MORNINGSTAR®

Treating Funds as a First-Class Citizen in Factor Models

Recasting multifactor models for funds.

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Lee Davidson, CFA
Head of Manager and Quantitative Research
Chicago +1 312 244-7541
lee.davidson@morningstar.com

Patrick Caldon
Director of Quantitative Research, Sydney
patrick.caldon@morningstar.com

Sabeeh Ashhar
Director of Quantitative Research, London
sabeeh.ashhar@morningstar.com

Darshit Doshi
Senior Data Scientist, Mumbai
darshit.doshi@morningstar.com

Summary

Fund performance attribution is a key part of the investment decision-making process, helping quantify active decisions of portfolio managers, monitoring consistency, and informing key stakeholders. Traditional analytical methods like benchmarking and Brinson attribution have often been used as intuitive and straightforward indicators of portfolio performance. However, these frameworks restrict fund managers from seeing all the underlying structural drivers of return and risk. Multifactor attribution methodologies help overcome these challenges by providing a general representation or lens for examining financial markets with richer insights that can be mapped back to the real-world, explaining portfolio performance.

In this paper, we explore a more expansive and recast multifactor model that uses funds as the primary subject of analysis, unlike conventional models, which attribute portfolio performance to popular style, sector, region, and currency factors. This is enabled through the inclusion of a host of fund-specific attributes like Expense Ratio, Morningstar Ratings, Manager Tenure, Fund Age, and Firm AUM that have long been studied as alternative drivers of fund performance. Hence, this recast multifactor model would enable a more robust understanding of managed funds performance.

We apply this new fund-level multifactor model for global equity Open-End Funds and ETFs to validate this alternative approach.

Key Conclusions:

- It is possible to build a robust multifactor model for funds that improves the explanation of fund versus portfolio returns measured through statistical goodness of fit.
- Firm AUM, Morningstar Ratings, Net Expense Ratio, Manager Tenure, and Fund Age factors, in order of importance, can help with the understanding of ex-post cross-sectional fund performance.
- In line with Morningstar's equity risk model, we found Growth and Quality style factors help attribute to fund returns.
- Exposure to Momentum factors leads to suboptimal returns for funds indicative of the higher operational costs in maintaining such fund strategies.
- A performance attribution case study based on the recast multifactor model for funds can improve return interpretation of managed funds versus portfolios.
- While this current paper is an attempt to build an alternate multifactor model for equities, the framework can eventually be extended to other asset classes like Fixed Income and Allocations.

Introduction

Multifactor models were first proposed by Barr Rosenberg in the mid-1970s and are based on a cross-sectional regression, which explains returns through a small number of observable security characteristics. For instance, the Morningstar Risk Model attributes portfolio returns with several style, sector, region, and currency factors at the security level. Further extensions to the framework allow for analysis of fixed-income securities and portfolios. Multifactor models help investors make informed decisions by decomposing portfolio returns and risk into factor- and security-specific parts. This decomposition provides a more accurate view into drivers of return and risk than a model-free examination of the securities. The analytics built on top of these models assist in return and risk attribution, manager selection, forecasting, and portfolio construction. These multifactor models are widely accepted today in the finance industry as key portfolio-management tools.

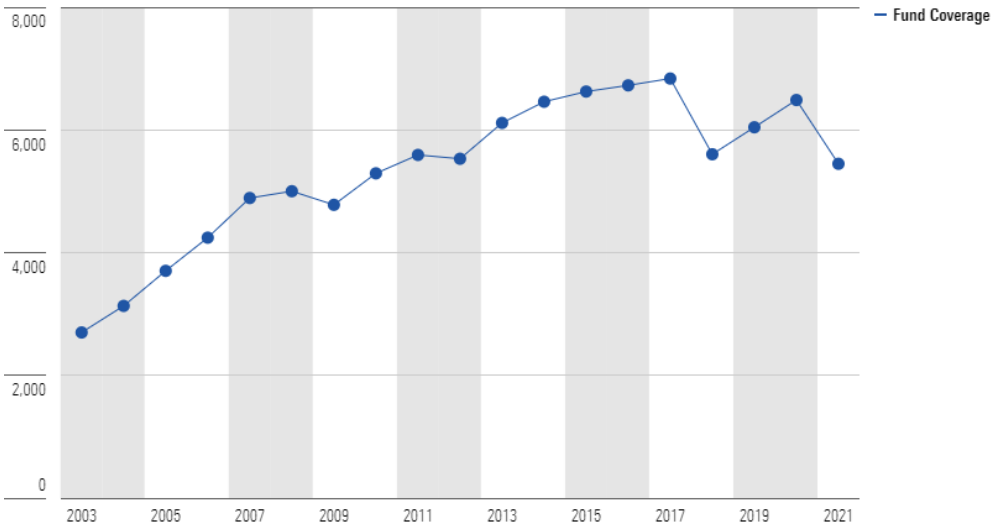
The current multifactor modeling framework assumes that funds perform like portfolios. Our hypothesis is that while fund returns can be attributed to style factors, there are additional factors to consider when evaluating funds. In this sense, funds are not just legal structures wrapping portfolios. Morningstar Manager Research team has published volumes of research, which indicates that, in addition to portfolio-specific style factors, there are several fund-specific factors like manager tenure, fund age, assets under management, or AUM, portfolio concentration, and fees that also influence performance of both active and passive funds. These factors, however, are not included in popular multifactor models, which are built from the ground up from securities due to reasons such as data quality and availability, limited computing power, and so on. Morningstar has been in a unique position here due to the rich history of valuable fund data attributes, which has been created through years of rigorous fund research. Morningstar has also been a fast adopter of modern technologies like cloud computing, which enables rapid research, prototyping, engineering and deployment of large-scale financial data assets and models, allowing for development of multifactor models at scale.

We therefore attempt to validate our hypothesis through a recast multifactor model for funds with inclusion of these additional fund-level factors. To ensure a holistic evaluation, we develop the model on the universe of global equity Open-End Funds and ETFs. We first explore the construction of a representative fund universe that will be used for modeling. Next, we evaluate the statistical and financial efficacy of various factors for inclusion in the model. Following that, we build a recast multifactor model for funds and evaluate its robustness for use in downstream analytics. We also examine the compatibility of a recast multifactor model with a security-level equity risk model. Finally, we focus on a use case for a newly developed model to better understand Fund Performance Attribution and help decision-makers with informed choices.

Model Universe Construction

The recast multifactor fund model universe is composed of global equity open-end and ETF funds. This model is built on a monthly level, dating back to May 2003. The recast multifactor fund model uses Morningstar's global, survivorship-bias-free mutual fund database. Our universe construction technique integrates monthly changes in the fund universe while including any funds that were subsequently combined or liquidated. The universe is further filtered for funds that are at least a year old with greater than $100 million in AUM. This is to ensure we have sufficient quality data for model construction while also ensuring global coverage. Exhibits 22 and 23 from Appendix A provide further details. Exhibit 1 depicts the year of the fund data coverage. Over the analysis period from May 2003 to January 2021, the universe coverage has improved gradually and hosts between 5,000 to 7,000 funds per time after 2007.

Exhibit 1 Estimation Universe* for Recast Multifactor Model for Funds



***Estimation Universe** includes approximately 13,000 Funds. (Curated Global Open-Ended Equity Funds at least 1-Year-Old and with $100 AUM.)

Source: Morningstar.

Model Factor Construction

As we proceed with the Factor Construction process, we explain some key terminologies pertaining to factor models:

- A **fund return** is the return of a fund over a one-month period. The fund return is defined in the following manner:

  fund return(t) = (NAV(t+1) - NAV(t) / NAV(t)) * 100

  Where, NAV(t) = Fund NAV (Net Asset Value) in current month

  NAV(t+1) = Fund NAV (Net Asset Value) one month after
- A **factor** is an observable property of a fund that appears to contribute to fund returns, such as AUM, Momentum, or Net Expense Ratio.
- A **factor exposure** measures the position of the factor in the cross-section of the fund-data distribution. Exposures might be positive, negative, or 0, depending on the circumstances. Exposures vary with time.
- A **factor premium** is indicative of return associated with a particular factor. They are derived from regression coefficients after running the multifactor models.

While we start to build these models, we identify more than 100 potentially relevant factors. These factors are a result of years of rigorous fund research conducted within Morningstar. We further trimmed the list based on the below aspects, ensuring that we are building a statistically robust model:

- First, we leveraged the expertise of our Manager and Quant research teams to identify a condensed list of factors, which have interesting attributes when explaining fund returns.
- Next, we checked the history and quality of factors over the entire modeling period starting from 2003. Only factors with a good history move up the analysis ladder.
- We then conducted a financial-efficacy analysis of factors through an information analysis while also checking the factor persistence, ensuring that the factors are investable. This is described in more detail below in the factor-efficacy analysis section.
- Finally, we check the statistical robustness of factors through pre- and post-model build techniques, such as goodness of fit, multicollinearity, t-stats, and so on. This is further detailed in the Statistical Efficacy section.

Factor Overview

After the above-mentioned selection process, we settled on a reduced set of 16 factors ensuring a robust and parsimonious model build. We group the factors into natural buckets as potential, people, process, performance, style, and market factor as illustrated in Exhibit 2.

Exhibit 2 Recast Multifactor Model Factors

Potential	People	Process	Performance	Style	Market Factor
Morningstar Star Rating	Fund Manager Tenure	Fund Net Expense Ratio	Trailing 12M Excess Return	Value-Growth	Equity Market Factor
Morningstar Medalist Rating		Portfolio Concentration		Size	
Fund Age		Fund Net Asset		Liquidity	
Firm AUM				Momentum	
				Risk	
				Quality	

Source: Morningstar.

Potential factors are indicative of future investor outcomes. Morningstar Medalist Rating and the Morningstar Rating are Morningstar's proprietary data indicative of improved investment outcomes. Whereby the star rating is about a fund's backward-looking performance, the medalist rating discusses the fund's forward-looking performance. The Fund Age is the fund's age in months from its inception and Firm AUM is the assets under management of the fund's parent firm.

The only relevant People factor-finding inclusion in the model is the fund manager's tenure. The tenure is measured at the fund level and is the number of years the current manager has been at the fund. For funds with more than one manager, the tenure of the manager who has been with the fund the longest is used in the calculation. This terminology is consistent with other Morningstar models like Quant Ratings, Flows models, and so on.

Process factors measure the ability of the fund's management to generate competitive advantage by executing a differentiated process consistently over time. Net Expense Ratio is one such factor used here and is indicative of cost associated with managing each share class of the fund. The Net Expense Ratio is derived at the fund level by taking asset-weighted aggregation from the share class level to the fund level. Portfolio Concentration represents the aggregated assets, expressed as a percentage of the fund's top 10 portfolio investment holdings. Fund Net Asset represents the fund's total market value of investments in USD.

Performance factor represents the fund's historical performance. Here we use the Trailing 12-Month Excess Return, which is derived using asset-weighted aggregation of share classes to fund level. It is indicative of the fund's past 12 months of performance in comparison with its category.

Style factors represent the factor tilts taken by a manager to generate excess return. It may be a natural choice to have them inside the process bucket, however, we have demarcated them as they are more aligned with the Morningstar Risk Model and are indicative of portfolio returns. Some popular factors

here are size, value, and growth. Style factors are calculated at the security level and rolled up to the fund level using portfolio holdings data. Through factor efficacy and statistical testing, we found that Momentum and Trailing 12-month excess return factors, although they sound similar, are very different.

Finally, the variable of interest we are trying to model is the Fund Return. Fund Return is derived from the fund's monthly price or NAV, or Net Asset Value, data, and it represents the fund's gross return.

Furthermore, to incorporate the dynamics of equity markets we have included an equity market factor in the model. The equity market factor is represented by a column of constant 1 in the exposure table.

Please refer to Appendix B for a detailed definition of each factor.

Factor Cleansing and Transformation

Factor cleansing and transformation is a critical part of multifactor model-building, ensuring reliable model estimates. As part of the process, we apply the below analytical steps:

- We first check for missing factor data and impute it with a forward-fill approach.
- To ensure regression model assumption pertaining to linearity, we first check right-skewed or left-skewed factor data distribution. Because Fund Age and Fund Net Asset have a skewed distribution, we log-transform these factors.
- Next, we check for any data outliers using winsorization. We winsorize data at lower (1%) and upper (99%) levels.
- Finally, we normalize all continuous factors at a monthly cross-sectional level by subtracting the cross-sectional mean and dividing by a cross-sectional standard deviation.

Refer to Appendix C for more details on Factor Cleansing and Transformation.

Statistical Efficacy Analysis

Before we start building models, we further filter out correlated factors, as it is one of the key assumptions of a regression model. We check correlation between factors through a bivariate analysis. As shown in Exhibit 3, we do not observe a high positive or negative correlation between the factors. All factors are correlated at less than 50%.

Exhibit 3 Recast Multifactor Model Factors' Correlation Heatmap

	Fund Net Expense Ratio	Trailing 12M Excess Return	Manager Tenure	Fund NetAsset	Firm AUM	Fund Age	Portfolio Concentration	Liquidity	Size	Momentum	Value-Growth	Risk	Quality	Medalist Rating	Star Rating
Fund Net Expense Ratio	1														
Trailing 12M Excess Return	-0.02	1													
Manager Tenure	-0.02	-0.02	1												
Fund NetAsset	-0.19	0.03	0.11	1											
Firm AUM	-0.19	0.02	0.04	0.31	1										
Fund Age	0.16	-0.03	0.14	0.24	0.06	1									
Portfolio Concentration	0.04	0.02	-0.06	-0.15	-0.06	-0.07	1								
Liquidity	-0.13	0.01	0.06	0.08	0.14	0.08	-0.21	1							
Size	0.11	0	0.03	-0.13	-0.04	-0.04	-0.15	0.06	1						
Momentum	0.05	0.32	0.02	0.01	0.02	0.03	-0.06	0.17	0.01	1					
Value-Growth	0.05	0.12	0.01	0.02	0.02	0.06	0	0.23	0.02	0.38	1				
Risk	0.07	0.02	-0.01	-0.07	-0.01	-0.07	0.02	0.01	0.42	0.1	0.15	1			
Quality	0.08	0.03	0.01	-0.03	-0.06	0.06	0	-0.1	-0.04	0.15	0.28	0.03	1		
Medalist Rating	-0.14	0.17	0.28	0.25	0.13	0.1	0.01	-0.04	0.03	0.02	0.04	-0.01	0.02	1	
Star Rating	-0.01	0.24	0.07	0.15	0.04	0.1	-0.03	-0.01	0	0.09	0.08	-0.04	0.05	0.46	1

Source: Morningstar.

While the above exhibit is a bivariate correlation test, we would also like to conduct multivariate multicollinearity testing, through Variance Inflation Factor, or VIF. The variance inflation factor assesses multicollinearity among multiple independent factors. A common rule of thumb is to keep VIF below 5.

We calculate the VIF score for all the factors as discussed in Appendix D.

As shown in Exhibit 4, for all the factors, VIF score is below 2, which suggests that all these factors are uncorrelated.

Exhibit 4 VIF Analysis

Factor	VIF
Fund Net Expense Ratio	1.16
Trailing 12M Excess Return	1.18
Fund Manager Tenure	1.05
Firm AUM	1.15
Fund Age	1.16
Fund Size	1.28
Portfolio Concentration	1.12
Liquidity	1.21
Size	1.38
Momentum	1.65
Value-Growth	1.35
Risk	1.33
Quality	1.15
Star Rating	1.91
Medalist Rating	1.98

Source: Morningstar.

Financial Efficacy Analysis

Before inclusion of factors in the model, we also want to ensure that factors are financially efficient, meaning that they can explain the cross-section of fund returns. This factor efficiency should hold in the long run. In addition, the persistence of these factors should be high, suggesting that the factor has low turnover and is investable. To investigate these aspects, we analyze the information coefficient, or IC, and factor persistence over various time periods: six months, 12 months, and 24 months.

Exhibit 5 Information Analysis

Information Analysis	6M	12M	24M
Fund Manager Tenure	1.70%	1.70%	2.20%
Firm AUM	3.00%	4.50%	6.60%
Fund Net Expense Ratio	-1.70%	-3.60%	-5.90%
Quality	5.80%	6.90%	8.20%
Value-Growth	3.60%	4.70%	8.50%

Source: Morningstar.

The IC is rank correlation between the factor exposure and the N-months ahead fund returns (where N is 6, 12, 24 months as shown in Exhibit 5). A positive value for IC suggests a higher likelihood that the factor is explaining fund returns over a longer time horizon, whereas a negative value for IC suggests otherwise. Here, positive IC value of Fund Manager Tenure, Firm AUM, Quality, and Value-Growth factors suggest a positive contribution toward fund performance. Alternatively, Net Expense Ratio factor is implying negative contribution, as we would expect from higher fees. Please refer to Exhibit 40 from Appendix D for details on additional factors.

Exhibit 6 Persistence Analysis

Persistence Analysis	6M	12M	24M
Fund Manager Tenure	73.44%	60.62%	43.50%
Firm AUM	84.36%	75.66%	62.96%
Fund Net Expense Ratio	81.74%	72.50%	59.56%
Quality	58.68%	47.24%	36.20%
Value-Growth	67.40%	57.06%	46.36%

Source: Morningstar.

Persistence Analysis tells us how consistently funds stay in the same factor quintile and do not shift from one factor quintile to another across six months, 12 months, and 24-month time periods. The implication here is that if there are frequent shifts then it would lead to higher strategy turnover. We established 5 quintiles for each factor, with the top quintile containing funds with higher factor exposure and the bottom quintile containing funds with lower factor exposure. We would prefer to have higher factor persistence because it signifies greater stability. A lower factor persistence score may indicate that the fund regularly oscillates across quintiles, which may incur additional costs, such as slippage and commission. As shown in Exhibit 6, factors like Fund Manager Tenure, Firm AUM, Net Expense Ratio, Quality, and Value-Growth have high factor persistence over time. Refer to Exhibit 41 from Appendix D to analyze Persistence Analysis for each factor.

Model Framework Methodology

The above series of steps helps us finalize the most important factors that would help model fund returns. We next move into the model-building phase where we try to model our variable of interest (monthly fund returns) as a function of finalized factors through a cross-sectional regression model built at a monthly frequency. The model is built at each cross-section on funds passing the filter criteria as discussed in the Universe Construction section. Exposures from time t are the independent variables and returns from time t to t+1 are the dependent variables. We roll forward the regression models from May 2003 until January 2021.

Factor Premium Estimation

Given a collection of fund factor exposures Xt, at time t, we perform a cross-sectional regression of exposures on fund returns from time t to t+1, rt, to estimate the factor premium ft. This is indicative of regression coefficient in the model below.

$$r_t = X_t f_t + \epsilon_t$$

Where,

r_t = (n x 1) vector of fund returns between time t and t + 1

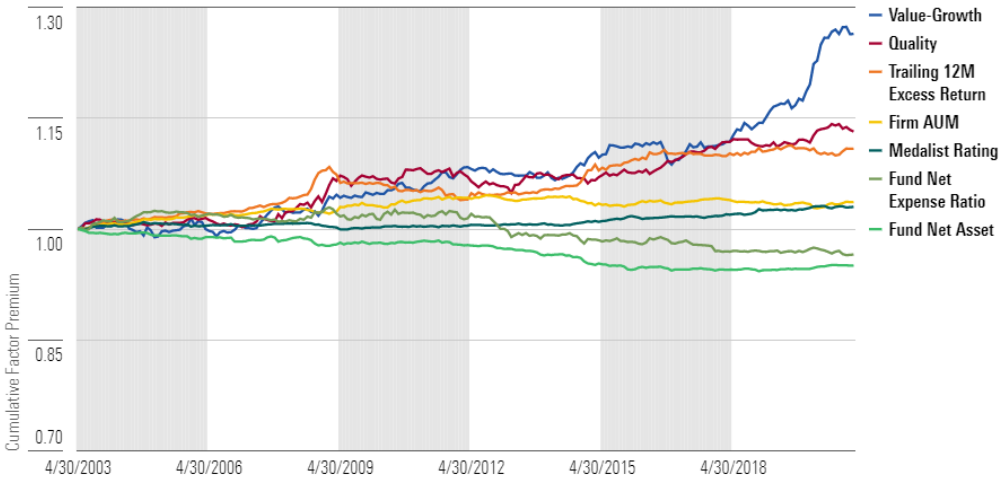
X_t = (n x m) matrix of funds' exposures to factors at time t

f_t = (m x 1) vector of factor premiums between time t and t + 1

ϵ_t = (n x 1) vector of error terms between time t and t + 1

We generate a historical time series of cumulative factor premium by repeating this cross-sectional regression over time.

Exhibit 7 Historical Cumulative Effect of Factor Premiums for Recast Global Equity Multifactor Model



Source: Morningstar.

Exhibit 7 shows the cumulative premium plots for the most relevant factors. The cumulative premiums are indicative of returns an investor would expect (by initially investing $1) solely attributed to the factor while neutralizing effects of other factors. These premium plots suggest that funds with higher exposures to factors like Trailing 12-Month Excess Return, Value-Growth, Firm AUM, Quality, and Medalist rating have a higher significance on fund returns. On the other hand, if investors had invested

in funds with higher Net Expense Ratio or Fund Net Assets then they would have received relatively lower returns.

Model Efficacy Evaluation

Once we build the model, we would also test its robustness to ensure usage for downstream analytics. In the sections below, we describe the statistical tests conducted to ensure robustness.

Recast Multifactor Model Regression Diagnostics

As shown in Exhibit 8, for each factor, we checked average absolute T across time. Average absolute T value of greater than 2 is indicative of a statistically significant factor. Next, we also calculate percentage absolute T greater than 2 (indicative of statistical stability) over all cross-sectional models. We also calculate annual factor returns, annual factor volatility, Sharpe ratio, and T-statistics using factor premium data.

Exhibit 8 Model Regression Summary

Factors	Avg Abs T	% Abs T>2	Annual Factor Return	Annual Factor Volatility	Sharpe Ratio	T-Statistics
Equity Market Factor	33.60	94.83	6.16	14.78	0.42	6.09
Fund Net Expense Ratio	5.35	74.65	-0.19	0.91	-0.21	-3.09
Fund Manager Tenure	3.61	67.14	-0.25	0.62	-0.40	-5.77
Trailing 12M Excess Return	4.87	69.48	0.59	0.92	0.64	9.35
Firm AUM	3.03	55.87	0.20	0.48	0.42	6.17
Fund Age	2.49	49.77	-0.10	0.48	-0.20	-2.95
Fund Net Asset	2.31	49.77	-0.28	0.46	-0.61	-8.95
Portfolio Concentration	5.31	74.18	0.01	0.87	0.01	0.20
Liquidity	15.36	89.20	0.31	2.87	0.11	1.59
Size	11.28	89.20	0.18	2.09	0.09	1.28
Momentum	11.66	90.14	-0.25	2.44	-0.10	-1.51
Value-Growth	8.88	82.16	1.34	1.64	0.82	11.95
Risk	14.89	90.61	-0.03	3.07	-0.01	-0.13
Quality	7.38	80.75	0.71	1.21	0.58	8.53
Medalist Rating	1.99	45.07	0.17	0.32	0.53	7.72
Star Rating	2.01	39.44	0.14	0.77	0.17	2.55

Source: Morningstar.

We analyze the factor return as shown in Exhibit 8. As an example, Value-Growth's annualized premium is 1.34%, meaning 1 standard deviation increase in the factor adds 1.34% to the fund return. This positive trend is expected as Growth funds have outperformed Value funds over most of the period (last 10 years), as we will discuss in next few sections. Similarly, the Net Expense Ratio's annualized return premium is negative 0.19%, so a 1-standard deviation increase in fund net expense decreases the fund

return by 0.19%. This is again expected as fees detract from returns, per research conducted by the Manager Research team. We also observe that factors like Value-Growth, Trailing 12-Month Excess Return, Quality, Medalist Rating, Firm AUM, Star Rating, and Liquidity have positive contribution on fund returns in order of importance, while factors like Fund Net Asset, Fund Net Expense Ratio, Fund Manager Tenure, Fund Age, Momentum, and Risk have negative contribution on fund returns. Momentum Style Factor premium is negative and is identified as an anomaly, which we will discuss in the next sections. This is a great insight on factor relevance, as fund-level factors did not find inclusion in the Equity Risk Model.

Model Goodness-of-Fit Analysis

Next, we do a diagnostic review of the cross-sectional models measured through statistical measure like goodness of fit. The goodness of fit of a regression model is measured through Adjusted R2 whereby a higher value is indicative of a better model fit in explaining fund attribution. Exhibit 9 shows the 12-month rolling window mean R-squared score for all cross-sectional models. The Fund Risk Model's average R-squared score (from regression model) is 32.18% over the entire period.

Exhibit 9 Model 12-Month Moving Average R-Squared

Source: Morningstar.

Fund and Equity Risk Model Outcome Study

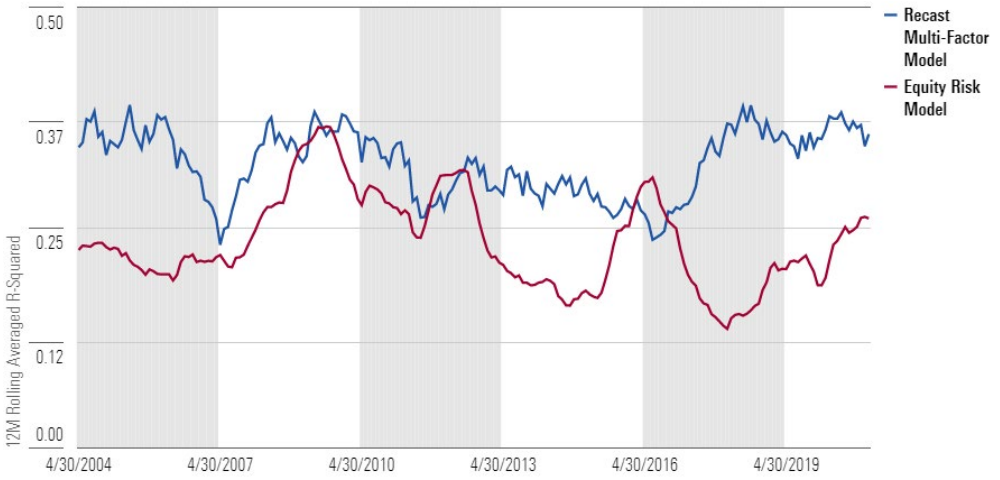
We now move on to study the outcomes between the recast multifactor fund model and equity risk model. We need to acknowledge that the equity risk model is built on daily frequency holdings data while the recast multifactor fund model is built upon monthly fund level data. Therefore, it is inequitable to compare the models peer to peer, but this section accentuates the compatibility between them. We

would first like to evaluate the statistical performance and then move ahead to account for key differences between the models.

Statistical Model Performance Study Using R-Squared

We evaluate the goodness-of-fit statistic, R-squared scores of both the models. Exhibit 10 shows the 12-month rolling mean averaged R-squared score for both the models. As can be seen, the goodness-of-fit statistic for the recast model stands out as good as the equity risk model across time.

Exhibit 10 12-Month Rolling Averaged R-Squared



Source: Morningstar.

We now move on to account for some of the key differences attributable to this model. Referring to Exhibit 11 and the premium weightage for each factor, we could see that additional factors found most significant in the recast model are:

Fund Net Expense Ratio: Higher fees reflective of management style, asset classes invested, or skill set of the fund manager negatively impact returns. This corroborates with earlier Morningstar research Clear Link Between Fees and Performance. The equal-weighted average U.S. fund fee clocked in at 0.98% in 2020--nearly a 20% decrease from 1990, when it was 1.22%, leading to more investors flocking to cheaper entrants driven by long-term performance differences.

Trailing 12 Months Excess Return: We see that the excess return calculated over category return is positively driving returns. This is attributable to fund managers' skill set in identifying undervalued securities and trade to exploit this knowledge. The level of skill advantage that a manager carries would translate to generate this excess return over long time periods.

Fund Size: Higher fund size negatively impacts the returns over long periods. As per Berk and Green (2004), there is a differential ability to generate high returns across managers but a decreasing return to scale in deploying these abilities as the fund size increases. As size increases, volatility or tracking error decreases. Hence a fund is forced to become more like an index fund and cannot generate the active differentiated return.

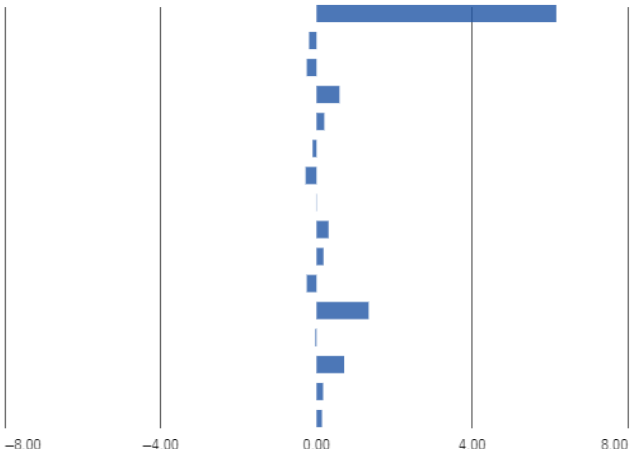
Fund Age: Fund Age also negatively impacts fund returns. As per Morningstar Study 'Why Funds Die' some evidence shows that funds aren't able to generate the similar levels of returns with rising AUMs, leading to eventual shutdowns.

Medalist and Star Ratings: Both Morningstar ratings are forward-looking evaluations of how these funds might behave in a variety of market environments, which helps investors choose superior funds that will have improved investment outcomes. Morningstar has tested the ratings methodology and found that funds having ratings in sequence from Gold to Negative have differentiated performance.

The directionality of above added factors further bolsters our hypothesis, as shown in Exhibit 11, that funds must be viewed differently than portfolios and that funds have additional drivers explaining performance.

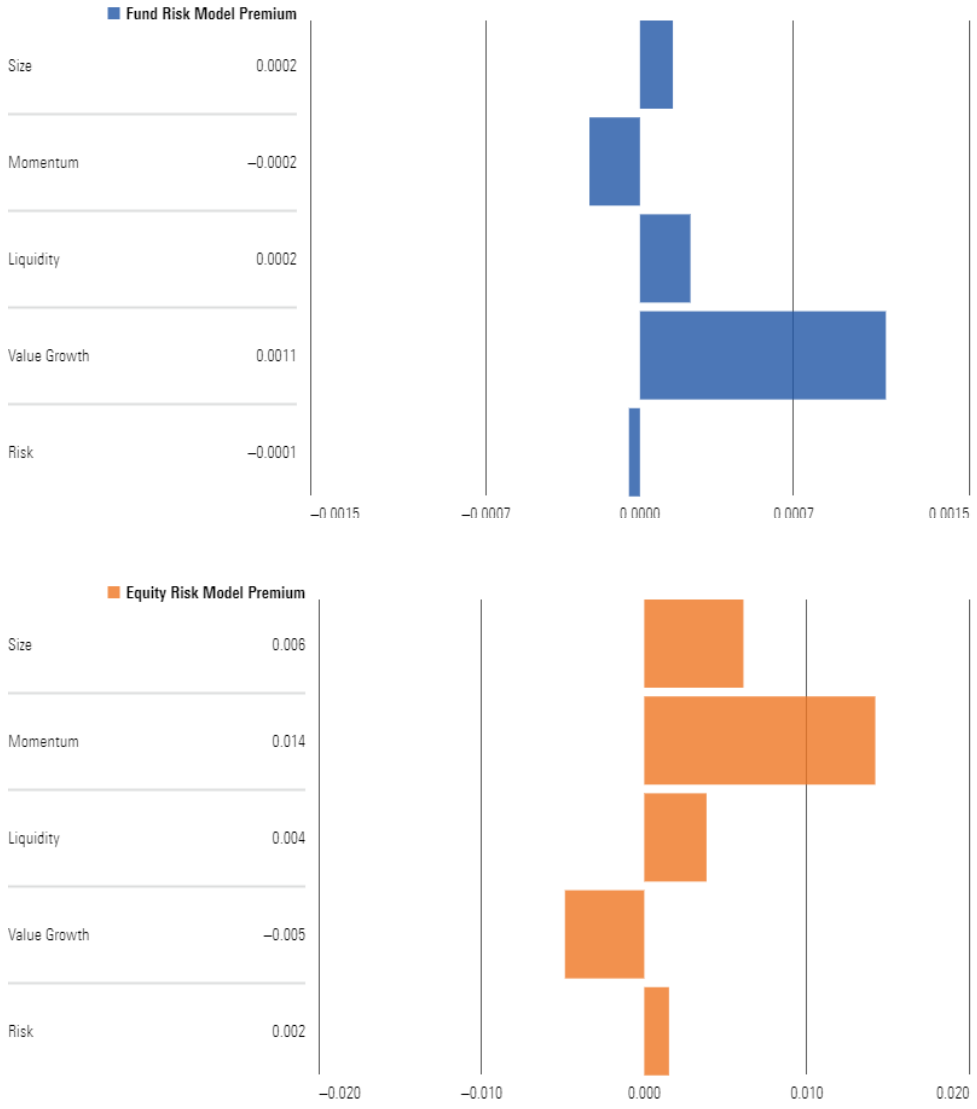
Exhibit 11 Factor Premium in Recast Multifactor Model for Funds (May 2003 to January 2021)

	Annual Return Premium
Equity Market Factor	6.16
Fund Net Expense Ratio	–0.19
Fund Manager Tenure	–0.25
Trailing 12M Excess Return	0.59
Firm AUM	0.20
Fund Age	–0.10
Fund Size	–0.28
Portfolio Concentration	0.01
Liquidity	0.31
Size	0.18
Momentum	–0.25
Value-Growth	1.34
Risk	–0.03
Quality	0.71
Medalist Rating	0.17
Star Rating	0.14



Source: Morningstar.

Exhibit 12 Style Factor Premium Comparison From May 2003 to January 2021

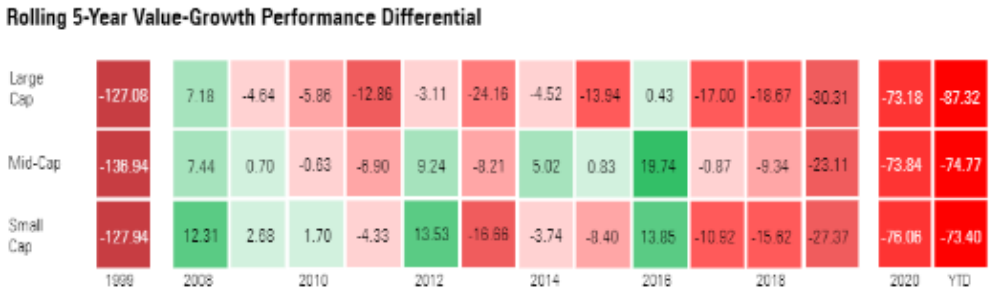


Source: Morningstar.

We now move on to understanding some of the key differences between the equity factor model and the recast multifactor model. This may not be an apples-to-apples comparison as not all factors from the Equity Risk model were included in the new model. We would hence focus our attention on factors that are common across both the models. Exhibit 12 shows the factor premium for both the models attributed to common Style Factors. The magnitude and directionality of Size, Liquidity, and Risk Factors are similar across both the models. The major difference between both models is attribution power of Momentum and Value-Growth Factor.

First, we find that Value-Growth Factor has a higher proportion of weightage in the recast model, driving fund performance. This has been a pattern as observed in the Morningstar Value-Growth Performance Differential Report where Growth Funds have outperformed Value Funds over the past several years. In Exhibit 13 below, we show the rolling difference between Value and Growth Funds. A negative value across a majority of the period is indicative of Value Funds underperforming Growth Funds.

Exhibit 13 Value-Vs-Growth Performance Gap Heatmap



Source: Morningstar.

Momentum Anomaly

Momentum in stocks is perhaps one of best-performing factors. Therefore, portfolios based on momentum tilts add remarkable value in most time periods and asset classes, all over the world; however, results for funds from our recast model indicates surprisingly weak results. To test this out we first looked at the Momentum Tilted Portfolios by filtering the universe through the risk model portfolio holdings exposure for funds having positive Momentum scores. We then evaluated the three-year excess returns for all the funds. This is detailed in Exhibit 14 below. As can be seen, 74.71% of the momentum funds have not been able to generate excess return above their benchmarks. This is also reflective in excess alpha, which has been at negative 3.25%.

Exhibit 14 Momentum Anomaly Analysis

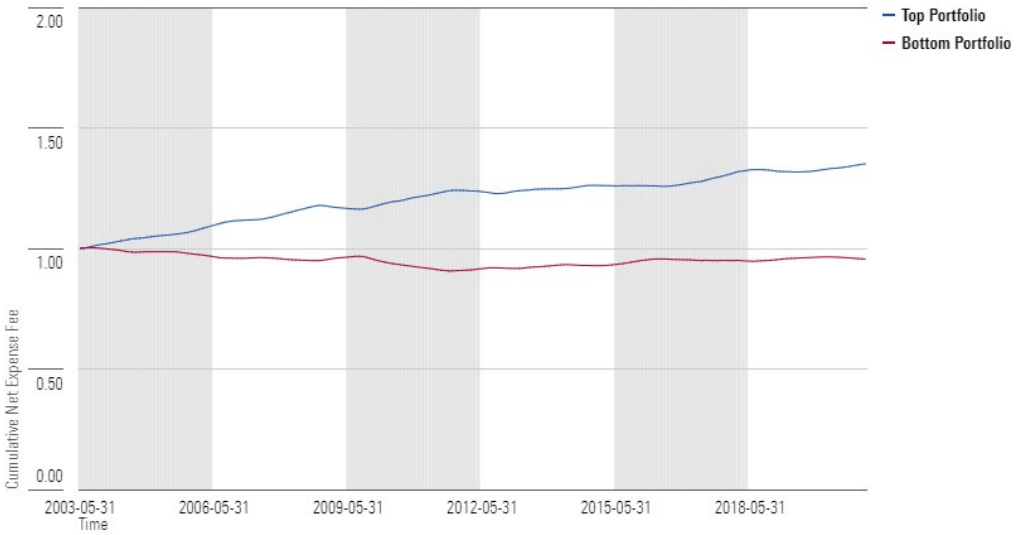
No of Funds	Average Excess Return	% Funds Having Positive Excess Return (2020)	% Funds Having Negative Excess Return (2020)
4492	-3.25	25.28	74.71

Source: Morningstar.

As per research by Rob Arnott, Vitali Kalensik, Lillian Wu (2007), some reasons for the underperformance of momentum factors in funds is the price impact of trading costs associated with a strategy's high turnover. Momentum factor is also a fast-decaying factor, unlike value factors, and a strong buy-sell

discipline must be maintained for underlying strategies. Since most funds rebalance at a specific schedule, a significant effort is required to avoid stale-momentum (late in momentum cycle) constituents while also accounting for turnover. This results in a higher operations effort to research and manage Momentum strategies. The additional effort may often lead to an increase in fund-management costs. To test the hypothesis of increased costs for Momentum strategies, we create Quintile Portfolios based on Momentum Factor exposure for funds. We evaluate the expense ratio differences between the top (20%) and bottom (20%) quintile over the period while maintaining a monthly rebalancing schedule. As can be seen in Exhibit 15, the top Quintile has a consistently higher Expense Ratio compared with the bottom Quintile.

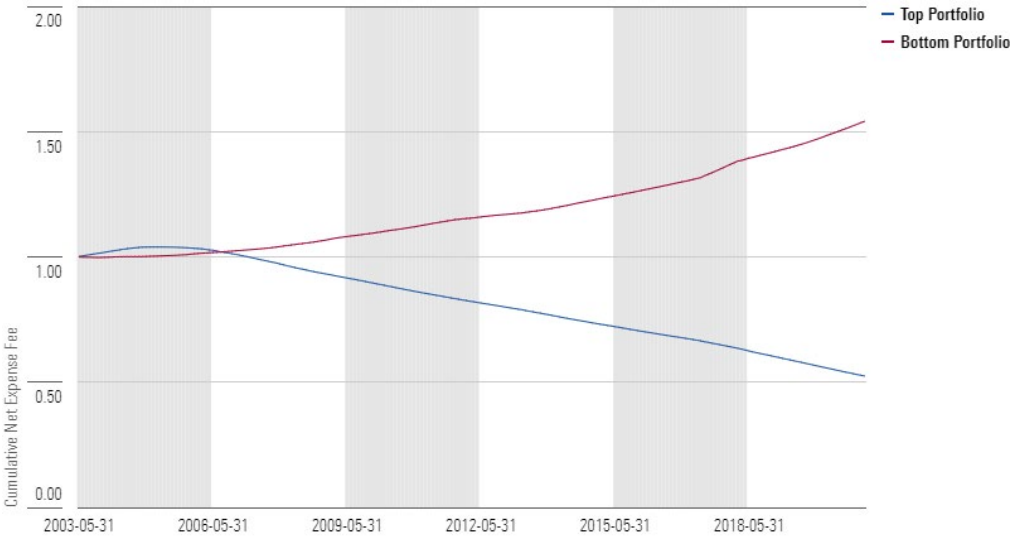
Exhibit 15 Momentum Factor-Based Cumulative Net Expense Ratio of Portfolio



Source: Morningstar.

To further ensure that the analysis is not an outcome of chance, we create similar Quintile portfolios for another Factor, such as Firm AUM. As can be seen in Exhibit 16, the expense ratio of Top Quintile fund is consistently decreasing over time. This is the outcome of technological advancement and operational effectiveness whereby fund houses are optimally able to manage operations as they start to manage more assets.

Exhibit 16 Firm AUM Factor-Based Cumulative Net Expense Ratio of Portfolio



Source: Morningstar.

The above explanation discusses more of the impact of the momentum factor in the current universe, and since this is a big area of research, it will be a focus area for our next series of papers.

Case Study

We will now turn to demonstrating analytics around our newly discovered fund factor model. We would like to conduct a performance-attribution study between two funds to explain the ability of a fund's performance. We take two different funds from the same Morningstar Category that have equivalent fund net asset. For example, we evaluate the performance of Laudus U.S. Large Cap Growth (LGILX) and Jackson Square Large Cap Growth (JSPJX) funds placed in the Morningstar Large-Growth category. The AUM for the LGILX fund is $3.6 billion and for the JSPJX fund it is $1.6 billion. The LGILX fund is 23 years old while the JSPJX fund is 27 years old. Also, from January 2018 to December 2020, LGILX has given a 23% return while JSPJX has given a 20% return.

Through this Performance Attribution study, we try to answer some of the below questions that would help in fund due diligence:

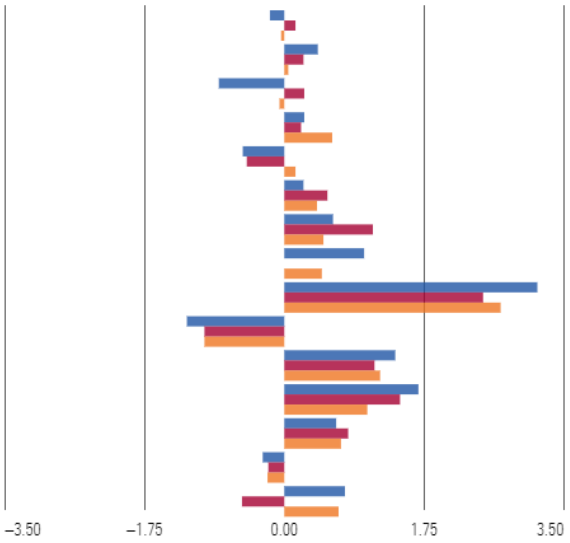
- How does a fund's historical overall positioning compare with category exposures?
- What are additional return attribution insights we get from newly recast models?
- Why has the fund sustained higher returns than peers?
- Which returns can be explained by factors vs. manager skill?

Let us start the analysis by first understanding the exposure of the funds on various factors for the period January 2020 to December 2020. As illustrated in Exhibit 17, we infer that the LGILX fund has low cost, low manager tenure, favorable rating, young age, alongside high growth-oriented asset exposure and quality compared with the JSPJX fund and the category average. In terms of Style Factors

exposures, it seems that both funds follow an investing strategy in large-cap growth companies, which is higher than the category average. The above exposures are consistent with Analyst reports available for funds in Morningstar Direct.

Exhibit 17 Fund Average Exposure Vs. Category Average Exposure

	LGILX	JSPJX	Category
Fund Net Expense Ratio	–0.18	0.14	–0.04
Trailing 12M Excess Return	0.42	0.24	0.05
Fund Manager Tenure	–0.82	0.25	–0.06
Fund Net Asset	0.25	0.21	0.60
Firm AUM	–0.52	–0.47	0.14
Fund Age	0.24	0.54	0.41
Portfolio Concentration	0.61	1.11	0.49
Star Rating	1.00	0.00	0.47
Medalist Rating	3.17	2.49	2.71
Size	–1.22	–1.00	–1.00
Momentum	1.39	1.13	1.20
Value-Growth	1.68	1.45	1.04
Liquidity	0.65	0.80	0.71
Risk	–0.27	–0.20	–0.21
Quality	0.76	–0.53	0.68



Source: Morningstar.

Let us now break down the fund returns for both the funds from January 2020 to December 2020 in order to investigate factors contributing to the funds' performance. We observe that the LGILX fund has consistently been generating excess return compared with the JSPJX fund. As illustrated in Exhibit 18, at a high level, the factor return is attributable to 80% of total fund return for LGILX and 83% for the JSPJX fund. Manager skill is attributed to 20% for the LGILX fund and 16% for the JSPJX fund.

We also see that in comparison with the JSPJX fund, the LGILX fund's low expense ratio, low manager tenure, high Medalist ratings (Silver vs. Neutral, respectively) and high-quality factors have helped generate positive returns, combined with the strategy of investing in high-growth companies that have translated to positive returns for both the funds. This attribution study uncovers an important insight that reliance on existing factor models would not have helped in understanding return differences.

Exhibit 18 Fund Return Attribution From January 2020 to December 2020

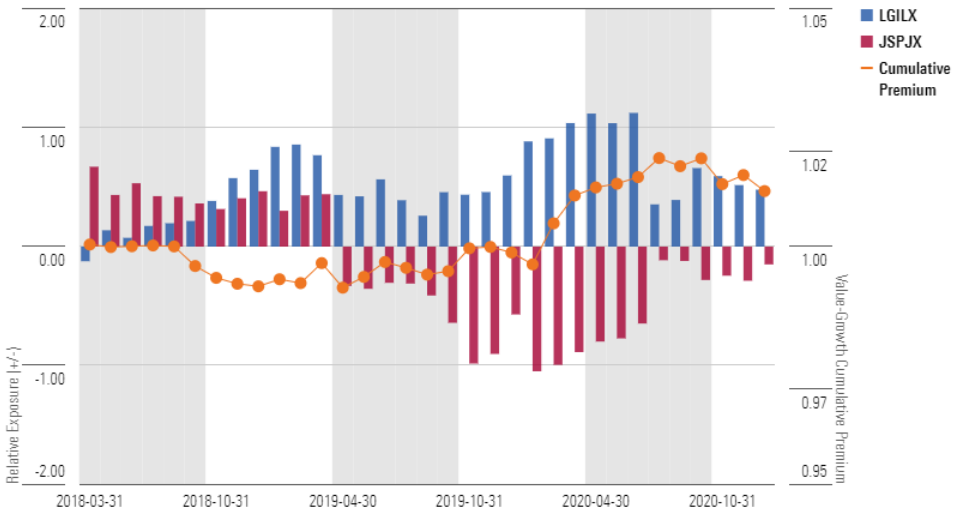
Factor	LGILX	JSPJX
Factor Total (%)	79.49	83.85
Fund Specific (%)	20.51	16.15

Factor	LGILX - Net Return(%)	JSPJX - Net Return(%)
Equity Market Factor	13.79	13.79
Fund Net Expense Ratio	0.10	-0.08
Trailing 12M Excess Return	-0.01	0.00
Fund Manager Tenure	0.10	-0.03
Fund Net Asset	0.12	0.10
Firm AUM	-0.10	-0.09
Fund Age	-0.16	-0.35
Portfolio Concentration	0.01	0.02
Star Rating	-1.33	0.00
Medalist Rating	0.63	0.50
Size	-0.49	-0.40
Momentum	3.17	2.56
Value-Growth	10.72	9.23
Liquidity	1.01	1.25
Risk	-1.40	-1.05
Quality	0.98	-0.68

Source: Morningstar.

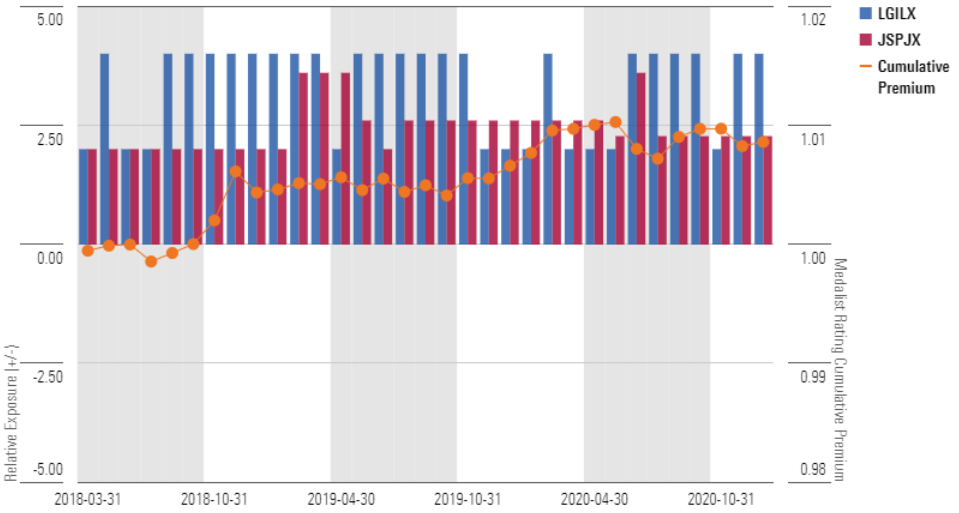
We further analyze the exposures across time for some important factors in Exhibits 19, 20, and 21. As can be seen, the LGILX fund has consistently commanded a good Morningstar Analyst Rating, invested in high quality and growth-oriented holdings compared with the JSPJX fund. Our model suggests that these factor tilts have attributed to higher returns over time.

Exhibit 19 Fund's Historical Relative Quality Exposure Vs. Cumulative Premium



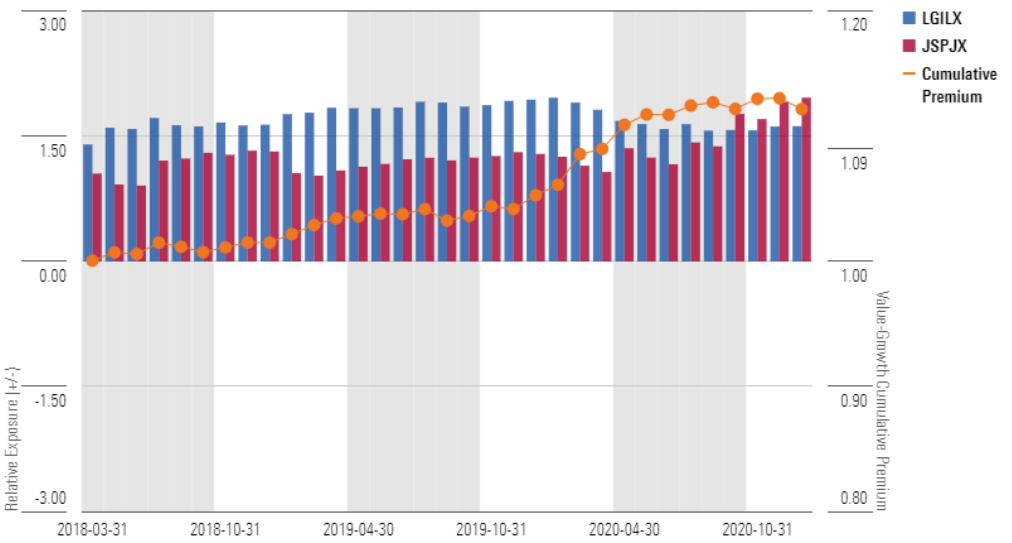
Source: Morningstar.

Exhibit 20 Fund's Historical Relative Medalist Rating Exposure Vs. Cumulative Premium



Source: Morningstar.

Exhibit 21 Fidelity Fund's Historical Relative Value-Growth Exposure Vs. Cumulative Premium



Source: Morningstar.

Conclusion

In this paper, we explored a new framework for attributing the sources of fund returns. This allows for funds to be treated differently than portfolios. Based on our analysis, we can conclude a few things. First, a recast multifactor fund model is differentiated from a standard security-level risk model with the addition of explanatory fund-specific factors such as Fund Net Assets, Fund Net Expense Ratio, Firm AUM, Fund Age, Fund Manager Tenure, and Portfolio Concentration. In addition, Morningstar Medalist and Star Ratings also help further improve attribution. These factors were not accounted for in equity risk models and are really the driving difference for funds vs. portfolios. Second, the recast multifactor model for funds has an equivalent explanatory power measured through statistical goodness of fit, which shows compatibility between the models. Third, compared with the Equity Risk Model, we found that recast multifactor model for funds demonstrated an anomaly whereby the Momentum factor premium is negative. This is attributed to higher costs associated with managing the strategy through an increase in operations costs. Last, we also demonstrated through the case study that the recast multifactor model framework encompasses both holdings and manager characteristics into a single coherent framework. So, the influence of each factor can be measured against each other to determine the fund alpha. As an example, we compared two funds and saw why one fund performed better than the other. Also, the insights from the case study are consistent with the analyst assessment available in Morningstar Direct, indicating that the model has been detecting the correct patterns.

The above analysis was an exercise for checking the possibility of developing a compatible model in line with the Equity Risk Model, where the fund is being treated as a first-class citizen. This may have far-reaching implications and accounts for the benefits that managed funds bring versus portfolios. In the future, we can further extend this work to account for other asset classes like Fixed Income and Allocations. We could also extend the model by including sustainability-related attributes as well, and we could perform many interesting analytics on the newly developed model, like risk decomposition, scenario analysis, and forecasting. We could also extend the insights for portfolio construction, which would enable advisors and asset managers to build portfolios in a more robust way. We wish to explore this additional work in the next series of papers.

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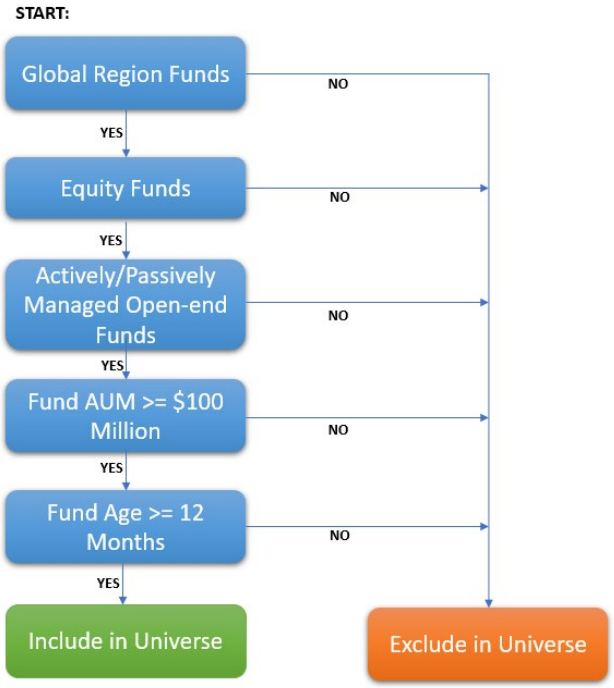
Appendix A: Fund Risk Model Universe

Exhibit 22 Fund Risk Model Universe Construction Logic



Source: Morningstar.

Exhibit 23 Countrywide Fund Coverage

Country	Initial Count	Final Count	% Coverage
USA	7344	6740	92
CAN	1636	1458	89
IRL	1485	1130	76
GBR	1041	752	72
JPN	1357	706	52
SWE	408	388	95
DEU	441	314	71
DNK	338	306	91
ESP	341	266	78
FIN	213	194	91

Source: Morningstar.

As shown in Exhibit 23, the universe is covering about 90% of open-ended equity funds from the U.S., Canada, and Europe.

Appendix B: Fund Risk Model Factor Definition

Potential Factors

Morningstar Star Rating

The Morningstar Star Rating™ is a quantitative assessment of a fund's past performance—both return and risk. It uses focused comparison groups to better measure fund manager skill on an after-fee basis. The peer group for each fund's rating is its Morningstar Category. Ratings are based on funds' risk-adjusted returns. Funds must first have a minimum three-year track record. Performance is then assessed after fees and on a risk-adjusted basis. The Morningstar Rating rewards long-term consistent performance, low volatility of returns, and low fees—aspirational areas for the typical investor. More information can be found in the link listed in the References section.

Morningstar Star Rating is measured using 1 to 5 stars. In the model, we define dummy variables for the level of star ratings that take value 1 when a fund is rated greater than 3 stars and 0 otherwise.

Morningstar Medalist Rating

Morningstar Medalist Ratings are comparable to Morningstar's Analyst Ratings for open-end funds and ETFs, which are the summary expression of Morningstar's forward-looking analysis of a fund. The Analyst Rating is based on the analyst's conviction in the fund's ability to outperform its peer group and/or relevant benchmark on a risk-adjusted basis over a full market cycle of at least five years. Ratings are assigned on a five-tier scale with three positive ratings of Gold, Silver, and Bronze; a Neutral rating;

and a Negative rating. Morningstar calculates the Quantitative Rating using a statistical model derived from the Analyst Rating our fund analysts assign to open-end funds.

Fund Age

The number of months from fund commencement to time t is used to calculate fund age. The fund age was skewed to the right, necessitating log-transformation. A higher score denotes an older fund, whilst a lower score denotes a younger fund.

Firm AUM

The firm-level AUM value is the sum of each fund's AUM assigned to the firm. AUM at the firm level is stated in US dollars. A higher score denotes a larger company. Firm size counts when it comes to fund performance. Larger firms appear to provide superior fund returns.

People Factors

Fund Manager Tenure

The asset-weighted average of the longest manager tenure of each fund assigned to the firm is used to calculate the fund-level tenure number. At the fund level, the tenure number represents the number of months the current manager has been with the fund. The tenure of the manager who has been with the fund for longest time, is considered in the calculation for funds with more than one manager. A higher score indicates that the fund maintains stronger manager continuity across its fund lineup.

Process Factors

Fund Net Expense Ratio

The Global Net Expense Ratio Equivalent data point definition should be consistent with Morningstar's Expense Ratio definition: "The annual fee that all funds or ETFs charge their shareholders. It expresses the percentage of assets deducted each fiscal year for fund expenses, including 12b-1 fees, management fees, administrative fees, operating costs, and all other asset-based costs incurred by the fund."

Moreover, this data point definition should hold across boundaries. The following is the logic for calculating a globally consistent expense ratio.

Exhibit 24 Global Net Expense Ratio Equivalent

Single Fund:

$Net\ Expense\ Ratio\ Equivalent\ (NER_{eq})$ uses the following logic:

Calculation	Domicile
Indirect Cost Ratio or Management Expense Ratio (MER)	Australia
MER	Canada or New Zealand
Representative Cost or Ongoing Charge + Performance Fee	Europe or United Kingdom
Japan After Tax Total Expense Ratio	Japan
Net Expense Ratio (NER)	United States
NER	Else

Fund of Funds:

$Net\ Expense\ Ratio\ Equivalent\ (NER_{eq}) = FoFexp_i + \sum_{i=1}^{N} w_i NER_{eq}$ when Fund of Funds = TRUE

Source: Morningstar.

Portfolio Concentration

This is the total assets of the fund's top 10 portfolio holdings represented as a percentage. This value represents the portfolio concentration, which could indicate management conviction or fund risk. The higher the percentage, the more concentrated the fund is in a few firms. This means that the fund is more vulnerable to market volatility in these few holdings, but it also means the more probable it is that management believes strongly in the prospects of these holdings. A higher score suggests that the portfolio is more concentrated.

Fund Net Asset

Fund Net Asset is defined as the total market value of the fund's investments in USD. This data point is heavily skewed to the right, with many small funds and fewer larger ones. We apply log transformations. A higher score suggests that the fund is larger in size.

Performance Factors

Trailing 12-Month Excess Return

For each share class, we calculate the trailing 12-month cumulative U.S.-dollar return. For each category, we calculate the simple average of the trailing 12-month cumulative U.S.-dollar return for all share classes in the category. We then subtract the category average from each share class' return. For each fund, we calculate the net asset-weighted average across the constituent share classes. A higher score indicates a fund with a higher excess return.

Style Factors

Size

The Size factor represents market capitalization of a fund. Higher scores correspond to small-cap funds and lower scores correspond to large-cap funds. A value near 0 implies a mid-cap fund.

Momentum

The Momentum factor is the total return momentum over the horizon from negative 12 months through negative one month, like Carhart momentum. Higher scores imply greater return momentum.

Value-Growth

The Value-Growth factor uses the Morningstar Style Box raw style. Higher scores correspond to funds that are more growth and less value oriented and lower scores correspond to funds that are more value and less growth oriented.

Liquidity

The Liquidity factor is the normalized value of the share turnover measured over the trailing 30 days. The factor is unbounded, and higher scores indicate higher liquidity. A score of 0 indicates an average level of liquidity.

Quality

The Quality factor is based on a portfolio quality score. At the stock level the score is the average of the z-score of the Debt/Capital ratio and the z-score of the Return on Equity across stocks in the universe. High scores imply high-quality firms.

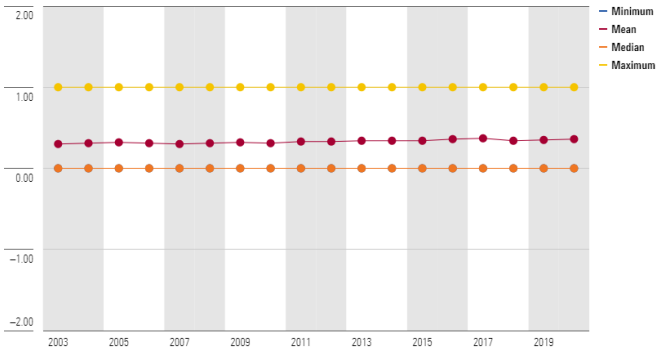
Risk

Risk factor is the measure of the risk exhibited by the fund managers who own a company. Higher scores imply more risk exhibited by owners.

Appendix C: Fund Risk Model Factor Exposure Distribution

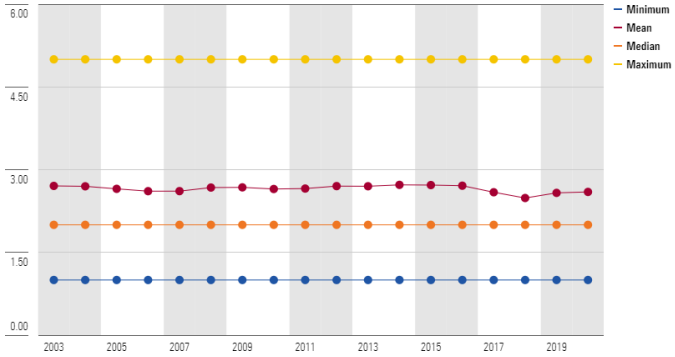
Potential Factors

Exhibit 25 Morningstar Star Ratings



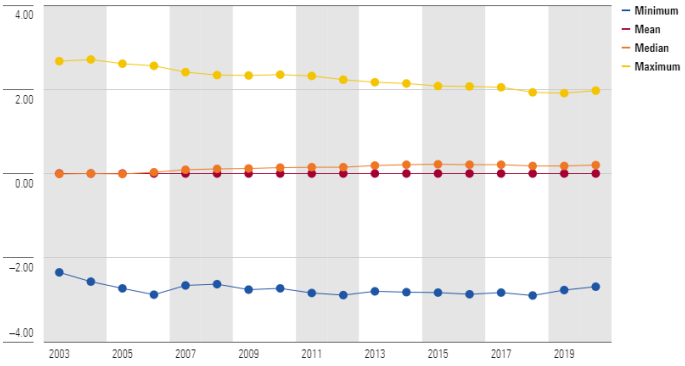
Source: Morningstar.

Exhibit 26 Morningstar Medalist Ratings



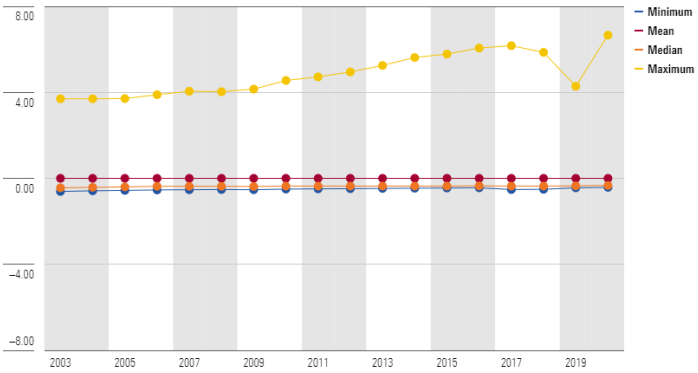
Source: Morningstar.

Exhibit 27 Fund Age



Source: Morningstar.

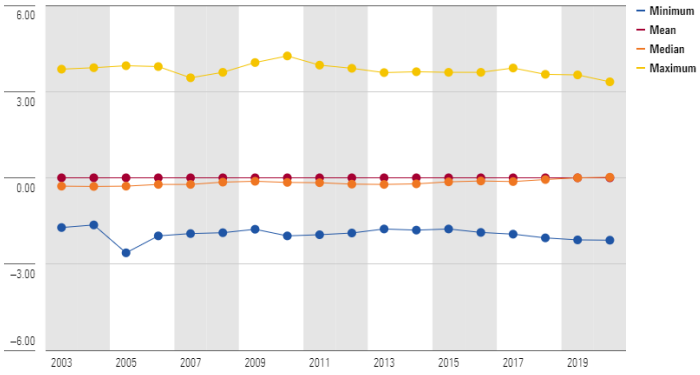
Exhibit 28 Firm AUM



Source: Morningstar.

People Factors

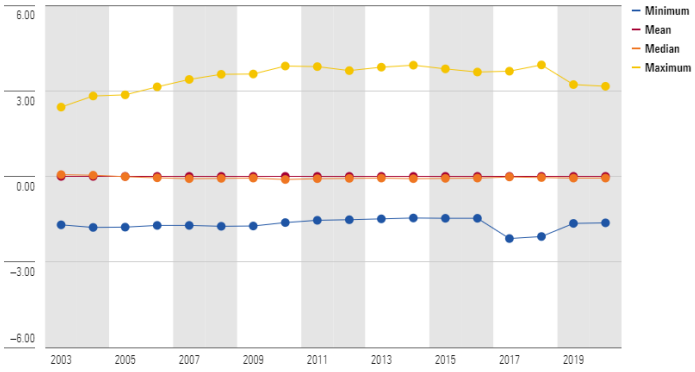
Exhibit 29 Fund Manager Tenure



Source: Morningstar.

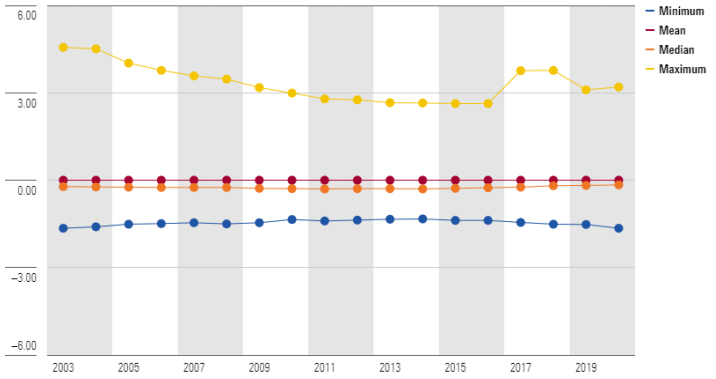
Process Factors

Exhibit 30 Fund Net Expense Ratio



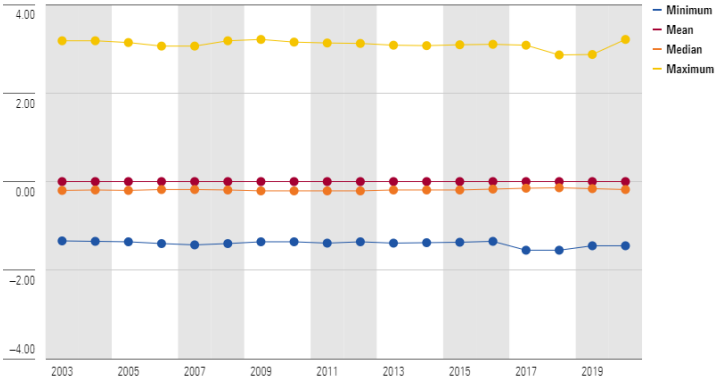
Source: Morningstar.

Exhibit 31 Portfolio Concentration



Source: Morningstar.

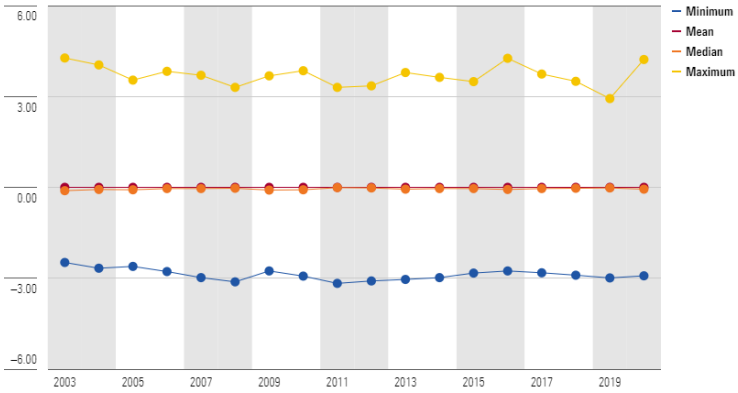
Exhibit 32 Fund Net Asset



Source: Morningstar.

Performance Factors

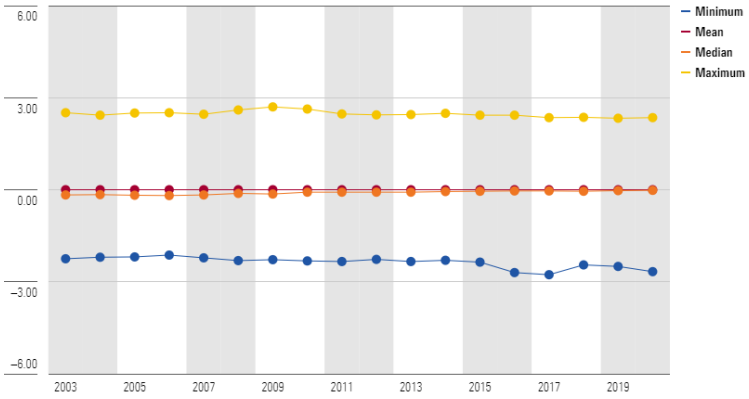
Exhibit 33 Trailing 12-Month Excess Return



Source: Morningstar.

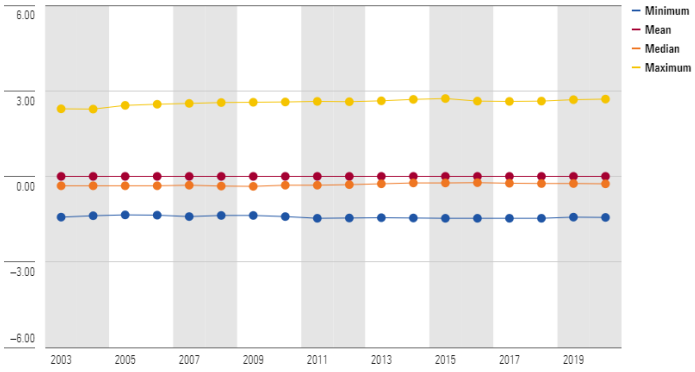
Style Factors

Exhibit 34 Value-Growth



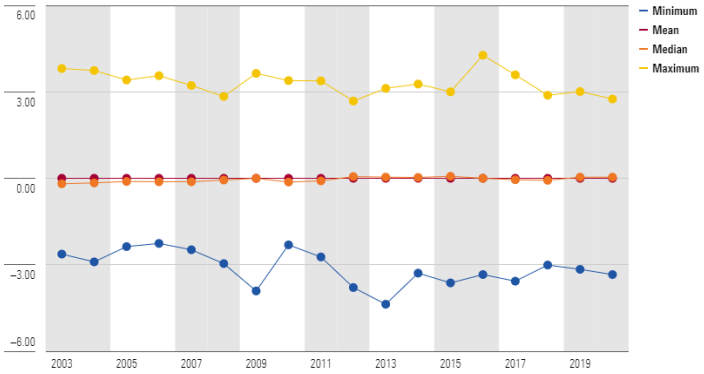
Source: Morningstar.

Exhibit 35 Size



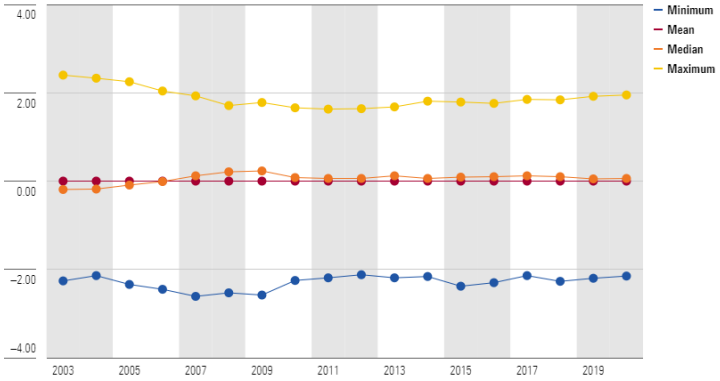
Source: Morningstar.

Exhibit 36 Momentum



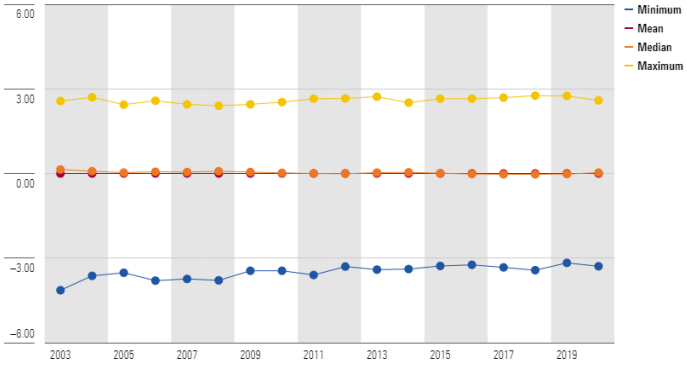
Source: Morningstar.

Exhibit 37 Liquidity



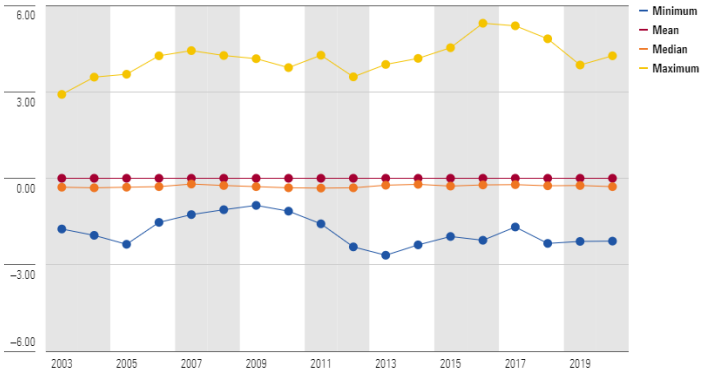
Source: Morningstar.

Exhibit 38 Quality



Source: Morningstar.

Exhibit 39 Risk



Source: Morningstar.

Appendix D: Fund Risk Model Factor Exposure Analysis

Statistical Efficacy Analysis

Recall the VIF ratio for multiple factors can be identified by following 2 steps.

Step 1:

First, we run ordinary least square error,

$$X1 = \alpha 0 + \alpha 1 * X2 + \ldots. + \alpha N * X\mathrm{N} + \varepsilon$$

Where,

Xi = Fund Risk Model factors

αi = Weights of factors

α0 = Constant term

ε = Error term

Step 2:

Calculate Variation Inflation Factor ratio using the following formula:

$\boldsymbol{VIF} = {}^{\mathbf{1}}/_{\mathbf{1}} - \boldsymbol{R2}$, Here R2 is adjusted R-squared score.

Financial Efficacy Analysis

Exhibit 40 Information Analysis

Information Analysis	6M	12M	24M
Fund Manager Tenure	1.70%	1.70%	2.20%
Firm AUM	3.00%	4.50%	6.60%
Fund Net Expense Fee	-1.70%	-3.60%	-5.90%
Quality	5.80%	6.90%	8.20%
Value-Growth	3.60%	4.70%	8.50%
Fund Net Asset	2.60%	4.70%	8.20%
Fund Age	1.20%	1.70%	3.10%
Trailing 12-M Excess Return	2.70%	3.10%	3.60%
Portfolio Concentration	-1.50%	-1.30%	-1.10%
Size	1.50%	-0.30%	-3.20%
Liquidity	3.00%	4.00%	7.80%
Momentum	2.40%	2.90%	5.10%
Risk	-6.20%	-10.90%	-13.20%

Source: Morningstar.

As shown in Exhibit 40, increase in Fund Net Asset, Fund Age, Trailing 12-Month Excess Return, Liquidity and Momentum factors are showing positive contribution over a longer time while decrease in Portfolio Concentration and Risk factors are showing a positive contribution over a longer time period. Size factor indicates that small-cap factor may have positive impact up until six months, and large-cap factor may show positive contribution later.

Exhibit 41 Turnover Analysis

Turnover Analysis	6M	12M	24M
Fund Manager Tenure	26.56%	39.38%	56.50%
Firm AUM	15.64%	24.34%	37.04%
Fund Net Expense Fee	18.26%	27.50%	40.44%
Quality	41.32%	52.76%	63.80%
Value-Growth	32.60%	42.94%	53.64%
Fund Net Asset	27.26%	40.28%	54.60%
Fund Age	16.16%	27.08%	43.02%
Trailing 12-M Excess Return	64.86%	78.38%	81.50%
Portfolio Concentration	27.84%	38.32%	48.90%
Size	22.74%	32.64%	43.92%
Liquidity	32.30%	41.36%	50.68%
Momentum	62.86%	74.46%	76.62%
Risk	33.18%	46.14%	60.00%

Source: Morningstar.

As shown in Exhibit 41, other than the Trailing 12-Month Excess Return and Momentum factors, other factors indicate lower- to moderate turnover.

Appendix E: Fund Risk Model Input Data FAQ

Why Fund-Level Model?

We are constructing a universe at fund level and not at share class level because we are interested in modeling the returns variation between funds rather than share classes.

Why Month-Level Model?

We are constructing Fund Risk Model at a monthly level, as many fund-level factors like Fund Net Expense Ratio and Morningstar Ratings are available monthly.

About Morningstar Quantitative Research

Morningstar Quantitative Research is dedicated to developing innovative statistical models and data points, including the Morningstar Quantitative Rating, the Quantitative Equity Ratings, and the Global Risk Model.

For More Information

+1 312 244-7541
lee.davidson@morningstar.com

22 West Washington Street
Chicago, IL 60602 USA