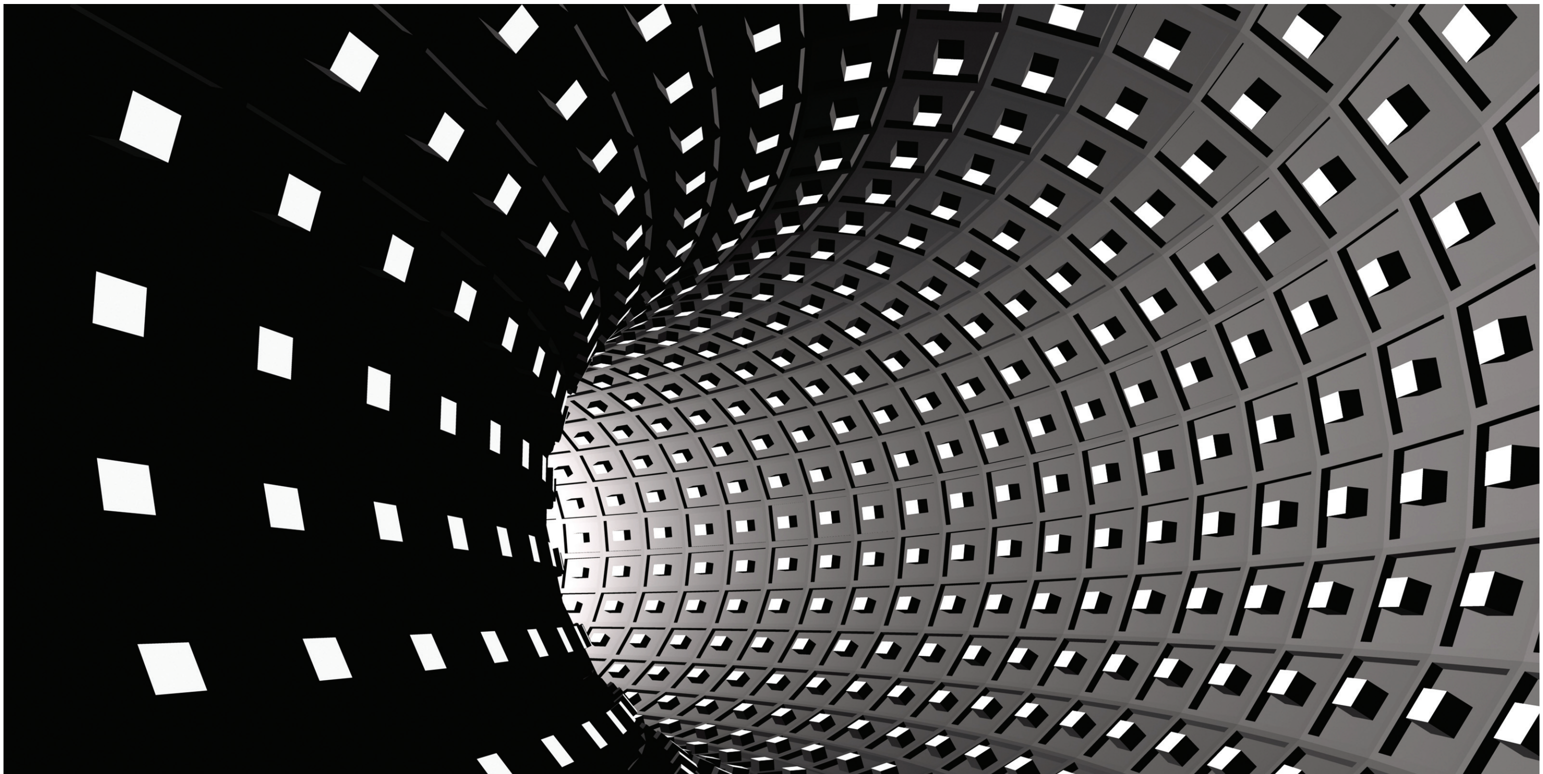


Back to the Future

Why Portfolio Construction with Risk Budgeting is Back in Vogue

SOLUTIONS—Innovative and practical approaches to meeting investors' needs

Much like Avatar director James Cameron's comeback after nearly a decade-long hiatus, risk budgeting is once again back in style as investors reassess portfolio risk following the credit crisis.

The chief appeal of conducting a risk budgeting study is the ability to deconstruct the individual components of risk and return—at both the asset class ("beta") and manager levels ("alpha"). As a tool in the portfolio construction process, risk budgeting can help uncover "hidden" exposures and interactions between beta and alpha, which a skilled investor can use to make portfolio-wide allocation decisions.

The quest to quantify risk is as old as the disciplines of accounting, finance and statistics. Risk budgeting traces its origins back to value-at-risk analysis, but it began to reach a critical mass as a distinct concept in strategic asset allocation in the early 2000's after the dot com bubble burst. It has never gone away completely since then, but a prolonged bull market mid-decade and an interest in the so-called "endowment model" shifted the spotlight away from risk and onto returns. In the aftermath of the credit crisis, risk has resurfaced as the pre-eminent topic in the market. As a result, many investors are revisiting the risk tolerances of their portfolios and that has brought risk budgeting back into vogue.

So what is risk budgeting? In real world terms, it is a diagnostic tool that allows us to measure the total risk of a portfolio by breaking down the two components of risk into: (1) "beta risk"—the risk coming from the selection of asset classes; and (2) "alpha risk"—the risk coming from the selection of individual active managers. The key to risk budgeting is understanding the interaction (or correlation) between the asset classes (beta to beta), between the managers (alpha to alpha), and between the asset classes and managers (beta to alpha). With that information one is better able to evaluate not only the risk/return performance of the total portfolio, but also the contribution of the individual asset classes and managers.

J.P.Morgan
Asset Management

As numerous research studies have shown, “beta risk” accounts for about 90% of a pension plan’s total asset risk.[1] Therefore, for risk reduction purposes, it is crucial to select a manager whose alpha is lowly correlated with other managers’ alpha and lowly correlated with various beta sources. Selecting the right mix of active managers may actually reduce the overall portfolio risk and also provide the potential for generating excess return above the markets.

The core insights provided by a risk budgeting include:

1. A measure of the historic total risk of the entire portfolio.
2. A measure of the risk generated from decisions to invest in specific asset classes (beta risk) and managers (alpha risk).
3. An understanding as to how asset classes and managers interact with each other (correlation analysis).
4. An indication as to which asset classes/managers provide the most diversification benefits.
5. A method of identifying individual sources of return from both beta and manager excess returns.

Once a risk budgeting analysis has been completed, the same concepts can be applied to run an optimization on a portfolio in its entirety. The main objective of the optimization is to identify improvements to the current asset allocation—whether by adjusting allocations to specific asset classes and managers or by introducing new asset classes/managers to the portfolio. The resulting output is a range of portfolio options that represent improved risk return trade-offs. What’s more, a variety of constraints can be incorporated into the optimization process: maximums and minimums per asset class, groups of asset classes, manager or group of managers, as well as relative constraints.

Importantly, optimizations can target a wide array of outcomes for the entire portfolio as well, such as:

1. Maximizing total or relative return for different risk levels
2. Minimizing total risk or tracking error for different return levels
3. Maximizing alpha
4. Maximizing information ratio
5. Maximizing Sharpe ratio

To be sure, risk budgeting simply provides guidelines for optimal portfolio construction and cannot mitigate all investment risk or guarantee any outcomes. However, it can be a powerful tool to calibrate exposures by illuminating the individual components of risk at the asset class and manager levels. Risk budgeting may not be a brand new concept in investing, but like pointed-toe flats and skinny ties it has reemerged from the back of closets to renewed prominence in an era of renewed concern about portfolio risk.

Total Risk Budgeting at JPMAM

The Strategic Investment Advisory Group (SIAG), which assists institutional clients on strategic asset allocation and portfolio construction issues, is responsible for developing and maintaining J.P. Morgan Asset Management’s Total Risk Budgeting tool and framework. We are also available to conduct specific/tailored studies for our clients.

Data Requirements for Conducting a Descriptive Analysis

J.P. Morgan clients interested in a Total Risk Budgeting study are asked to provide the following:

1. Current or target asset allocation data, including relevant benchmarks and weights
2. Manager total return data, monthly for at least 30 months (5 years preferred)
3. Benchmark return data, monthly for the same period as above
4. Optional: manager expected returns and volatility

Note: SIAG has developed a proprietary input template to facilitate collection of the requisite data.

[1] Gary P. Brinson, L. Randolph Hood, and Gilbert L. Beebower, “Determinants of Portfolio Performance,” *The Financial Analysts Journal*, July/August 1986; Brinson, Brian D. Singer, and Gilbert L. Beebower, “Determinants of Portfolio Performance II: An Update,” *The Financial Analysts Journal*, May/June 1991.

Example of a Descriptive Analysis

To demonstrate our Total Risk Budgeting analysis, consider a simple portfolio composed of 40% fixed income benchmarked to the Barclays Capital Aggregate index and 60% equity benchmarked to the S&P 500. Our example includes two fixed income managers and two equity managers. Exhibit 1 gives the summary statistics for the alpha only portion of the sample portfolio: total alpha (arithmetic), tracking error and information ratio. Similar output is generated for the beta only portion of the portfolio—detailed in the Technical Definitions section.

EXHIBIT 1: SUMMARY STATISTICS FOR ALPHA ONLY SECTION OF PORTFOLIO

Portfolio Alpha (arithmetic)	1.56%
Alpha only risk contribution	1.75%
Information ratio	0.89

Exhibit 2 shows the breakdown by manager. The alpha is simply the annualized excess return over the stated benchmark. The alpha risk contribution is the risk that's attributed to each manager with the sum of those three numbers adding up to total (1.75% as in Exhibit 1 above). The numbers reveal not only the performance of each manager but the risk contribution. For example, Manager B has negative alpha, and has added significantly to risk (0.99% risk contribution). Manager C, on the other hand, has positive alpha and has added only marginally to risk.

EXHIBIT 2: ALPHA ONLY ANALYSIS OF MANAGER DETAIL

Manager	Allocation (%)	Excess return (alpha) (%)	Tracking error (%)	Benchmark	Alpha only risk contribution (%)
Manager A	15.00	0.88	1.33	BarCap Agg	0.03
Manager B	25.00	-0.77	4.86	BarCap Agg	0.99
Manager C	35.00	3.48	1.60	S&P 500	0.15
Manager D	25.00	1.62	3.47	S&P 500	0.59
				Sum	**1.75**

Exhibit 3 shows the total portfolio analysis, with return (4.63%), volatility (11.16%) and alpha (1.56%). The most interesting numbers are the alpha contribution to total portfolio volatility (1.14%) and beta contribution to total portfolio volatility (10.01%).[2] The sum of 1.14% and 10.01% is the total portfolio volatility of 11.16%. In other words, the beta allocation of the portfolio is responsible for 90% of total risk (10.01% ÷ 11.16%), with the alpha allocation adding only a small portion to total risk 10% (1.14% ÷ 11.16%).

EXHIBIT 3: SUMMARY STATISTICS FOR TOTAL PORTFOLIO

Portfolio return (arithmetic)	4.63%
Portfolio volatility	11.16%
Portfolio alpha (arithmetic)	1.56%
Alpha contribution to total portfolio volatility	1.14%
Portfolio Beta return (arithmetic)	3.06%
Beta contribution to total portfolio volatility	10.01%

Exhibit 4 shows the breakdown by manager for the total portfolio. This is the most important section that allows for mapping the exact risk exposure to each manager in the total portfolio context. These risk numbers are different from the numbers in Exhibit 2 because they are derived using the full correlation matrix with beta to alpha correlations taking into account a manager's excess return interactions with other managers, as well as the benchmarks. Here again we see that not only did Manager C vastly outperform the benchmark, but that Manager C's fund also actually lowered total portfolio risk as evidenced by its negative risk contribution (-0.06%). That is a product of the alpha return streams of Manager C having such low correlations with the other managers and the underlying benchmarks.

J.P. Morgan's Total Risk Budgeting tool also generates correlation matrices which, together with information on the allocation, and historical risk and return data are useful for analyzing why certain asset classes and managers have a particularly high or low risk contribution.

EXHIBIT 4: TOTAL PORTFOLIO ANALYSIS OF MANAGER DETAIL

Manager	Allocation (%)	Excess return (alpha) (%)	Tracking error (%)	Alpha & beta risk contribution (%)
Manager A	15.00	0.88	1.33	-0.05
Manager B	25.00	-0.77	4.86	0.91
Manager C	35.00	3.48	1.60	-0.06
Manager D	25.00	1.62	3.47	0.35
			Sum	**1.14**

2 You will notice that the alpha contribution to volatility in Exhibit 3 (1.14%) is lower than the Alpha only risk contribution in Exhibit 1 and 2 (1.75%). This is because Exhibit 3 looks at the Total Portfolio, capturing beta to beta, alpha to alpha, and beta to alpha interactions. Exhibit 1 and 2 only examines the alpha to alpha interactions.

Example of an Optimization Study

Our proprietary optimization study takes risk budgeting to the next level by seeking improvements to a portfolio following a Total Risk Budgeting descriptive analysis. In **Exhibit 5** we show a series of portfolios that have been optimized for volatility and for efficiency. For portfolio 1, we optimized for maximum return at the same risk level as the current portfolio 11.16%. The result is a portfolio with a 0.81% higher return, and with a higher efficiency of 0.49 than the current portfolio. You can see allocations are split between Managers A and Managers B. For portfolio 2, we optimized for the highest efficiency possible. The result is a portfolio with a higher return by 0.87% than the current portfolio, lower volatility 10.00%, and much higher efficiency at 0.55. These specific optimization allocations may be too big of a departure from how the hypothetical current portfolio is currently allocated, but nevertheless demonstrates the benefits of allocating more capital to managers with the most favorable return, risk and correlation properties.

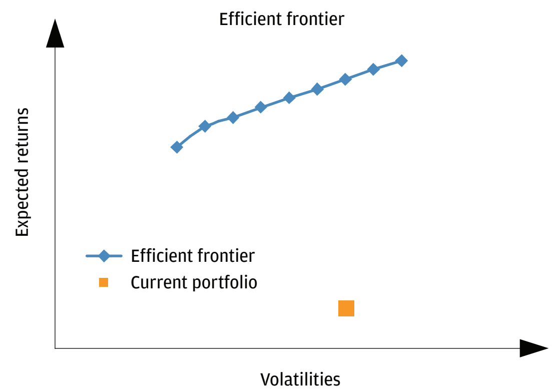
EXHIBIT 5: OPTIMIZED PORTFOLIO FOR CURRENT RISK LEVEL

Managers	Current (%)	Portfolio 1 Optimized for volatility (%)	Portfolio 2 Optimized for efficiency (%)
Manager A	15.00	31.05	38.88
Manager B	25.00	0.00	0.00
Manager C	35.00	68.95	61.12
Manager D	25.00	0.00	0.00
Total	100.00	100.00	100.00
Portfolio return (arithmetic)	4.63%	5.44%	5.50%
Portfolio volatility	11.16%	11.16%	10.00%
Efficiency	0.41	0.49	0.55

The J.P. Morgan optimization tool is very flexible both for setting constraints and also for the choice of optimization method. The most sensible approach is, therefore, to run several different iterations in order to generate an efficient frontier, or several different scenarios that can help focus on the directional changes that could be made to a portfolio.

Exhibit 6 shows the outcome of a series of optimizations for our hypothetical portfolio as it moves up the risk curve, and then compares it to the current portfolio. As illustrated, there are portfolios with equal or lower risk (volatility), but higher returns than the original portfolio.

EXHIBIT 6: A SERIES OF OPTIMIZED PORTFOLIOS IN COMPARISON WITH THE CURRENT



Technical Definitions and Clarifications

Definitions of beta and alpha risk:

Beta risk

- Beta risk represents the risk of a portfolio's underlying market exposures, used interchangeably with the benchmark exposure.

- In the aforementioned sample case study, SIAG analysis used the standard deviation equation (for a multiple-asset portfolio; see Appendix) to obtain the beta risk of a total portfolio. The equation, which assumes a normal distribution of the underlying benchmark returns, integrates three variables:
  - standard deviation of the underlying benchmarks (which we often refer to as "stand-alone risk")
  - allocation weights to these benchmarks
  - all pair-wise correlations. For n assets, the number of pair-wise correlations is (n^2-n) ÷ 2. So a four-asset portfolio contains (4^2 – 4) ÷ 2 , or, six distinct correlation pairs

- The beta risk of the portfolio may also be referred to as "benchmark" risk, "asset class" risk, or "passive" risk. In this context, the term "beta" is not to be confused with an equity beta, which relates the sensitivity of an individual stock's performance to the performance of the overall market (e.g., S&P 500).

- If the given portfolio is managed entirely passively, then the beta risk of the portfolio also represents the total portfolio risk.

Alpha risk

- A portfolio's alpha risk is based on the risks managers are taking in order to generate excess return, usually relative to some market benchmark. Alpha risk is also referred to as "active risk" and "tracking error."

- In order to measure alpha risk, the above hypothetical analysis simply subtracted the benchmark return from the total return for each period over the investment horizon. The standard deviation of this stream of excess returns is "alpha risk."

- The hypothetical analysis measured alpha risk for a particular manager, as described above, or for a particular asset class. In addition to using manager benchmarks, it is also possible to use other levels of benchmarks at the asset class and total portfolio levels. These additional layers of benchmarking introduce additional levels of alpha risk measurement. For example, a plan sponsor may measure the performance of its total U.S. equity portfolio versus the S&P 500 benchmark. SIAG can measure each manager's alpha risk relative to the Russell 3000; the aggregate of these alpha risks tells us how closely the portfolio's overall U.S. equity allocation is "tracking" the Russell 3000 benchmark. If, in this hypothetical example, the plan sponsor did not employ the Russell 3000 as the asset class benchmark, U.S. equity total alpha risk is simply the aggregate of each manager's alpha risk relative to its own, specific benchmark. Note that when the term "aggregate" is used in this context, it does not suggest a simple summation of individual asset risks to get a total risk number—we must consider the impact of correlations. Only in the theoretical case that asset returns in a portfolio are perfectly correlated with one another (+1), is total risk the weighted average sum of the individual risks (like portfolio return). In all other cases, total risk is lower due to the benefits of diversification.

Accounting for manager benchmark changes, and recently terminated or hired managers

- For managers who were hired recently (so, a long return history does not yet exist), SIAG believes it is best to backfill the data using that manager's composite for the given strategy. Using the historical composite data is the best way, in SIAG's view, to ensure that alpha risk and correlation structure of the strategy are characterized as accurately as possible.

- If composite data is unavailable, estimates of a strategy's expected alpha and tracking error target may be provided; These statistics can then be used to generate a simulated historical return series for the manager. If the strategy is actively-managed, both of these options are superior to backfilling the manager's history using index data. Such an approach would make the strategy appear passive, and, if the strategy represents a significant allocation, the portfolio's total risk profile could become significantly distorted.

- SIAG believes that it is best to keep recently-terminated managers out of an analysis; If the assets have not yet been re-allocated, they can be temporarily placed in cash. If managers have undergone benchmark changes during their tenure, it may be advisable to use the existing benchmark for the entire period of the analysis. Both of these scenarios—excluding terminated managers, and using current benchmarks—assume a desire to provide the most accurate possible picture of the existing portfolio's alpha risk profile. The use of terminated managers, or old benchmarks would simply give a picture of the portfolio's historical risk profile.

Working with manager alpha targets

- Manager alpha targets provide an attribution of total portfolio alpha to broad asset classes, as well as individual managers. The attribution of alpha is helpful to analyze alongside the attribution of alpha risk in that the two statistics can be compared in order to determine the adequacy of reward for taking a particular alpha risk.

- If alpha targets cannot be sourced, basic assumptions can be used to derive these targets. For example, SIAG's proprietary manager research allows for some general conclusions about the information ratios of median-level managers representing different asset classes; These information ratios can be paired with the actual tracking error of the manager and thereby "derive" a reasonable alpha target.

Working with alternative investments, overlay strategies or other strategies lacking traditional benchmarks

- In the Total Risk Budgeting framework, SIAG always measures alpha risk with respect to some market benchmark. Consequently, it is important to define reliable, appropriate benchmarks for the various portfolio investments.

- For alternative investments, private equity and hedge funds can pose the most difficulty as these two asset classes do not necessarily have “standard” benchmarks.
- For private equity, it is advisable to use a proxy, such as a micro-cap index. For hedge funds, it is recommended that cash be used as the benchmark for a manager that identifies a fund as truly market-neutral.
- Naturally, the periodicity of all the return streams must match and the minimum data required is monthly frequency dating back for at least 30 months (5 years preferred).
- If the overall allocation to strategies with no reliable benchmark is fairly small (i.e., less than 5%), it may be advisable to exclude it from an analysis entirely.
- Asset allocation and currency overlay allocations are generally defined with respect to the total portfolio; so, the alpha risk of these overlays should also be defined with respect to the total portfolio.

Definitions of key statistical output

A typical Total Risk Budgeting study will present the findings in three key categories: Beta only risk, Alpha only risk and Total risk.

BETA ONLY RISK EXAMPLE

Benchmark	Allocation (%)	Benchmark return (%)	Standard deviation (%)	Beta only risk contribution (%)
BarCap Agg	40.00	5.04	3.70	0.57
S&P 500	60.00	1.74	16.05	9.53
			Sum	10.10

Continuing with the same 2- asset class, 4-manager portfolio example, beta-only risk is 10.10%, based on the volatilities and correlations of these asset classes to each other. Perhaps not surprisingly, equity accounts for the majority of the beta only risk, with the fixed income exposure contributing a minimal amount to beta only risk. The reason is that equity is more volatile in itself, as well as having a high allocation. In sum, risk contribution is a function of its a) its allocation in the portfolio, b) its stand-alone volatility and c) correlation to the other benchmarks in the portfolio (see Appendix for exact definition).

ALPHA ONLY RISK EXAMPLE

Manager	Allocation (%)	Excess return (alpha) (%)	Tracking error (%)	Alpha only risk contribution (%)
Manager A	15.00	0.88	1.33	0.03
Manager B	25.00	-0.77	4.86	0.99
Manager C	35.00	3.48	1.60	0.15
Manager D	25.00	1.62	3.47	0.59
			Sum	1.75

The total alpha only risk, or tracking error of the same portfolio is 1.75%, which is much smaller than the beta only risk. Of the four managers it is clear that Manager B is contributing the most risk amongst the managers. This again is a function of its weight in the portfolio, its stand-alone risk and the correlation dynamics with the other alpha sources in the portfolio. Evaluating the performance of Manager B it is clear that not only did it underperform the benchmark, but it also contributed to a significantly higher alpha risk.

TOTAL RISK EXAMPLE

Manager/ Benchmark	Allocation (%)	Contribution to portfolio volatility (%)	Contribution to portfolio return (%)
Manager A	15.00	-0.05	0.13
Manager B	25.00	0.91	-0.19
Manager C	35.00	-0.06	1.22
Manager D	25.00	0.35	0.41
Total alpha		1.14	1.56
BarCap Agg	40.00	0.54	2.02
S&P 500	60.00	9.47	1.05
Total beta		10.01	3.06
Total portfolio	100.0	11.16	4.63

This final and most important table looks at all the interaction combinations in the portfolio: beta to beta, alpha to alpha, and beta to alpha. The total portfolio risk of 11.16%, which is the sum of 1.14% and 10.01%. Total portfolio return is 4.63% which is the sum of the alpha return of 1.56% and beta return of 3.06%. In this case, the bulk of return and risk was generated by the beta allocation, with 1.56% of additional return coming from alpha.

APPENDIX 1: TOTAL RISK BUDGETING EQUATIONS

Covariance of two assets (x and y):

$$\sigma_{x,y} = \text{covar}_{x,y} = \sum_{i=1 \text{ to } n} \frac{(x_i - \overline{x}) * (y_i - \overline{y})}{n}$$

Two-asset portfolio standard deviation (or volatility):

$$\sigma_p = \sqrt{w_x{}^{2} * \sigma_x{}^{2} + w_y{}^{2} * \sigma_y{}^{2} + 2 * w_x * w_y * \text{covar}_{x,y}}$$

Where:

$\text{covar}_{x,y}$ = covariance of assets x and y

x^i = return of asset "x" in a single observation

$$= \frac{w_x{}^{2} * \sigma_x{}^{2} + w_y{}^{2} * \sigma_y{}^{2} + w_x * w_y * \text{covar}_{x,y} + w_x * w_y * \text{covar}_{x,y}}{\sigma_p}$$

Note: To calculate portfolio tracking error (or volatility of excess returns) rather than volatility of total returns, use excess returns (rather than total returns) for all x_i, y_i, x, y, σ_X and σ_Y. Contribution of assets "x" and "y" will then be contribution to portfolio tracking error (or active risk) rather than to portfolio volatility.

To analyze a multi-asset portfolio (more than tao assets), asset and pairwise terms are expanded.

APPENDIX 2: FULL CORRELATION MATRIX

	Manager A	Manager B	Manager C	Manager D	BarCap Agg	S&P 500
Manager A	1.00					
Manager B	-0.06	1.00				
Manager C	0.19	-0.05	1.00			
Manager D	-0.01	0.29	-0.06	1.00		
BarCap Agg	-0.36	0.11	-0.12	0.23	1.00	
S&P 500	-0.27	0.71	-0.16	0.30	0.25	1.00

Alpha-Alpha	Beta-Beta	Alpha-Beta

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