Scorecard Methodology

Morningstar Manager Research Services

Morningstar Research Services
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Contents

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Introduction

Morningstar's Scorecards introduce a quantitative scoring framework to compare mutual funds and ETFs on a composite of important characteristics.

While many investors are familiar with fund rankings based on past performance, the Scorecards systematically rank funds on characteristics which, when combined, will partially drive their risk-adjusted returns in the future. The fund rankings compare similar funds to each other, based on investment type, active/passive, and category.

As a guidance tool for fund selection, the Scorecards help investors efficiently compare a list of funds and identify those with strong characteristics–low fees, experienced management, from a fund family with excellent stewardship, and high risk-adjusted performance. This is often a recipe for outperformance.

The Scorecards can also identify the opposite characteristics–funds with high fees, inexperienced management, from a fund family lacking in stewardship, and low risk-adjusted performance. This is often a recipe for underperformance.

For investors who are tasked with evaluating dozens of funds, or due diligence teams that are responsible for maintaining a platform with thousands of funds, the research process can create frustration. With Morningstar's Scorecards, investors will be more likely to reach their financial goals and select funds poised for success, while avoiding the funds most likely to fail.

With our transparent scoring process, investors can incorporate the Scorecards into their due diligence workflow and consider them a better starting point than past performance measures.

> *"At Morningstar's core is research and data, but transparency and clarity explain why investors have trusted us for decades." - Kunal Kapoor, Morningstar CEO*

How Morningstar's Scorecards Work

Implications for Investors

With the ability to choose from thousands of funds, the sheer amount of data can sometimes be overwhelming, and the data can hold little value until it is contextualized and transformed into useful information. Morningstar's Scorecards are designed to assist investors with fund selection along three dimensions that investors want – forecasting power, transparency, and broad coverage.

Rankings, Not Ratings

Morningstar's Scorecards are very specifically not about making recommendations; they are about acknowledging that if you have the right information, you can make the right decision for yourself. They are meant to enhance, not replace, an investors' process.

More Than Past Performance

Don Phillips, a managing director with Morningstar, has said that successful investing is about accumulated insights. Smart investors prize metrics for what they surface. However, sometimes the data can hold minimal value until it is contextualized and transformed into useful information.

Each Scorecard reflects the interrelationship of 12 data points that represent characteristics of a fund's process, performance, people, parent, and price.

Since there isn't a single variable that fund performance hinges on, Morningstar's Scorecards combine intercorrelated factors using our proprietary scoring models, which are based on our five-pillar research framework and 14 years of data-driven analysis. When compared to fund evaluation tools that are frequently used in the industry, and which can be scaled to compare all (or nearly all) funds, Morningstar's Scorecards have been tested to demonstrate an increased likelihood of selecting the best performers on a risk-adjusted basis over future five-year periods.

Scorecard Reports

Service and Delivery Details

Scorecards	Active Equity, Active Bond, Passive Equity/Bond, Allocation, Alternative, ETFs The results from each scorecard are delivered in a single Scorecard Report.
Report Frequency	Monthly
Report Delivery	Morningstar can deliver the Scorecard results in one or more of the following file types via FTP, Morningstar's software, or email. 1. Excel file 2. PDF file 3. Flat file (.csv, .txt) 4. Morningstar Direct

Morningstar's Scorecard reports are distributed on the fifth business day of the month. The reports include embedded screens, filters, and sorting tools to help navigate through the results. Morningstar's Scorecard Templates are permissioned in Morningstar Direct upon request for clients with a license.

Scorecard Results

A fund's score is the result of aggregating the 12 scoring factors using a weighted average calculation. The formula for this calculation is defined below [1], where *y* represents each factor and *w* represents the assigned weighting. The scores range from 1 to 100, where the highest score is one and the lowest score is 100. Each fund's score is a relative measure against all other funds in its peer group.

[1] $$Score = w_1 y_1 + w_2 y_2 + \cdots + w_{12} y_{12}$$

Once each fund's score is determined, funds are ranked within their peer group. The fund with the best score receives a rank of 1. The fund with the second-best score receives a rank of 2, and so on. The lowest rank will depend on the number of funds in the peer group.

Once each fund's rank is determined, we divide the rankings into quartiles within each peer group. Many investors find the quartiles helpful when trying to quickly separate the wheat from the chaff.

Many investors find the rankings valuable when comparing funds that receive the same rating from Morningstar.

Scoring Factors

In order to combine different scoring factors, the raw data values need to be adjusted such that they all appear on the same scale. Morningstar converts the raw data values to percentile rankings. Each raw data value for each scoring factor for each fund is measured against the associated list of funds in the same scorecard and category. After the percentile ranks have been calculated, they are multiplied by the assigned weights for each factor. The percentile ranks are calculated in a descending order or an ascending order depending on the direction of the relationship—"higher is better" or "lower is better", respectively. The values are then added together to calculate a fund's score.

The scoring factors, displayed as peer group percentile ranks, are displayed after the Scorecard results. Morningstar's Scorecards are not considered a black box. If a fund receives a high or low ranking, you will immediately know why. The factors are color-coded to highlight each fund's strengths and weaknesses.

Scoring Guide

Morningstar's Scorecards Calculation Guide illustrates the step-by-step process behind the calculations.

► Scorecards Calculation Guide

Stability

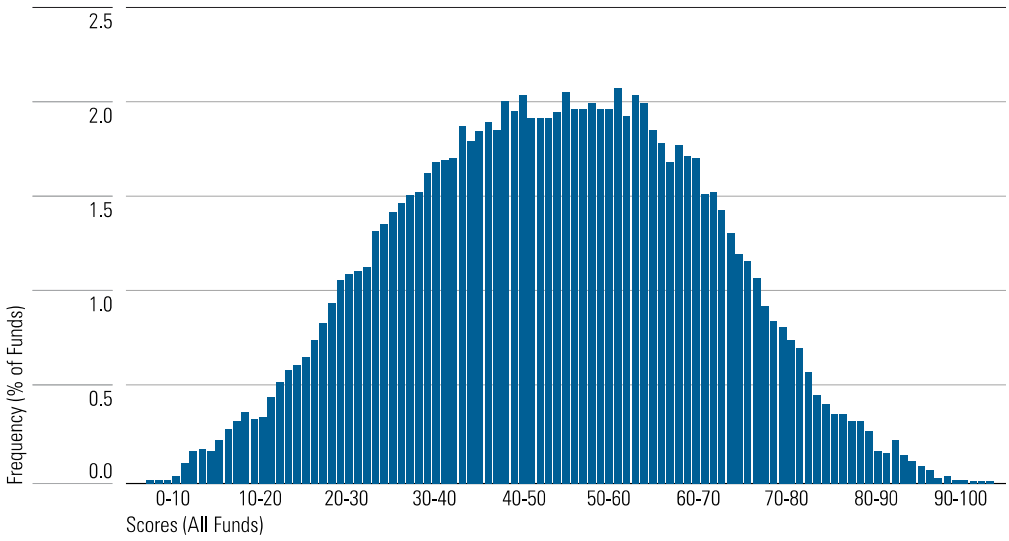
In contrast to most mean-reverting performance measures, the Scores are reasonably stable over short and long horizons. The historical average monthly standard deviation for all Scores (range: 0-100) is 2.4, which reflects consistency in the rankings.

A significant change in a fund's rank is typically attributed to a material change in its expense ratio or the departure of an experienced portfolio manager. Extreme outperformance or underperformance can also cause a fund's rank to improve or decline. Significant changes across multiple criteria is also more likely to materially affect a fund's rank in categories with fewer peers.

Historical Distribution of Scores

Morningstar's Scorecards' results aggregated across all asset classes follow a normal distribution.

Exhibit 1 Distribution of Scores (0-100)



Source: Morningstar Research Services LLC. Scores calculated for 15,147 share classes. Data as of dates: 1/1/2017 - 6/30/2017.

Scorecard Factors

The six Scorecards are designed to accurately compare funds across asset classes and investment styles.

The rankings are always determined by 12 scoring factors, which reflect the interrelationship of a fund's process, performance, people, parent, and price. However, the 12 scoring criteria and weights are different across the six Scorecards. Many of the scoring criteria are proprietary data points.

Exhibit 2 Scorecard Factors and Weightings

				Scorecards					
				1	2	3	4	5	6
Pillars	Scoring Factors	Years	Direction	Active Equity	Active Bond	Passive	Alloc.	Alt.	ETF
Price	Expense Ratio		↓	40%	44%	50%	45%	33%	50%
	Market Impact Cost	1	↓						4%
	Estimated Holding Cost	1	↓						4%
Performance	Morningstar Risk-Adj Return	3	↑	5%	5%	3%	5%	5%	3%
	Morningstar Risk	3	↓	5%		3%	3%		3%
	Information Ratio	5	↑	3%	3%			5%	
	Sortino Ratio	5	↑		3%			5%	
	Max Drawdown	5	↑		3%		4%	5%	
	R-Squared	5	↑			5%			3%
	Beta	5	↓			5%			5%
	Beta Standard Error	5	↓			3%			3%
	Alpha	5	↑			3%			3%
	Sharpe Ratio	5	↑				3%		
	Calmar Ratio	5	↑					5%	
	Omega Ratio	5	↑					5%	
	Alt Factor Correlation	3	↓					15%	
	Alt Factor Relative Volatility	3	↓					7%	
	Tracking Volatility	1	↓						5%
Process	Portfolio Turnover	1	↓	5%		15%	10%		15%
	Portfolio Concentration	1	↓						2%
People	Manager Tenure (PM)		↑	10%	10%		5%		
	Manager Tenure (Team)		↑	7%	7%				
Parent	Manager Retention	5	↑	6%	6%	4%	6%	6%	
	Manager Investment		↑	6%	6%		6%		
	Success Ratio	5	↑	5%	5%	3%	5%	5%	
	Manager Tenure		↑	4%	4%	3%	4%		
	Fee Level		↓	4%	4%	3%	4%	4%	

Source: Morningstar Research Services LLC

In each Scorecard, the scoring factors for each fund are displayed based on the fund's percentile rank within its peer group.

The price contributes the most to the overall score. Most people react to the weights of the expense ratio with skepticism, but they are, after all, the most reliable estimator of a fund's future return prospects.

As Vanguard founder Jack Bogle has stated, "In investing, you get what you don't pay for." That doesn't mean investors should select funds based solely on fees. In Morningstar's Scorecards, 11 additional factors are included, and those factors contribute at least 50% to every fund's ranking.

Performance Factors

We take a different approach from the other scorecard tools in the industry as we place relatively small importance on past performance. For funds without a long track record, Morningstar's Scorecards automatically adjust the calculation to reweight the factors based on the available data. For new share classes of funds that have a longer track record, Morningstar's Scorecards use our Extended Performance calculation, which leverages the historical performance of a fund if the share class does not have the required historical performance for the time period.

Missing Factors

If the data for a scoring factor is unavailable, the value is removed from the calculation and the remaining scoring factors are reweighted proportionately to total 100%. This will occur for funds which have a short track record.

Fund Eligibility

Morningstar's Scorecards include funds with at least 50% representation of their respective scoring factors, at least one year of performance, and placement in a peer group with three or more funds.[1] Consistent with Morningstar's research methodology, funds placed in categories that are undefined or which have an objective that does not aim to provide high risk-adjusted returns are excluded.[2]

Peer Groups

The Morningstar Category fund classification system is used to group similar funds together.

[1] Additional eligibility criteria are included for each Scorecard to ensure the most important factors contribute to the score. Funds in the Active Equity and Active Bond Scorecards must include the manager tenure data point for the longest-tenured portfolio manager. Funds in the Passive and ETFs Scorecards must include the turnover ratio data point to capture the portfolio's annual turnover.

2 As of April 1, 2018, Morningstar classified open-end mutual funds and exchange-traded funds into 123 categories. Morningstar's Scorecard calculations do not include funds in the following categories: Money Market Taxable, Money Market Tax-Free, Money Market Non-40 Act, Prime Money Market, Trading Leveraged Commodities, Trading Inverse Commodities, Trading Leveraged Debt, Trading Inverse Debt, Trading Leveraged Equity, Trading Inverse Equity and Trading Miscellaneous. Funds in these categories account for less than 1% of assets in U.S. mutual funds and exchange-traded funds.

To determine a category assignment, the fund's underlying securities are the primary factor as the investment objective and investment strategy stated in a fund's prospectus may not be sufficiently detailed. Funds are placed in a category based on their portfolio statistics and compositions over the past three years. If a fund is new, Morningstar estimates where it will fall before giving it a permanent category assignment. Category assignments may change based on changes to a fund's portfolio, although buffering rules are designed to ensure that a fund is re-categorized only when a material and sustained change in its characteristics has occurred.

Benchmark Selection

The benchmark assignments for each fund are determined by Morningstar's Data and Research groups. Relative performance measures are calculated with the Morningstar Category Index serving as each fund's benchmark. We assign the U.S. Treasury T-Bill Auction Average 3-Month index as the default risk-free rate.

Additional Data

Morningstar's Scorecard reports include additional information about each fund's size, flows, fees, and other meaningful data to help investors perform their due diligence.

Our high-quality data is the foundation of everything we do. Collecting data goes back to the roots of our company, because it's how to understand investments. Since our start, we've built a global database that covers half a million investments. We collect and analyze data on investments to make them more transparent for investors, which we do through our research, proprietary metrics, technologies, and services. We're obsessed with high-quality data because we know investors need it to make informed decisions. Through our research, we turn our data into valuable metrics that give investors information they can act on.

Factor Selection

Morningstar's Scorecards were created in two stages. First, we leveraged our Manager Research group's principles-based framework as a starting point for determining the scoring factors. Then, we performed data-driven analysis to determine the weights assigned to each factor.

Manager Research Five-Pillar Framework

When trying to determine which data points drive performance, there are so many factors to choose from that John Cochrane of the University of Chicago coined the term "zoo of factors." Given this zoo of hundreds of factors, anyone with the right dataset, a computer, and some programming knowledge could back-test any number of factor-based strategies in short order and report only the favorable results. To design a Scorecard that would not only detect favorable results from the past, but also succeed in the future, we started with our Manager Research group's five-pillar framework. From the start, we decided the scoring factors would represent each of the five pillars.

When our analysts evaluate a fund, their evaluation of five pillars—Price, Performance, Process, People, and Parent—determines the rating. As a general starting point, the People, Process, and Parent pillars are worth 25%, Performance is worth 15%, and Price is worth 10%. (This is not strict and does not apply to every fund.) While the price pillar receives the lowest importance, it's important to note that our analysts assign ratings at the fund level. (Morningstar's Scorecards rank funds at the share class level.)

1. Price

Low costs help investors build wealth by keeping more of what they earn. Morningstar's research has found that fees are the best single variable for predicting future relative performance (except for the Scorecards). Low fees often correlate with higher future returns, all else equal. In some asset classes, price differences account for 80% of the differences in returns. Investors must recognize the impact that high fees have on long-term performance.

2. Performance

Past performance, specifically in the short term, is not predictive of future performance. This is supported by many academic studies which show that performance persistence is difficult to detect and,

when detected, tends to be driven by persistent under-performance rather than over-performance (Carhart et al., 2002).

3. Process

Our research shows that equity strategies with high turnover underperform over long time horizons on average. High turnover means high transaction costs and can also indicate that a portfolio manager has a short time horizon. We believe in a long-term investing philosophy.

4. People

Experienced managers often have more skill at implementing and perfecting their methods in different market environments. However, portfolio managers currently have an average tenure of only five years. Our research shows that funds run by experienced managers are less likely to encounter abrupt manager turnover, thereby mitigating manager risk.

5. Parent

Fund companies that put the needs of investors first, over and above the interests of any third party, typically succeed over the long term. Those that retain their talented managers, rarely liquidate or merge funds, and keep costs low often have a strong culture of stewardship that rewards investors.

Quantitative Analysis

With thousands of data points to choose from in Morningstar's database, we identified a group of fund characteristics to represent each pillar and constructed a dataset which included all U.S. open-end funds and ETFs between 2002-2015. Our sample period includes different market environments. The dataset contained every share class during the 14-year period, including those liquidated or merged, which ensured our dataset was survivorship bias-free. In addition to the quantitative data, we included classification measures to differentiate funds by asset class, model, and style. For historical risk/reward measures, we included data for the three-, five-, and 10-year trailing periods.

To forecast risk-adjusted performance, we considered a 10-year prediction variable, but this would have reduced the number of observations in our dataset by half. Unfortunately, many funds don't live for 10 years. Instead, we decided to use the five-year Sharpe ratio. We selected this measure because we believe the quality of a fund can be thought of as the expectation that it will outperform on a risk-adjusted basis in the future. By selecting a risk-adjusted measure rather than a total return measure, we aimed to reward funds that achieved high performance without taking excessive risks.

The explanatory variables included risk measures, performance measures, proprietary firm-level measures, and operational data. Funds that don't have a long history are often a challenge to evaluate, but if we know that a fund comes from a successful fund family, there is a higher likelihood that it will outperform in the future.

Exhibit 3 Explanatory Variables

Performance / Risk	Fund-Level	Firm-Level
Morningstar Risk-Adjusted Return	Expense Ratio	Firm Manager Retention Rate
Morningstar Risk	Manager Tenure	Firm Manager Investment
Sharpe Ratio	Turnover Ratio	Firm Success Ratio
Information Ratio		Firm Average Manager Tenure
Downside Capture		Firm Average Fee Level
Upside Capture		
Max Drawdown		
Alpha		
Beta		
Tracking Error		
R-Squared		

Source: Morningstar Research Services LLC

After our dataset was constructed, we ranked the values across each factor, with respect to a fund's category. For example, a large-cap value fund was compared only with other large-cap value funds. If a fund's expense ratio had a value of 25, this meant the fund's expense ratio was in the 25th percentile among all funds in the same category. Our dataset had robust coverage for each variable and spanned more than 220,000 observations across 14 years. In the instances of missing data, we substituted the median value for the category.

Exhibit 4 Time Periods Analyzed

Reference Periods for the 25 Explanatory Variables	Evaluation Period for the Prediction Variable
2002-2007	2007
2003-2008	2008
2004-2009	2009
2005-2010	2010
2006-2011	2011
2007-2012	2012
2008-2013	2013
2009-2014	2014
2010-2015	2015

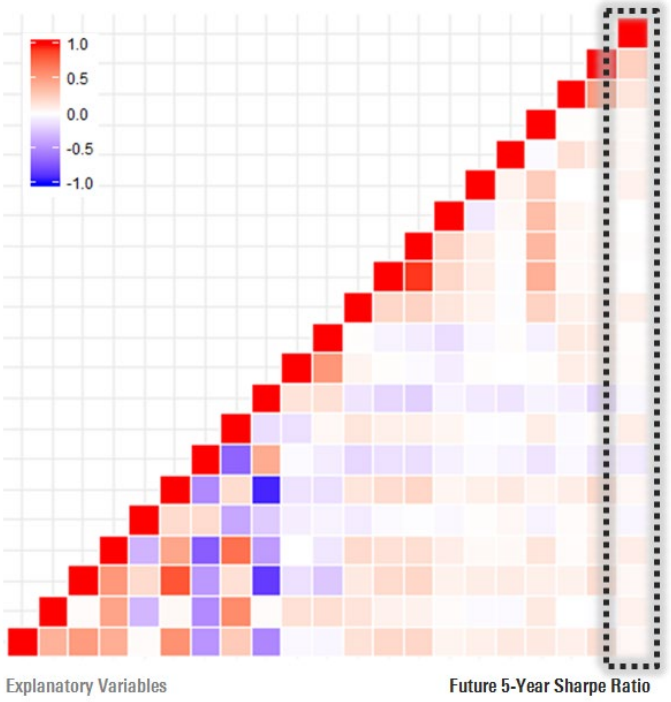
Source: Morningstar Research Services LLC

To create our prediction variable, we shifted time backward five years for each five-year Sharpe ratio. This aligned the future, unknown Sharpe ratio with the explanatory variables from which we would make predictions. The reference periods in our analysis were rolling one-year intervals such that the explanatory variables would be measured ex ante, and the evaluation period was always five years later, measured ex post. We divided the observations into training, validation, and test sets to allow for out-of-sample testing.

Correlation Testing and Weak Signals

To begin our analysis, we hypothesized that few variables would correlate with future performance in isolation. This was confirmed from a correlation plot that showed the prediction variable's correlation with the explanatory variables. A darker shade of red (positive) or blue (negative) reflects a stronger correlation. The far-right column reflects the prediction variable and displays a light shade for each variable, suggesting that these measures do not correlate with future performance on their own.

Exhibit 5 Variable Correlations



Source: Morningstar Research Services LLC. Data as of dates: 1/1/2002 - 12/31/2015. Correlation calculations use the Pearson method.

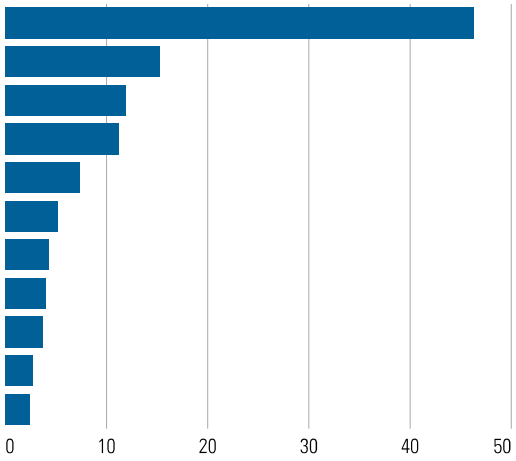
Variable Importance Testing

Once we confirmed that none of the factors showed strong correlation with future performance in isolation, we hypothesized that combining the measures with the highest correlation could extrapolate an aggregated score that was more predictive than any measure on its own. Figuratively speaking, the whole would end up being greater than the sum of its parts.

To identify the most important factors, we analyzed variable importance charts from a linear regression model.

Exhibit 6 Variable Importance: Linear Model

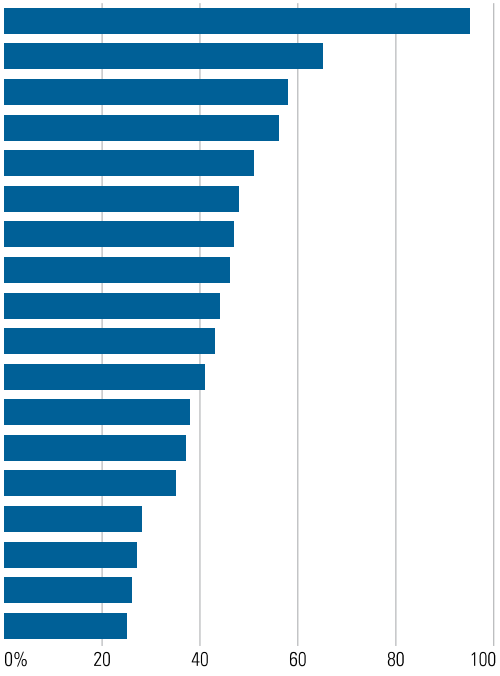
Explanatory Variables	T-value
Expense Ratio	46.31
Firm Manager Investment	15.26
Turnover	11.91
Manager Tenure	11.20
Morningstar Risk-Adj. Return	7.40
Morningstar Risk	5.23
Firm Manager Retention	4.28
Firm Success Ratio	4.02
Alpha (5-Year)	3.68
Firm Manager Tenure	2.74
Firm Average Expense Ratio	2.43



Source: Morningstar Research Services LLC. Includes variables with a t-value greater than 2. Data as of dates: 1/1/2002 - 12/31/2015.

Exhibit 7 Variable Importance: Nonlinear Model

Explanatory Variables	% RMSE
Expense Ratio	95
Firm Manager Investment	65
Firm Manager Tenure	58
Morningstar Risk	56
Turnover	51
Manager Tenure	48
Firm Average Expense Ratio	47
Firm Success Ratio	46
Firm Manager Retention	44
Morningstar Risk-Adj. Return	43
Max Drawdown (5-Year)	41
Sharpe Ratio (5-Year)	38
Information Ratio (5-Year)	37
Downside Capture (5-Year)	35
Information Ratio (10-Year)	28
Sharpe Ratio (10-Year)	27
Downside Capture (10-Year)	26
Max Drawdown (10-Year)	25



Source: Morningstar Research Services LLC. Data as of dates: 1/1/2002 - 12/31/2015.

We also analyzed results from a nonlinear random forest model, which were generally consistent with the linear model. This gave us greater conviction that we identified the most important factors.

In both models, the least important variables were 10-year measures, which we believe is a reflection that 40% to 50% of funds, on average, are liquidated or merged before they reach their tenth birthday. As nearly half of the funds didn't have 10 years of performance history, this eliminated much of these variables' importance.

The results reflected two important insights. First, the expense ratio contributed the most to future performance. Fees have a substantial negative effect on returns. As Jack Bogle said, "The surest route to top returns is low expenses." Second, none of the most important variables represented a fund's performance, which is often the one measure used by investors to compare funds.

Weight Allocations

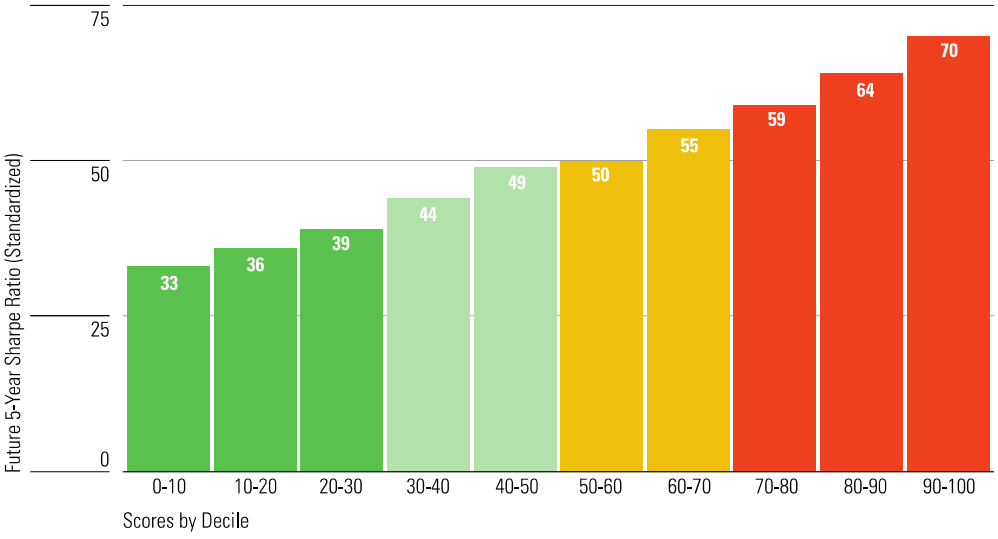
With the insights described above, we created Morningstar's Scorecards by calibrating the art of our Manager Research framework with the results from our data analysis. We were conscious of data mining and the danger of false precision, so the results from our quantitative testing influenced the selection of factors and weightings, but the final decisions were made independently and based on the guiding principles of our research framework.

In some situations, such as the expense ratio, we leaned more heavily on the data analysis. As a result, a significantly higher weight is given to the expense ratio relative to its importance in our analysts' framework. In other situations, we used the information collected from interviews with our analysts to determine the final weight assignments.

Scorecard Testing

During our testing, we compared Morningstar's Scorecards' results over a 14-year period (2002-2015) with each fund's future five-year Sharpe ratio, which was treated as our response variable to represent each fund's unknown, future risk-adjusted performance. Our analysis, including annual time series, included more than 200,000 observations. We segmented the Scorecards' results into deciles and observed a monotonic relationship between each decile and its average performance in subsequent periods.

Exhibit 8 Morningstar's Scorecards Correlate with Future Risk-Adjusted Performance (Percentiles)



Source: Morningstar Research Services LLC. Data as of dates: 1/1/2002 - 12/31/2015. Includes active and passive equity, bond, & allocation funds.

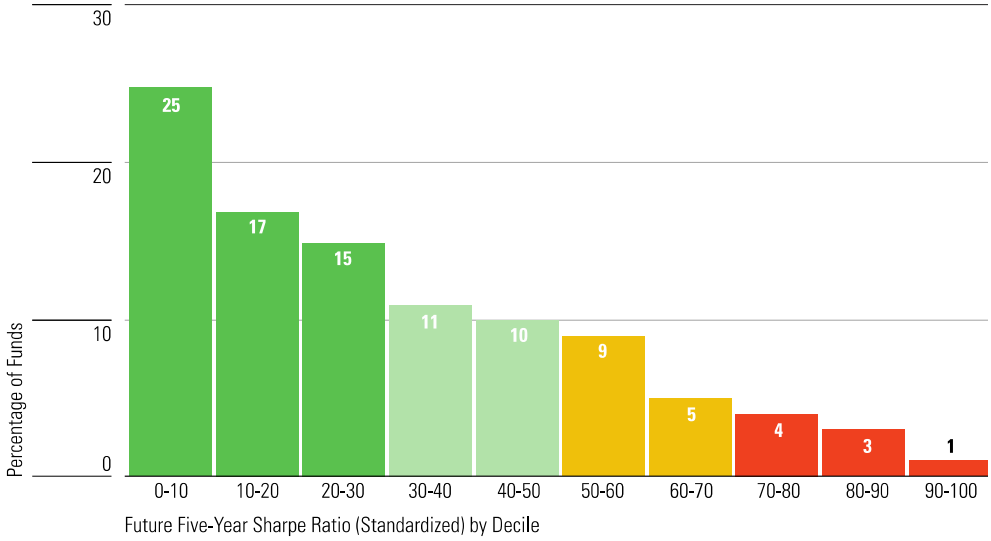
Above, we bin the scores into deciles – ten groups from best-to-worst – against the percentile rankings of forward-looking, five-year Sharpe ratios. Funds with the best scores, between 0 and 30, are shaded in green. Funds with scores between 30 and 50 are shaded in light green. Funds with scores between 50 and 70 are shaded in yellow. Finally, funds with the worst scores, between 70 and 100, are shaded in red.

The vertical axis represents the funds peer group percentile rank for the 5-year Sharpe ratio, adjusted backwards five years to align with the time each fund's score was calculated.

In our experience, some investors are interested only in the best funds to own, so we evaluated funds that scored in the top 30% of their categories.

Below we show there was a 78% probability that a top-scoring fund would perform better than its peer group average. Further, there was only a 6% probability that a top-scoring fund would perform in the bottom quartile.

Exhibit 9 The Top-Scoring Funds Correlate with Better Future Risk-Adjusted Performance



Source: Morningstar Research Services LLC. Data as of dates: 1/1/2002 - 12/31/2015. Includes active and passive equity, bond, & allocation funds.

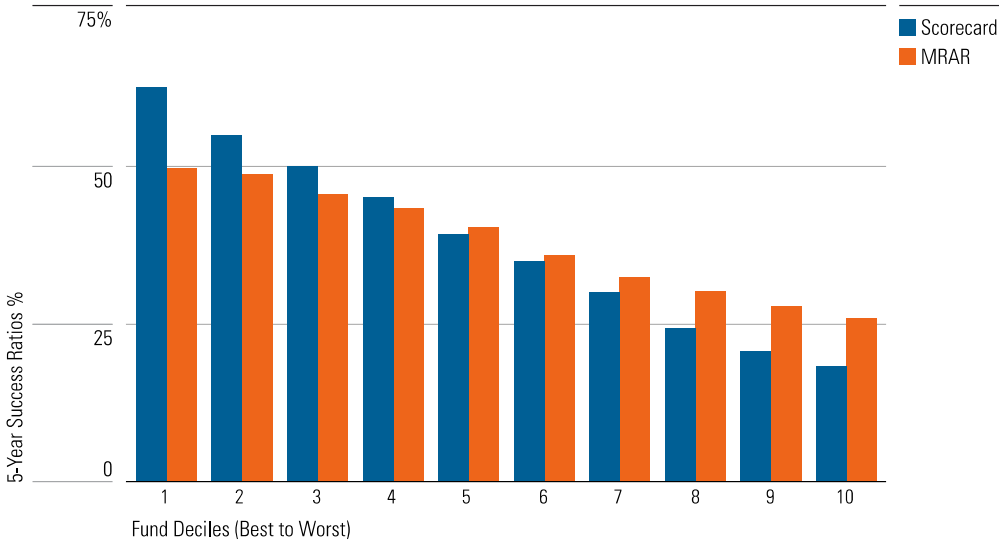
The Scorecards' correlation with future risk-adjusted returns isn't perfect, but we don't want perfect in this context. Perfect would be a sign of overfitting, the post-hoc exploitation of fortuitous coincidences in the scoring model. Since the scoring factors only have part of the information that determines future returns, we should only want them to be partially correct in their predictions.

Comparison with Morningstar's Star Ratings

Today, many investors select funds based on historical performance, evidenced by positive flows for 5-star funds. While it's understandable that investors prefer making decisions based on metrics that are objective and unambiguous, Morningstar's asset flows database suggests that many investors select funds for reasons that don't correlate with future outperformance.

To compare Morningstar's Scorecards with Morningstar's proprietary risk-adjusted return measure, which is the data point responsible for determining Morningstar's Star Rating, we analyzed the success ratios for both measures. Success ratios capture the percentage of funds that survive and outperform the category average over a five-year time period. The results suggest Morningstar's Scorecards are more effective at predicting the best and worst funds in advance.

Exhibit 10 Morningstar's Scorecards Succeed at Identifying the Best and Avoiding the Worst



Source: Morningstar Research Services LLC. Data as of dates: 1/1/2002 - 12/31/2015. Calculations are provided for Morningstar's Scorecards that were included in the initial release on 1/1/2017. The calculations behind this chart are provided here.

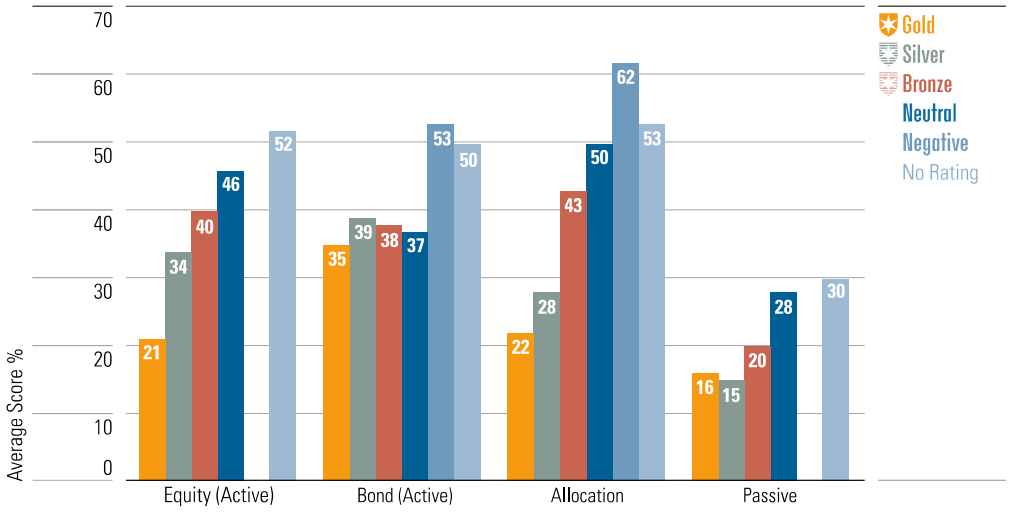
Comparisons Across Different Time Periods

The time horizon in our analysis included a bull market as well as a bear market (2007 to 2009). Our results didn't show any significant changes before or after the financial crisis, nor did we find any indication that the importance of any variable changed significantly over time. This suggests the most important factors are as predictive today as they were in the 2000s and that they will continue to be important in the future.

Correlation with Morningstar's Analyst Ratings

It would be fair to say Morningstar's Scorecards codify our research framework, and as a result, there should be high correlation with Morningstar's Analyst Ratings.

Exhibit 11 Average Scores by Morningstar Analyst Rating



Source: Morningstar Research Services LLC. Data as of 12/31/2016. The average scores are displayed for funds in Morningstar's Scorecards that were included in the initial release on 1/1/2017.

In rare instances, Morningstar's Scorecard results are inconsistent with our analysts' ratings. It is important to remember that Morningstar's Scorecards calculate rankings at the share class level and a fund's expense ratio is the most important driver of the result. Conversely, Morningstar's Analyst Ratings are determined at the fund level and each share class receives the same rating, irrespective of each share class's expense ratio. This can cause differences between the two.

Future Testing

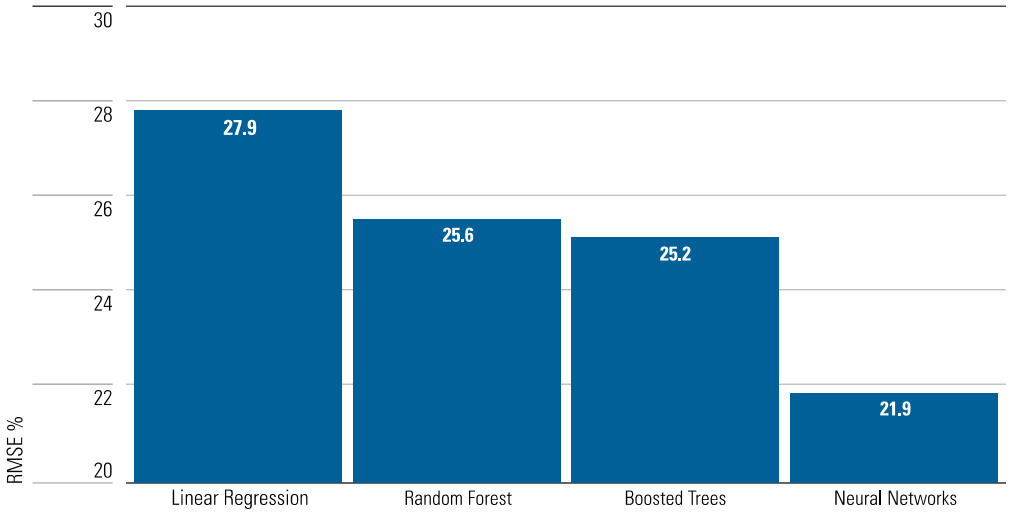
While Morningstar's Scorecards use a transparent multivariate algorithm, there are also nonlinear techniques that could be implemented to compare funds. We decided to evaluate our scoring framework against other methods.

First, we established a baseline regression model that included every variable from the dataset and generated a root mean squared error, or RMSE, of 27.9. A lower RMSE suggests higher confidence. We also tested a series of lasso regression models with cross-validation and received similar results.

Next, we tested a series of random forest models and varied the robustness to include 500, 1,000, and 1,500 trees. We also implemented a boosting technique to capture more predictability from the most important variables. The smallest out-of-sample RMSE that we generated was 25.2.

We also explored neural network models that could potentially capture complex signals from the factors that were undetected in the other models. We tested different neural network models by tuning the parameters (for example, architecture and number of hidden layers, neurons, and epochs). The best neural network model generated an out-of-sample RMSE of 21.9.

Exhibit 12 Error Rates (RMSE) for Different Models



Source: Morningstar Research Services LLC. Data as of dates: 1/1/2002 - 12/31/2015.

Compared with the linear model, there could be benefits to using nonlinear models to increase predictive power. The Morningstar Quantitative Rating is an example of an assessment that uses a nonlinear model to rate mutual funds. However, it is worth noting the benefits of additional predictive power from a nonlinear model come at the cost of transparency and clarity. We will continue to evaluate these models in the future.

Conclusion

While it is impossible to predict every fund's future with certainty, Morningstar's Scorecards succeed at ranking funds in an order that correlates with future risk-adjusted performance on average.

Definitions

Price

Expense Ratio

The Prospectus Net Expense Ratio measures the cost to an investment company to operate a fund. The fund's operating expenses are divided by the average dollar value of its assets under management. Operating expenses are taken out of a fund's assets and lower the return to a fund's investors. The three components that make up the expense ratio are management fees (which go straight to the fund company), administrative fees (which cover mailings, annual reports, account statements), and 12b-1 fees (which cover distribution, advertising and shareholder service fees).

Market Impact Cost

This factor measures the liquidity of an ETF. Less liquid securities are more thinly traded and a single large trade can move their prices considerably. This calculation is an estimate of the basis point change in an ETF's price caused by a $100,000 trade. A lower market impact implies the ETF is more liquid, but the actual size of price movements due to a single trade may vary considerably from this estimate depending on market activity. The market impact cost for an ETF incorporates the information of the bid-ask spread and the depth of market order books by measuring the volatility of market prices around the true portfolio value. This calculation standardizes the volatility to a basis point value from a $100,000 trade through the common assumption that trades in the ETF are sequentially independent and return variance caused by the trade increases in linear proportion with the dollar size of each trade. This factor is a proprietary calculation for ETFs and requires one year of data.

Estimated Holding Cost

This factor measures the realized performance of an ETF manager relative to the benchmark index after all expenses both disclosed and undisclosed. It represents the returns of the portfolio's net asset value relative to the underlying benchmark. A higher cost can contribute to greater underperformance. A smaller or even negative cost shows that the manager is doing a better job finding the lowest cost ways to replicate the benchmark index. This factor is a proprietary calculation for ETFs and requires one year of data.

Performance

Morningstar Risk-Adjusted Return 3 Year

This factor measures how a fund has performed on a risk-adjusted basis against its peers in the same Morningstar Category.

Morningstar Risk 3 Year

This factor measures a fund's downside volatility against its peers in the same Morningstar Category.

Information Ratio 5 Year

This factor measures how much a fund outperformed its benchmark per level of risk. It is helpful for evaluating actively managed strategies that deviate from their benchmark to add alpha and also identifies the consistency of the portfolio manager.

Sortino Ratio 5 Year

This factor measures performance efficiency, similar to the Sharpe Ratio, and is calculated by dividing excess return by downside risk (Downside Deviation). Volatility caused by negative returns is considered bad or undesirable by an investor, while volatility caused by positive returns is good or acceptable. In this way, the Sortino ratio can help an investor assess risk in a better manner than simply looking at excess returns to total volatility, as such a measure does not consider how often returns are positive as opposed to how often they're negative.

Max Drawdown 5 Year

This factor measures a fund's maximum loss (%) in a peak-to-trough decline before a new peak is attained. It represents the downside risk during a specified time period.

R-Squared 5 Year

This factor measures the correlation between the returns of a fund and its benchmark.

Beta 5 Year

This factor measures the systematic risk that is based on the covariance of a fund's return with the return of the benchmark. A low beta does not imply that a fund has a low level of volatility, but it does suggest that a fund's index-related risk is low.

Beta Standard Error 5 Year

This factor measures how close a fund tracks an index. It calculates the volatility of a fund's returns after accounting for the volatility of the index.

Alpha 5 Year

This factor measures the value added or subtracted by a fund's management team. It represents the difference between a fund's actual returns and its expected performance, given its level of risk as measured by beta.

Sharpe Ratio 5 Year

This factor measures a fund's risk-adjusted return and signals how much volatility a fund had to take to earn excess return over the risk-free rate (U.S. Treasury three-month Treasury Bill). It is calculated by dividing a fund's excess return by the standard deviation.

Calmar Ratio 5 Year

This factor measures a fund's compound annualized rate of return during a specified time period divided by the absolute value of maximum drawdown during the same time period.

Omega Ratio 5 Year

This factor measures a fund's risk-adjusted return, similar to the Sharpe ratio. In contrast to the Sharpe ratio, it does not assume a normal return distribution.

Alternative Factor Correlation

This factor measures the correlation with the total returns of the Morningstar Gbl Mkts NR USD index during the trailing three years. Funds with low correlation are more likely to add to a portfolio's diversification.

Alternative Factor Relative Volatility

This factor measures the relative volatility, based on standard deviation, to the Morningstar Gbl Mkts NR USD index during the trailing three years.

Tracking Volatility

This factor measures the random variation in an ETF against its benchmark. This seeks to isolate the ability of a portfolio manager to track the index, ignoring the confounding effects of liquidity on market prices. The calculation compares NAV returns, rather than market returns, to the benchmark. The statistical model includes a lagged error term to account for stale prices that can cause spurious daily pricing differences against many fixed-income and foreign equity indices. Lower tracking volatility shows better replication of the benchmark by the manager. This factor is a proprietary calculation for ETFs and requires one year of data.

Process

Portfolio Turnover

This factor represents a portfolio manager's trading activity. It is calculated by taking the lesser of purchases or sales, excluding all securities with maturities of less than one year, and dividing by the average monthly net assets. It is often used to estimate the percentage of a fund's holdings that have changed during the trailing year. Turnover data are sourced from a fund's annual report.

Portfolio Concentration

This factor measures the idiosyncratic non-market risk taken on by an ETF and represents the aggregate assets, expressed as a percentage, of the ETF's top 10 portfolio holdings. Specifically, the higher the percentage, the more concentrated the fund is in a few companies or issues, the more the fund is susceptible to the market fluctuations in these few holdings, and the more likely the manager has a strong belief in the future prospects of these holdings. Cash and cash equivalents are generally not included in this calculation. Since higher idiosyncratic risks are not always compensated with higher returns, a lower portfolio concentration is better for investors seeking to avoid security-specific and sector-specific risks. This measure is calculated for U.S. equity, international equity, and fixed-income ETFs, as those broad asset classes have diversified return factors generally agreed upon in the academic finance literature. Equity ETFs use proxies for U.S. or global market, size, and value risk factors to separate diversified, systemic portfolio risk from idiosyncratic risk. Fixed-income ETFs use proxies for market, credit, and duration risk factors to separate diversified, systemic portfolio risk from idiosyncratic risk. This factor is a proprietary calculation for ETFs and requires one year of data.

People

Manager Tenure (PM)

This factor measures the number of years that the longest-tenured portfolio manager has been managing the fund.

Manager Tenure (Team Avg)

This factor measures the average number of years that the current portfolio management team has been managing the fund.

Parent

Morningstar's proprietary stewardship measures are calculated for fund companies that offer open-end funds. The stewardship measures are not available for fund families that offer exchange-traded funds but do not offer open-end funds.

- Morningstar's Stewardship Data Methodology
- Morningstar's Stewardship Data Analysis

Manager Retention

The percentage of portfolio managers that stayed with the fund family during the last five years. A new manager doesn't count against the rate, only departures.

Manager Investment

The percentage of fund assets at each fund family where at least one portfolio manager has invested $1 million or more.

Success Ratio

The percentage of funds that were active five years ago, have not been merged or liquidated, and delivered a Morningstar Risk-Adjusted Return better than the median fund in their respective categories during the last five years.

Manager Tenure

The average number of years that the portfolio manager of each fund has stayed with the fund family. For funds with more than one manager, the tenure of the manager who has been with the fund the longest is included in the calculation.

Fee Level Average

A percentile measure that reflects the average expense ratio relative to similar share classes in the same category, distribution channel, and with a similar expense structure.

Additional Data

Low Cost Share Class

"Yes" represents the share class with the lowest net expense ratio. If "No", you will also see the next expense ratio of the cheapest share class.

Flows %

The estimated flows into or out of a fund derived from the beginning net assets, ending net assets, and total return of the fund. The flows are displayed as a percentage of beginning net assets for each time period. Morningstar's Assets and Flows data are sourced from Morningstar Direct's Asset Flows module. The figures include open-end mutual funds and exchange-traded funds, excluding fund-of-funds and money market funds. The percentage figures normalize the impact of size and help identify inflection points in investor behavior because they account for the effect of large asset bases, and are commonly referred to as the organic growth rate.

Appendix

Morningstar's Mission

Our mission is to empower investor success. Everything we do at Morningstar is in the service of the investor. The investing ecosystem is complex and navigating it with confidence requires a trusted, independent voice. Our perspective--built every day by more than 5,000 employees across the globe--is delivered to institutions, advisors, and individuals with a single-minded purpose: to empower every investor with the conviction that he or she can make better-informed decisions and realize success on his or her own terms.

Our independence and our history of innovation make us a trusted resource for investors. While other companies may offer research, ratings, data, or software products, we are one of the few companies that can deliver all of these with the best interest of the investor in mind. We believe putting investors first, paired with the way we use information design and technology to communicate complex financial information, sets us apart from our peers in the financial services industry.

Morningstar's Scorecards align with Morningstar's mission to create the most effective investment data, research, and ratings for investors. Consistent with Morningstar's guiding principles, Morningstar's Scorecards put investors first, reflect our independent research framework, focus on the long term, reward low costs, and help investors build portfolios holistically.

Built on Morningstar's Data – One of Morningstar's greatest assets is our extensive data coverage. Morningstar's proprietary coverage on approximately 30,000 open-end mutual funds and exchange-traded funds in the U.S. enables us to offer a Scorecard that is reliable and complete.

Investors First – Morningstar always conducts its research with the end investor in mind.

Methodology Oversight by Morningstar Manager Research – Decades of manager research experience provides inputs to our methodology.

An Independent View – Morningstar does not charge fund companies to be rated, nor do fund companies commission research or ratings.

Investor Recognition – According to a Wall Street Journal survey, Morningstar ranked highest among the four leading mutual fund information providers in name recognition and in perceptions of data accuracy and completeness. Because investors know and trust Morningstar, they feel more confident in making informed investment decisions when they're armed with Morningstar information.

Timeline

Version 1.1: January 1, 2017

Initial release of Morningstar's Scorecards for Active Equity, Active Bond, Passive, and Allocation mutual funds. Morningstar's Scorecard for ETFs was released on April 1, 2017.

Version 1.2: July 1, 2017

Minor weight adjustments applied to the performance-related scoring factors. Initial release of Morningstar's Scorecard for Alternative mutual funds.

Version 1.3: February 1, 2019

Many funds in Morningstar's alternatives categories now have a five-year track record and the performance-related scoring factors in Morningstar's Scorecard for Alternatives have been adjusted to reflect five-year periods. Two new data points for alternative funds, Alternative Factor Correlation and Alternative Factor Relative Volatility, from our Manager Research group have been added to the Alternatives Scorecard and replace Correlation and Beta, respectively. Their weights remain unchanged. For all Scorecards, the Morningstar Risk-Adjusted Return and Morningstar Risk factors are now calculated for the trailing three years. Previously, these two data points were calculated for the three-, five-, and 10-year periods, and then the overall scoring factor was based on a weighted average of the available time-period data.

Future Iterations

Morningstar will adjust the scoring methodology infrequently, but potential improvements will be evaluated on an ongoing basis. Any modifications will likely be attributed to evolving market conditions or new insights from Morningstar's Manager Research group.

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References

Carhart, M. 1997. "On Persistence in Mutual Fund Performance." *The Journal of Finance*, Vol LII, 57-82.

Cohen, R., Coval, J., & Pastor, L. 2005. "Judging Fund Managers by the Company They Keep." http://www.nber.org/papers/w9359

Kinnel, R., Morningstar Research Services, LLC. 2016. "Predictive Power of Fees: Why Mutual Fund Fees Are So Important."

Ptak, J., Morningstar Research Services, LLC. 2016. "Winning Funds Often Look Like Losers."

Ptak, J., Morningstar Research Services, LLC. 2017. “Do Active Funds Belong in the 'Too Hard' Pile?”

Vanguard Research. 2015. “Shopping for alpha: You get what you don’t pay for.” https://personal.vanguard.com/pdf/ISGSFA.pdf

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