA000608
USD Diversified Bond	EUCA000580	Global Bond - GBP Biased	EUCA000605
USD High Yield Bond	EUCA000583	Macro Trading USD	EUCA001007
China Equity - A Shares	EUCA000896	Multi-strategy GBP	EUCA001009
EUR Flexible Allocation - Global	EUCA000739	Multi-strategy USD	EUCA001010
Equity Market Neutral EUR	EUCA000811	Other	EUCA000999
Equity Market Neutral USD	EUCA001004	Property - Direct Other	EUCA000540
Europe Bond	EUCA000594	Sector Equity Precious Metals	EUCA000646
Fixed Term Bond	EUCA000888	USD High Yield Bond	EUCA000583
Global Emerging Markets Corporate Bond	EUCA000878	EUR Flexible Allocation	EUCA000864
Global Flexible Bond - CHF Hedged	EUCA000900	Other Bond	EUCA000771
Islamic Allocation - Other	EUCA000681	Spain Equity	EUCA000643
Islamic Global Bond	EUCA000680	EUR Corporate Bond - Short Term	EUCA000819
Long/Short Equity - Other	EUCA000880	Property - Indirect Eurozone	EUCA000847
QDII Fund	PGSZ0BTTTT	Global Inflation-Linked Bond - USD Hedged	EUCA000861

SEK Flexible High Yield Bond	EUCA001003	Turkey Equity	EUCA000703
USD Cautious Allocation	EUCA000695	GBP Flexible Bond	EUCA000757
USD Flexible Allocation	EUCA000746	Global Inflation-Linked Bond	EUCA000858
ASEAN Equity	EUCA000669	Global Inflation-Linked Bond - GBP Hedged	EUCA000860
Australia & New Zealand Equity	EUCA000503	Long/Short Equity - Other	EUCA000880
CHF Cautious Allocation	EUCA000619	GBP Money Market - Short Term	EUCA000831
EMEA Equity	EUCA000824	SEK Flexible Allocation	EUCA000745
Equity Asia Pacific w/o Japan	AUCA000009	Global Inflation-Linked Bond - EUR Hedged	EUCA000859
Equity Emerging Markets	AUCA000008	EUR Flexible Allocation - Global	EUCA000739
Equity World Large Blend	AUCA000027	CHF Cautious Allocation	EUCA000619
Global Bond - CHF Hedged	EUCA000760	GBP Inflation-Linked Bond	EUCA000758
Global Corporate Bond - CHF Hedged	EUCA000890	Global Bond	EUCA000759
Global Emerging Markets Allocation	EUCA000741	USD Flexible Allocation	EUCA000746
Global Emerging Markets Corporate Bond - EUR Biased	EUCA000879	EUR Inflation-Linked Bond	EUCA000625
Global Flexible Bond	EUCA000899	EUR Cautious Allocation - Global	EUCA000564
Global Inflation-Linked Bond	EUCA000858	EUR Cautious Allocation	EUCA000863
Global Inflation-Linked Bond - USD Hedged	EUCA000861	Japan Large-Cap Equity	EUCA000521
Japan Equity PP	EUCA000664	Switzerland Equity	EUCA000548
Korea Equity	EUCA000523	Sector Equity Healthcare	EUCA000537
Long/Short Equity - Global	EUCA000808	CHF Bond	EUCA000573
Macro Trading GBP	EUCA001006	Property - Indirect Global	EUCA000541
Money Market - Other	EUCA000833	Capital Protected	EUCA000615
Nordic Small/Mid-Cap Equity	EUCA000920	USD Corporate Bond	EUCA000691
Norway Equity	EUCA000531	Asia-Pacific Equity	EUCA000502
SEK Corporate Bond	EUCA000905	Norway Equity	EUCA000531
Switzerland Equity	EUCA000548	US Small-Cap Equity	EUCA000530
Thailand Equity	EUCA000783	Asia-Pacific ex-Japan Equity	EUCA000501
Venture Capital	EUCA001015	Euro Cautious Balanced PP	EUCA000653
Global Real Estate	$FOCA$GR$$	India Equity	EUCA000520
Property - Direct UK	EUCA000795	China Equity - A Shares	EUCA000896
Multi-strategy GBP	EUCA001009	Guaranteed PP	EUCA000662
Alternative Other	EUCA000881	Sweden Small/Mid-Cap Equity	EUCA000546
Global Emerging Markets Bond - Local Currency	EUCA000765	Latin America Equity	EUCA000524
Latin America Stock	$FOCA$LS$$	Denmark Equity	EUCA000505
Multi-strategy EUR	EUCA000812	USD Diversified Bond	EUCA000580
Macro Trading EUR	EUCA000804	Japan Small/Mid-Cap Equity	EUCA000522
Macro Trading Other	EUCA001008	Global Bond - CHF Hedged	EUCA000760
Macro Trading USD	EUCA001007	Nordic Small/Mid-Cap Equity	EUCA000920
Multi-strategy USD	EUCA001010	Japan Flex-Cap Equity	EUCA000915
Capital Protected	EUCA000615	Euro Diversified Bond PP	EUCA000654
EUR Money Market	EUCA000591	Global Emerging Markets Allocation	EUCA000741
EUR Money Market - Short Term	EUCA000830	NOK Moderate Allocation	EUCA000566
Equity Precious Metals	$FOCA$SP$$	Asia ex-Japan Small/Mid-Cap Equity	EUCA000907

Global Bond - USD Biased	EUCA000581
Alt - Fund of Funds – Multi-strategy	EUCA000802
Convertible Bond - Global, CHF Hedged	EUCA000821
Convertible Bond - Global, EUR Hedged	EUCA000750
Convertible Bond - Global, GBP Hedged	EUCA000822
Convertible Bond - Global, USD Hedged	EUCA000823
Global Bond - NOK Hedged	EUCA000882
Infrastructure Direct	EUCA001014
Multi-strategy Other	EUCA001011
Russia Equity	EUCA000642
USD Money Market - Short Term	EUCA000832
Asia Bond	EUCA000570
Commodities - Broad Basket	EUCA000785
Commodities Focused	$FOCA$CF$$
Convertible Bond - Global	EUCA000749
Currency	EUCA000797
Emerging Markets Equity PP	EUCA000651
Equity Region Asia Pacific	NZCA000044
Global Bond - ILS	EUCA000731
High Yield Credit	AUCA000045
Islamic Equity - Other	EUCA000673
JPY Bond	EUCA000595
Long/Short Equity - US	EUCA000810
Miscellaneous Sector	$FOCA$MR$$
Multisector Flexible	AUCA000070
NOK Moderate Allocation	EUCA000566
Non-Euro Absolute Return	EUCA000650
Property - Direct Global	EUCA000794
Sector Equity Private Equity	EUCA000708
Singapore Equity	EUCA000544
USD Flexible Bond	EUCA000775

Commodities - Broad Basket	EUCA000785
Money Market - Other	EUCA000833
Islamic Equity - Other	EUCA000673
Equity Market Neutral USD	EUCA001004
Options Trading	EUCA000814
Alternative Other	EUCA000881
Global Bond - NOK Hedged	EUCA000882
QDII Fund	PGSZ0BTTTT
USD Inflation-Linked Bond	EUCA000767
Islamic Global Bond	EUCA000680
Long/Short Equity - Global	EUCA000808
Trading - Leveraged/Inverse Commodities	EUCA000815
USD Flexible Bond	EUCA000775
ASEAN Equity	EUCA000669
Trading - Leveraged/Inverse Equity	EUCA000816
Africa Equity	EUCA000697
Australia & New Zealand Equity	EUCA000503
Global Bond - CHF Biased	EUCA000574
Korea Equity	EUCA000523
USA Equity PP	EUCA000665
Euro Money Market PP	EUCA000657
Sector Equity Private Equity	EUCA000708
Asia Allocation	EUCA000559
Commodities - Energy	EUCA000786
Commodities - Softs	EUCA000792
Event Driven	EUCA000800
Long/Short Equity - US	EUCA000810
Thailand Equity	EUCA000783
USD Money Market - Short Term	EUCA000832
Commodities - Grains	EUCA000787
Commodities - Livestock	EUCA000789
Currency	EUCA000797
Emerging Markets Equity PP	EUCA000651
Equity Emerging Markets	AUCA000008
Equity Region World	NZCA000051
Macro Trading GBP	EUCA001006
Macro Trading Other	EUCA001008
Relative Value Arbitrage	EUCA000798
CHF Money Market	EUCA000575
Commodities - Broad Agriculture	EUCA000784
Commodities - Industrial & Broad Metals	EUCA000788
Equity Asia Pacific w/o Japan	AUCA000009
Global Bond - USD Biased	EUCA000581
High Yield Bond - Other Hedged	EUCA000820

Multi-strategy Other	EUCA001011
NOK Bond	EUCA000596
Singapore Equity	EUCA000544
Target Date 2011 - 2015	EUCA000867
Vietnam Equity	EUCA000829
Alt - Fund of Funds – Multi-strategy	EUCA000802
Alt - Long/Short Credit	EUCA000805
Bonds - Global	AUCA000033
Convertible Bond - Global, EUR Hedged	EUCA000750
Convertible Bond - Global, USD Hedged	EUCA000823
DKK Bond	EUCA000576
Diversified Credit	AUCA000051
EMEA Equity	EUCA000824
Equity Global Resources	AUCA000058
Equity World Large Value	AUCA000029
Greater China Allocation	EUCA000919
Islamic Allocation - Other	EUCA000681
Israel Large/Mid-Cap Equity	EUCA000726
NOK Bond - Short Term	EUCA000599
South Africa & Namibia Equity	EUCA000715
Systematic Trend USD	EUCA001012
US Equity - Currency Hedged	EUCA000849
Global Emerging Markets Bond - Local Currency	EUCA000765
Asia Bond	EUCA000570
Convertible Bond - Other	EUCA000751
Convertible Bond - Global, GBP Hedged	EUCA000822
Asia High Yield Bond	EUCA000877
Russia Equity	EUCA000642
NOK High Yield Bond	EUCA000913
Convertible Bond - Global	EUCA000749
Property - Indirect Switzerland	EUCA000826
DKK Bond - Short Term	EUCA000579
Asia Bond - Local Currency	EUCA000897
China Bond	EUCA000856
Global Real Estate	$FOCA$GR$$
RMB Bond - Onshore	EUCA000906
SEK Diversified Bond	EUCA000600
SEK Ultra Short-Term Bond	EUCA000602
Systematic Trend Other	EUCA001013
Commodities - Precious Metals	EUCA000791
Property - Direct UK	EUCA000795
Property - Direct Global	EUCA000794
Greater China High Yield Bond	EUCA001002
SEK Bond - Short Term	EUCA000603
UK Large-Cap Growth Equity	EUCA000551
DKK Domestic Bond	EUCA000911
Equity Region Asia Pacific	NZCA000044

High Yield Bond	$FOCA$HY$$
Property - Direct Europe	EUCA000793
Property - Direct Switzerland	EUCA000914
SGD Bond	EUCA000774
HKD Bond	EUCA000768
High Yield Credit	AUCA000045
Alt - Fund of Funds - Equity	EUCA000801
Alternative - Macro Trading	AUCA000074
Alternative – Multi-strategy	AUCA000067
Bank Loan	$FOCA$BL$$
Convertible Bond - Asia/Japan	EUCA000627
Convertible Bond - Other Hedged	EUCA000752
Emerging-Markets Local-Currency Bond	$FOCA$XP$$
Equity Region Emerging Markets	NZCA000047
Equity World Long Short	AUCA000073
Global Bond - ILS	EUCA000731
Global Bond - Other Hedged	EUCA000762
JPY Bond	EUCA000595
Multisector - Moderate	NZCA000060
Multisector Flexible	AUCA000070
Other Asia-Pacific Equity	EUCA000506
Other Inflation-Linked Bond	EUCA000770
PLN Bond	EUCA000772
Trading - Leveraged/Inverse Fixed Income	EUCA000817
ZAR/NAD Cautious Allocation	EUCA000717

Appendix E: Contributors and Version History

Version 1.4, Oct. 25, 2024

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Updates in This Version

► Updated to reflect methodology implementation of a new volatility mapping grid for US region RBSA scores.

Version 1.3, Aug. 15, 2024

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Updates in This Version

► Updated to reflect new methodology changes for the UK calculation region – application of RBSA methodology only, and use of distinct volatility-to-MPRS mapping grids between UK and all other calculation regions.

Version 1.2, July 17, 2024

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Updates in This Version

► Updated to reflect residual variance scaler methodology enhancement applying to both HBSA and RBSA MPRS calculations.
► Updated to include a description of the new Multi-asset Risk Model residual forecast methodology.
► Updated to reflect that conventionally rounded values are used in determining the risk score range for display in Product.

Version 1.1, March 19, 2024

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Updates in This Version

- Updated Real Return Threshold for Client Portfolios to 50% from 90%, and corresponding examples.
- Added Appendix E: Contributors and Version History.

Version 1.0, March 19, 2024

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Updates in This Version

- All versions of this document before Jan. 31, 2024, are represented as Version 1.0.

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