BRIDGING THE GAP

Adding Factors to Passive and Active Allocations

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CONTENTS

EXECUTIVE SUMMARY

Asset owners enjoy a growing array of choices in implementing equity factor allocations. In addition to traditional passive and active mandates, single factor, and more recently, multi-factor investment strategies are used increasingly by long-term institutional investors aiming to enhance returns or manage volatility.

Asset owners face a challenge in determining how the factor allocation fits into the overall equity program: How does the factor allocation relate to the existing roster of active managers? This paper uses a risk budgeting framework to investigate how active mandates and factor allocations can be combined. Risk budgeting connects the manager selection process with the factor allocation process, without requiring expected return assumptions.

Key questions: 1) how does the level of active risk in active management affect the factor allocation decision, 2) what share of the portfolio can be deployed to the factor allocation and 3) what are the implications of a top-down versus a bottom-up factor allocation?[1]

Active managers with relatively high levels of tracking error may have factor exposures that affect the appropriate factor allocation. Asset owners whose managers have a preference for smaller-capitalized, more volatile, value stocks may be able to diversify these exposures by allocating to factors such as low volatility, quality or momentum.

Asset owners who wish to maintain their existing roster of active managers and incorporate *factor views* may consider a top-down factor implementation, funded entirely from the core passive allocation. This approach distributed most of the active risk to active managers. The factor allocation preserved active managers' specific views and diversified systematic risk.

Asset owners who wish to preserve their existing roster of active managers and incorporate *high-conviction factor views* may consider an allocation between active management and a bottom-up factor implementation. This approach more evenly distributed the risk budget to active management and the factor allocation. The factor allocation was partially funded from active management in this scenario.

Lastly, asset owners who pursue a "barbell" strategy between core passive allocations and concentrated active managers could implement a low volatility factor allocation. This allocation may lower the total risk of the equity program, releasing active risk budget that can be deployed to active managers. In our analysis, allocating 20% of capital to a low volatility mandate reduced total volatility in the equity program by almost 10%. Alternatively, the allocation to active management could have been increased to over 50% from 30%, while maintaining the same level of total volatility.

[1] Top-down and bottom-up refer to two methods of multi-factor index construction. Top-down allocates among stand-alone factor indexes. Bottom-up selects securities based on their exposures to targeted factors.

INTRODUCTION TO A RISK ALLOCATION FRAMEWORK

Several studies address the optimal mix of active and passive investments in the equity program. Jack Treynor and Fischer Black noted more than four decades ago that the optimal combination of an actively managed portfolio and a passively managed portfolio can be determined in two stages.[2]

The first stage determines the weights of individual securities in the active portfolio. These weights depend on a portfolio manager's security-level views. The second stage determines the share of total assets in the active portfolio. This share depends on the expected return and volatility of the passive portfolio, and the beta of the active portfolio to the market.

Violi (2011) noted that the Treynor-Black approach has had a surprisingly low level of acceptance in practical portfolio construction and asset allocation. The reason, he proposed, is "due to the difficulty investors have in forecasting active manager alphas with sufficient precision." In contrast, other approaches to asset allocation such as Black-Litterman, resampling and Monte Carlo simulation have won adherents because they address the outsized impact of expected returns on allocations.

Alternatively, asset owners could use risk budgeting to determine the appropriate allocation to passive and active mandates. This approach eliminates the need for expected returns and aligns with existing asset owner practices on four levels:

Policy benchmark. Typically, an asset owner's board of trustees sets an overall policy benchmark. This policy reflects a tolerance for a given total risk budget. The equity policy might reflect a tolerance level for productivity and real growth risk. Similarly, a sovereign bond policy might reflect a tolerance level for inflation risk.

Staff decisions. While the board sets the policy benchmark, investment staff are tasked with deploying active risk — that is, acceptable deviations from the policy risk level.[3] Staff then allots the active risk budget to factor and manager selection decisions. Risk budgeting removes the burden of forecasting manager or factor returns. This process also provides transparency into how different weights to the three equity sleeves (passive, active and factors) consume the risk budget.

Allocating to managers. With a risk budgeting process, the only inputs needed for a proposed allocation are the pairwise correlations between sleeves and the standalone active risk of each sleeve to the policy benchmark. Various allocations can be generated, each

[2] Treynor and Black (1973).

[3] Stewart (2013) notes that the risk budget can include measures other than standard deviation of active returns. Downside risk, value at risk or total portfolio beta can be used in place of active risk. This paper uses standard deviation of active returns as the measure of tracking error.

subject to a constraint on overall active risk across the equity program. Each sleeve's share of capital, share of active risk and correlation to the overall equity program can be quantified. In this study, the MSCI Global Equity Model (GEMLT) and Barra Portfolio Manager toolkit are used to provide the inputs and for quantifying the risk budget.

All-passive approach. Lastly, in the simplified case where the passive allocation is identical to the equity policy benchmark, only the active and factor allocations consume active risk. MSCI ACWI is used as both the passive allocation and the policy benchmark throughout this study. This simplification helps illustrate how the active and factor allocations compete for the risk budget.

While this study intentionally omits consideration of skill in active management, a manager's risk profile can nevertheless be linked with their skill. Manager skill is clearly a key component in reaching an asset owner's portfolio objectives. In the Appendix, we examine a framework for incorporating manager returns into the analysis.

ACTIVE MANAGEMENT AND THE FACTOR ALLOCATION DECISION

The style of each active manager affects the factor allocation decision. Consider, for example, a roster in which every manager employs a value investing strategy. Thus, including a value-oriented factor allocation might be duplicative. Alternatively, an allocation to momentum or quality factors would likely provide superior diversification.

We can explore this dynamic further by adding hypothetical mandates to the three sleeves. Specifically, we examine an equity program with the following passive, factor and active allocations:

Passive Allocation

1. An allocation that tracks the MSCI ACWI Index

Factor Allocation

1. An allocation that equal-weights six single factor indexes ("top-down" approach)
2. An allocation that tracks the MSCI ACWI Diversified Multiple-Factor Index ("bottom-up" approach)[4]

Active Allocation

1. An allocation that equal-weights 10 global active managers

[4] Melas (2015) has a comprehensive review of the MSCI Diversified Multiple-Factor index construction. The index targets the four factors in Exhibit 1, while also targeting market risk. Low volatility and dividend yield tilts are not included by construction.

Exhibit 1: Passive, Factor and Active Allocations in the Equity Program

	Investment Vehicle	Comments
Passive Allocation	MSCI ACWI	Core passive tracks the policy benchmark of MSCI ACWI
Factor Allocation	1. **Top-down** Tracking portfolio that equal weights ACWI Momentum, Quality, Minimum Volatility, Enhanced Value, Equal Weighted, High Dividend Yield 2. **Bottom-up** ACWI Diversified Multiple-Factor Index	Top-down based on an equal weighted combination of six standalone MSCI factor indexes. Bottom-up based on integrating stock-level value, quality, momentum and size characteristics into a single index.
Active Allocation	Equal weights 10 global active managers	Manager holdings sourced from the MSCI Peer Analytics mutual fund universe

Nielsen (2012) suggests that a manager's active risk is an effective measure of manager potential. Deploying high active risk managers in a core-satellite structure enables both passive and active managers to focus on their competencies.

To identify high active risk managers in our analysis, the fund universe[5] (approximately 600 funds) is divided into 10 deciles by each fund's ex-ante tracking error (TE) to the MSCI ACWI Index.[6]

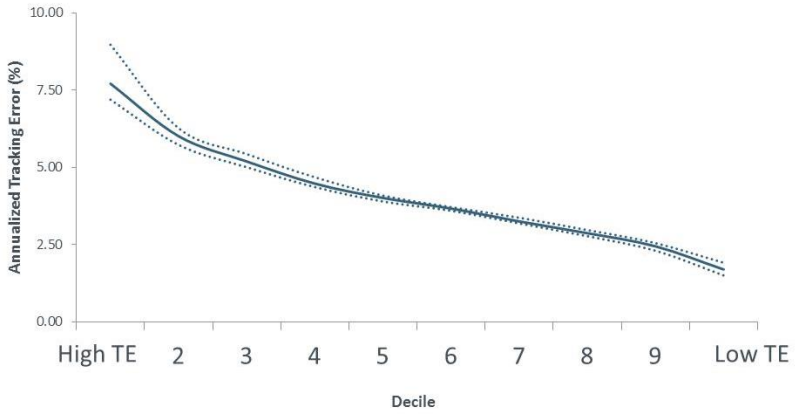
Deciles 1, 5 and 10 then correspond to the highest, median and lowest tracking error cohorts, respectively, with 60 funds in each decile. Exhibit 2 shows the median, upper and lower quartile values of tracking error across the universe as of September 2016. We can see there was a steady decline in tracking error by decile, with decile 10 containing very low tracking error funds. This study principally focuses on the highest tracking error (decile 1) managers.

To form a manager roster of realistic size, we rank the funds in the first decile by assets under management, equally weighting the top 10. The smallest 50 funds by assets under management are dropped.

[5] We start with the 25,000 mutual funds available in the Peer Analytics universe and apply a series of screens. Funds with benchmarks of MSCI World, World ex USA, ACWI, or ACWI ex USA are included. Also included are funds with Lipper Global Classification of "Equity Global" or "Equity Global ex US" or U.S. Mutual Fund Classification of "Core." Excluded are non-equity, currency-focused, single-country focused, sector-focused and index tracking funds; multiple share classes of the same fund; and funds with asset coverage ratios of less than 90% and less than USD 50M in assets as of September 2016.

[6] All analyses use the MSCI Long-Term Global Equity Model (GEMLT), with manager and index holdings as of September 2016.

Exhibit 2: Tracking Error of Active Managers to MSCI ACWI



Each decile contains approximately 60 managers from a universe of global funds. The solid line corresponds to the median value within each decile. Dotted lines correspond to the upper and lower quartile manager within each decile. As of September 2016.

MANAGER EXPOSURES

Risk exposures are a common tool in profiling individual, or groups of, active managers. To better understand the active managers in this study, the factor exposures of each decile are plotted in Exhibit 3. The exposures are shown relative to the policy benchmark and measured using the MSCI Long-Term Global Equity Model (GEMLT). The exposures reveal that high TE managers, on the whole, had portfolios with higher volatility and earnings uncertainty, cheaper book valuations, and lower size than other managers.

Exposures can also be used to form clusters of managers with similar strategies. For example, a group of managers that hold assets with higher profitability and richer valuations than their peers would likely form a “quality growth” cluster. Exhibits A1, A2 and A3 in the Appendix show results of a cluster analysis on the manager universe used in this study.

The broad manager universe contains three clusters: value, small/mid and quality growth. High TE managers tended to be small/mid- and value-oriented, with a smaller proportion that were quality growth-oriented. The value-oriented managers held relatively cheap, small stocks, that were also of lower quality and higher volatility. Readers will recognize this as the familiar risk-profile of a small-cap value manager.

Small/mid-oriented managers were primarily characterized by their size and low-dividend tilts. Quality growth-oriented managers held expensive, profitable stocks, as expected. These stocks, however, also tended to have high momentum and high volatility.

Exhibit 3: Style Factor Exposures of Active Manager Deciles

Vertical axes correspond to the active exposure (z-score) of each decile against the ACWI policy benchmark. Solid lines correspond to the median value within each decile. Dotted lines correspond to the upper and lower quartile manager within each decile. As of September 2016.

MANAGER CORRELATIONS

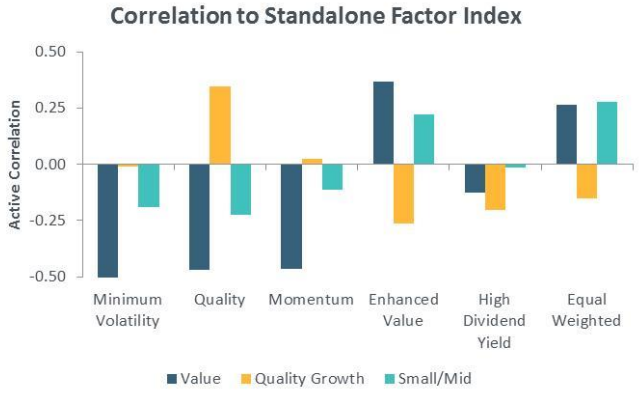
A key input for risk budgeting is the relationship between the active and factor allocations. Exhibit 4 shows the correlation of the active weights of the managers to the active weights of standalone factor indexes. The exhibit also segments the correlations by cluster.

There are several observations. Value managers were positively correlated with the MSCI Enhanced Value and Equal Weighted indexes. These indexes aim to tilt towards the value and size factors, respectively. These same managers were *negatively* correlated with the MSCI Minimum Volatility, Quality and Momentum indexes. For asset owners whose active roster has a value bias, introducing low volatility, quality or momentum factor allocations could have provided diversification benefits in our example.

Small/mid managers also tended to be positively correlated with the Enhanced Value and Equal Weighted indexes. They were negatively correlated with the Minimum Volatility, Quality and Momentum indexes. They were similar to value managers in this regard.

Conversely, quality growth managers had little in common with value and small/mid managers. As expected, they were positively correlated with the MSCI Quality Index, but negatively correlated with the Enhanced Value and Equal Weighted indexes. For asset owners whose active roster has a growth bias, introducing value, dividend yield or size factor allocations could have provided diversification benefits.

Exhibit 4: Correlation of Active Managers to Standalone Factor Indexes



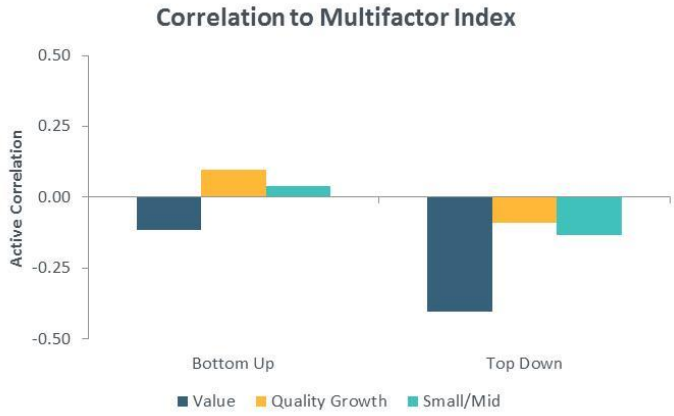
Correlations shown are the median value for each cluster within the highest tracking error decile. For example, decile 1 contains approximately 60 managers. The active returns of the median high tracking error value manager tended to be negatively correlated (-0.50) to the active returns of the MSCI Minimum Volatility index. Correlations are ex-ante as of September 2016 using the GEMLT model. All factor indexes are standard MSCI ACWI Factor Indexes.

Now let us examine the relationship of the same manager clusters to the bottom-up and top-down multi-factor choices.

In general, manager correlations to the bottom-up implementation were higher than to the top-down implementation (Exhibit 5). This pattern has two implications. First, the managers in our sample have exposures that are more similar to the bottom-up factor implementation. Second, the bottom-up implementation would likely compete with active managers for the risk budget.

Additionally, value managers had the lowest correlations to either multi-factor choice. The top-down implementation included the Minimum Volatility, Quality and Momentum indexes. The bottom-up implementation also included a quality and momentum tilt. All of these tilts diversify value-oriented managers. For asset owners whose active roster has a value bias, introducing the top-down implementation could have provided more of a diversification benefit than the bottom-up implementation in our example.

Exhibit 5: Correlation of Active Managers to Multifactor Indexes



Correlations shown are the median value for each cluster within the highest tracking error decile. Decile 1 contains approximately 60 managers. Correlations are ex-ante as of September 2016 using the GEMLT model. The bottom-up and top-down multi-factor indexes are those described in Exhibit 1.

SHARE OF THE PORTFOLIO IN THE FACTOR ALLOCATION

Now that we have a better understanding of the relationship between the active and factor allocations, we can examine weighting decisions. There are many approaches investors can deploy; Exhibit 6 highlights common risk-based approaches.

Exhibit 6: Selected Risk-Based Weighting Schemes within the Equity Program

	Objective	Rationale
Classic Core-Satellite	Split between cap-weighted passive and active managers	Alpha generation concentrated in active managers. Minimal style bias in core allocation.
Equal Weight	Equal capital to core, active and factor	Simple, 1/n heuristic is transparent and easily communicated
Active Risk Parity	Risk shared equally between manager and factor sleeves	Distribute active risk evenly based on capital, volatilities and correlations
Minimum Volatility	Reduce total equity volatility by desired percentage	De-risk equity allocation by allocating to Minimum Volatility. Less consideration given to return-seeking factors.
Target Active Risk	150 bps target	Target broad market equity volatility with a constraint on active risk

The manager roster (containing 10 managers) is shown in Exhibit 7. The roster is principally value and size-biased: five managers are classified in the value cluster, three are small/mid, and two are quality growth.

The roster's tracking error was considerably lower than the average of the individual manager tracking errors. For example, the median manager in decile 1 had a tracking error of 750 bps (Exhibit 2), yet the manager roster had a tracking error of 447 bps. The roster suffers from an "over-diversification" effect, a common challenge in building high tracking error, multi-manager portfolios. Garvey (2017), for example, demonstrates how multi-manager portfolios concentrate common, systematic risks, while diversifying away an individual manager's specific views on assets.

Exhibit 7: Factor and Active Manager Rosters

	Managers in Roster	Tracking Error to ACWI (Sep 2016)
High tracking error managers	10	4.47%
Top-down factor allocation	6	1.99%
Bottom-up factor allocation	1	2.38%

In our analysis, we start with a base case in which 66% of the hypothetical portfolio is passively managed and 34% actively managed. These capital weights correspond to 150 bps of active risk – all of which is consumed by the active managers in the base case. We then gradually fund a factor allocation from the passive allocation, subject to the 150 bps constraint on overall active risk.

This scenario could represent a board of trustees that adopts a factor program with the goal of harvesting long-term premia. Investment staff decide to use a top-down factor allocation, with the added restriction of keeping the existing managers and their allocations (largely small-cap and value-oriented strategies in our example).

The four panels in Exhibit 8 illustrate the effect that funding decisions had on correlations and on the allocation of active risk. Moving along the x-axis in each panel reduced the share in the passive allocation, while staying within the overall risk constraint.

For example, the top left panel shows that it is possible to fund a factor program without necessarily defunding active management. A 40% weight to core passive (highlighted in the pink oval along the x-axis) corresponds to 36% and 24% weights to the active and factor allocations, respectively.[7]

The top right panel shows that this set of weights distributed almost all of the active risk to the active managers. This implies that deviations in the equity program's active return were most likely due to decisions by the active managers.

The bottom left panel also shows the distribution of active risk, similar to the top right panel. The distribution, however, is now to systematic and specific sources of risk. Systematic includes sector, factor, country and currency sources. Specific risks are the idiosyncratic, firm-specific risks.

The panel confirms what previous studies have shown, namely that multi-manager portfolios concentrate risk in systematic sources. Increasing the share to the factor allocation, however, did not further concentrate the systematic risk beyond the base case. Managers' views on assets were preserved.

[7] The weight to active management increases slightly from 34% to 36% in order to keep the passive weight at 40% and meet the 150 bps risk constraint.

Exhibit 8: High Tracking Error Managers and a Top-down Factor Implementation

"Base Case" refers to a split of core passive and active management that resulted in 150 bps of active risk against the MSCI ACWI policy benchmark. This split is approximately 70% passive and 30% active when using the high TE manager roster for the active allocation. Top-down implementation refers to the equal-weighted combination of six MSCI factor indexes. Correlation refers to the active correlation to the overall equity program.

Finally, the bottom right panel shows the correlation of the active and factor allocations with the equity program. The factor allocation diversifies the equity program through much of the range. Consequently, the bulk of the tracking error (top right panel) stems from the active managers. Including minimum volatility in the allocation, which is negatively exposed to the beta and residual volatility GEMLT factors, balances the active managers' relatively high exposures to these two risk factors. We will explore using minimum volatility as the entire factor allocation in the next section.

As we increase the weight of the factor allocation, its correlation with the equity program and its risk consumption also increase. This behavior is consistent with the principles of risk budgeting.

TOP-DOWN VERSUS BOTTOM-UP FACTOR ALLOCATION

In our second scenario, a board of trustees again decides to adopt a factor program with the goal of harvesting long-term premia. Investment staff is now given greater discretion in allowing the factor program to compete with active managers for funding, and in the risk budget.

The parameters are identical to the previous scenario; however, the factor allocation is now accomplished via the bottom-up implementation. Exhibit 9 illustrates a considerably different outcome for asset owners who choose this method, based on our sample of high tracking error managers.

A 40% weight to passive resulted in a 27% weight to active and 33% to factor allocations, respectively (top left panel). These weights, split approximately 40/30/30, reflect a high conviction toward managers and factor premia. This time, some of the funding for the factor allocation comes from the active managers; in the previous scenario, the factor allocation was funded entirely from the passive allocation.

The top right panel shows that the active risk is now shared between the active and factor allocations. In the previous scenario, the active managers consumed the bulk of the 150 bps risk budget.

The bottom left panel shows that increasing the funding to the factor allocation did not further concentrate systematic risk beyond the base case. In fact, the portion of active risk represented by stock-specific risk increased marginally, because both the manager roster and the factor allocation hold relatively concentrated portfolios.[8] While not shown, the portion of active risk due to GEMLT style factors also increases marginally as funding is increased to the bottom-up factor allocation.

Lastly, the bottom right panel again shows that as the factor allocation's funding is increased, its correlation with the equity program also increases. However, in this scenario, the correlation is positive from the beginning. This relationship implies that the bottom-up implementation competes with the active managers: It does not hedge the risk budget, but rather immediately begins consuming it.

[8] The bottom-up allocation held approximately 600 assets as of September 2016. The top-down allocation held the same number of assets (approximately 2,500) as the ACWI policy benchmark as of September 2016, but at different weights.

Exhibit 9: High Tracking Error Managers and a Bottom-up Factor Implementation

Bottom-up implementation refers to the MSCI ACWI Diversified Multiple-Factor Index. As of September 2016.

MINIMUM VOLATILITY AS THE FACTOR ALLOCATION

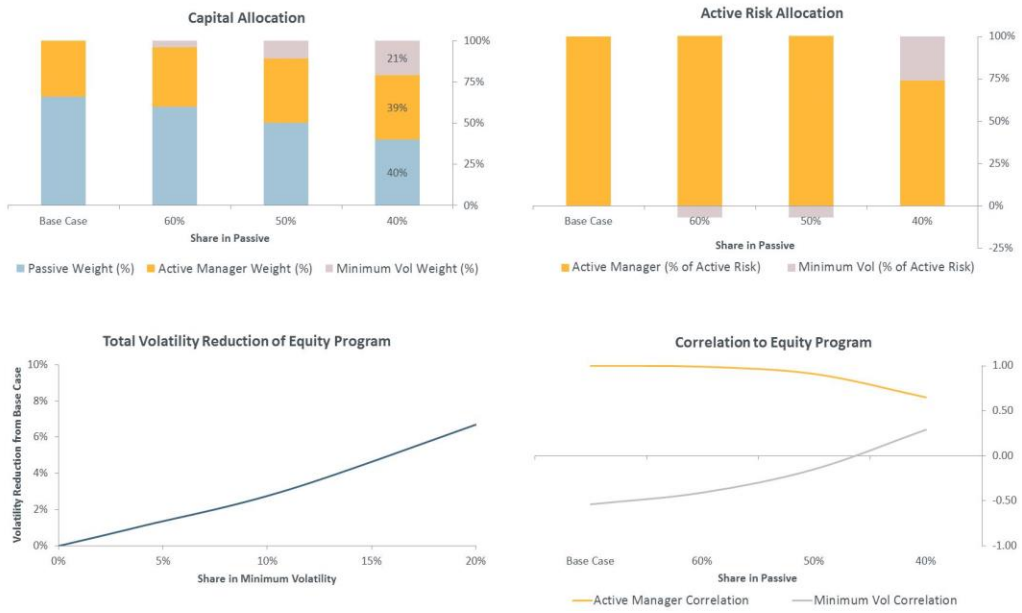
As equity markets have rebounded since the 2008 financial crisis, plan sponsor funding ratios have improved. These circumstances present an opportunity to use low volatility as the entire factor allocation, allowing plan sponsors to de-risk the equity program while remaining fully equitized.

One characteristic of high TE managers, regardless of style cluster, was the bias towards high volatility assets. Exhibit 10 shows that a hypothetical asset owner with high TE managers could have committed almost 20% to a minimum volatility allocation without breaching the risk budget, or defunding active managers (top left panel). A 20% commitment corresponded to an approximate 8% reduction in total equity risk compared to the base case (bottom left panel).

Alternatively, the asset owner could maintain the same level of total equity risk and increase the allocation to active managers. In this scenario, the passive allocation funds the active and low volatility allocations. We find that the share of the equity program given to active managers could increase to more than 50%.

A common characteristic of many low volatility strategies is their high tracking error relative to a policy benchmark. The MSCI ACWI Minimum Volatility Index, for example, had approximately 700 bps of tracking error as of September 2016. This is significantly larger than the tracking error of the high TE managers. Yet when the two allocations were combined, they did not breach the 150 bps risk budget. In this scenario, minimum volatility's high tracking error is offset by the diversification benefit it provides to the equity program. This phenomenon is illustrated in the bottom right panel.

Exhibit 10: De-risking the Equity Program with Minimum Volatility



Volatility reduction refers to the decrease in total equity risk relative to the base case. As of September 2016.

CONCLUSION

Asset owners face many considerations when making factor investments. These include aligning the organization's investment beliefs with risk premia, deciding whether the allocation is strategic or tactical, and choosing the optimal weight to the factor program.

This study revisited a core-satellite structure consisting of passive, active and factor allocations. For investors working within a risk budget, the optimal allocation to each depends on the relationship between the factor and active allocations, and also the desired distribution of active risk. The relationship is nuanced: managers with different styles may correlate very differently with factor allocations.

Exhibit 11 summarizes the results for a hypothetical asset owner with active managers who have high tracking error (largely small-cap and value managers). In most cases, the allocator can implement a sizeable return-seeking, or risk-reducing, factor allocation without defunding current managers. The allocation to active managers in this example can in fact increase from 30% to 40% using a top-down approach for the factor investing program.

Asset owners may consider adding a high-conviction, bottom-up factor allocation alongside their high tracking error managers. The managers would likely have to share the risk budget, and the factor allocation would likely be partially funded from the manager allocation.

In all of the above cases, a risk-based framework was helpful in connecting manager styles, risk constraints and implementation choices with allocation decisions.

Exhibit 11: Summary Results for High Tracking Error Managers and 150 bps Risk Budget

Factor Implementation	Optimal Allocation
Top-down	40% Passive/40% Active/20% Top-down Funding Source: Passive Risk allocation: Active Managers
Bottom-up	40% Passive/30% Active/30% Bottom-up Funding Source: Active and Passive Risk allocation: Active Managers and Bottom-up
Minimum Volatility	40% Passive/40% Active/20% Minimum Vol Funding Source: Passive Risk allocation: Active Managers and Minimum Vol

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APPENDIX

RESULTS CALCULATIONS

MSCI Analytics are used to calculate all risk-related measures. A portfolio of three composites – passive, active and factor allocation – is used as the managed portfolio. The MSCI ACWI index is set as the benchmark, with GEMLT as the risk model.

The passive composite is the MSCI ACWI, and the factor composite is either the "top-down" or "bottom-up" index. The active manager composite is a portfolio of 10 managers, equal-weighted.

The base allocation contains only passive and active managers, with weights to each that result in 150 bps of tracking error. The factor allocation is then "funded" by reducing the weight in the ACWI composite and increasing the weight in either the factor or manager composites, while keeping 150 bps of overall tracking error.

The calculated fields "Active Total Risk," "% Contribution to Total Tracking Error," "Active Correlation" and "Active Specific Contribution" are captured for each possible allocation. Active Total Risk provides the tracking error for the overall equity program (e.g., 150 bps) and also the standalone tracking error of each composite. The field "% Contribution to Total Tracking Error" measures how much each composite consumes of the overall tracking error.

MANAGER CLUSTER ANALYSIS

A standard clustering method, K-means cluster analysis, is used to group managers of similar style, based on GEMLT style factor families. This method partitions data into clusters by minimizing the squared Euclidean distance of data points to a cluster center. K-means can be implemented via common statistical packages.

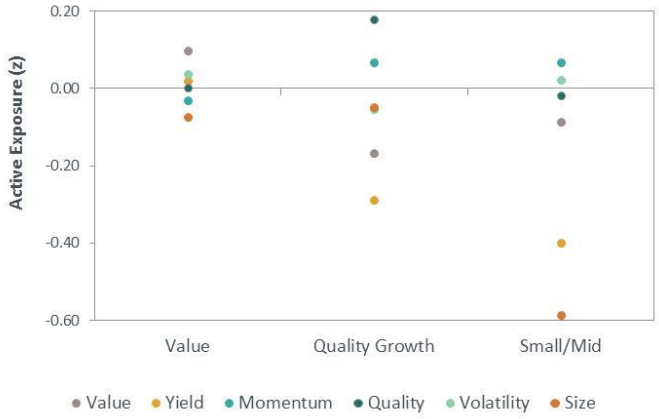
Each point in Exhibit A1 represents the median exposure to a particular factor for all the managers in a cluster.[9] The full fund universe is made up of approximately 600 funds that meet criteria of global geographic focus, an appropriate global benchmark, minimum asset coverage, and minimum number of assets. Each manager falls into only one cluster.

The quality growth cluster is principally characterized by managers with high quality, high momentum, and rich valuations. The small/mid cluster is characterized by managers with a

[9] In this exhibit, the GEMLT style factors are grouped into factor families as follows: value is a composite of book to price and earnings yield; quality is a composite of profitability, the negative of earnings variability and the negative of leverage; volatility is a composite of beta and residual volatility; size is a composite of the size factor and the negative of mid-capitalization; yield is dividend yield; momentum is the momentum factor.

small- to mid-cap tilt, high momentum and low dividend yields. The value cluster is characterized by managers with cheap valuations, high volatility and low size.

Exhibit A1: Style Clusters for Full Fund Universe



Each point represents the median active exposure to MSCI ACWI of all managers within a cluster, regardless of tracking error decile. For example, managers classified as quality growth have an average 0.20 exposure to the quality factor family.

Exhibit A2 shows a similar analysis as Exhibit A1, but only for the high tracking error managers from decile 1 of the fund universe. Exposures for high TE managers are generally more pronounced than for the universe, as expected.

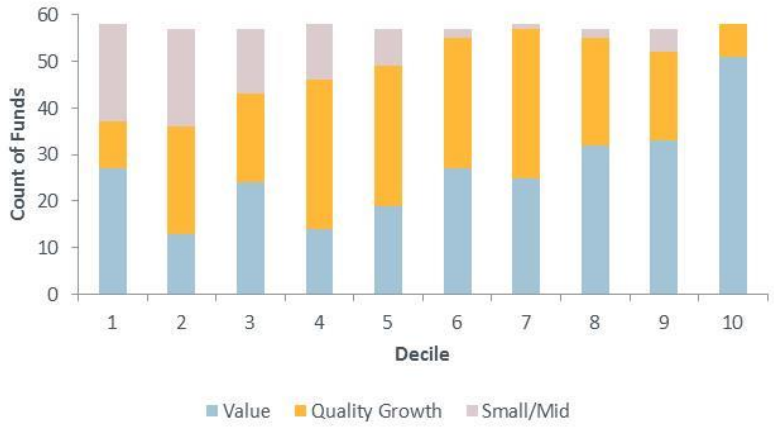
An average value-oriented manager drawn from the universe, for example, has a 0.10 exposure to the value factor (top left point in Exhibit A1). An average value-oriented, high tracking error manager, however, has a 0.25 exposure to the value factor. Importantly, the manager's higher value exposure also results in more volatile assets.

Exhibit A2: Style Clusters for High Tracking Error Managers

Each point represents the median active exposure decile 1. For example, the topmost left point shows that a high TE value manager has an average 0.30 exposure to volatility; whereas a quality growth manager has 0.40 exposure to momentum.

Exhibit A3 shows the count of funds for each cluster, by decile. The most active managers, as measured by tracking error, tended to be either size- or value-oriented. Median tracking error managers, in decile 5, tended to be either growth- or value-oriented.

Exhibit A3: Distribution of Manager Styles Within Each Decile



High tracking error managers (decile 1) are primarily composed of small/mid and value managers. Managers with lower tracking error (decile 5) are primarily quality growth managers.

INCORPORATING EXPECTED RETURNS

Menchero (2007) demonstrates that the total portfolio's information ratio (IR) is the sum of each sleeve's contribution to it. A sleeve can be a single manager or the aggregate of many managers. The contribution to IR is the product of each sleeve's risk weight, its standalone IR and the inverse of its active correlation.

A realistic return objective for investment staff could be 75 bps of annualized outperformance against the equity policy benchmark. Given the 150 bps active risk constraint we use in this study, a minimum IR of 0.50 is therefore required to meet the objective.

We use the risk weights and correlations from Exhibits 8 and 9, and supplement these with assumptions on the level of skill in the active manager and factor allocations.[10] In this simplified example, we define the standalone IR as the measure of skill.

In the first case, we assume the active roster can achieve an IR of 0.40 and that the top-down factor allocation has *half* the skill of the managers (IR of 0.20). The pink oval in the top panel of Exhibit A4 indicates that capital weights of 40% passive, 40% active and 20% factor meet the return objective of 75 bps (corresponding to an IR of 0.50). The stacked columns represent the contribution to IR from each sleeve. Note that the active managers contribute the majority of overall IR.

In the case of the bottom-up factor allocation, we assume it has *equal* skill to active management (the IR of both allocations is 0.40).[11] The pink oval in the bottom panel of Exhibit A4 indicates that capital weights of 40% passive, 30% active and 30% factor meet the return objective. However, increasing the share to the factor allocation above 30% *reduces* both active return and overall IR.

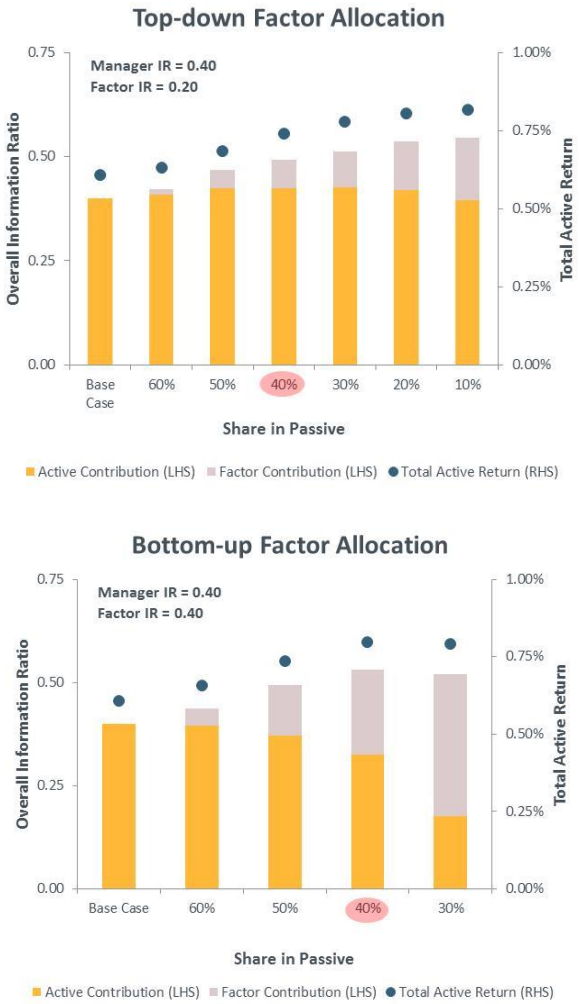
Note that the bottom-up allocation has a much larger contribution to overall IR than in the previous case. Importantly, because the bottom-up allocation consumes more of the risk budget, and is less diversifying than the top-down allocation, it must have a higher IR (it is twice as "skilled") in order for the return objective to be met.

Also note that in both cases, the overall IR of 0.50 is higher than for the active managers (IR of 0.40) and factors (IR of 0.20 or 0.40).

[10] Using the definition Information Ratio = Active Return / Active Risk, we produce return expectations. We use the predicted tracking errors from Exhibit 7 and assume an ex-ante IR to produce a return expectation.

[11] Nielsen (2012) shows that top-quartile active equity managers had ex-post IRs of 0.40 to 0.60. Our ex-ante IR of 0.40 for the active managers reflects a conservative estimate of top-quartile active management. The IR of 0.20 for the top-down and 0.40 for bottom-up factor allocations are conservative estimates of the IR based on historical simulations. See Melas (2015) for simulation results.

Exhibit A4: Return Objective as a Function of Manager Skill



"Base Case" refers to a split of core passive and active management that results in 150 bps of active risk against the MSCI ACWI policy benchmark. Moving along the x-axis reduces the capital weight in the passive allocation and increases the capital weight in the factor allocation. Contribution to IR (left y-axis) is calculated using the method described in Menchero (2007). Total Active Return (right y-axis) is calculated using the capital weights and return expectations for each allocation.

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