CHAPTER 1

Style Analysis: Asset Allocation and Performance Evaluation

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Several changes have taken place in the past three decades in the U.S. capital markets. An important one among them is the reduction in the direct holdings of corporate equities by individual investors and a corresponding increase in institutional holdings. The growth of mutual funds and pension funds during this period has been the primary cause of the sharp increase in the institutional holdings of equities in the U.S. Whereas mutual funds and pension funds held only 14% of all U.S. corporate equities in 1970, they held almost 40% by 2001.[1] While holding equities through money management institutions has made it possible for individual investors to reap diversification benefits and plan sponsors to benefit from specialization, it has not been without cost. Individual investors as well as pension plan sponsors who invest through

[1] Based on the Flow of Funds Accounts of the U.S., Board of Governors of the Federal Reserve System.

professional money managers need to monitor their actions and evaluate their performance and this introduces invisible agency costs.

For example, consider a large plan sponsor who allocates the funds across several money managers based on each manager's unique investment style. How can a plan sponsor verify that the investment decisions taken by the manger and the securities he or she purchased are consistent with the assigned investment style? How can a plan sponsor ensure that the bets taken by different external managers do not offset each other? Furthermore, external money mangers are compensated based on their performance. In many cases an active investment manger's performance is assessed in terms of her ability to "beat a benchmark."[2] How can the pension fund manger evaluate the nature of the risk the manager undertook in order to attain a performance that is superior to that of the benchmark? These problems are not unique to plan sponsors, but are also of considerable concern to individual investors who own actively managed mutual funds.

Return-based style analysis provides a way of identifying the asset mix of the fund manager and comparing it with the asset mix of the performance benchmark. This enables the plan sponsor to understand the nature of the style and selection bets taken by an active manager. The correlation structure among the type of bets taken by different active managers provides a plan sponsor or an individual investor with valuable insights regarding the extent to which the bets cancel or reinforce each other. This chapter provides a comprehensive description of how return-based style analysis can be used to analyze the investment style of professional money mangers and examine their relative performance. After a brief overview of portfolio-based style analysis, we describe the methodology and the mechanics of return-based style analysis with several examples using mutual funds data. We also discuss several common pitfalls in implementing the technique and how it can used to analyze the style of hedge fund managers.[3]

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[2] An example would be a management fee of 10 basis points (0.10%) of assets under management plus an additional 15 basis points for each 1% of performance over the benchmark such as the S&P 500. Typically the fees are determined from time to time through negotiation between the manger and the pension plan

[3] The section "Return-Based Style Analysis" follows closely the exposition in William Sharpe, "Asset Allocation, Management Style, and Performance Measurement," *Journal of Portfolio Management*, 18 (1992), pp. 7–19. The section "Style Analysis of Hedge Funds" follows closely the exposition in William Fung and David Hsieh, "Empirical Characterization of Dynamic Trading Strategies: The Case of Hedge Funds," *Review of Financial Studies*, 10 (1997), pp. 275–302, and William Fung and David Hsieh, "The Risks in Hedge Fund Strategies: Theory and Evidence from Trend Followers," *Review of Financial Studies*, 14 (2001), pp. 313–341.

EXHIBIT 1.1 An Example of Portfolio Based Analysis for a Global Manager (January 2001 through December 2001)

	Manager Holdings	Benchmark Composition	Difference in weights	Return	Total Effect
Japan	65%	40%	25%	8%	2.0%
Europe and U.S.	20%	30%	–10%	5.5%	–0.55%
Emerging Markets	15%	30%	–15%	3%	–0.3%
Overall	100%	100%	—	—	1.15%
Total difference in returns					1.65%
Attributed to country-weighting					1.15%
Return due to selection					0.50%

PORTFOLIO-BASED STYLE ANALYSIS

The performance of money managers is often evaluated by comparing the performance of the managed portfolio against the performance of a particular manager-specific passive benchmark (e.g., S&P 500 for a Large Cap Core manager). Performance attribution seeks to explain the sources of the difference between the manager's performance and that of the specified benchmark. In other words, once it is clear what the results were, the goal is to find out why they were what they were. One commonly used approach is to examine the composition of the manager's portfolio and compare the characteristics or attributes of the securities the manager has invested in with the characteristics of the securities that make up the performance benchmark. Some of the common characteristics that are often used in such comparisons include: market cap, book-to-market ratio, historic earnings growth rate, dividend yield and for fixed income securities attributes such as duration, rating, etc. The attributes are averaged across securities and the returns associated with each attribute are determined.

Exhibit 1.1 provides a simple example of a global manager that outperformed his benchmark during 2001 by 165 basis points (1.65%). The analysis shows that of the total difference, 115 basis points could be attributed to the portfolio "tilt" toward investing in Japanese stocks during a period in which Japanese stocks outperformed stocks of firms from other developed countries and emerging markets countries. The remaining 50 basis points could then be associated with the manger's ability to select "winners" within the various regions.

As mentioned earlier the use of portfolio-based style analysis requires knowledge of the composition of the managed portfolio as well as the performance benchmark at the time of the analysis. In the case of

a pension plan sponsor the money manger typically would provide the necessary information to the pension plan for performing the analysis. In the case of mutual funds, the investor can obtain this information from quarterly filings. Some Web sites also provide information on mutual fund characteristics computed using portfolio-based style analysis and classify the funds they cover into various categories.

Exhibit 1.2 displays information available from the Morningstar Web site (www.morningstar.com), for the Goldman Sachs Growth and Income Fund as of January 2002. Panel a displays the equity characteristics of the fund portfolio and a comparison to the S&P 500 Index. The portfolio attributes represent an aggregation of the individual securities comprising the fund portfolio (the top 25 holdings are shown in Panel b). The fund invests in only 95 stocks with no bonds, and also maintains some exposure to foreign markets (roughly 5%). The companies owned by the fund are much smaller than those included in the S&P 500 (the median firm size is roughly $28 billion versus $58 billion in the S&P 500) and the industry weightings differ substantially (see Panel c). The fund has a somewhat higher average price-to-book ratio, but a lower price-to-earnings ratio. This is probably because the stocks owned by the fund experienced a higher earning growth relative to price in the past than the stocks comprising the benchmark. The difference in returns between the fund and the benchmark that may arise may be attributed to the characteristics bets the fund took relative to the performance benchmark. For example, the difference in industry weighting between the fund and the benchmark, coupled with the returns for each industry can be used to calculate the contribution of 'industry bias' to the overall return difference as shown in Exhibit 1.1.

EXHIBIT 1.2 **Portfolio-Based Analysis for Goldman Sachs Growth and Income Fund, Based on Morningstar Data as of 01/31/2002**
Panel a. Equity Characteristics

	Growth and Income Fund	S&P 500
Number of Stocks	95	500
Median Market Cap	$27.84B	$58.0B
Price/Earnings Ratio	25.1×	30.3×
Price/Book Ratio	4.2×	3.7×
Price/cash flow	13.2×	18.85×
Earnings Growth Rate	16.2%	14.2%
Bond holding	0%	—
Foreign Holdings	4.93%	—
Turnover Rate (Fiscal Year)	40.0%	—
Cash Investments	0.1%	—

EXHIBIT 1.2 (Continued)
Panel b. Portfolio Stock Composition

	Name of Holding	Sector	P/E	YTD Return %	% Net Assets
1	ExxonMobil	Energy	17.64	–0.19	3.35
2	Citigroup	Financial	16.00	–13.50	3.32
3	ChevronTexaco	Energy	26.54	–8.00	2.87
4	Bank of America	Financial	12.36	–2.81	2.70
5	ConAgra	Staples	18.71	–0.66	2.46
6	Merck	Health	19.51	4.18	2.43
7	Philip Morris	Staples	13.43	13.35	2.26
8	Freddie Mac	Financial	11.18	–3.44	2.18
9	Heinz HJ	Staples	28.99	1.53	2.08
10	XL Cap Cl A	Financial	23.48	3.04	2.05
11	Kimberly-Clark	Industrial	20.38	4.26	2.04
12	U.S. Bancorp	Financial	22.24	–6.50	1.74
13	SBC Comms	Services	17.39	–4.80	1.70
14	PPL	Utility	26.66	–6.69	1.61
15	KeyCorp	Financial	78.00	–0.66	1.52
16	Alliance Cap Mgmt Hldg	Financial	20.57	–9.20	1.46
17	Wells Fargo	Financial	23.32	6.33	1.43
18	Anheuser-Busch	Staples	25.53	7.14	1.34
19	Energy East	Utility	11.98	2.81	1.33
20	PNC Finl Svcs Grp	Financial	29.22	0.09	1.27
21	Keyspan	Energy	20.16	–10.42	1.24
22	Aon	Financial	45.35	–1.01	1.21
23	Deere	Industrial	—	3.28	1.21
24	Motorola	Technology	—	–17.64	1.19
25	Intl Paper	Industrial	—	6.82	1.13

Portfolio-based style analysis requires information on portfolio composition, which may be difficult to obtain. Further the classification of individual securities into slots based on characteristics can involve substantial amount of judgment. For example, a conglomerate firm would typically have operations in several different sectors of the economy and it may be difficult to identify how much of the firm goes into each sector. In addition, portfolio compositions may change over time. Point in time categorization may result in significant style "drift." Such "drift" would render long-term style comparisons not very meaningful. One solution is to calculate these characteristics at different points in time and use multiple portfolios to classify the investment manger.

EXHIBIT 1.2 (Continued)
Panel c. Industry Weightings

Sector Diversification (% of Common Stocks)	Growth and Income Fund	S&P 500 Index	Difference
Utilities	6.40	2.89	3.51
Energy	10.00	6.42	3.58
Financials	36.20	17.78	18.42
Industrials	10.40	11.06	–0.66
Durables	0.70	2.82	–2.12
Staples	11.00	8.92	2.08
Services	10.80	4.86	5.94
Retail	1.00	13.56	–12.56
Health	6.30	14.90	–8.60
Technology	7.30	16.80	–9.50

Another problem arises from simply calculating portfolio characteristics based on the portfolio holdings. A domestic equity mutual fund investing in domestic stocks that derive a majority of their revenue from sales abroad will clearly be influenced by factors in foreign economies. If the foreign economies go into recession, the fund will be affected. In this way, the fund, although domestic, responds to factors in foreign economies with a manner similar to an international equity fund. An investor interested in foreign exposure may be able to obtain it through investing in such a domestic fund. In William Sharpe's often-quoted words, what is important here is that "If it acts like a duck, assume it's a duck." One advantage of the approach however, is that it provides updated information on the money manger investment strategy and asset allocation.

RETURN-BASED STYLE ANALYSIS

While it is possible to determine a fund's investment style from a detailed analysis of the securities held by the fund, a simpler approach that uses only the realized fund-returns is possible. Return-based style analysis, requires only easily obtained information, while portfolio-based style analysis requires knowledge of the actual composition of the portfolio.

Relation to Multifactor Models

Multiple factor models are commonly used to characterize how industry factors and economy wide pervasive factors affect the return on individual securities and portfolios of securities. In such models a portfolio of factors is used to replicate the return on a security as closely as possible. Equation (1) gives a generic *n*-factor model that decomposes the return on security *i* into different components:

$$\tilde{R}_{i,t} = \beta_{i,1}\tilde{F}_{1,t} + \beta_{i,2}\tilde{F}_{2,t} + \ldots + \beta_{i,n}\tilde{F}_{n,t} + \tilde{\varepsilon}_{i,t} \qquad t = 1, 2, 3, \ldots, T \quad (1)$$

where $\tilde{R}_{i,t}$ is the return on security i in period t; $\tilde{F}_1$ represents the value of factor 1; $\tilde{F}_2$ the value of factor 2; $\tilde{F}_n$ the value of the nth factor and $\tilde{\varepsilon}_i$ is the "nonfactor" component of the return. The coefficients $\beta_{i,1}, \beta_{i,2}, \ldots, \beta_{i,n}$ represent the exposure of security i to the different set of industry and economy-wide pervasive factors.

The expression

$$\beta_{i,1}\tilde{F}_{1,t} + \beta_{i,2}\tilde{F}_{2,t} + \ldots + \beta_{i,n}\tilde{F}_{n,t} + \tilde{\varepsilon}_{i,t}$$

is the particular combination (portfolio) of factors that best replicates the return $\tilde{R}_{i,t}$. In factor models the portfolio weights, $\beta_{i,1}, \beta_{i,2}, \ldots, \beta_{i,n}$ need not sum to 1; and a factor, $\tilde{F}_{k,t}$, need not necessarily be the return on a portfolio of financial assets.

Sharpe's return-based style analysis can be considered a special case of the generic factor model.[4] In return-based style analysis we replicate the performance of a managed portfolio over a specified time period as best as possible by the return on a passively managed portfolio of style benchmark index portfolios. The two important differences when compared to factor models are: (i) Every factor is a return on a particular style benchmark index portfolio, and (ii) the weights assigned to the factors sum to unity. Rewriting equation 1 yields

$$\tilde{R}_{p,t} = [\delta_{1,p}x_{1,t} + \delta_{2,p}x_{2,t} + \ldots + \delta_{n,p}x_{n,t}] + \tilde{\varepsilon}_{t,p} \qquad t = 1, 2, 3, \ldots, T \quad (2)$$

where $\tilde{R}_{p,t}$ represents the managed portfolio return at time t and $x_{1,t}$, $x_{2,t}$, …, $x_{n,t}$ are the returns on the style benchmark index portfolios. The slope coefficients, $\delta_{1,p}$, $\delta_{2,p}$, …, $\delta_{n,p}$, also referred to as style asset class exposures, represent the average allocations among the different style benchmark

[4] W. Sharpe, "Asset Allocation: Management Style and Performance Measurement," *Journal of Portfolio Management*, 18 (1992), pp. 7–19; and "Determining a Fund's Effective Asset Mix," *Investment Management Review,* 2 (December 1988), pp. 59–69.

index portfolios during the relevant time period. The sum of the terms in the square brackets is that part of the managed portfolio return that can be explained by its exposure to the different style benchmarks and is termed the *style* of the manger. The residual component of the portfolio return, $\tilde{\varepsilon}_{t,p}$, reflects the manager decision to deviate from the benchmark composition within each style benchmark asset class. This is the part of return attributable to the manager stock picking ability and is termed *selection*.

Given a set of monthly returns for a managed fund, along with comparable returns for a selected set of style benchmark index portfolios (asset classes), the portfolio weights, $\delta_{1,p}$, $\delta_{2,p}$, …, $\delta_{n,p}$, in equation (2) can be estimated using multiple regression analysis. However, in order to get coefficients' estimates that closely reflect the fund's actual investment policy, it is important to incorporate restrictions on the style benchmark weights. For example, the following two restrictions are typically imposed:

$$\delta_{j,p} \geq 0 \qquad \forall j \in \{1, 2, \ldots, n\} \tag{3}$$

$$\delta_{1,p} + \delta_{2,p} + \ldots + \delta_{n,p} = 1 \tag{4}$$

The first restriction corresponds to the constraint that the fund manager is not allowed to take short positions in securities. The second restriction imposes the requirement that we are interested in approximating the managed fund return as closely as possible by the return on a portfolio of passive style benchmark indexes. The "no short-sale constraint" is standard for pension funds and mutual funds. For funds that employ some leverage, short-selling, or derivatives (such as hedge funds discussed later in this chapter), other bounds may be invoked.[5]

As before, the objective of the analysis is to select a set of coefficients that minimizes the "unexplained" variation in returns (i.e., the variance of $\tilde{\varepsilon}_{t,p}$) subject to the stated constraints. The presence of inequality constraints in (3) requires the use of quadratic programming to estimate the parameters since standard regression analysis packages typically do not allow imposing such restriction. Writing equation (2) in vector form and rearranging the terms yields

$$E_p = R_p - X\Delta_p \tag{5}$$

[5] The Investment Company Act of 1940 requires mutual funds to state their likely use of derivatives in their prospectuses. Although most of the mutual funds do explicitly state so in their prospectuses, they rarely use derivatives. See J.L. Koski and J. Pontiff, "How Are Derivatives Used? Evidence from the Mutual Fund Industry," *Journal of Finance,* 54 (1999), pp. 791–816. They find that only 20% of the mutual funds in their sample of 675 equity mutual funds invest in derivatives.

where X is the $T \times n$ matrix of asset classes returns, R_p is the $T \times 1$ vector of portfolio returns and Δ_p is the $n \times 1$ vector of slope coefficients δ_1, δ_2, ..., δ_n. The term on the left E_p is the T dimensional vector $[\varepsilon_{1,p}, ..., \varepsilon_{T,p}]'$ of differences between the returns on the fund and the returns on the portfolio of passive benchmark style indexes corresponding to the n dimensional vector Δ_p of style benchmark portfolio weights (also referred to as asset class exposures).

The goal of return-based style analysis is to find the set of nonnegative, style-asset class exposures, $\Delta'_p = \delta_{1,p}, \delta_{2,p}, ..., \delta_{n,p}$, that sum to 1 and minimize the variance of $\tilde{\varepsilon}_{t,p}$, referred to as fund's tracking error over the style benchmark. The objective of this analysis is to infer as much as possible about a fund's exposures to variations in the returns of the given style benchmark asset classes during the period of interest. The mathematics of this procedure is fully explained in Chapter 19 in this book by Thomas Becker.

The style asset class exposures, referred to hereafter as *style*, identified by return based style analysis represent the average style over the period covered when style varies over time. The return on the portfolio of passive benchmark style indexes is commonly referred to as the *style benchmark return* for the fund. In any given month the return on the fund will in general be different from the style benchmark return. That may be due to style rotation, i.e., time variations in the style of the fund and selection of securities within asset classes in a way that is different from the composition of the securities that make up the primitive style indexes used in the analysis.

Active Versus Passive Management

The decomposition of a managed portfolio return into two components, *style* and *selection,* provides a natural distinction between "active" and "passive" managers. An "active" manager is looking for ways to improve performance by investing in asset classes as well as individual securities within each asset classes that she considers underpriced. She will therefore deviate from the style of the performance benchmark index (i.e., tilt towards style benchmarks that she considers undervalued and away from style benchmarks she considers overvalued), and select individual securities within each style benchmark asset class that she considers as being good buys. Hence she will typically have different exposure to the style benchmark asset classes when compared to her performance benchmark. She will also be holding a different portfolio of securities within each style benchmark asset class. She may also be holding securities that fall outside the range of asset classes spanned by the style benchmarks.

As a result, the benchmarks will have a lower explanatory power and the residual terms $\tilde{\varepsilon}_i$ will be larger in absolute value for the managed funds when compared to their respective performance benchmarks. In

contrast, "passively managed" funds do not buy and sell securities based on research and analysis; rather, the fund's assets are simply deployed among different asset classes. As a result, the $\tilde{\varepsilon}_i$'s will be closer to zero for passively managed funds when compared to actively managed funds. In this sense, a passive fund manger provides an investor with an investment *style*, while an active manger provides both *style* and *selection*.

When the right style benchmarks are used, R^2 is an useful measure for identifying "active" managers from "passive" managers; where R^2 is the proportion of the variance "explained" by the selected style benchmark asset. Using the traditional definition of R^2 for portfolio p, we have

$$R^2 = 1 - \frac{\text{Var}(\tilde{\varepsilon}_p)}{\text{Var}(\tilde{R}_p)} \tag{6}$$

The right side of equation (6) equals 1 minus the proportion of variance "unexplained." The resulting R-squared value thus indicates the proportion of the variance of $\tilde{R}_p$ "explained" by the n asset classes.

Notice also that the vector of residuals is not necessarily orthogonal to the matrix of benchmark returns as is the case in multivariate regression, because of the constraints (e.g., $X'E_p \neq 0$). As a result the alternative definition of R^2 given by

$$R^2 = \text{Var}(\delta_{1,p}x_{1,t} + \delta_{2,p}x_{2,t} + \ldots + \delta_{n,p}x_{n,t})/\text{Var}(R_p)$$

is not in general equivalent to the definition given in equation (6) for return-based style analysis.

Applying Return-Based Style Analysis

To demonstrate how return-based style analysis is applied in practice, we analyze a set of open-end mutual funds returns using *StyleAdvisor* software of Zephyr Associates Inc. We use twelve asset classes, each represented by a market capitalization-weighted index of a large number of securities. See Appendix 1.1 for a description of the asset classes. In addition to Bills (Cash equivalent with less than three months to maturity), the model includes intermediate and long term government bonds (between 1–10 years and over 10 respectively) and corporate bonds as three distinct asset classes. Longer maturities government bonds correspond to higher risk due to variation in the shape of the yield curve and higher expected returns. Corporate bonds returns are also affected by changes in the market price of default risk (credit spread).

We use the Russell 3000 index as a measure of the value of all publicly traded corporate equities in the U.S. The Index tracks the performance of the 3,000 largest U.S. companies and represents approximately 98% of the investable U.S. equity market. The largest 1,000 companies in the Russell 3000 constitute the Russell 1000 index and the remaining companies are included in the Russell 2000 index. The Frank Russell Company also assigns all stocks in each index to growth and value subindexes based on their relative price-to-book ratio and the Institutional Brokers Estimate System (I/B/E/S) consensus analyst forecast for long-term earnings per share growth rate. All four indexes are mutually exclusive and exhaustive, market cap-weighted, annually rebalanced and include only common stocks domiciled in the U.S. and its territories. This division captures the two key dimensions that previous research found to affect the variation in equity returns: size ("small/large") and book to market ("growth/value").

The returns on foreign stocks are measured by MSCI Japan, MSCI EASEA and MSCI EM Free, which represent Japan, Developed Countries excluding Japan and Emerging Markets countries, respectively. Finally, the Lehman non-U.S. bond index is used as a proxy for all fixed income securities outside the U.S. It is important to note that each index represents a strategy that could be followed at low cost using index funds (or Exchange Traded Funds for some of the equity indexes).

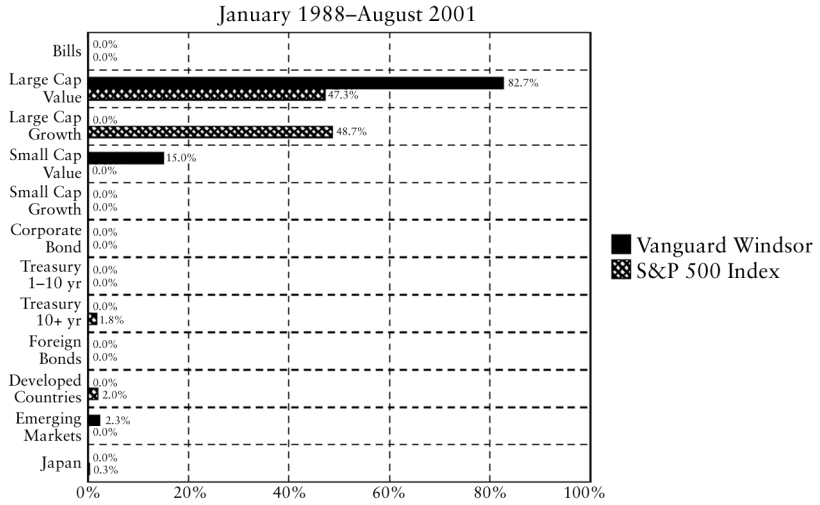
Example 1: Windsor Fund

Exhibit 1.3.a portrays the results of a style analysis of the Vanguard Windsor mutual fund using return data for the period January 1988–August 2001. The fund is classified as a large value fund by Morningstar and has $18 billion in assets under management as of December 2001. The bar chart suggests that consistent with Morningstar classification, the fund invests primarily in large value stocks (roughly 83% invested in the Russell 1000 value) with the rest invested in small value stocks. As indicated by the pie chart (Exhibit 1.3.b) during the period investigated over 87% of the month-to-month variation in returns on the fund could be explained by the concurrent variation in the return of this particular mix of large and small value stocks. The pie chart also demonstrates the additional information we get from return-based style analysis. The S&P 500 stock index, a commonly used performance benchmark for large cap funds, explains only 66% of the variation in monthly returns of Vanguard Windsor Fund whereas the return on the style benchmark asset classes explain 87%. It would be wrong to conclude that the relatively low R^2 with respect to S&P 500 is due to Windsor management following a very active strategy. Part of the low R^2 with respect to the benchmark is due to the fact that the S&P 500 may not be the best performance measure. The S&P 500 had an

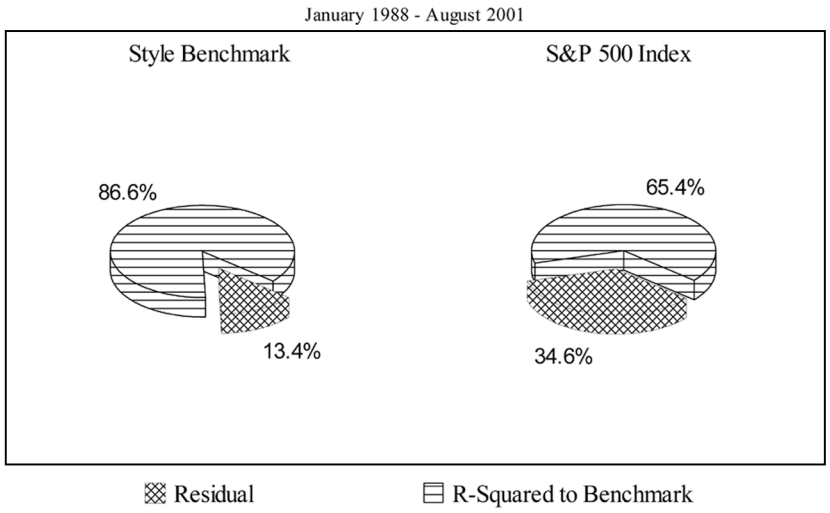
equal share of value and growth stocks whereas Windsor invested nearly 83% of its assets in value stocks. A large cap value index may be a more appropriate performance benchmark for the Windsor fund.

EXHIBIT 1.3 Vanguard Windsor Fund

Panel a.



Panel b.



Example 2: Growth and Income Funds

The universe of domestic equity funds in the U.S. includes thousands of mutual funds. Investors frequently make inferences about a fund's investment policy from its classification by companies such as Morningstar or Lipper or simply from the fund's name. We now examine whether return-based style analysis provides any incremental information beyond that conveyed by the fund's classification and investment policy as it appears in its prospectus. Specifically, we compare the results of style analysis for a group of funds, all with an identical name (Growth and Income Fund) offered by several leading money management firms. The fund's objective, size and fee structure are described in Appendix 1.2.

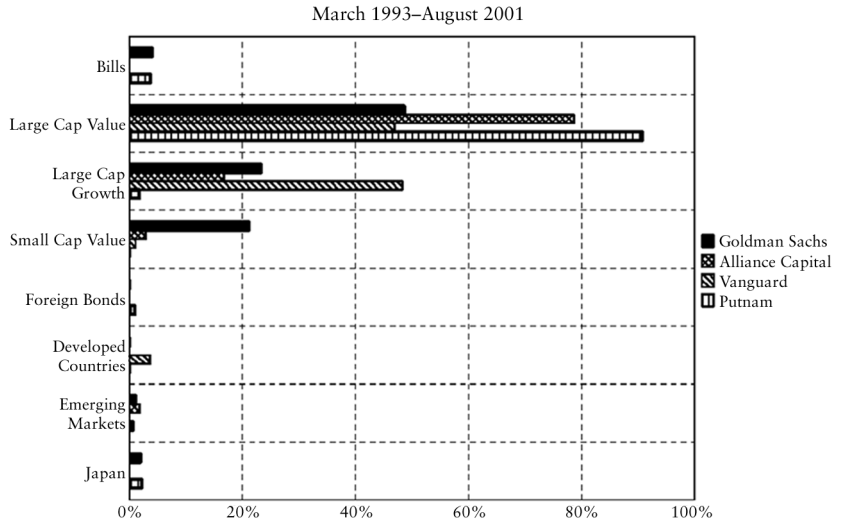
An examination of the investment objective and strategy of each fund (based on its Prospectus) reveals little differences. Basically, all funds follow a value strategy where they invest in stocks they deem undervalued based on fundamental research or compared to similar companies. The funds focus on stocks of large and established companies that are expected to pay dividends (the income component). The funds maintain a long-term investment horizon and do not engage in market timing. An investor who considers investing in a growth and income fund should have little reason to prefer one fund over the other based on their declared investment policies.

The style analysis results for the group of funds using return data for the period March 1993 through August 2001 are presented in Exhibit 1.4.a. For expositional purposes, we omit all the benchmarks that received zero weighting for each of the funds. Despite the similarities in objectives and investment strategy they have substantial differences in their style. While Putnam's style reflects over 90% exposure to large value stocks, Goldman Sachs fund has less than half that exposure. Although the fund followed a "value strategy," the analysis reveals extensive style exposure to Large Growth (20%) and Small Value. These findings are generally consistent with results of the portfolio-based style analysis for GS Growth & Income fund reported in the previous section. The comparison reveals however, the advantages of the technique, mainly its easy graphical representation and quantitative nature.

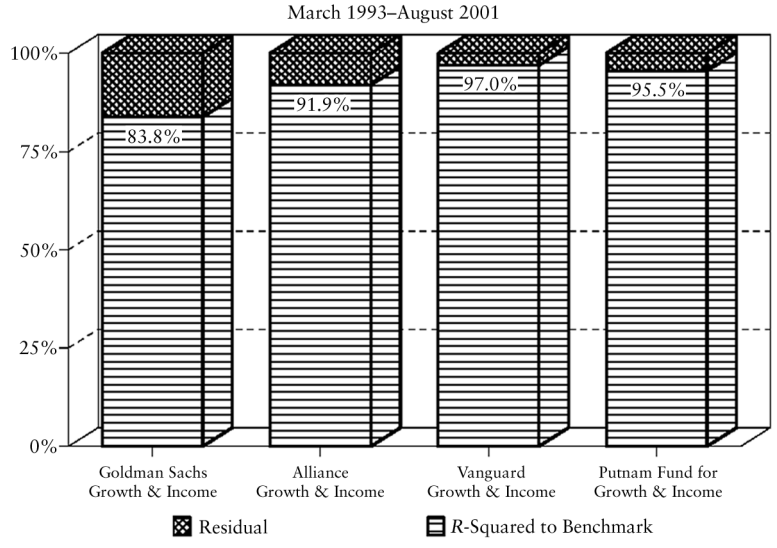
The style of the Vanguard fund on the other hand, reflects an S&P 500-like composition with equal-holding of large value and growth stocks. The exposures to European and Japanese stocks might reflect the activity of American companies in these markets, rather than a direct investment in foreign stocks. Note also the difference in the selection component of return among the funds (Exhibit 1.4.b). The relatively low R^2 obtained using style benchmarks for the Goldman Sachs fund may indicate that the fund may be pursuing a relatively more active stock selection strategy within each style asset class. This may also explain why the fund charges

the highest front-load commission (5.50%) and has the highest expense ratio (1.19%). Overall, the results point to substantial style differences among funds that appear similar based on stated objectives.

EXHIBIT 1.4 Growth and Income Funds
Panel a.



Panel b.



Example 3: Fidelity Convertible Securities Fund

Although convertibles are not represented as a distinct asset class in the model, return-based style analysis is able to capture over 86% of the monthly variation in the fund's returns through a combination of stocks, bonds and bills, as shown in Exhibit 1.5. This should not come as a surprise however, as convertible bonds exhibit characteristics of both stocks and bonds. These results demonstrate the versatility of return-based style. Note that the fund holds a substantial fraction (about 12%) of its assets in foreign securities (probably convertibles) as measured by its exposure to the MSCI indexes.

Style Analysis for Multiple-Manager Portfolios

Sharpe defines the "effective asset mix" as the style of the investor's overall portfolio or pension fund overall assets. Once the style of the individual mutual funds or money mangers have been estimated, it is quite straightforward to determine the corresponding effective asset mix. Denote by ω_j the proportion of the assets allocated to manger j. The overall portfolio return ($\tilde{R}_p$) will be

$$\tilde{R}_p = \sum_j \omega_j \tilde{R}_j \tag{7}$$

EXHIBIT 1.5 Fidelity Convertible Securities Fund
Panel a.

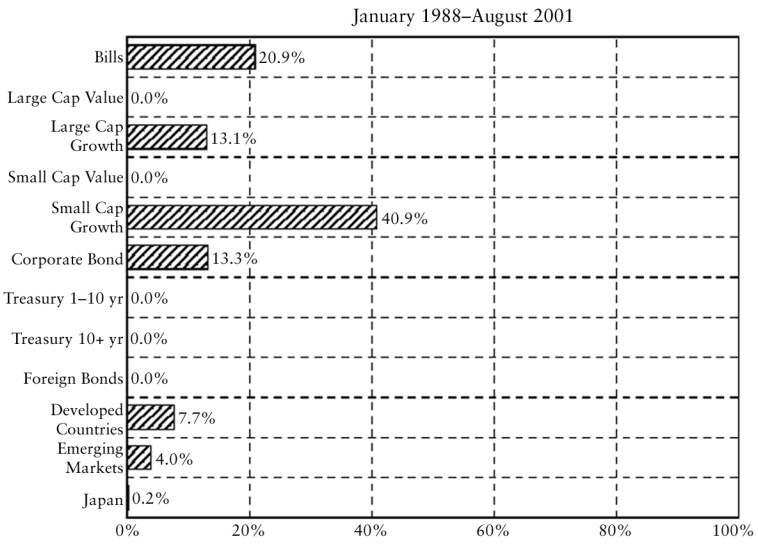
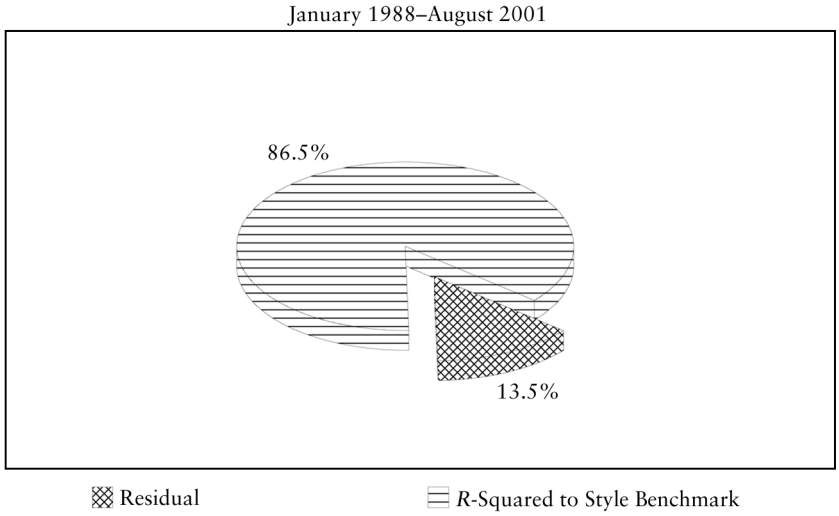


EXHIBIT 1.5 (Continued)
Panel b.



Substituting equation (2) in (7) yields another linear equation:

$$\tilde{R}_{p,t} = \left[\sum_j \omega_j \delta_{1,j}\right] x_{1,t} + \left[\sum_j \omega_j \delta_{2,j}\right] x_{2,t} + \ldots + \left[\sum_j \omega_j \delta_{n,j}\right] x_{n,t} \qquad (8)$$

which can be rewritten as follows:

$$\tilde{R}_{p,t} = [\Psi_{1,p} x_{1,t} + \Psi_{2,p} x_{2,t} + \ldots + \Psi_{n,p} x_{n,t}] + \tilde{\zeta}_{t,p} \qquad t = 1, 2, 3, \ldots, T \qquad (9)$$

where $\Psi_{1,p}$, $\Psi_{2,p}$, ..., $\Psi_{n,p}$ are the pension fund or investor's portfolio overall exposure to each style benchmark asset class. As can be seen by comparing equations (8) and (9), each $\Psi_{j,p}$ is the weighted average of the exposures of the different managers to style benchmark asset class, j, with the relative amount of money allocated to each manager used as the weight for that manager.

The effective style benchmark asset mix will account for a large proportion of the month-to-month variation in the return of a portfolio invested with several money managers, when the residual terms across different managers are uncorrelated since diversification across different fund managers will substantially reduce the variance of the aggregate

nonfactor component. An examination of the correlation among the residuals will indicate the extent to which the managers are taking similar selection bets.

Asset Allocation and Style Consistency over Time

It is important to remember that the style identified in each of the three examples is, in a sense, an average of potentially changing styles over the period covered. Since a fund's style can change substantially over time, it is also helpful to study how the exposures to various style benchmark asset classes evolve. For that purpose we conduct a series of style analyses, using a fixed number of months for each analysis, rolling the time period used for the analysis through time.

Example 4: Balanced Index Fund

Exhibit 1.6.a portrays the style evolution of the Vanguard Balanced Index fund, using a 60-month rolling window between October 1992 and August 2001. The point at the far left of the diagram represents the fund style when the sixty months ending in September 1997 are analyzed. Every other point represents the results of an analysis using a different set of sixty months. Note that each set has 59 months in common with its predecessor. As its name suggests, the fund is indeed balanced, spreading its investments among stocks, bonds and bills. As documented in Exhibit 1.6.b Style accounted for practically all the variation in the fund's return and remained largely constant throughout the period analyzed.

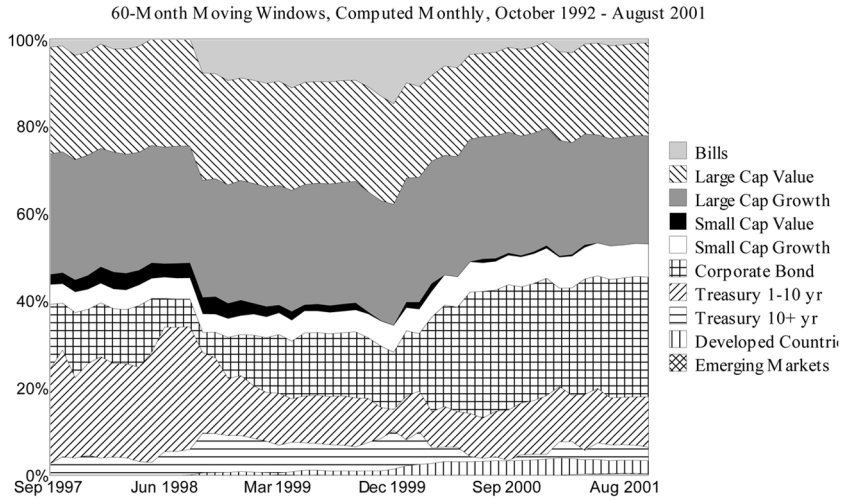
Example 5: Vanguard Windsor Fund

In contrast, Exhibit 1.7 shows that the style of Vanguard Windsor Fund changed several times between 1990 and 2001. The fund was a "pure" value fund until August 1997, investing about 75% of its assets in large stocks and the rest in small stocks. It then eliminated completely its exposure to small value stocks (Russell 2000 value) and replaced it with mostly small growth stocks and emerging markets stock.[6] About a year later, another style change occurred which lasted through the rest of the time period covered. The fund began investing again in small value stocks but still kept an exposure to small growth stocks (roughly 7%). The fund also developed a substantial exposure to emerging markets through holding stocks of companies from these countries (10% on average).

[6] Based on Morningstar records, there was no management change in that year.

EXHIBIT 1.6 Vanguard Balanced Fund

Panel a.



Panel b.

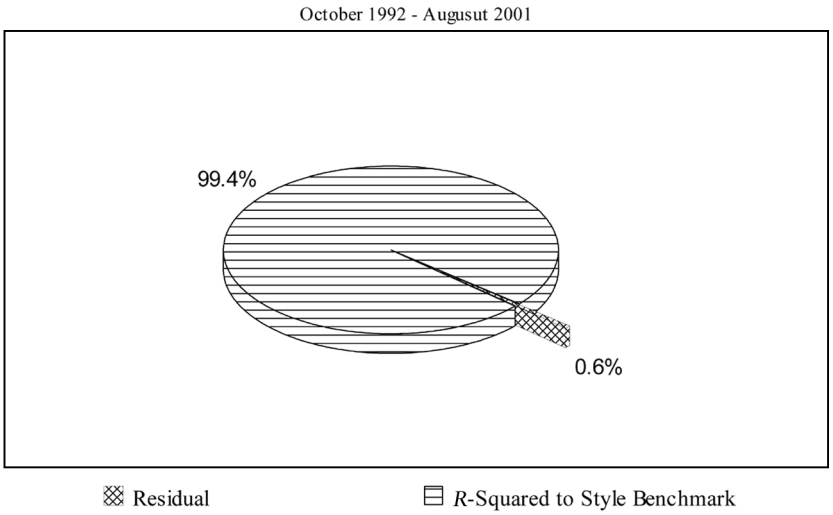
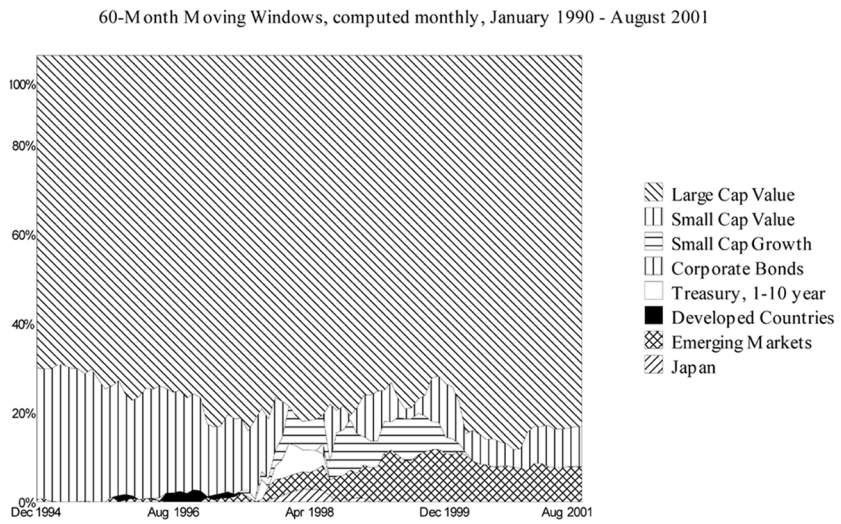


EXHIBIT 1.7 Vanguard Windsor Fund



The ability of return-based style analysis to capture changes in investment style over different time horizons is one of its key advantages. While portfolio-based style analysis description of a fund style is accurate for a point in time, return-based style analysis describes an average style over a time period (much like a balance sheet and an earning report) and can account for changes in style. An investor who owned shares in the fund anytime after August 1998 and thought (based on the Morningstar classification) that he was betting solely on a value strategy in the U.S., would in fact have also been exposed to risks and rewards associated with investing in small growth stocks and Emerging Markets (to some extent).

Performance Evaluation

While a passive fund manager provides investors with an investment *style*, an active manager provides both *style* and *selection*. This suggests that the performance benchmark should consist of a portfolio of asset classes that gives the desired exposure to benchmark style asset classes. Superior performance relative to the performance benchmark that provides a static mix of the style benchmark asset classes would justify the higher fees usually paid to "active" as opposed to "passive" managers. We follow this approach and focus on the fund's selection return, defined as the difference between the fund's return and that of a passive mix with the same style. We assume that the active manager declares the

fund style at the beginning of each period and is engaged only in picking undervalued securities within each style benchmark asset class; and that the style benchmark is a more appropriate benchmark for measuring performance than the commonly used S&P 500 index.[7] Note that this differs from the use of the selection term $\tilde{\varepsilon}_{t,p}$ obtained as by products of a style analysis, because the $\tilde{\varepsilon}_{t,p}$'s were constructed in-sample.

To illustrate this approach for the Vanguard Windsor Fund we employ the following steps for each month *t*:

1. The fund's style is estimated, using returns from month *t–36* through *t–1*. The length of the estimation period while somewhat arbitrary, tries to balance between two opposing issues. A longer estimation period reduces "noise" and provides a more accurate description of the fund's style exposure. For active managers who dynamically rotate among several asset classes in addition to providing stock-picking abilities however, a longer estimation period will not produce accurate estimates. A shorter estimation period will be able to better track such managers.
2. The return on the resulting style (i.e., using the coefficients estimated in step 1) is calculated for month *t*.
3. The difference between the actual return in month *t* and that of the style benchmark determined in the previous steps is computed. This difference is defined as the fund's selection return for *t*.

Exhibit 1.8 shows the excess returns from January 1988 through August 2001 for Vanguard Windsor. On average, the fund underperformed its style benchmarks by 90 basis points per year, with a standard deviation of 5.97% per month. The *t*-statistics associated with the mean difference is however small in absolute value suggesting that the average difference was not statistically significantly different from zero.

Exhibit 1.9 demonstrates the advantages of using style analysis to analyze the performance the way we have done. It compares the return on Vanguard Windsor with the S&P 500 stock index. The fund's performance so measured was almost three times as good as that shown previously: the cumulative difference was 9.75% and the average difference was –65 basis points per year. However, such a comparison includes results attributable to both *style* and *selection*. During the period in question the fund's style outperformed that of the S&P 500. But for poor selection the fund would have outperformed the S&P 500 by 25

[7] This approach would not be valid when the portfolio manager is a style timer (or a market or sector timer). Evaluating the performance of a style timer is beyond the scope of this chapter.

basis points per year. As Sharpe points out, results (good or bad) associated with the choice of a *style* should be attributed to taking *style* bets. To the extent an investor chose the fund because its style favored value and small stocks, the rewards to taking the risk associated with the style bet should go to the investor. To the extent the style bets involve superior style timing skills the rewards after suitably adjusting for the added risks should go to the manager.

Common Pitfalls in Interpreting Style Analysis Results

The popularity of return-based style analysis lies in the ease with which it can be applied. The ability to correctly interpret the results, however, depends on the selection of appropriate style benchmark asset classes to use, which raises several questions. What types of style benchmarks and how many style benchmarks should one include in the model? Which index should be chosen to represent a style asset class when there are several indexes available? Is the set of benchmarks appropriate for one fund necessarily appropriate for another?

EXHIBIT 1.8 **Vanguard Windsor Excess Return versus Style Benchmark**

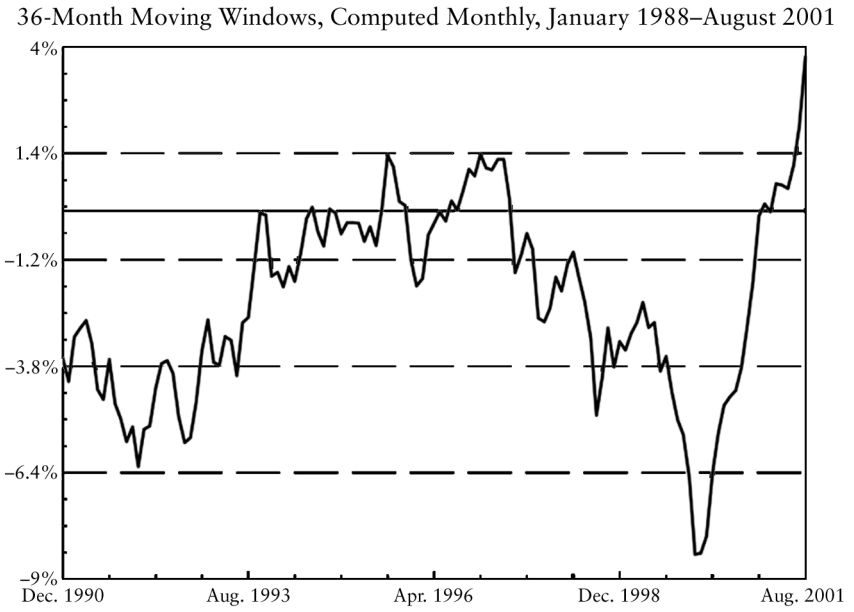
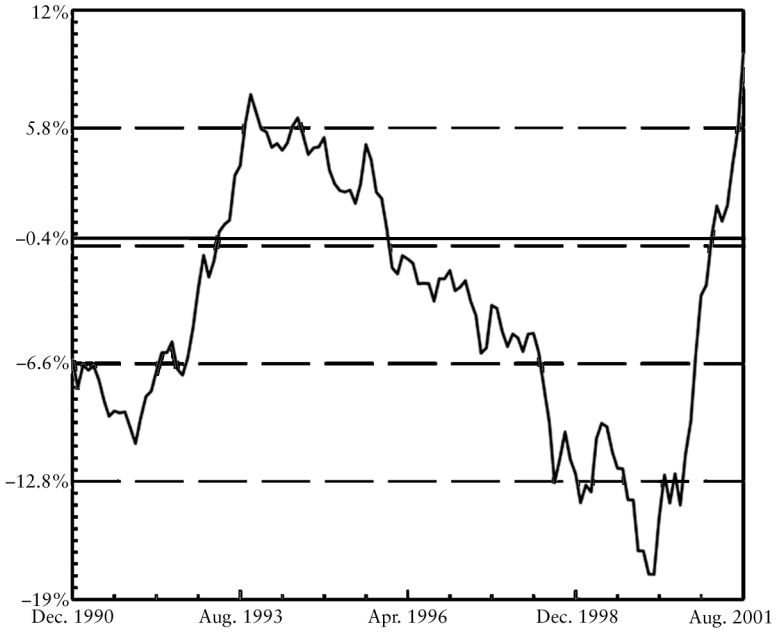


EXHIBIT 1.9 **Vanguard Windsor Excess Return versus S&P 500**

36-Month Moving Windows, Computed Monthly, January 1988–August 2001



In general, it is desirable that the asset classes used in the model include as many securities as possible, and are mutually exclusive such that no security is included in more than one asset class. Benchmarks that are not mutually exclusive might cause the factor weightings to oscillate between the correlated asset classes. A similar problem arises, if the set of benchmarks is incomplete (i.e., not exhaustive) or inadequate. The optimization algorithm will have trouble pinning down a benchmark that consistently explains the fund's behavior from period to period, and the regression is likely to flip-flop between those that temporarily provide a best fit (a fact that will likely be reflected in a low R^2 as well). Finally, asset class returns should either have low correlation with one another or, in cases where correlation is high, different standard deviations.

The number of asset classes used in the model represents a tradeoff. Using a larger number of distinct asset classes or a finer partition of the investment universe facing the portfolio manager will provide more information and better tracking of the portfolio performance. An example of that is the division of the Russell 2000 index to growth and value

subindexes, or the use of several regional indexes instead of the MSCI EM (Latin America, Asia, Africa and the Middle East). However, it is necessary to consider not only the ability of a model to explain a given set of data but also the number of style benchmark indexes used. The use of a larger number of benchmarks has the potential of introducing more "noise" into the analysis. This problem is especially acute, since we have no easily available statistical procedure for assessing the significance of the exposure coefficients.[8] In addition, the higher the number of benchmarks used, the longer the estimation period required. Other things equal (e.g., R^2), the fewer the style benchmark indexes used, the higher likelihood that the model will capture continuing fundamental relationship with predictive content.

Model Misspecification: An Example

Exhibit 1.10 highlights the potential for misinterpretation of style analysis results when the benchmarks used are inadequate. The column entitled "basic model" presents the result of style analysis performed on Putnam Utilities Growth and Income during January 1992 through August 2001. As demonstrated previously, in the case of Fidelity Convertible Securities fund, the technique tracks how a portfolio returns covary with other asset classes rather than its composition. As Sharpe observed, although utility funds hold common stocks, Putnam Utility returns behave more like a passive portfolio invested in both stocks and bonds. That is, utility revenues are "sticky" because of the regulatory process, causing shares of such companies to have features that are both stocklike and bondlike.

Note that Putnam Utilities Growth and Income has large exposure to Large Value stocks. It is not that the fund invests in such stocks. Rather, it is just that this asset class reflects the return characteristics of the fund's investment in utilities during this period. The low R^2 is not a result of a highly "active management" strategy, but merely a manifestation of inadequate benchmarks.[9]

It is clear from this example that when style analysis is applied for sector oriented funds (e.g., healthcare, precious metals, energy, technology, etc.), the set of benchmarks should include sector or industry indexes. For example, in the case of a REIT (Real Estate Investments Trust) asset classes related to real estate such as mortgages and housing indexes will be used.

[8] The conventional assumptions regarding the distributional properties of the benchmark coefficients are not valid in the presence of inequality constraints as in equation (3).

[9] The result is not unique for Putnam utility fund. In "Asset Allocation: Management Style and Performance Measurement," Sharpe reports a similar average value of R^2 for a sample of utility funds.

EXHIBIT 1.10 Putnam Utilities Growth and Income (January 1992 through August 2001)

Asset Class	Basic Model	Extended Model
Bills	0	3.4%
Treasury 1–10yr	11.9%	0
Treasury 10+ yr	20.5%	0
Corporate Bonds	0	0
Large Cap Value	56.8%	14.7%
Large Cap Growth	0	0
Small Cap Value	0	4.4%
Small Cap Growth	0	0
Developed Countries	0	0
Japan	0	0
Emerging Markets	0	0
Foreign Bonds	10.8%	10.6%
Dow Jones Utilities	—	44.6%
Dow Jones Communications	—	16.5%
Dow Jones Energy	—	5.9%
R^2	0.669	0.929

The column entitled Extended Model reports the analysis result for Putnam Utilities when the basic 12 asset classes model is extended by adding three sector indexes: Utilities, Communication and Energy, constructed by Dow Jones. The addition of the Energy and Communications indexes reflects the focus of utility companies in these industries and can potentially capture some of the variation in the fund's return. Contrasting the analysis results with and without the inclusion of sector indexes is striking. The selection component of returns decreases from roughly 33% to about 7%, confirming our prior assertion that the fund does not employ a highly active management strategy. As expected the fund invests primarily in utility stocks. The loading on Energy and Communication indexes reflects the common component in returns of utility companies stocks' that operate in these industries (such as Gas, Electricity and Phone companies), as well as actual holdings of energy and communication firms stocks. Note the exposure to Bills, which probably results from the actual cash holdings of the fund, to meet liquidity needs.

We revisit the issue of model misspecification and inadequate benchmarks in the next section, when we demonstrate how style analysis can

be used to analyze the performance of hedge funds by suitable choice of style index benchmarks.

Interpreting R^2: Active Management or Inadequate Benchmarks?

Although some see a low value of R^2, solely as an indicator of "active" management, a higher R^2 also implies that the technique is better and often more consistently able to explain the long-term return behavior of the fund. As the last example demonstrates, style analysis using an inadequate set of benchmarks can result in a low R^2.

Drawing inferences on a fund solely from the overall ability of the technique to explain the monthly variation in returns (e.g., R^2) is improper and should be done in tandem with an analysis of style changes through time (e.g., a rolling-window methodology) and cost structure. A relatively unstable style graph could indicate inadequate benchmarks or market timing/sector rotation. In the latter case, the fund manager may be switching in and out of asset classes or sectors, with the result that the customized benchmark that best explains the fund's return changes from time to time.

Typically a high fund turnover ratio will accompany market timing. If the turnover on the fund is low, it could be that the types of securities held by the fund themselves are changing and causing a constant shift in style. Funds with high concentrations in individual securities are candidates for this type of activity. The Windsor Fund, for example, has an unstable style graph, but a turnover that rarely exceeds 35% annually. Based on the 3rd quarter report of 2001, the fund's top five holdings comprise 20% of total assets and the top 10 holdings comprise over 30% of total assets. Clearly, this fund will be highly sensitive to how quickly its top holdings go in and out of favor, how much they behave like value or growth stocks, etc.

It is also important to examine the fund's cost structure. Funds with active management differ from passive funds in their cost structure. Active funds typically charge a buying or selling fee known as a load (either a front-load or a back-load) and have higher management fees. Superior performance should be evaluated after allowing for these costs.

Another method to examine whether a low R^2 coupled with large variation in style is due to active management or ill-specified benchmarks is to compare the average R^2 for the period covered, with the series of R^2 that result from the rolling window technique. If the series of R^2 are low as well, it indicates that active management is likely to be the case. If, on the other hand, the individual R^2 is higher than the overall period R^2, then some benchmarks are probably ill-specified.

STYLE ANALYSIS AND HEDGE FUNDS

A mutual fund or pension fund manager is typically evaluated by how much the portfolio she manages earns in excess of some well defined performance benchmark. She also faces several constraints when managing her portfolio to deliver superior performance: The tracking error of her portfolio relative to the performance benchmark should be within acceptable range; she has to invest only in certain well defined asset classes; and the weights she chooses for the different asset classes should be within some bounds—for example most fund managers cannot short sell or take levered positions. Because of these restrictions a fund manager tends to generate returns that are highly correlated with the return on a portfolio of the well-defined asset classes as well as the performance benchmark. The asset classes that the mutual fund manager is allowed to invest help identify the style benchmark indexes in a natural way. Incorporating the portfolio weight restrictions placed on the fund manager, while estimating the manager's style and comparing it with the style of the performance benchmark, helps improve the precision of the estimates. Hence the success of Sharpe's return-based style analysis in analyzing the performance of mutual fund and pension fund managers should come as no surprise.

As Fung and Hsieh point out, return-based style analysis can be particularly helpful in characterizing the risk in the strategies employed by Hedge Funds and Commodity Trading Advisors (CTAs) that employ dynamic trading strategies also when suitable style benchmark asset classes are used.[10] However, standard style benchmarks will not work with hedge funds and CTAs that have the flexibility to choose among many asset classes and employ dynamic trading strategies that frequently involve short-sales and substantial leverage.[11]

While dynamic trading strategies that have been discussed in the literature focused primarily on mutual funds, the range of trading strategies employed by hedge funds are far more complex.[12] The literature on

[10] A commodity trading advisor (CTA) is an individual or trading organization, registered with the Commodity Futures Trading Commission (CFTC) through membership in the National Futures Association, granted the authority to make trading decisions on behalf of a customer in futures, options, and securities accounts established exclusively for the customer.

[11] Hedge fund managers derive a substantial part of their compensation from incentive fees, which are paid only when these managers make a positive return. A "high-watermark" feature in their incentive contracts require them to make up all previous losses before an incentive is paid.

[12] For an excellent review on the organization, compensation and trading strategies of hedge funds see: W. Fung and D. Hsieh, "A Primer on Hedge Funds," *Journal of Empirical Finance*, 6 (1999), pp. 309–331.

market timing for example, has focused on the ability of mutual funds managers to time the market on the long side (see Dybvig and Ross, and Merton).[13] In contrast, hedge fund managers can make money on the short side as well. In addition, hedge funds positions can involve time horizons much shorter than a month (and sometime just several days). Furthermore, hedge fund managers can use derivatives and complex options. As a result, these alternative managers generate returns that have low correlation with the returns of standard asset classes. Because of the dynamic strategies followed by hedge funds, the number of asset classes needed to proxy hedge funds styles becomes very large, even though they trade the same asset classes as mutual funds (see Fung and Hsieh, and Laing for an excellent discussion of related issues).[14]

Applying Style Analysis to Hedge Funds

Hedge funds' strategies are typically classified as Directional or Nondirectional. Directional strategies hope to benefit from broad market movements, while Nondirectional strategies have low correlation with any specific index by being "market neutral." These strategies aim to exploit short-term pricing discrepancies between related securities while keeping market exposure to minimum. Some popular directional strategies include: Emerging Markets, Equity Nonhedge, and Short-Selling. Nondirectional strategies include: Event Driven, Relative Value Arbitrage, and Equity Hedge.[15] We use net-of-fees return data on two directional funds (Emerging Market fund and a Managed Futures advisor) and two nondirectional funds (Market Neutral) to demonstrate the difficulties of analyzing the return pattern of alternative managers.[16] Appendix 1.3 contains a more detailed description of the funds.

Exhibit 1.11.a (the columns entitled Basic Model) and Exhibits 1.11.b–c present the style analysis for the four hedge funds when no leverage or short-sales constraints are imposed.[17] In contrast to the mutual fund examples in the previous sections, the ability to track the

[13] H. Dybvig and S. Ross, "Differential Information and Performance Measurement using a Security Market Line," *Journal of Finance*, 40 (1985), pp. 383–399; and R.C. Merton, "On Market Timing and Investment Performance I: An Equilibrium Theory of Values for Markets Forecasts," *Journal of Business*, 54 (1981), pp. 363–406.

[14] William Fung and D. Hsieh, "Empirical Characterizations of Dynamic Trading Strategies: the Case of Hedge Funds," *Review of Financial Studies*, 10 (1997), pp. 275–302; and B. Laing, "Hedge Funds: The Living and the Dead," *Journal of Financial and Quantitative Analysis*, 35 (2000). pp. 309–336.

[15] For a more detailed description of the various strategies employed by hedge funds, see the Hedge Fund Research Company Web site www.hfr.com

[16] We thank David A. Hsieh for providing us with the hedge funds data.

[17] The sum of the coefficients is still constrained to 1.0.

market neutral funds is extremely low (as measured by the R^2). The analysis was more successful in the case of directional funds, although it still captured at most only 57% of the monthly variation in returns of the Axiom fund. Not surprisingly, with the debt crisis in Russia and South America during the time period analyzed, this fund was shorting emerging markets bonds and investing in U.S. Corporate bonds and emerging markets equities. The magnitudes of some of the coefficients imply extreme levels of leverage and shorting activity. In particular notice that there is no significant exposure to any component of the Russell 3000 Index. This finding probably reflects the nature of the dynamic trading strategies employed by the funds rather than actual holdings.

Fung and Hsieh illustrate this point, by considering a manager involved in index arbitrage on the S&P 500 by trading futures contracts and cash (e.g., individual stocks comprising the index). Without leverage, a fully invested position of being consistently long 1 futures contract (i.e., buy-and-hold) will result in the style analysis showing a coefficient of 1 on the S&P 500 index. If the manager leverages up to 3 futures contracts, the coefficient will be 3. If the manger is short 1 futures contract, the coefficient will be –1. When the manager alternates between long and short positions each month however, the regression coefficient will be close to 0. Although in all examples, the manger invests in the U.S. stock market, the returns are very different depending on the trading strategy. In the first two cases, the returns are positively correlated with U.S. stocks. In the third case, the returns are negatively correlated with U.S. stocks. And in the fourth case, the returns are uncorrelated with U.S. stocks.

Using Peer Evaluation

Another approach for evaluating the performance of hedge funds often used by practitioners is peer-comparison. To help investors understand hedge funds, consultants and database vendors group hedge funds into "categories" of funds based on the managers' self-disclosed strategies. The objective of the peer-group approach is to compare the performance of funds operating "similar" strategies.

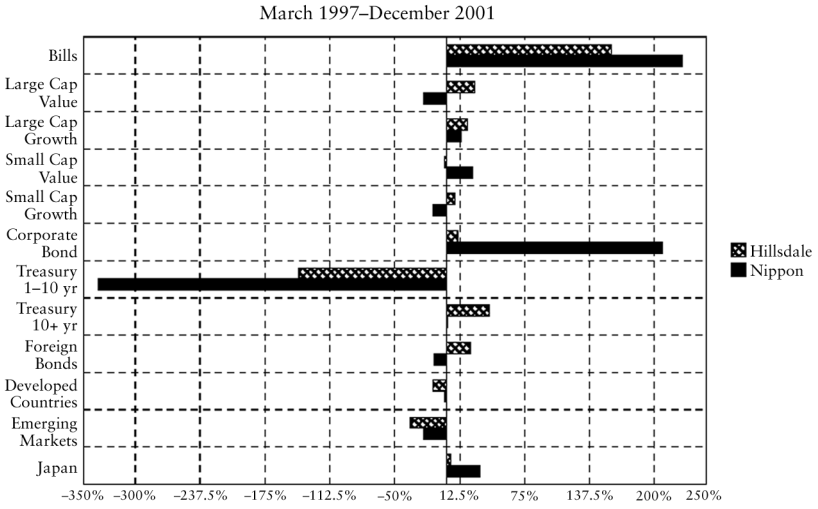
To demonstrate this approach, the performance of each fund is regressed against an index that is composed of hedge funds with similar investment strategy. The returns of Hillsdale and Nippon funds are compared to a Market Neutral Hedge Fund index while we use Emerging Market and Managed Futures indexes as benchmarks for Axiom Fund and John W. Henry & Company CTA respectively. Out of the many companies that offer hedge fund indexes, we use those constructed by the Hedge Fund Research Company (HFR), CSFB/Tremont and MAR Futures. For a description of the indexes, see Appendix 1.4.

EXHIBIT 1.11 Hedge Funds Style Analysis (I)

Panel a. This exhibit reports the results of style analysis for three hedge funds and a CTA during March 1997 to November 2001. The coefficients are not constrained to be nonnegative due to the use of leverage and short-sales, but the sum of the coefficients is constrained to one. All figures in the table are in percents. The columns titled "Basic Model" report the results for the set of 12 asset classes. The next four columns show the results of reestimating the coefficients for each fund using the 12 asset classes and returns on four S&P 500 options strategies. At-the-money call (put) options are denoted as $C_{at}(P_{at})$ and out-of-the-money call (put) option as $C_{out}(P_{out})$.

	Basic Model				Basic Model + Options Strategy			
	Hillsdale	Nippon	Axiom	CTA	Hillsdale	Nippon	Axiom	CTA
Bills	161.9	219.0	257.5	9.2	137.7	295.7	393.7	–432.0
Treasury 1–10yr	–161.4	–281.6	–324.8	676.0	–223.1	–404.0	–450.0	698.5
Treasury 10+ yr	44.0	–6.6	–21.9	85.3	32.4	8.8	–35.5	–4.5
Corporate Bonds	22.9	177.6	216.8	–297.0	79.8	215.1	240.1	–166.1
Large Value	27.4	–22.3	–24.8	14.0	40.6	–33.5	–44.4	7.6
Large Growth	21.1	10.0	–5.0	–32.6	48.9	–12.3	–23.0	–7.0
Small Value	–3.4	28.3	50.1	24.4	2.2	20.8	89.0	19.5
Small Growth	7.7	–11.3	–23.9	–9.8	0.3	–4.8	–38.2	–12.5
Developed Countries	–14.8	2.4	14.3	0.2	–8.9	4.3	19.5	8.8
Japan	6.7	25.8	25.5	–30.4	10.2	19.7	38.9	–53.3
Emerging Markets	–36.7	–16.7	37.9	30.8	–38.4	–15.5	21.8	28.7
Foreign Bonds	27.4	–24.7	–94.4	–15.0	16.7	4.4	–107.2	8.5
C_{at}	—	—	—	—	0.1	3.3	–0.1	5.9
P_{at}	—	—	—	—	–2.0	2.9	–12.7	11.2
C_{out}	—	—	—	—	–0.8	–1.7	–0.8	–4.3
P_{out}	—	—	—	—	4.1	–3.3	9.0	–9.1
R^2	28.3	29.6	55.4	37.5	32.2	39.8	77.3	55.4

EXHIBIT 1.11 (Continued)
Panel b. Nondirectional Funds Style Analysis with Basic Model



Panel c. Directional Funds Style Analysis with Basic Model

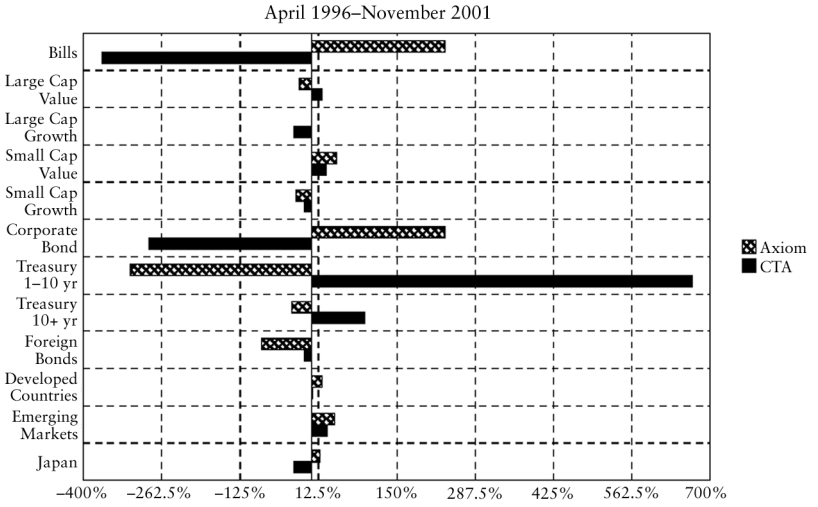
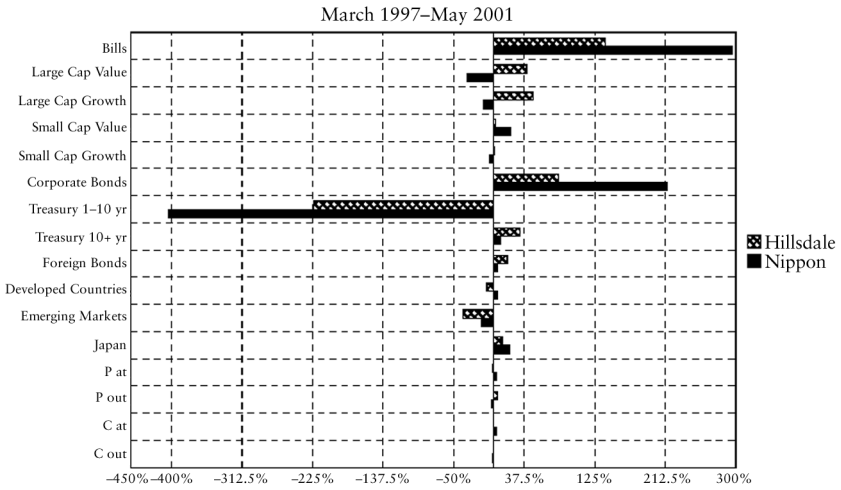
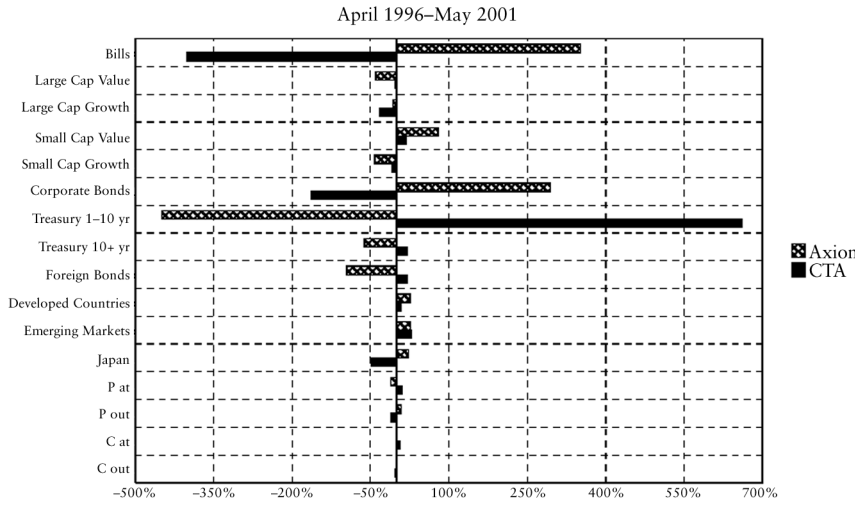


EXHIBIT 1.11 (Continued)
Panel d. Nondirectional Funds Style with Basic Model Plus Options



Panel e. Directional Funds Style with Basic Model Plus Options



The peer-evaluation results are presented in Panel a of Exhibit 1.12. The Market Neutral funds exhibit extremely low correlation with the index benchmarks and in three out of six cases, the coefficients are not even significant. Although, for the two other funds (Emerging Market and Trend Following CTA), the benchmarks are highly significant, they still capture only about 60%–70% of the variation in returns. Notice also the large differences in explanatory power among the various indexes for the same fund.

Peer evaluation is useful as a first step to understanding the multitude of hedge fund styles. However, as Exhibit 1.12 demonstrates, the allocation of funds to "peer" (or style) groups is largely judgmental and can even be *ad hoc*. Database vendors' interpretations of what fund managers say they do may not correspond to what managers actually do. There is a need to verify that similar sounding strategies do indeed deliver similar performance characteristics.

Another problem with peer evaluation is that over time there has been an increasing tendency for hedge fund mangers to employ multiple strategies to meet the need for a more stable stream of returns over different market cycles. Homogeneous peer-groups are easier to verify if the number of strategies involved in the group is small. When different funds employ different combinations of strategies dynamically over time, using an aggregation measure of "peers" to closely capture the essence of both the strategies employed and the dynamical allocation of capital to these strategies over time becomes an extremely difficult task.

Panel b of Exhibit 1.12, repeats the peer evaluation using five different benchmarks instead of one. The Event Driven and Fixed Income indexes are included to better capture the range of trading possibilities facing the four hedge funds. The fact that indexes, which represent different trading strategies than the primary investment strategy of each fund, have significant coefficients confirms that hedge funds employ multiple trading strategies. For example, the table reveals that the Axiom fund returns also covary with the CSFB/Tremont Event Driven index returns and the improvement in R^2 is substantial (from 55% to 68%).

Optionlike Features in Hedge Fund Returns

As the last section demonstrated, performing peer evaluation using an index of hedge funds with the same investment strategy does not provide satisfactory results. Furthermore, in some cases (such as for the market neutral hedge funds), style analysis using standard asset classes has more explanatory power than any single hedge fund index.

EXHIBIT 1.12 Hedge Funds Style Analysis (II)

Panel a reports the results of regressing the returns of each fund on a benchmark index that is composed of hedge funds with similar investment strategy. The returns of Hillsdale and Nippon funds are compared to a Market Neutral Hedge Fund index. Emerging Market and Managed Futures indexes are the benchmarks for Axiom Fund and John W. Henry & Company respectively. The analysis is repeated separately for each hedge fund database. Panel b repeats the procedure in Panel a, using five different benchmarks. *, ** denotes significantly different than zero at the 5% and 1% level, respectively.

	Hillsdale Market Neutral			Nippon Market Neutral			Axiom Emerging Markets			CTA		
	HFR	CSFB	MAR	HFR	CSFB	MAR	HFR	CSFB	MAR	HFR	CSFB	MAR
Panel a. Peer Evaluation Using Single Hedge Fund Index												
Benchmark	1.29**	0.42	0.52	0.60	0.95**	1.14**	0.96**	0.91**	1.12**	—	1.45**	1.55**
R^2	0.17	0.01	0.01	0.05	0.13	0.09	0.57	0.55	0.66	—	0.52	0.71
Panel b. Peer Evaluation Using Multiple Hedge Fund Indexes												
Market Neutral	1.45**	0.50	0.09	0.28	1.00*	1.44	0.39	–0.53	–1.22	2.68**	0.08	0.94
Emerging Market	–0.21	–0.27	–0.32	–0.01	–0.02	0.05	0.91**	0.47**	0.88**	–0.02	–0.26*	–0.16
Managed Futures	—	0.17	0.04	—	–0.16	–0.15	—	–0.30	–0.15	—	1.44**	1.52**
Event Driven	–0.07	0.16	0.71	0.04	–0.17	–0.27	0.00	1.53**	1.26	–1.12*	0.12	–0.27
Fixed Income	–0.05	0.24	—	0.74	0.79*	—	0.24	0.11	—	0.32	0.66	—
R^2	0.27	0.13	0.09	0.11	0.23	0.12	0.57	0.68	0.72	0.13	0.56	0.72

Fung and Hsieh extended the traditional style analysis to incorporate dynamic trading strategies by defining "style" as the common factor in the highly correlated returns of a group of mangers.[18] They argued that the concept of "style" should be thought of in two dimensions: namely location choice and trading strategy. Location choice refers to the asset classes; i.e., the xs in equation (2), used by the managers to generate returns. Trading strategy refers to the direction (long/short) and leverage (i.e., the δ's in equation (2)), applied to the assets to generate returns. The actual returns are, therefore, the products of location choice and trading strategy (recall the example about the manger involved in index arbitrage on the S&P 500). They applied principal components and factor analysis on hedge fund returns to extract style factors. By extracting these common factors, they obtain the most popular investment styles. However, the results are difficult to interpret and, like peer evaluation, do not shed light on how exactly hedge funds operate.

Simply improving the style analysis explanatory power by incorporating a larger number of asset classes (or shorter time periods to account for the changes in trading strategies) faces another problem. Glosten and Jagannathan argued that the returns of portfolios managed using active strategies (as is the case with hedge funds) would exhibit optionlike features.[19] Mitchell and Pulvino, and Fung and Hsieh have recently demonstrated that returns generated by hedge fund strategies exhibit significant nonlinear option like patterns.[20] The nonlinear return pattern results from the use of derivatives (either explicitly or implicitly through the use of dynamic trading), which amounts to the investor having written a call option.

When a manager's returns relate to the benchmark in a nonlinear manner, linear regression models such as style analysis can lead to incorrect inference. Grinblatt and Titman and Jagannathan and Korajczyk showed that if investors were to evaluate the performance of a manager by measures like Jensen's alpha or Treynor-Black's appraisal ratio, then a manager selling call options on a standard benchmark will appear to

[18] W. Fung and D. Hsieh, "Performance Attribution and Style Analysis: From Mutual Funds to Hedge Funds," Working Paper, Fuqua School of Business, Duke University (1998).

[19] L. Glosten and R. Jagannathan, "A Contingent Claim Approach to Performance Evaluation," *Journal of Empirical Finance*, 1 (1994), pp. 133–160.

[20] M. Mitchell and T. Pulvino, "Characteristics of Risk in Risk Arbitrage," *Journal of Finance*, 56 (December 2001), pp. 2135–2175; and W. Fung and D.A.Hsieh, "The Risks in Hedge Fund Strategies: Theory and Evidence From Trend Followers," *Review of Financial Studies*, 14 (2001), pp. 313–341.

be a falsely classified as a superior performer.[21] Dybvig and Ross, and Merton noted that portfolios managed with superior information would typically result returns that exhibit optionlike features even when the managers do not explicitly trade in options.[22]

Glosten and Jagannathan suggested augmenting the return on style benchmark indexes with returns on selected options on the style benchmark indexes in order to capture the investment style of portfolio managers who employ dynamic trading strategies.[23] Agarwal and Naik showed how the systematic risk of hedge funds can be expressed through a combination of naïve option-based strategies on the S&P 500 index and standard asset classes like equities and bonds.[24] Agarwal and Naik also found that the inclusion of options trading strategies increased the explanatory power of the regression dramatically and accounted for the non-linear component of returns.

The options strategy used by Agarwal and Naik involves trading once-a-month in short-maturity highly liquid European put-and-call options on the S&P 500 index. On the first trading day in every month, an at-the-money call or option on the S&P 500 with one month to maturity is purchased. On the first trading day of the following month, the option is sold and another at-the-money call or put option on the S&P 500 index that expires a month later is bought. This trading pattern is repeated every month. The returns from this trading strategy are calculated for two options: an at-the-money and out-of-the-money options.[25] The at-the-money call (put) option on the S&P 500 index are denoted as $C_{at}(P_{at})$ and out-of-the-money call (put) option as C_{out} (P_{out}).

Below we shall repeat the style analysis for the four hedge fund including the options strategy (as performed in Exhibit 1.11.a in the column titled Basic Model+ Options Strategy and in Exhibits 1.11.d–e).[26]

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[21] Mark Grinblatt and S. Titman, "Mutual Fund Performance: An Analysis of Quarterly Portfolio Holdings," *Journal of Business*, 62 (1989), pp. 393–416; and R. Jagannathan and R. A. Korajczyk, "Assessing the Market Timing Performance of Managed Portfolios," *Journal of Business*, 59 (1986), pp. 217–236.

[22] Dybvig and Ross, "Differential Information and Performance Measurement using a Security Market Line; and Merton, "On Market Timing and Investment Performance."

[23] Glosten and Jagannathan, "A Contingent Claim Approach to Performance Evaluation."

[24] V. Agarwal and Narayan Naik, "Characterizing Systematic Risk of Hedge Funds with Buy-and-Hold and Option-Based Strategies," Working Paper, London Business School (2001).

[25] From the different strike price contracts available, Agarwal and Naik select the option where the strike price is closest to the current index value and define this to be at-the-money option. For calls (puts), they select the option with next higher (lower) strike price to be the out-of-the-money option.

[26] We thank Narayan Naik for providing us with the options strategy return data.

The explanatory power of the model increases substantially especially for the directional funds. We also perform a "horse race" comparison between the hedge fund indexes and the style analysis benchmarks to see which has more explanatory power. Since the total number of variables or factors is above 20 and some of them are highly correlated we use stepwise regression to identify the most important factors for each fund. Stepwise regression involves adding and/or deleting variables sequentially depending on the F-value. We specify a 10% significance level for including an additional variable in the stepwise regression procedure. The advantage of this approach in our setting lies in its parsimonious selection of factors.[27]

The stepwise regression estimation is presented in Exhibit 1.13. As before, the regressions demonstrate a higher ability to track the variation in returns of directional funds relative to nondirectional funds. The R^2 for the emerging market and CTA funds range between 70%–80%, a somewhat higher figure than the style analysis. The analysis also reveals that options are used in different ways by the funds. Market neutral funds for example use them to hedge, selling call (put) options if they positive (negative) exposure to the market. The trend following fund returns are similar to being long in an out of the money put and call options.

To summarize this section we believe that, by including new style benchmark asset classes such as options and benchmark portfolios that use prespecified dynamic trading strategies, return-based style analysis can be extended to analyze the style of hedge fund managers as well.

SUMMARY AND CONCLUSION

Portfolio-based as well as return-based style analysis enable investors to keep their actual asset allocation consistent with their investment goals and evaluate the performance of fund managers against a proper benchmark.

[27] For more information on stepwise regressions, see N. Draper, and H. Smith, *Applied Regression Analysis, 3rd ed.* (NewYork: John Wiley and Sons, 1998); and R.R. Hocking, "The Analysis and Selection of Variables in Linear Regression," *Biometrics* 32 (1976), pp. 1–50.

EXHIBIT 1.13 Hedge Funds Style Analysis Using Stepwise Regression

This exhibit reports for each fund, the results of a stepwise estimation using 12 asset classes, five hedge funds indexes and four option strategies. The analysis is repeated separately for each hedge fund database. Stepwise regression involves adding and/or deleting variables sequentially depending on the *F* value. We specify a 10% significance level for deleting a variable in the stepwise regression procedure. *, ** denotes significantly different than zero at the 5% and 1% level, respectively.

	Hillsdale Market Neutral			Nippon Market Neutral			Axiom Emerging Markets			CTA		
	HFR	TRE	MAR	HFR	TRE	MAR	HFR	TRE	MAR	HFR	TRE	MAR
Bills	–23.36*						31.9**		23.36			
Treasury 1–10 years							–7.32**	–4.58**	–6.07**			
Treasury 10+ years												–0.37
Corporate Bonds							3.11**	1.75*	2.62**	2.86**		
Large Cap. Value				–0.21	–0.24*	–0.37**						
Large Cap. Growth		0.38**	0.35**			–0.29*						
Small Cap. Value											0.47**	0.52**
Small Cap. Growth							–0.39**	–0.18**	–0.26**		–0.17	–0.23*
Developed countries											–0.29	
Japan							0.23**		0.15	–0.23*	–0.33**	–0.19**
Emerging Markets		–0.33**	–0.33**				0.36**					
Foreign Bonds							–0.58**			0.60	0.49*	0.72**
Market Neutral	1.86**				0.98*	2.49**	1.89**	1.44**	3.01*			
Emerging Markets	–0.51**							0.32**	0.81**			–0.17
Managed Futures		0.32									1.28**	1.51**
Fixed Income				0.81*	0.85**							
Event Driven							1.47**	1.82**				
At the money call				0.014*	0.012*	0.02**					0.02**	
At the money put	–0.10*								–0.12		0.08	–0.10**
Out of the money put	0.08*					–0.02				0.2**	–0.08	0.09**
R^2	0.46	0.27	0.22	0.21	0.33	0.29	0.82	0.82	0.80	0.19	0.68	0.77

Return-based analysis is easy to implement and interpret. Portfolio-based analysis provides a more in-depth analysis but is more data intensive, and requires knowledge of portfolio holdings (which may not be readily available or current). Both methods can be used in tandem to enhance the asset allocation process. Return-based analysis is often a precursor to the more detailed analysis associated with portfolio-based analysis. That is, return-based analysis is employed to define a particular universe of funds that appear to exhibit the same style. Subsequently, portfolio-based analysis can help one understand the exact strategies and exposures that distinguish each of those funds.

Although return-based analysis is an effective tool for analyzing the sources of a portfolio's performance, as we illustrated using several examples, there are limitations. The technique critically relies on the correct specification of the style benchmark asset classes. Inappropriate or inadequate choice of style benchmarks may lead to wrong inferences about performance and the level of "active" management. In addition, since the data used are historical returns, it is difficult to draw any conclusions about the future risk/return profile of the manager. The method also tends to detect style changes slowly and at times may leave some style changes completely undetected. It may occasionally indicate style changes that never occurred, often due to how the style indexes are correlated with each other. In short, correlation anomalies may occur, resulting in false signals.

We also show how return-based style analysis can be modified to analyze the style of hedge fund managers and other alternative investment managers who use dynamic trading strategies and derivative instruments. For analyzing the style of such managers, portfolio-based style analysis can be difficult to apply for the simple reason that hedge fund managers are typically reluctant to disclose their portfolio holdings. Another difficulty arises from the fact that portfolio holdings can change rather frequently. In many such cases, return-based style analysis offers an attractive alternative.

APPENDIX 1.1 ASSET CLASSES IN RETURN-BASED STYLE ANALYSIS

Asset Class	Index	Description
Bills	Salomon Brothers' 90-day Treasury Bill index	Cash equivalence with less than 3-months to maturity
Government Bonds	Salomon Brothers' Treasury Indexes	Intermediate Government bonds have maturity between 1 and 10 years. Long Term Bonds have maturity over 10 years.
Corporate Bonds	Salomon Corporate composite Index	Corporate bonds with ratings of at least BB.
U.S. Equity	Russell 3000 style sub-indexes	The Russell 3000 Index measures the performance of the largest 3,000 companies domiciled (incorporated) in the U.S., based on total market capitalization. The index represents approximately 98% of the investable U.S. equity market. The Russell 1000 Index measures the performance of the 1,000 largest companies in the Russell 3000 and represents approximately 92% of its total market capitalization. The next 2,000 stocks constitute the Russell 2000 Index. The two indexes are reconstituted annually to reflect changes in the marketplace. The returns of their constituents are market cap-weighted and include dividends. Stocks in each base index (the Russell 1000 and Russell 2000), are ranked by their price-to-book ratio (PBR) and their I/B/E/S forecast long-term growth mean (IBESLT).
Developed countries	MSCI EASEA	Composite country index of all Developed countries except the U.S. The securities in each country are organized by industry group, and stocks are selected, targeting 60% coverage of market capitalization. Selection criteria include: size, long- and short-term volume, cross-ownership and float.
Japan	MSCI Japan	

Asset Class	Index	Description
Emerging Markets	MSCI EM Free	The index covers 27 emerging market country indexes. Designation as an emerging market is determined by a number of factors such as GDP per capita, local government regulations, perceived investment risk; foreign ownership limits and capital controls. The index reflects only investable opportunities for global investors by taking into account local market restrictions on share ownership by foreigners.
Non-U.S. Bonds	Lehman Global Excluding U.S. Bond Index	Bonds outside the U.S. and Canada.

Note: For more details on the methodology and composition of the indexes see the Russell Company and MSCI Web sites: www.russell.com and www.msci.com.

APPENDIX 1.2 GROWTH AND INCOME FUNDS OBJECTIVE AND INVESTMENT STRATEGY (BASED ON FUNDS' PROSPECTUSES AS OF DECEMBER 2001)

Goldman Sachs Growth & Income

Objective: This Fund seeks long-term growth of capital and growth of income through investments in equity securities of well-established companies that are considered to have favorable prospects for capital appreciation and/or dividend-paying ability.
Primary Investment Strategies: Based on a research-intensive approach, the fund employs a value investing strategy that emphasizes stocks they believe to be inexpensive relative to the fund's estimate of their actual worth. The fund maintains a long-term investment horizon with low turnover.

Size: $335 millions Front Load: 5.50% Expense Ratio: 1.19%

Putnam Fund for Growth & Income

Objective: The fund seeks to provide capital growth and current income by investing primarily in common stocks that offer the potential for capital growth while also providing current income.
Primary Investment Strategies: The fund invests mainly in common stocks of U.S. companies, with a focus on value stocks that offer the potential for capital growth, current income, or both. Value stocks are those that we believe are currently undervalued by the market. We look for companies undergoing positive change. If we are correct and other investors recognize the value of the company, the price of the stock may rise. We invest mainly in large companies.

Size: $18.6 billions Front Load: 5.75% Expense Ratio: 0.81%

Vanguard Growth & Income

Objective: The Fund seeks to provide a total return (capital appreciation plus dividend income) greater than the return of the S&P 500 Index.
Primary Investment Strategies: The Fund's adviser uses computer models to select a broadly diversified group of stocks that, as a whole, have investment characteristics similar to those of the S&P 500 Index, but are expected to provide a higher total return than that of the Index. At least 65% (and typically more than 90%) of the Fund's assets will be invested in stocks that are included in the Index. Most of the stocks held by the Fund provide dividend income as well as the potential for capital appreciation.

Size: $6.6 billions Front Load: 0 Expense Ratio: 0.38%

Alliance Capital Growth & Income

Objective: The Fund seeks to provide Income and Capital appreciation. *Primary Investment Strategies:* The fund primarily invests in dividend-paying common stocks of good quality. It may also invest in fixed-income and convertible securities. The fund tries to maintain a defensive dividend yield and price-to-earnings ratio, a fully invested posture, and a high degree of sector and industry diversification. The fund invests in quality companies that trade at undeserved discounts to their peers. The fund does not make sector or market timing bets, but instead emphasize intensive, bottom-up research and careful stock selection.

Size: $3.2 billions Front Load: 4.25% Expense Ratio: 0.91%

APPENDIX 1.3 HEDGE FUNDS DESCRIPTIONS

Hillsdale U.S. Market Neutral Fund (http://www.hillsdaleinv.com)

The U.S. Market Neutral Equity Fund is beta, style and industry neutral. It invests in up to 150 companies and may use leverage up to 1 times equity. The investment objective of the strategy is to provide a consistent 10–15 percent annualized return with volatility less than or equal to bonds and 0% correlation with major U.S. equity indexes. The portfolio is constructed by taking long and short positions in common share of U.S. corporations primarily with a market capitalization in excess of one billion dollars.

Hillsdale Investment Management, Inc. also manages the U.S. Aggressive Hedged Equity Fund and two additional funds with similar strategies that focus on the Canadian market.

The investment strategies are based on a proprietary investment platform that uses a dynamic, fundamental based, multi-factor approach to stock selection and portfolio construction. The firm, founded in 1996, is majority owned by its employees and is registered with the Ontario Securities Commission as an Investment Counsel, Portfolio Manager and a Limited Market Dealer.

Nippon Fund (http://www.aventineinvestments.com)

The Nippon Performance Fund is a market neutral hedge fund designed to deliver consistent and positive returns with a low level of risk and virtually no correlation to the Nikkei 225, or any global equity or bond market. The Fund capitalizes on the undervaluations in Japanese convertible bonds and equity warrants by employing a convertible arbitrage strategy to extract these undervaluations. These undervaluations allow the Fund to deliver a superior rate of return with a low level of volatility while removing the unwanted and unnecessary risks associated with Japanese securities. The Fund's long positions include convertible bonds and warrants, which are hedged by selling short the underlying stocks to remove the equity risk, and interest rate futures to remove interest rate risk. The Fund is denominated in U.S dollars, and utilizes currency futures, forwards, options and swaps to remove any currency risk.

Axiom Fund (http://www.axiom-invest.com)

Axiom Balanced Growth Fund invests primarily in listed shares of companies deriving a significant portion of their revenues from emerging markets (including those in Southeast Asia), but will also invest in fixed

income obligations (such as U.S. dollar Brady-type bonds) of issuers in emerging markets (including those outside Southeast Asia). A wide range of hedging techniques and instruments will, however, be employed where considered appropriate with a view to minimizing the level of volatility, which is normally associated with Emerging Market funds. The fund was launched on April 15th 1996.

John W. Henry & Company—Financial and Metals Portfolio (http://www.jwh.com)

John W. Henry & Company Inc. (JWH) is an alternative asset manger and one of the largest managed futures advisor in the world. The Financial and Metals Portfolio is JWH's second longest running program. The program seeks to identify and capitalize on intermediate-term price movements in four worldwide market sectors: currencies, interest rates, metals, and non-U.S. stock indexes. The program seeks to detect repetitive price behavior in these sectors using computer systems and capitalize on them.

APPENDIX 1.4 HEDGE FUNDS INDEXES

Hedge Fund Research

Hedge Fund Research (www.hfr.com) provides 29 equally weighted-style categories and a composite index. Funds of funds are not included in the composite index. The indexes are based on 1,100 funds drawn from a database of 1,700 funds. Funds in the database represent $260 billion in assets. The index was launched in 1994 with data back to 1990. Funds are assigned to categories based on the descriptions in the offering memorandums. Survivorship bias is minimized by incorporating funds that have ceased to exist.

Credit Suisse First Boston/Tremont

Credit Suisse First Boston/Tremont (www.hedgeindex.com) covers nine strategies and is based on 340 funds, representing $100 billion in invested capital, selected from a database of 2,600 funds. It is the only asset (capitalization) weighted hedge funds index. The CSFB/Tremont Index discloses its construction methods and identifies all the funds within it. CSFB/Tremont accepts only funds (not separate accounts) with a minimum of $10 million under management and an audited financial statement. If a fund liquidates, its performance remains in the Index for the period during which the fund was active in order to minimize survivorship bias. The index was launched in 1999, with data going back to 1994. It incorporates the TASS+ database.

MAR Futures

MAR Futures (www.marhedge.com) reports especially on the performance of Managed Futures strategies in each of 15 categories, 10 of which are combined into four submedians. The variety of Zurich (formerly MAR) index databases contains 1,300 funds. Managers usually select their own categories. The firm's Web site identifies the number of funds and assets in each category. MAR, the former publisher of the index, sold its database business to Zurich Financial Services in spring 2001.