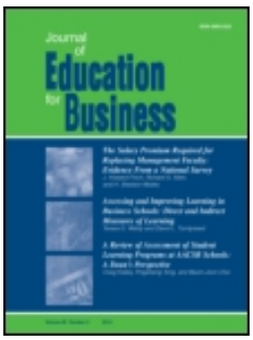

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Returns-Based Style Analysis: An Excel-Based Classroom Exercise

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W. Sharpe's (1988, 1992) returns-based style analysis provides an excellent opportunity to use a sophisticated portfolio-analysis tool in the classroom to help illustrate important topics in investment and operations research courses. Students can perform classic returns-based style analysis by creating a spreadsheet model and using the Solver add-in in Microsoft Excel. The technique can also be used to supplement classroom units on performance measurement and style drift in investment courses or to illustrate a finance application in an introductory operations research course. An example analysis using a popular mutual fund is provided as well as the accompanying Excel model.

Keywords: Analysis, Fund, Mutual fund, Performance, Style analysis

There are many methods available to financial analysts to conduct a style analysis of a portfolio or mutual fund. Two potential methods are holdings-based style analysis popularized by Morningstar and Sharpe's returns-based style analysis (RBSA). RBSA was introduced by Sharpe (1988, 1992) and is a powerful analytical tool that is used to capture the style of a portfolio or mutual fund using only returns data. Specifically, RBSA uses nonlinear optimization to construct a portfolio of indices to minimize the tracking error with the portfolio being analyzed. RBSA is widely used and accepted in the investment community and forms the basis for the popular investment analysis software Zephyr StyleADVISOR.

The objective of this teaching note and the accompanying classroom exercise is to provide students with exposure to a powerful analytical technique and also provide some work in building an Excel model and using the Solver add-in to conduct nonlinear optimization. I use a well-known mutual fund, the Dodge and Cox Balanced Fund (DODBX), to illustrate the technique.

STYLE ANALYSIS

Analysts and researchers may desire to determine the style of a particular fund manager. The issue of style is particularly relevant in institutional money management when managers are normally hired to manage a particular asset class (e.g., U.S. Small value) in a portfolio. Style determination is also important in manager performance measurement when the aim is to separate true alpha from beta. The selection of a benchmark index is often based on style determination.

Holdings-Based Style Analysis

In holdings-based style analysis, the actual holdings (e.g., individual stocks, mutual funds, exchange-traded funds [ETFs]) in the portfolio are disaggregated and then classified into general categories based on asset classes, geography, or industry classification. Morningstar also classifies the portfolio into one of nine style boxes based on the portfolio's general size (large cap, mid cap, small cap) and value–growth orientation. Kaplan (2003) provided a detailed discussion of Morningstar's style classification methodology.[1]

A major drawback of holdings-based analysis is that an individual or mutual fund's holdings may vary, perhaps significantly, through time. A snapshot of a portfolio's holdings one day, especially in the case of a portfolio comprised of actively managed funds or individual stocks, may not be at all representative of the history of the fund or of its holdings in the future. Portfolio holdings are, in general, self-reported and therefore subject to manipulation. For example, a portfolio manager may engage in window dressing, which is the practice of altering the holdings just prior to reporting to make the portfolio look better to investors.[2] In contrast with self-reported holdings, realized returns are objective and external, not subjective and internal.

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The reported holdings of a portfolio may also lead to incorrect conclusions about a portfolio's true asset class exposure and the extent of its diversification. For example, consider a position in a large foreign-based multinational company (e.g., Honda Motor) that does a much of its business in the United States and also trades as an American Depository Receipt (ADR)on the New York Stock Exchange. Similarly, what about a large U.S. multinational (e.g., Exxon) that does a much of its business internationally? What exactly is the nature of these holdings in a portfolio? Holdings-based analysis is not and cannot be precise on this issue; it most likely would classify Honda as an international and Exxon as a U.S. holding. The stock returns, however, may be telling a very different story. RBSA is purposely agnostic to the debate about how a particular firm should be classified; it is only interested in how the stock behaves in the context of characterizing the overall portfolio's returns.

Returns-Based Style Analysis

Given the potential shortcomings of holdings-based analysis, the attention turns to returns-based style analysis. RBSA compares the returns of a stock portfolio or mutual fund against the returns of a tracking portfolio of indices that represent the various equity and fixed income asset classes. The analysis defines a mix of the indices that would have best explained the behavior of the returns of the portfolio being analyzed. Technically speaking, RBSA determines a long-only portfolio of mutually exclusive and exhaustive indices that minimizes the variance of the tracking error relative to the portfolio being analyzed.

Beginning with the historical returns (typically the last 60 months) of a portfolio or mutual fund, I denote the client's portfolio total return in month t as R_t. Next, I choose a set of n mutually exclusive and exhaustive indices to create a portfolio that as closely as possible mimics the client's portfolio returns. The monthly return on index i in period t is denoted as $I_{i,t}$.

The difference between the client's portfolio returns and the return on a mix of the n indices in month t is defined as as ε_t. Further, the tracking error (TE) is defined as variance of this difference over the t time periods. Specifically,

$$\varepsilon_t = R_t - \left[w_1 I_{1,t} + w_2 I_{2,t} + \ldots\ldots + w_n I_{n,t}\right]$$
$$TE = Var\ [\varepsilon_t]$$

where w_i, equals the weight on index i. The term in brackets is return on a portfolio of the indices. The weights are constrained to be nonnegative and to sum to 1.[3]

$$w_i \geq 0$$
$$\sum_{i=1}^{n} w_i = 1$$

It is important to choose the set of index weights so that the tracking error between the portfolio and the mix of indices is as small as possible. Specifically, the problem is:

Choose w_i *for* $i = 1, n$
to Minimize TE
subject to

$$w_i \geq 0$$
$$\sum_{i=1}^{n} w_i = 1$$

The constrained quadratic minimization described previously is the essence of RBSA. The minimization can also be solved by numerical methods in a number of software programs including Solver in Excel.[4]

To implement RBSA, the selected indices should ideally be mutually exclusive (i.e., they do not overlap) and nearly exhaustive[5] (i.e., they cover the investable universe). The popular indices I have used successfully are the following:[6]

Fixed Income Indices:
Citigroup 3-month T-Bill
Lehman U.S. Aggregate Bond
Lehman U.S. Corporate High Yield
Lehman Global (ex U.S.) Treasury

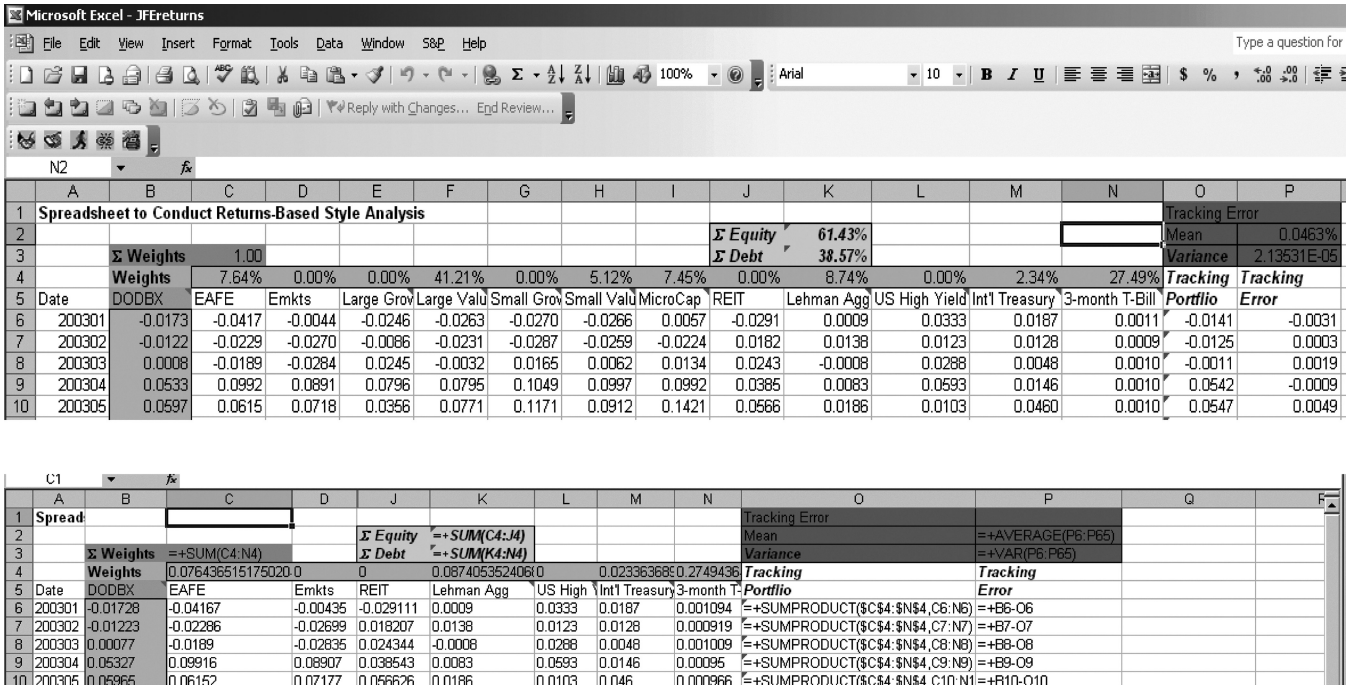
U.S. Equity Indices:
Dow Wilshire Large Growth
Dow Wilshire Large Value
Dow Wilshire Small Growth
Dow Wilshire Small Value
Dow Wilshire Micro Cap

International Equity Indices:
MSCI EAFE
MSCI Emerging Markets

Normally, it is preferable to use at least the last 36 months of returns data available to conduct the RBSA—obviously the need for a longer time horizon increases with the number of indices used in the analysis. Monthly returns data for mutual funds and indices are available in many financial databases and can also be obtained from public websites such as Yahoo Finance. Dow Wilshire Style Indices are available to download at www.wilshire.com.

AN ILLUSTRATION OF RETURNS-BASED STYLE ANALYSIS

The DODBX is a very large[7] actively managed mutual fund that was just recently reopened (in February 2008) to new investors.[8] An excerpt from the holding-based analysis of DODBX from Morningstar is shown in the Appendix.[9] Morningstar classifies the fund's U.S. equity holdings as large value and its fixed income holdings as high quality and intermediate maturity. The DODBX is a large balanced fund with low turnover; I expect these characteristics to minimize the differences between returns-based and holding-based analyses in order to illustrate the legitimacy and power of RBSA to infer style as well as equity and fixed income from returns data only.



Microsoft Excel - JFEreturns

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Spreadsheet to Conduct Returns-Based Style Analysis**														Tracking Error	
2										*Σ Equity*	*61.43%*				Mean	0.0463%
3		*Σ Weights*	1.00							*Σ Debt*	*38.57%*				*Variance*	2.13531E-05
4		*Weights*	7.64%	0.00%	0.00%	41.21%	0.00%	5.12%	7.45%	0.00%	8.74%	0.00%	2.34%	27.49%	*Tracking*	*Tracking*
5	Date	DODBX	EAFE	Emkts	Large Grow	Large Valu	Small Grow	Small Valu	MicroCap	REIT	Lehman Agg	US High Yield	Int'l Treasury	3-month T-Bill	*Portfolio*	*Error*
6	200301	-0.0173	-0.0417	-0.0044	-0.0246	-0.0263	-0.0270	-0.0266	0.0057	-0.0291	0.0009	0.0333	0.0187	0.0011	-0.0141	-0.0031
7	200302	-0.0122	-0.0229	-0.0270	-0.0086	-0.0231	-0.0287	-0.0259	-0.0224	0.0182	0.0138	0.0123	0.0128	0.0009	-0.0125	0.0003
8	200303	0.0008	-0.0189	-0.0284	0.0245	-0.0032	0.0165	0.0062	0.0134	0.0243	-0.0008	0.0288	0.0048	0.0010	-0.0011	0.0019
9	200304	0.0533	0.0992	0.0891	0.0796	0.0795	0.1049	0.0997	0.0992	0.0385	0.0083	0.0593	0.0146	0.0010	0.0542	-0.0009
10	200305	0.0597	0.0615	0.0718	0.0356	0.0771	0.1171	0.0912	0.1421	0.0566	0.0186	0.0103	0.0460	0.0010	0.0547	0.0049

C1

	A	B	C	D	J	K	L	M	N	O	P	Q
1	Spread									Tracking Error		
2					*Σ Equity*	*=+SUM(C4:J4)*				Mean	=+AVERAGE(P6:P65)	
3		*Σ Weights*	=+SUM(C4:N4)		*Σ Debt*	*=+SUM(K4:N4)*				*Variance*	=+VAR(P6:P65)	
4		*Weights*	0.076436515175020	0	0	0.087405352406	0	0.023363685	0.2749436	*Tracking*	*Tracking*	
5	Date	DODBX	EAFE	Emkts	REIT	Lehman Agg	US High	Int'l Treasury	3-month T-	*Portfolio*	*Error*	
6	200301	-0.01728	-0.04167	-0.00435	-0.029111	0.0009	0.0333	0.0187	0.001094	=+SUMPRODUCT($C$4:$N$4,C6:N6)	=+B6-O6	
7	200302	-0.01223	-0.02286	-0.02699	0.018207	0.0138	0.0123	0.0128	0.000919	=+SUMPRODUCT($C$4:$N$4,C7:N7)	=+B7-O7	
8	200303	0.00077	-0.0189	-0.02835	0.024344	-0.0008	0.0288	0.0048	0.001009	=+SUMPRODUCT($C$4:$N$4,C8:N8)	=+B8-O8	
9	200304	0.05327	0.09916	0.08907	0.038543	0.0083	0.0593	0.0146	0.00095	=+SUMPRODUCT($C$4:$N$4,C9:N9)	=+B9-O9	
10	200305	0.05965	0.06152	0.07177	0.056626	0.0186	0.0103	0.046	0.000966	=+SUMPRODUCT($C$4:$N$4,C10:N1	=+B10-O10	

FIGURE 1 Excel spreadsheet model set-up.

The Excel spreadsheet model set-up and Solver dialog box used to conduct the RBSA are presented in Figures 1 and 2.[10] Normally, I would provide the monthly returns data to my students in an Excel spreadsheet and have them structure the model, define the optimization in Solver, and interpret the results. The results of conducting the RBSA for the 60-month period January 2002 through December 2007 are presented in Figure 3.[11]

The portfolio of indices generated by the RBSA is referred to as the *custom benchmark*. How well does the custom benchmark track the DODBX? The answer is actually quite well. Figure 4 provides a comparison of growth of a dollar for the DODBX and the custom benchmark. Further, the R^2 of a simple linear regression of the fund's monthly returns on the custom benchmark's monthly returns is 0.93.

The key to interpreting RBSA is to understand that the provided mix of the indices creates a portfolio that most closely tracks the analyzed portfolio; the technique, despite its pedigree and sophistication, does not reveal the true allocations! First, it is important to recognize that the precision of neither holdings-based analysis nor RBSA is perfect. RBSA looks at the average asset exposures over the course of the entire period of the analysis, whereas holdings-based provides only a snapshot in time. In fact, we should not be surprised to see that returns based in some cases provides a very different picture than holdings based. Differences between the returns and holdings-based style analyses can be attributed to a variety of factors. Consider that the RBSA

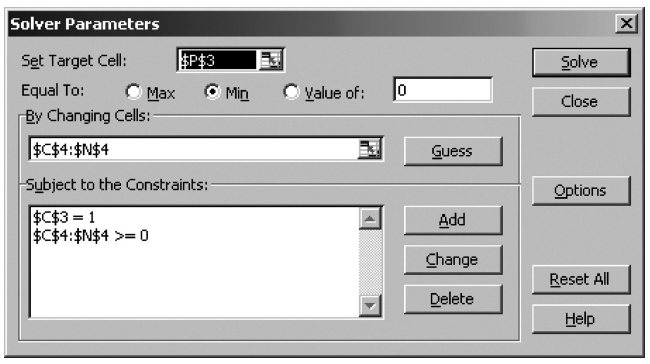


FIGURE 2 Solver dialog box.

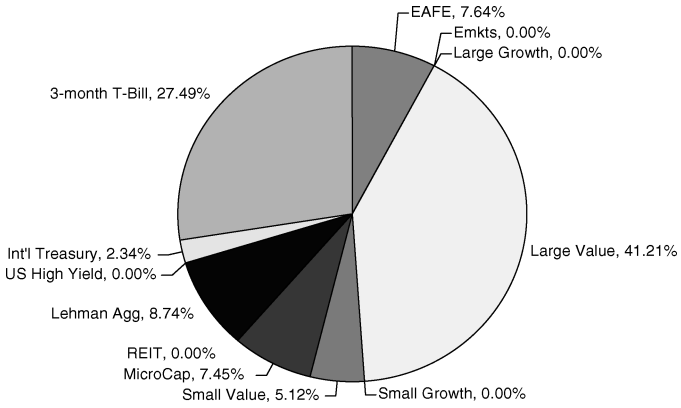


FIGURE 3 Dodge and Cox Balanced Fund returns-based style analysis, January 2002 to December 2007.

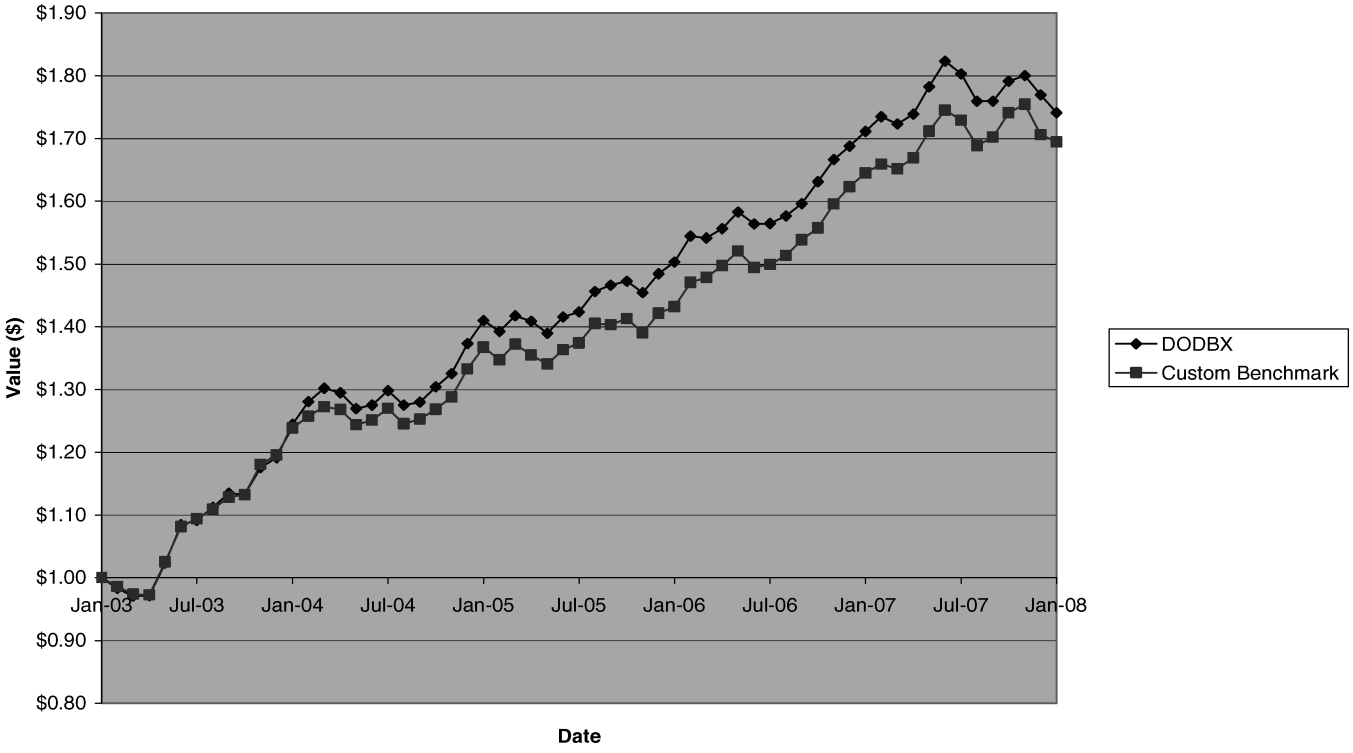


FIGURE 4 Growth of $1, January 2002 to December 2007.

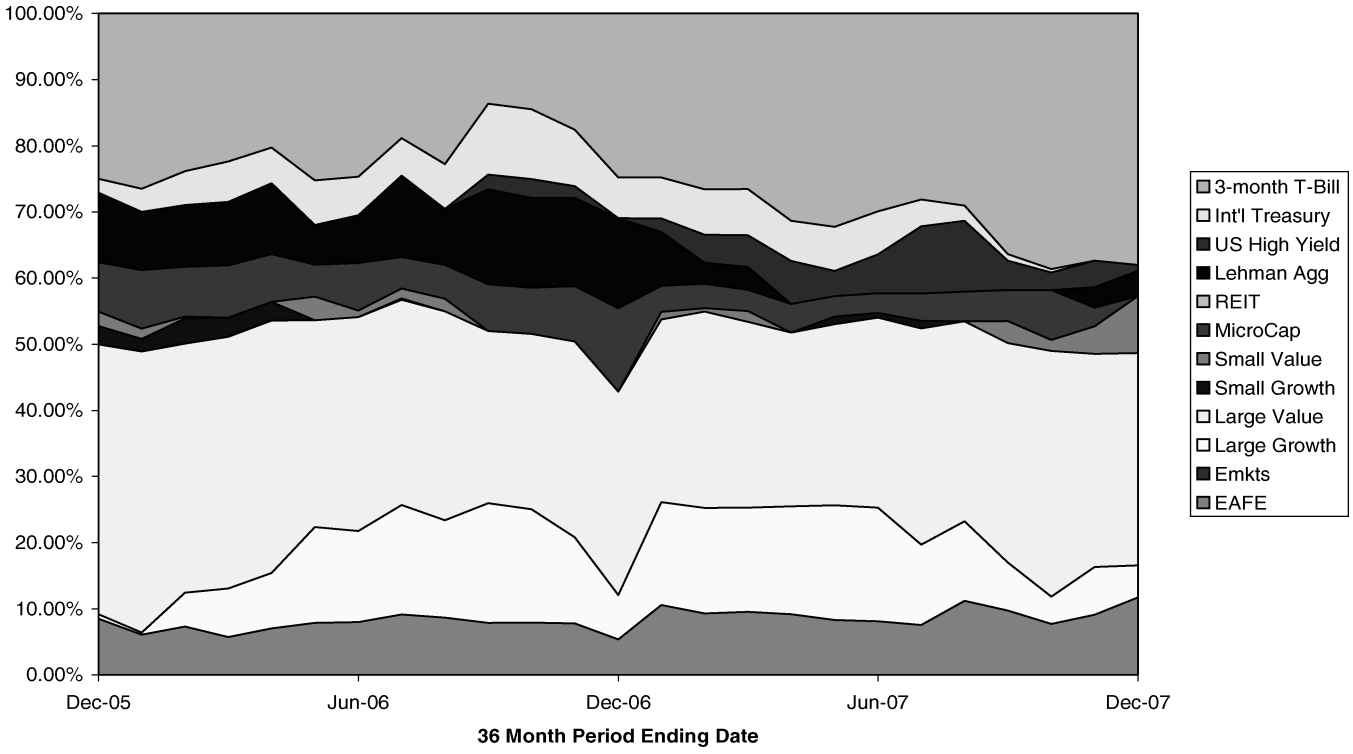


FIGURE 5 Returns-based style analysis, a 36-month rolling analysis of the Dodge and Cox Balanced Fund.

has no prior knowledge of the allocation by name; it is inferring an allocation for the historical returns of the portfolio. In some cases, the RBSA may attribute the influence of some of the holdings in one category into another category, if the returns of those holdings behave more like the second category. Considering a portfolio comprised of entirely U.S. stocks, it might be surprising to see RBSA indicates an exposure to emerging markets. But on closer inspection, it is noticeable that the U.S.holdings consist of several large multinational corporations with a significant presence in emerging markets economies. For example, a RBSA of Exxon allocates 51% to MSCI Emerging Markets Index in its custom benchmark.[12] RBSA can provide insights into the true nature of a portfolio, insight that holdings-based analysis cannot. I now provide a brief interpretation of the RBSA of the DODBX by major asset class.

Fixed Income

The DODBX's fact sheetat www.dodgeandcox.com states:

> The Fund primarily invests in a diversified portfolio of primarily investment-grade fixed income securities, including: U.S. government obligations, mortgage and asset-backed securities, corporate bonds, collateralized mortgage obligations and others. To a lesser extent, the fund may also invest in below investment-grade fixed income securities.

The RBSA presented in Figure 4 reveals, as expected, a high-quality and short-term bond strategy as the benchmark portfolio allocates 27% to T-Bills, 9% to the Lehman Aggregate Index, 2% to Global Treasury bonds and no weight to U.S. high-yield bonds.

The RBSA reveals the average equity–fixed income split of the DODBX as 62–38. A holdings-based analysis or a review of the fund's prospectus would be obscure or even inaccurate on this point. For example, the fund literature states only that "Under normal circumstances the Fund will hold no more than 75% of its total assets in stocks."[13]Although as of June 30, 2007, the fund reported that it held 69.2% in equities.

U.S. Equity

The large weight (41.3%) on the DJ Wilshire Large Value index in the custom benchmark reveals the equity side of the DODBX as primarily a U.S.Large Cap Value strategy. A look at the top 10 holdings of the fund as of March 31, 2008, lists large U.S.companies such as Comcast, Wal-Mart, Hewlett-Packard, confirming this finding. The RBSA also shows exposure to U.S.Small Value (5.0%) and U.S.Microcap (7.5%). Note the weight on both U.S. Growth indices (Large and Small Growth) are both zero in the style benchmark suggesting no or little exposure to this asset class. In sum, the RBSA suggests the fund's U.S.equity strategy has been primarily large value and secondarily small value and microcap.

International Equity

In contrast to international equity, RBSA indicates the U.S.equity position is much greater (i.e., 53.8% U.S.vs. 7.6% International); the mutual fund exhibits zero exposure to emerging markets and only 2.5% to international developed markets. Although the fund does hold some large international developed market stocks (e.g., Sony, Sanofi-Aventis, Novartis) that trade as ADRs, RBSA evidences the fund as overwhelmingly an investment in U.S.equity.

Performance Measurement

Sharpe (1988; 1992) suggested that the mean of the tracking error can be used as a performance measure. Ter Horst, Nijman, and de Roon (2004) suggested the use of RBSA to predict future performance. Alternatively, it is possible to use tracking portfolio as a customized benchmark and compute alpha relative to the benchmark. Ben Dor, Budinger, Dynkin, and Leech (2008) suggested the use of RBSA in constructing performance benchmarks. In this case, the mean of the tracking error is 4.62 bps (SD = 46.21 bps) per month (55.6 bps annualized). In comparison, the alpha of the fund relative to the customized benchmark is 60 bps ($t = 0.73$, $df = 59$). As previously mentioned, the R^2 of the fund regressed on the customized benchmark is 0.93.

Style Drift

The classroom assignment could be extended to determine the extent of style drift in the portfolio or mutual fund.[14] This could be accomplished by using subperiods and comparing the results or by conducting rolling period analysis (e.g., using rolling 36-month windows) to examine the changes in weights over time. An example of a rolling-period analysis is illustrated in Figure 5. The analysis reveals a fairly consistent style over time.

CONCLUSION

My example is a simple one by design. The DODBX strategy is well known and its equity style has been consistent (i.e., U.S. Large Value) through time. The fund is very large, held 84 different stocks on March 31, 2008, concentrated mostly in the U.S., and its turnover is quite low (27%) for an actively managed fund. Therefore, I would expect a holdings-based analysis to confirm the RBSA and it does, perhaps convincing the students of its validity and power. In contrast, consider a complicated portfolio of stocks, bonds, ETFs, and actively managed funds. Conducting a holdings-based analysis is fraught with potential problems for more complicated and dynamic portfolios. It is precisely this situation in which RBSA is most useful as a complement to holdings-based analysis.[15]

I believe an introduction to RBSA has a place in upper-level undergraduate course and introductory MBA courses in investments, and certainly in courses in portfolio analysis. I have used the topic as part of a larger case study on performance evaluation in a senior-level undergraduate finance capstone course. It could be, however, structured as a stand alone assignment on style analysis and performance measurement. For example, "Conduct a style analysis of Mutual Fund X using Sharpe's returns-based style techniques. Compare and contrast the results with Morningstar's holding-based style analysis" or "Construct a custom benchmark for Mutual Fund X using Sharpe's returns-based style analysis. How has the fund performed? Compare your result to a single (or multi-) factor model alpha. To what do you attribute the differences?"

I believe the topic is also well suited to an introductory course in operations research to illustrate a real-world application of mathematics science tools, Excel modeling, and the use of Solver to conduct nonlinear optimization. An assignment built on RBSA provides the students with an opportunity to develop an Excel model to do sophisticated quantitative analysis and to explore a widely accepted tool in industry to complement holdings-based style analysis.

NOTES

1. Available for download at: http://corporate.morningstar.com/UK/html/pdf.htm?../documents/MethodologyDocuments/ResearchPapers/Holdings-basedAndReturns-basedStyleModels_PK.pdf
2. There is an extensive literature on window dressing. Influential research includes Grinblatt and Titman (1993), Grinblatt, Titman, and Wermers (1995), and Wermers (2002).
3. The nonnegativity constraint on the weights can be relaxed when appropriate. For example, when analyzing a portfolio that uses derivatives, short positions, or leverage.
4. I find it instructive to run an ordinary least squares (OLS) regression with the mutual fund's monthly returns as the dependant variable and the monthly returns of the indices as the independent variables. The OLS results can be contrasted with the RBSA results specifically highlighting the natural interpretation of the RBSA slopes as portfolio weights.
5. You may be wondering about U.S. midcap stocks. They are split between the large and small-cap DJ Wilshire indices. S&P midcap indices use stocks 501 through 1000. The Dow Wilshire large-cap indices contain the 750 largest stocks in the U.S., whereas small-cap indices capture stocks 751 through 2,500 and the microcap has 2,500 through approximately 4,000.
6. Thanks to Jim Davis of Dimensional Fund Advisors for suggesting this set of indices.
7. As of December 31, 2007, DODBX had over $28 billion in assets.
8. See www.dodgeandcox.com.
9. See www.morningstar.com.
10. Please contact the author for the Excel workbook.
11. See Lobosco and Di Bartolomeo (1997) for calculating approximate confidence intervals.
12. A caution is necessary; the style benchmark can only explain about 41% of the variation in Exxon's monthly returns for the past five years ending in December 2007. This highlights the use of RBSA as a tool for analyzing portfolios.
13. See www.dodgeandcox.com/balancedfund.asp
14. Chan, Chen, and Lakonishok (2002) analyze style drift in mutual funds.
15. For example, Brown and Goetzmann (2001) used RBSA in analyzing the performance of hedge funds.

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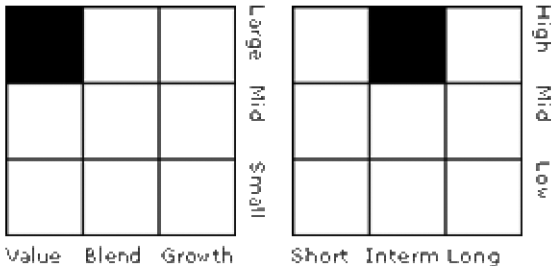
APPENDIX

Dodge and Cox Balanced (DODBX)

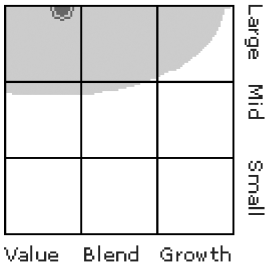
Portfolio Analysis more ▸▸ 03-31-08

Morningstar Style Box



Bond Data through 09-30-07

Ownership Zone



◉ Fund centroid represents weighted average of domestic stock holdings

○ Zone represents 75% of fund's domestic stock holdings

Asset Allocation % more ▸▸

	% Long	% Short	% Net Assets
Cash	3.0	0.0	3.0
Stocks	69.2	0.0	69.2
Bonds	27.6	0.0	27.6
Other	0.2	0.0	0.2

Sector Breakdown (% of stocks)

Information	**26.33**
Software	3.20
Hardware	10.70
Media	11.13
Telecommunications	1.31
Service	**48.50**
Healthcare	20.02
Consumer Services	9.14
Business Services	3.29
Financial Services	16.06
Manufacturing	**25.17**
Consumer Goods	5.49
Industrial Materials	11.39
Energy	8.29
Utilities	0.00

Annual Turnover %	27
% Assets in Top 10	22.31

Top 5 Holdings Get Price Quotes	**Sector**	**YTD Return %**	**% Net Assets**
⊕ Comcast Corporation A*	Media	15.98	3.26%
⊕ Hewlett-Packard Company*	Hardware	−5.90	3.13%
⊕ Wachovia Corporation*	Financial Services	−53.31	2.50%
⊕ News Corporation, Ltd. A*	Media	−15.23	2.23%
⊖ Wal-Mart Stores, Inc.*	Consumer Services	24.58	2.03%

⊕ Increase ⊖ Decrease ☆ New since last portfolio * Analyst Report available

YTD Return through 06-17-08.