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CAMBRIDGE ASSOCIATES LLC

PORTFOLIO RISK MEASUREMENT: SHORTFALL AND RELATIVE RISK ANALYSIS

2001

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SUMMARY

Introduction

This is one in a series of investment planning papers focused on various forms of risk—dating back to the 1994 paper, *Risk, Return, and Spending* and including last year's *Behavioral Finance*, which focused on qualitative rather than quantitative risk factors.

Our fundamental thesis is that investors tend to spend considerable time and energy measuring and monitoring returns, and virtually no time and energy measuring and monitoring risk. Since risk and return are inextricably linked, this seems like a potentially dangerous shortcoming. We have long argued that the two most important risks are depletion of purchasing power and a significant shortfall in expected returns, since each of these can impair an institution's ability to spend as much money as planned. In fact, if an institution can correctly define its liabilities, risk definition becomes easier, because the most basic risk is simply not having enough money to meet those liabilities.

In this paper, the focus is on how to think about and measure risk at two key stages in the investment management process: constructing a coherent long-term asset allocation policy, and implementing and evaluating that policy once it has been developed.

The first, which we call "shortfall risk," should be included in any thorough reconsideration of asset allocation policy.

The second, "measuring risk relative to benchmark," should be incorporated into investors' annual performance review. It is worth emphasizing, however, this review of portfolio risk relative to benchmark is *retrospective*—as is the review of portfolio performance. In other words, it is a tool for measuring whether certain specific kinds of risk *have been* rewarded, and does not necessarily indicate whether one should or should not now be incurring those same risks. As with so many such measuring tools, the value accrues over time; for example, if one finds that over an extended period active management in a given asset class virtually never adds value net of risk, this would lead one to consider passive investment strategies for that asset class.

Shortfall Risk

Investment portfolios are not ends in themselves, but the means by which some financial objective may be realized—for example, meeting a company's pension obligations, or funding a foundation's programs, or providing for an individual's retirement. It follows that the broadest definition of investment

"risk" is the possibility of failing to generate sufficient returns to meet this financial objective in a defined time period—"the probability of not having sufficient cash with which to buy something important," as Robert H. Jeffrey has put it.[1] This risk of shortfall is both investor specific and period specific.

The more demanding the objectives—for example an endowment spending rate of 6% as opposed to 4%—the greater the possibility that returns may fall short in some periods. This is the primary trade-off investors must make between risk and return. Those whose finances are most highly dependent on investment returns, whose budgets have the least flexibility to tolerate any reduction in the distributions from their portfolios, and who receive no periodic additions to capital, should tend to minimize shortfall risk even if this means sacrificing the possibility of higher returns. Those with other sources of income, periodic additions to capital, and a greater adaptability in their budgets, can afford to incur higher shortfall risk in the attempt to earn higher returns.

In constructing policy portfolios—portfolios designed to realize their financial objectives over the long term—investors should therefore define their tolerance for shortfall. For example, a foundation with annual expenditures of 5.5% may decide that it can tolerate no more than a 15% probability of earning a real annual return of 4% or less in any given five-year period; or a pension fund may determine that it can tolerate no more than a 20% probability that its funded status will drop below 90% in any one year (see Exhibit 1).

However, in defining shortfall risk as the probability of failing to realize a minimum level of return over a defined period, we fail to differentiate between returns that fall short of our objective by a small margin and those that fall catastrophically short. Consequently, the determination of shortfall risk should be enhanced by measuring the potential severity of shortfall, as illustrated in Exhibit 2.

The magnitude of loss is only the numerator of the shortfall equation, the denominator of which is the duration of shortfall, or approximate time to recover. For example, a fund that suffers a decline of 20%, but subsequently appreciates 12% per year and fully recovers in two years may be in far better shape than a portfolio that declines 15%, but only averages 3.5% gains per year thereafter, thus taking five years to fully recover. Analysis of the probability of suffering a decline in value of *x%* should therefore be complemented by analysis of the probability of failing to recover from a decline of *x%* within *y* years (see Exhibit 3).

[1] Robert H. Jeffrey, "A New Paradigm for Portfolio Risk," *Journal of Portfolio Management*, 1984.

In a comprehensive shortfall risk assessment these two analyses are combined into the joint probability of suffering a decline of *x%* from which one fails to recover within *y* years (see Exhibit 4). This enables investors to judge whether they are assuming too much or too little risk in their policy asset allocations. For example, is a 10% probability of suffering a decline in real market value of at least 15% from which one should not expect to recover within ten years an acceptable or excessive level of risk to incur? As indicated above, the "appropriate" level of shortfall risk is highly investor specific, dependent not only on objective criteria dictated by financial circumstances, but also on subjective criteria derived from the experience, expertise, and "comfort level" of those responsible for stewardship of the assets. Consequently, there is no right answer to the question, "how much risk can we afford to incur?" (except, perhaps, "it depends!"). However, these measures of shortfall probability do at least provide clear yardsticks that enable investors to compare the fundamental investment risks of competing portfolios in a more sophisticated context than is provided by such tools as efficient frontier analysis.

Like most asset allocation policy analyses, shortfall risk analysis focuses primarily on long time horizons. Thus, the inputs to our measures of shortfall probability, time to recover, and so on, are all long-term, "equilibrium" assumptions of return, variability of return, and correlations or returns among the various asset classes. However, investors also have strong vested interests in understanding what could happen in shorter time periods and often ask us to model "what if . . ." scenarios. Obviously, the number of "what ifs" is infinite and highly portfolio specific, but to illustrate this type of analysis we have appended an example that attempts to answer the (timely) question, "how badly would the portfolio suffer if the U.S. economy were to sink into severe recession?" Under this rather gloomy scenario, we assume that five-year returns to equities fall at the bottom end (90th percentile) of their expected distribution and all asset classes other than bonds performing relatively poorly. We answer the question by measuring the five-year cumulative decline in value, before and after spending (see Exhibit 5). This number can then be carried back to the time-to-recover analysis outlined above, so that the investor can gauge the probability of failing to recover from such a dismal outcome within *y* years. Although "what if…" scenarios generally focus on shorter time periods than are appropriate in policy deliberations, their incorporation into shortfall analysis helps focus investors' attention on what can happen at the tail ends of the return distribution. Ignoring these outlier results is dangerous precisely because they are the returns with the greatest risk, that is, the returns that fall the furthest below the mean.

Measuring Risk Relative to Benchmarks

Performance evaluation typically consists of measuring the returns of the total portfolio, of each asset class, and of individual managers against their respective benchmarks. For most investors the process ends here, with no determination of what caused the results and therefore no understanding of the risks taken (or not taken) to achieve the returns. For example, if manager A had an average annual compound

return of 30.0% from 1992 to 2000 compared to the S&P 500's return of 16.1% for the same period, we only know part of the story: that manager A significantly outperformed the benchmark. However, we have no knowledge of how that excess performance was achieved, how consistent it was, or the degree of risk incurred along the way—which are exactly the questions this kind of portfolio risk analysis seeks to answer.

We do this by answering a series of questions about risk and return *relative to the benchmark*. It is therefore worth stressing at the outset that careful benchmark selection is a prerequisite of any such analysis, and that an investor measuring a portfolio, asset class, or manager against an inappropriate benchmark is likely to make inappropriate decisions on the basis of this mis-measurement.

These are the questions the analysis asks and answers:

- **Has the portfolio outperformed the benchmark?**

  This is measured both by a *relative return ratio* and by *excess performance*, in basis points (bps) per annum.

- **How consistent has this relative performance been?**

  The consistency of outperformance (or underperformance) is measured in terms of frequency *(% of quarters of outperformance)*, and variability *(standard deviation of excess return)*.

- **Has the portfolio been more or less risky than the benchmark?**

  This is measured in terms of relative volatility *(standard deviation)*, and relative sensitivity to market performance *(beta)*.

- **Does the portfolio have higher risk-adjusted returns than those of the benchmark?**

  This is measured by the *relative Sharpe Ratio*; i.e., the Sharpe Ratio of the portfolio relative to the Sharpe Ratio of the benchmark.

- **Is the relative performance differential primarily attributable to taking more market risk (beta) or is it derived from other sources of value added (alpha)?**

  This is measured by the percentage of excess performance attributable to beta and alpha, such that the percentage attributable to both factors totals 100%.

- **How confident are we that relative performance is a result of skill rather than luck?**

  The degree of confidence is determined by the information ratio, or the portfolio's alpha divided by its alpha tracking error. The higher the ratio, the greater the level of confidence that relative performance is attributable to skill rather than to luck.

There are several limitations to this kind of portfolio risk analysis, including benchmark consistency, time horizon consistency, and the analysis of alternative asset managers. As already noted in the second point above, mis-benchmarking results in mis-measurement. For example, if the U.S. equity portion of an investor's portfolio is benchmarked to the S&P 500, while 75% of these assets are with active managers investing predominantly in mid-cap value stocks, an assessment of how the U.S. equity portion of the portfolio has performed relative to its benchmark (S&P 500) will be misleading. Similarly, historical changes in the composition of the policy portfolio must be accurately captured by the analysis to ensure accuracy in the measurement of the actual portfolio versus the policy benchmark. In any comparative analysis of managers, each should be measured over the same time horizon so that market-related factors have an equal opportunity to affect all the portfolios being compared.

Finally, marketable and non-marketable alternative asset managers should not be analyzed in the portfolio risk analysis model because these managers are not benchmarked against market index proxies reasonably reflective of their investment approach. Instead, the typical benchmarks for such managers loosely define the investor's objectives for these portions of the portfolio, ignoring factors like tracking error or beta. Additionally, non-marketable alternatives are not marked-to-market on the same basis as are marketable securities, rendering comparisons of their volatility virtually meaningless.

EXHIBITS

Measuring Shortfall Risk

NOTES TO SHORTFALL RISK EXHIBITS

Exhibits 1-5 illustrate shortfall risk for three hypothetical portfolios allocated as follows:

Asset Allocations of Sample Portfolios

Asset Class	Relatively Undiversified (%)	Average Endowment (%)	Average $1 Billion+ Endowment (%)
U.S. Equity	55.0	40.0	35.0
Global ex U.S. Equity	10.0	15.0	15.0
Absolute Return	---	4.0	5.0
Equity Hedge Funds	---	4.0	5.0
Venture Capital	---	3.5	7.5
Private Equity	---	3.5	7.5
Real Estate	---	5.0	5.0
U.S. Bonds	30.0	20.0	20.0
Cash	5.0	5.0	---
Real Arithmetic Return	6.79%	6.96%	7.58%
Real Compound Return	6.10%	6.39%	6.98%
Standard Deviation	12.14%	11.01%	11.38%

The input assumptions used for the shortfall risk analyses are the same as those used in all of our asset allocation modeling, and are shown in the Appendix (and institutions can, of course, use their own input assumptions). The assumptions are derived using a variety of empirical evidence and/or qualitative factors. For example, our average expected return for U.S. equities takes into consideration the average return over the entire twentieth century, the average rolling 25- and 50-year returns throughout the twentieth century, and the average return net of multiple expansion or contraction. Combining the expected returns, standard deviations, and correlations of historical returns for all invested asset classes, we calculate the expected overall portfolio return, which will vary depending on the percentage of assets allocated to each asset class.

Although no fund's asset allocation in fact remains static for decades, as these analyses implicitly assume, modeling of this sort give trustees the ability to compare the risk exposures of various proposed portfolio allocations, improving their ability to make informed decisions. In addition, institutions may want to select different returns (e.g., at the top or bottom of a return distribution) and run "what-if…" scenarios based on these alternative assumptions.

NOTES TO EXHIBITS 1 AND 2

For each portfolio, Exhibit 1 shows:

- The probability of the fund's suffering a decline in real market value at the end of specified time horizons of five, ten, 25, and 50 years.

- The probability of the fund's suffering a cumulative decline in real market value in excess of 25% value at the end of specified time horizons of five, ten, 25, and 50 years.

- The probability of the fund's suffering a decline in real spending at the end of specified time horizons of five, ten, 25, and 50 years.

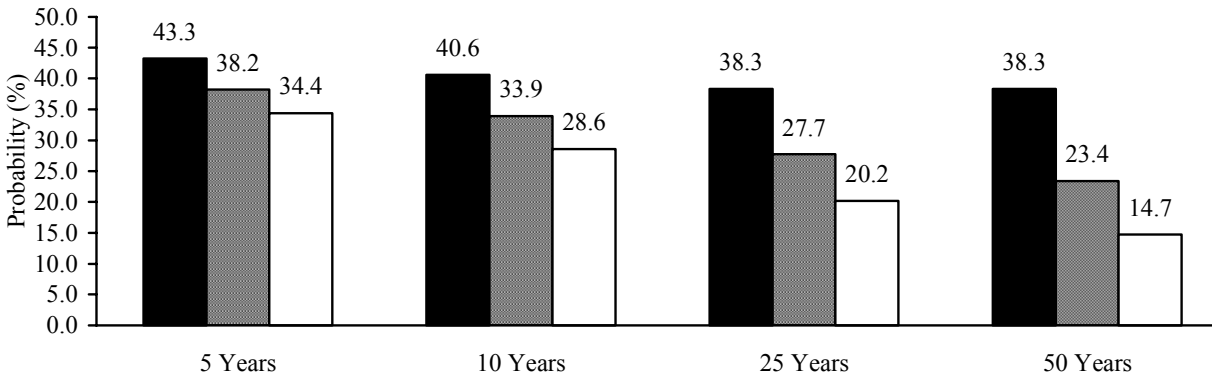
In each of these analyses, we assume a spending rate of 5% of a trailing 12-quarter moving average, with the added provision that nominal spending never decreases.

For each portfolio, Exhibit 2 shows the probabilities of suffering declines in real market value of various magnitudes (from greater than zero to greater than 25%) at the end of five, 25, and 50 years.

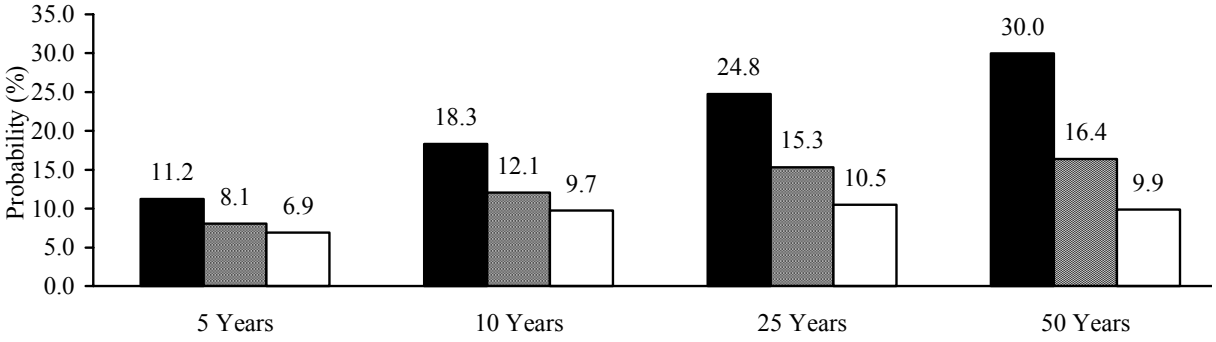
Exhibit 1

PORTFOLIO SHORTFALL RISK

Probability of a Decline in Real Market Value at the End of a Specified Time Horizon



Probability of a Cumulative Decline of more than 25% in Real Market Value at the End of a Specified Time Horizon

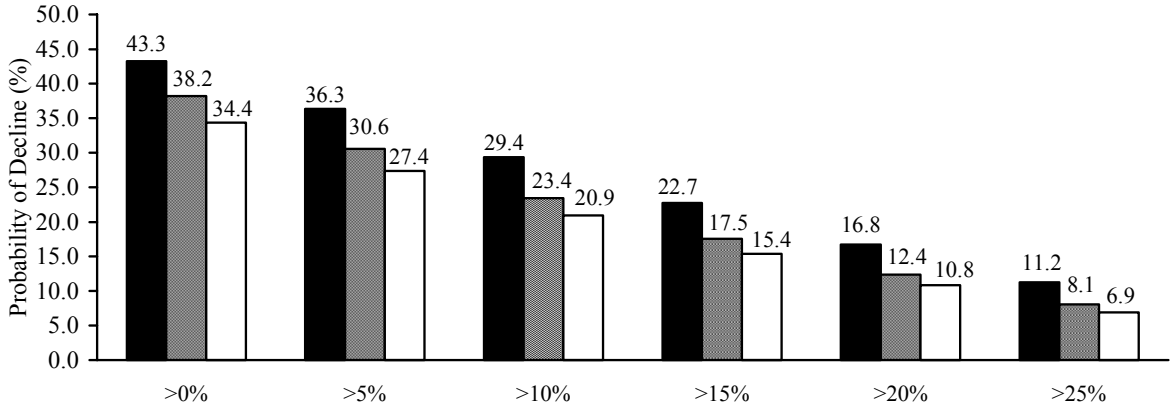


Probability of a Decline in Real Spending at the End of a Specified Time Horizon

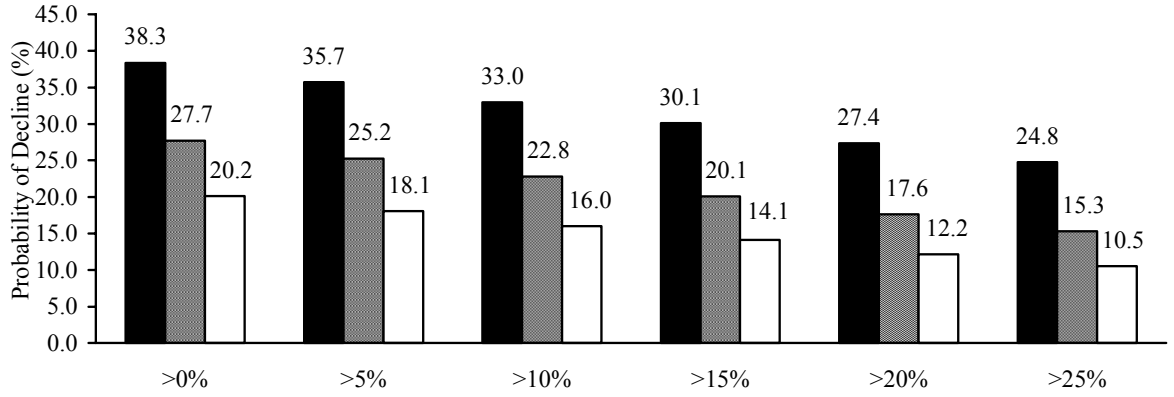
Exhibit 2

PROBABILITY OF A CUMULATIVE DECLINE IN REAL MARKET VALUE

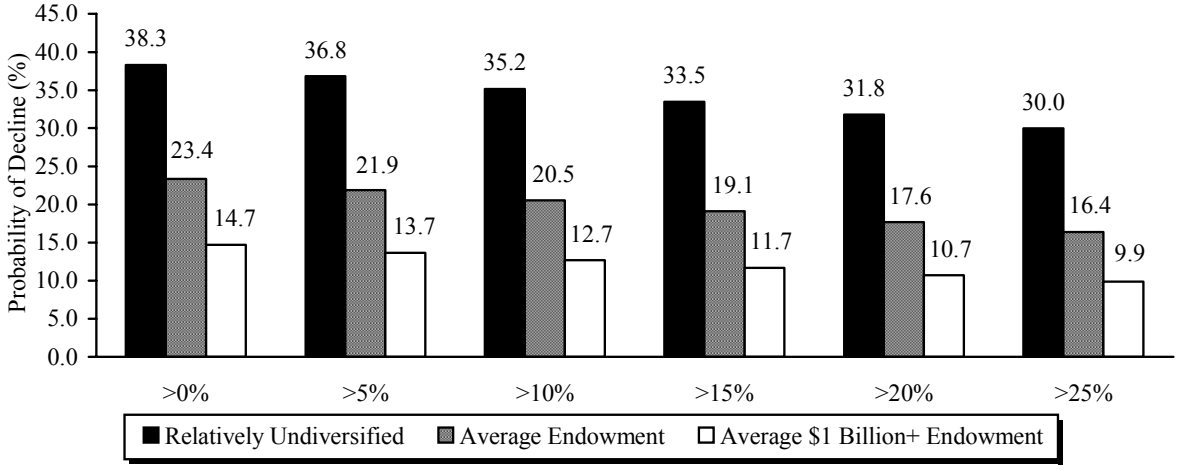
Probability of a Decline at the End of Five Years



Probability of a Decline at the End of 25 Years



Probability of a Decline at the End of 50 Years



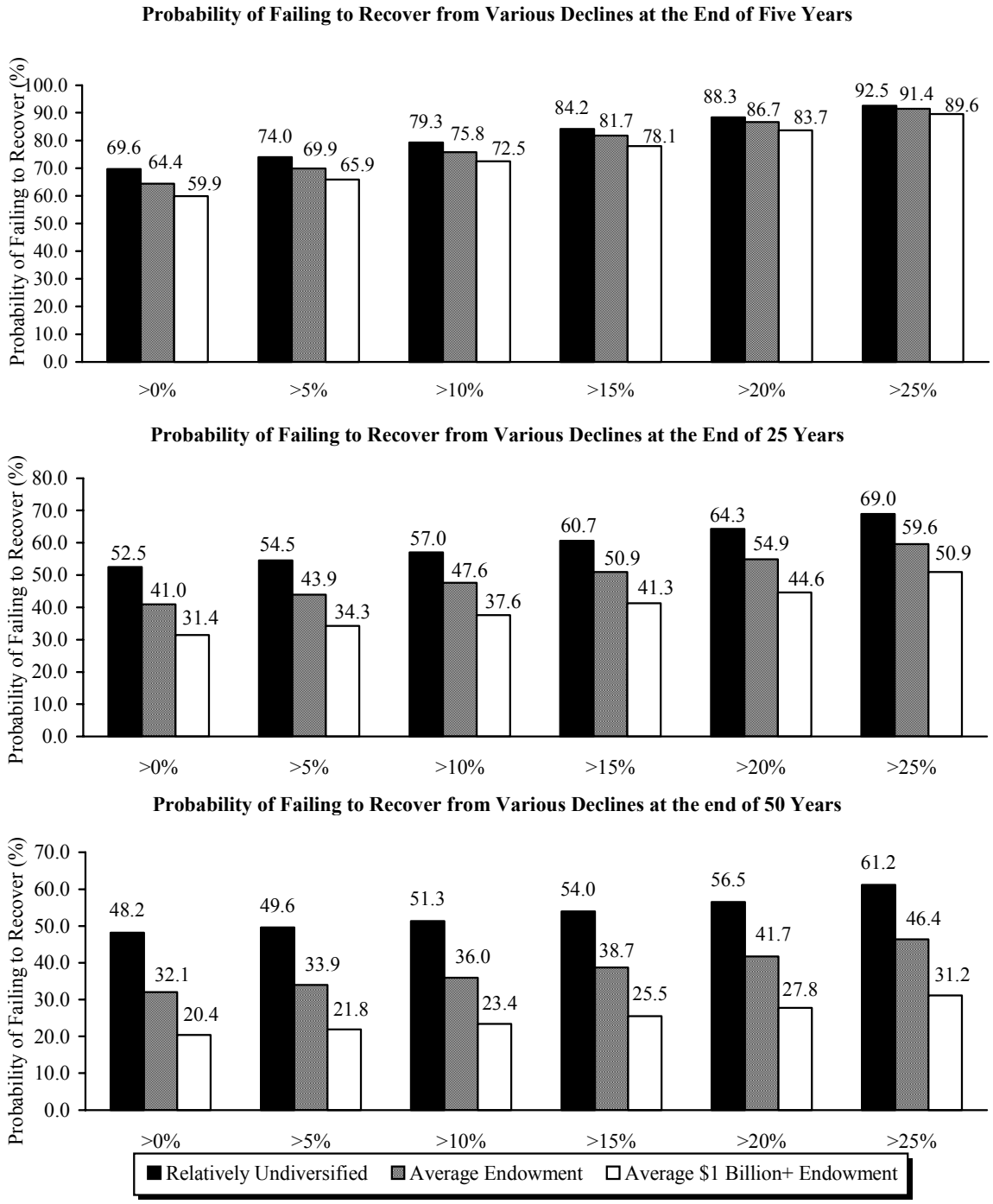
NOTES TO EXHIBIT 3

For each portfolio, Exhibit 3 shows the probability of failing to recover from declines of various magnitudes (from greater than zero to greater than 25%) after five, 25, and 50 years. By "recover" we mean regain all the ground lost, in terms of real market value, during the preceding decline. The point here is that if a fund's real market value declines by, say, 20% in one year, but has fully recovered 18 months later, its ability to provide a steady stream of spending to the operating budget will not have been impaired. If, however, a fund declines by, say, 15%, but then takes ten or more years to regain its previous value, trustees may find themselves faced with the choice of maintaining current spending by continuing to deplete the fund (in effect spending today at the expense of tomorrow), or trying to rebuild the value of the fund by cutting spending (in effect refusing to mortgage the future to meet today's demands).

We measure the probability of *failing* to recover, rather than the probability of recovery, because the former is a better measure of risk.

Exhibit 3

PROBABILITY OF FAILING TO RECOVER FROM A DECLINE IN REAL MARKET VALUE



Note: To "recover" means to attain the same real market value that existed prior to the decline.

NOTES TO EXHIBIT 4

Exhibit 4 provides the most definitive measure of "risk" trustees should consider, since it measures the probability of a portfolio suffering a decline in real value of *x%* from which it fails to recover within *y* years. The *x* is important because the bigger the decline a fund suffers, the harder it is to recover; the *y* is important because the longer it takes to recover, the greater the probability that spending will have to be cut to avoid running the fund into the ground. Although it is certainly instructive to consider each of these risk factors separately, doing so results in overestimation of the probability that the fund's ability to maintain spending will be impaired. Considering them together enables trustees to answer the most fundamental question: What is the probability that this portfolio will enable us to maintain spending without seriously depleting the fund's real value?

Is a 10% probability of a suffering decline of 20% from which one does not recover within ten years too much or too little risk to assume? Only trustees can answer that question, in light of the institution's reliance on spending from the endowment fund, their willingness to reduce spending in tough times, the institution's other revenue sources (if any), and so on. Although there is no easy, generic answer, this remains an essential question for trustees engaged in understanding and measuring the possible effects of their asset allocation decisions.

Exhibit 4

PROBABILITY OF EXPERIENCING A DECLINE IN REAL MARKET VALUE AND FAILING TO RECOVER FROM THAT DECLINE

Joint-Probability Matrixes

The portfolio has **these** probabilities of suffering a decline of **these** magnitudes in **these** time horizons five years from which it does not recover within

Relatively Undiversified

	5 Years	10 Years	25 Years	50 Years
>0%	30.1%	26.7%	22.7%	20.9%
>5%	26.9%	23.6%	19.8%	18.0%
>10%	23.3%	20.2%	16.7%	15.1%
>15%	19.1%	16.6%	13.8%	12.3%
>20%	14.8%	13.0%	10.8%	9.5%
>25%	10.4%	9.3%	7.8%	6.9%

Average Endowment

	5 Years	10 Years	25 Years	50 Years
>0%	24.6%	20.7%	15.6%	12.2%
>5%	21.4%	17.8%	13.4%	10.4%
>10%	17.8%	14.8%	11.2%	8.4%
>15%	14.3%	11.9%	8.9%	6.8%
>20%	10.7%	9.0%	6.8%	5.2%
>25%	7.4%	6.3%	4.8%	3.7%

Average $1 Billion+ Endowment

	5 Years	10 Years	25 Years	50 Years
>0%	20.6%	16.7%	10.8%	7.0%
>5%	18.0%	14.6%	9.4%	6.0%
>10%	15.2%	12.1%	7.9%	4.9%
>15%	12.0%	9.7%	6.3%	3.9%
>20%	9.1%	7.5%	4.8%	3.0%
>25%	6.2%	5.3%	3.5%	2.2%

Notes: The joint probability analysis is based on our long-term return, standard deviation, and correlation assumptions for asset classes, and includes no judgment as to the probability of being at the high end or low end of the return distribution in the near future. The analysis also assumes independence between the probability of experiencing a decline in real market value and the probability of failing to recover from that decline. Therefore, the probability of experiencing a decline in real market value may be understated if valuations have been particularly high, while the probability of failing to recover from the decline may be overstated. The offsetting errors should result in a reasonably accurate joint probability estimate, given the underlying return, standard deviation, and correlation assumptions.

NOTES TO EXHIBIT 5

Despite the value of long-term asset allocation analyses of this sort, trustees often find it difficult to relate to periods extending far beyond their likely tenure on the investment committee. The five-year scenario test shown in Exhibit 5 addresses this head-on by asking the question: How would our portfolio perform over the next five years in the event of a weak economy resulting in very poor equity market returns?

To illustrate "very poor" we have assumed that the five-year return for U.S. equities falls at the 90th percentile of the estimated distribution of U.S. equity returns, that other equities also perform below average to greater or lesser degrees, and that only bonds perform well (assumptions shown in "Specified Percentile" column below the graph). Our return assumptions for other asset classes during this period of extended U.S. equity retrenchment are simply reasonable approximations. Because correlations are ever-changing and highly end-point sensitive, there is no sure-fire method for accurately forecasting how each asset class might perform. As a result, this scenario is intended only to illustrate a possible performance outcome for each portfolio when U.S. equity returns are well below the mean.

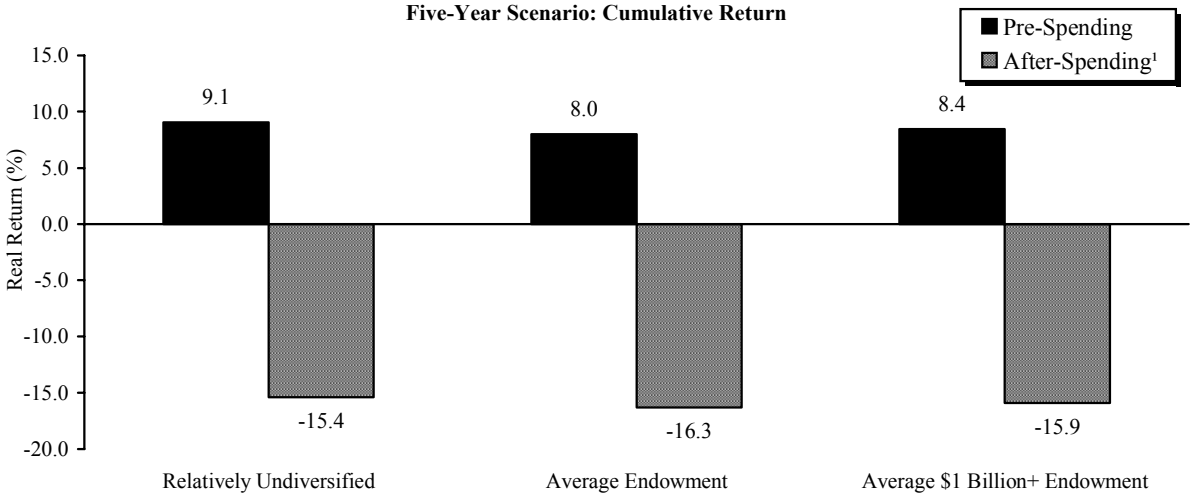
Under these conditions, our three hypothetical portfolios all suffer a decline, after spending, of 15% or more. Is this a tolerable or intolerable outcome? To answer that, one needs to go back to the "time to recover" analyses to gauge how long it might reasonably take to regain the lost ground, assuming no better than average returns in the years following the decline. The results are not encouraging: even the most diversified portfolio has a 78% probability of *failing* to recover from a 15% decline within five years, assuming no change in spending.

This should perhaps give pause to trustees who have raised their funds' equity allocations to unprecedented levels on the unproven assumption that their institutions can readily withstand the additional risk incurred.

Obviously, this exhibit is intended to illustrate a relatively simple approach to scenario modeling. Investors should consider adapting it to their own uses, running alternative "what-if…" scenarios for different time horizons, incorporating their own return and correlation assumptions, and so on.

Exhibit 5

FIVE-YEAR SCENARIO TEST



Asset Allocations

	Relatively Undiversified (%)	Average Endowment (%)	Average $1 Billion+ Endowment (%)
U.S. Equity	55.0	40.0	35.0
Global ex U.S. Equity	10.0	15.0	15.0
Absolute Return	---	4.0	5.0
Equity Hedge Funds	---	4.0	5.0
Venture Capital	---	3.5	7.5
Private Equity	---	3.5	7.5
Real Estate	---	5.0	5.0
U.S. Bonds	30.0	20.0	20.0
Cash	5.0	5.0	---

Returns for All Portfolios

	Median Return (%)	Five-Year Standard Deviation (%)	Specified Percentile	Five-Year Return (%)[2]
U.S. Equity	6.8	7.4	90th	-2.1
Global ex U.S. Equity	6.4	8.5	75th	0.9
Absolute Return	5.4	3.7	75th	3.0
Equity Hedge Funds	5.8	5.6	80th	1.2
Venture Capital	10.1	11.7	75th	2.7
Private Equity	8.8	10.0	90th	-2.9
Real Estate	5.4	5.9	60th	4.0
U.S. Bonds	3.8	4.1	10th	9.3
Cash	1.2	1.6	50th	1.2

Note: Returns are assumed to be lognormally distributed.

[1] Spending is 5% of trailing 12-quarter average market value with the added provision that nominal spending never decreases.

[2] Five-year return is derived from the assumed percentile for each asset class (i.e., 90th percentile for U.S. equity).

Measuring Risk Relative to Benchmarks

NOTES TO EXHIBITS 6 AND 7

Introduction

To illustrate the measurement of risk-relative-to-benchmark (often called "active" risk), we have analyzed a total portfolio (Exhibit 6b) and a single manager (Exhibit 7). However, a comprehensive analysis of this sort might also include analysis of the total portfolio minus alternative assets, analyses of each asset class included in the portfolio, and analyses of each individual manager.

These analyses are dynamic in the sense that they enable one to drill down into the portfolio to determine which managers or asset classes are contributing more or less to portfolio risk. They can also be used to compare the risk-adjusted performance of managers in a manager search. However, like any sharp tool, they should be used with caution. For example, the inclusion of non-marketable alternative assets in an analysis of the total portfolio may dilute the true "relative" risk picture in portfolios with large allocations to alternative investments. This is why we would recommend that such portfolios be analyzed both with and without alternative investments included.

NOTES TO EXHIBITS 6 AND 7 (continued)

1. The first analysis measures the portfolio's performance relative to that of the benchmark. A relative return greater than one indicates the portfolio has outperformed the benchmark, while a ratio less than one indicates underperformance. Significant variance from the benchmark may indicate significant bets relative to policy through implementation decisions that could affect the portfolio's ability to meet long-term investment objectives.

2. The consistency of relative performance provides some insight into how the portfolio's returns have varied from those of the benchmark and may indicate how closely returns might be expected to track those of the benchmark in the future. Note that a large degree of variability from the benchmark is not necessarily bad—what is bad is a large degree of unexpected variability.

3. By evaluating how much risk the portfolio has incurred one can gauge whether outperformance has been the result of taking more risk and underperformance the result of taking less risk than was implicit in the benchmark.

4. The standard way to measure risk-adjusted performance is the Sharpe Ratio. By measuring the Sharpe Ratio of the portfolio relative to the Sharpe Ratio of the benchmark, one can determine whether the portfolio has higher or lower risk-adjusted performance than the benchmark. This figure is expressed in bps per unit of risk, where one unit of risk equals 100 bps. For example, a figure of -15 means that, per 100 bps of risk (or 1% of risk), the portfolio returned an average of 15 bps less than the benchmark. In other words, the portfolio was less risk efficient.

5. By breaking down the portfolio's relative returns, one can determine whether those excess returns have come from taking greater market risk than the benchmark (i.e., higher beta), or from other sources of value added, such as manager structure or manager skill. For example, suppose that a manager with a beta of 1.1 returned 10.0%, versus a benchmark return of 8.0%. Of the portfolio's 10.0% return, 8.8% would be attributable to beta and 1.2% attributable to alpha. The 2.0% excess return can be broken down into the 0.8% attributable to beta and the 1.2% attributable to other factors (alpha). In this example, 40% of the excess (i.e., 0.8/2.0 = 40%) is attributable to beta and 60% is attributable to alpha.

6. The lower the volatility of excess performance, the more confidently we can attribute success to skill rather than to luck.

Exhibit 6

TOTAL PORTFOLIO ASSET ALLOCATION

As of March 31, 2001*

Asset Class	Policy Portfolio Allocation (%)	Actual Portfolio Allocation (%)
U.S. Equity	35.0	33.0
Global ex U.S. Equity	16.0	12.7
Emerging Markets Equity	5.0	2.9
Real Estate	5.0	6.3
Venture Capital	4.0	4.8
Private Equity	4.0	4.0
Oil & Gas	2.0	1.6
U.S. Bonds	29.0	32.9
Cash	---	1.7

*Policy portfolio allocations are as of the most recent time period, March 31, 2001, and do not necessarily represent the policy portfolio allocations over the full horizon analyzed. However, the returns of the policy benchmark used in the analysis that follows do reflect policy allocation changes over time.

Exhibit 6 (continued)

MEASURING RISK RELATIVE TO BENCHMARKS: PERFORMANCE OF TOTAL PORTFOLIO RELATIVE TO POLICY BENCHMARK

	April 1, 1996- March 31, 2001	April 1, 1991- March 31, 2001
1. Has the portfolio performed better or worse than the benchmark?		
Relative Return (ratio)	0.98	0.98
Value Added (average annual bps)	-209	-180
2. How consistent has this relative performance been?		
% of Quarters that Portfolio Outperformed	40.0	37.5
Standard Deviation of Value Added	2.54	2.04
3. Has the portfolio been more or less risky than the benchmark?		
Relative Standard Deviation (ratio)	0.88	0.89
Beta	0.86	0.87
4. Adjusted for risk, has the portfolio outperformed the benchmark?		
Relative Excess Return Per Unit of Risk (bps)	-13	-13
5. Is the relative performance primarily attributable to taking more market risk than the benchmark (beta) or to other sources of value added (alpha)?		
% Attributable to Beta	43.8	52.5
% Attributable to Alpha	56.2	47.5
6. How confident are we that the relative performance is a result of skill rather than luck?		
Confidence Level	60.9%	59.2%

MEASURING RISK RELATIVE TO BENCHMARKS INTERPRETATION

Exhibit 6

Key Findings:

1. The total portfolio has underperformed the policy benchmark over the trailing five-year and ten-year periods. The relative performance in the five-year period (-209 bps) was worse than the relative performance over the longer ten-year horizon (-180 bps).

2. Over the five-year and ten-year periods, the portfolio has outperformed the benchmark approximately 40% of the quarters. This finding is consistent with the degree of underperformance and suggests that the portfolio's returns were distributed fairly consistently around the benchmark.

3. The portfolio has taken on less risk than the benchmark, as illustrated by its relative standard deviations of 0.88 and 0.89, over the five-year and ten-year horizons, respectively. Although lower risk is often desirable, the combination of underperformance and lower risk suggests that the portfolio was incurring less risk than outlined in the policy benchmark and, as a result, not enough risk to achieve the performance objectives.

4. For every unit of risk (each unit is 100 bps) the portfolio delivered 13 bps less of return than the benchmark. Lower risk adjusted returns may be a warning sign of portfolio inefficiency—suggesting a need for more detailed analysis.

5. Is the portfolio's underperformance attributable primarily to its having taken less systematic risk than the benchmark (i.e., a lower beta), or to other sources (e.g., active managers detracting rather than adding value)? In this instance, the underperformance was almost equally attributable to both these factors.

6. However, as if often the case, the statistical results are not sufficiently conclusive for us to be sure that these results are not simply random—in other words, to be confident they are likely to persist over the next five and ten years.

Exhibit 7

MEASURING RISK RELATIVE TO BENCHMARKS: PERFORMANCE OF A U.S. GROWTH EQUITY MANAGER RELATIVE TO S&P 500

	April 1, 1996- March 31, 2001	April 1, 1991- March 31, 2001
1. Has the manager performed better or worse than the benchmark?		
Relative Return (ratio)	1.02	1.01
Excess Return (average annual basis points)	205	133
2. How consistent has this relative performance been?		
% of Quarters that Portfolio Outperformed	55.0	55.0
Standard Deviation of Excess Return	12.23	10.38
3. Has the manager been more or less risky than the benchmark?		
Relative Standard Deviation (ratio)	1.50	1.54
Beta	1.39	1.40
4. Adjusted for risk, has the manager outperformed the benchmark?		
Relative Excess Return Per Unit of Risk (bps)	-4	-14
5. Is the relative performance primarily attributable to taking more market risk than the benchmark (beta) or to other sources of value added (alpha)?		
% Attributable to Beta	103.3	162.6
% Attributable to Alpha	-3.3	-62.6
6. How confident are we that the relative performance is a result of skill rather than luck?		
Confidence Level	50.2%	53.2%

MEASURING RISK RELATIVE TO BENCHMARKS INTERPRETATION

Exhibit 7

Key Findings:

1. The manager (U.S. equity growth) outperformed the S&P 500 by an average of 205 bps in the most recent five-year period and 133 bps over the ten-year horizon. The significantly higher outperformance during the most recent period suggests two different performance trends between the first and second five-year periods. Examining the drivers of performance during these subperiods, relative to the index, may provide insight regarding key facets of the manager's investment style.

2. The manager outperformed the index in slightly more than half the quarters (55% of the time). Based on the manager's significant overall outperformance, especially in the most recent five-year period, it appears that the quarters of outperformance were relatively more significant than the quarters of underperformance. In addition, the manager did not generate a steady rate of excess return; rather, there was considerable volatility in the excess returns.

3. The manager's portfolio was approximately 50% more volatile than the index (relative standard deviation of 1.50 over five years and of 1.54 over ten years). This is not necessarily bad. The more important question is whether this is an intentional characteristic of the manager's investment strategy of which clients are fully forewarned.

4. The degree of excess risk taken by the manager overwhelmed the relative outperformance. In other words, the manager underperformed the benchmark on a risk-adjusted basis. However, it is interesting to note that while the relative performance improved markedly over the most recent five-year period, the relative risk level decreased (e.g., the manager sacrificed 14 bps of return per unit of risk over the ten-year period, but only four bps of return per unit of risk over the most recent five-year period).

5. The manager outperformed by taking on excess market risk, while other sources of value added have actually been a drag on relative performance—particularly over the full ten-year period. This is an important finding because active managers should not be rewarded simply for incurring more systematic risk (i.e., beta) since this is a commodity investors can buy at very low cost. What investors seek from active managers is alpha; that is, excess return attributable to manager skill rather than to the assumption of greater systematic risk.

6. However, we cannot determine with confidence whether this allocation of risk between beta and alpha is likely to prove persistent over time.

APPENDIX

LONG-TERM ASSET ALLOCATION ASSUMPTIONS

Asset Class	Symbol	Real Arithmetic Avg. Return (%)	Real Compound Return (%)	Risk (%) (Std. Dev. of Returns)
U.S. Equity	USE	8.00	6.75	16.50
Global ex U.S. Equity	GE	8.00	6.25	19.00
Emerging Markets Equity	EM	11.00	7.75	27.00
Absolute Return	AR	5.75	5.50	8.25
Equity Hedge Funds	HF	6.50	5.75	12.50
Venture Capital	VC	13.00	10.00	26.25
Private Equity	PE	11.00	8.75	22.25
REITs	REIT	7.25	6.25	15.00
Real Estate	RE	6.25	5.50	13.25
Commodities	CM	6.25	4.50	19.25
U.S. Bonds	BND	4.25	3.75	9.25
Cash	CA	1.25	1.25	3.50

Correlation Coefficients

	USE	GE	EM	AR	HF	VC	PE	REIT	RE	CM	BND	CA
USE	1.00											
GE	0.52	1.00										
EM	0.08	0.28	1.00									
AR	0.55	0.28	0.46	1.00								
HF	0.57	0.27	0.52	0.64	1.00							
VC	0.54	-0.03	-0.13	0.27	0.37	1.00						
PE	0.40	0.10	0.06	0.69	0.57	0.84	1.00					
REIT	0.59	0.35	0.46	0.63	0.75	0.52	0.72	1.00				
RE	0.29	0.33	-0.47	0.06	0.07	-0.02	0.19	0.10	1.00			
CM	-0.35	-0.22	0.09	-0.11	-0.31	0.12	-0.02	-0.32	-0.17	1.00		
BND	0.57	0.22	0.26	0.61	0.27	0.02	0.23	0.27	-0.01	-0.20	1.00	
CA	0.12	0.25	-0.13	0.54	0.02	-0.31	-0.04	0.27	0.38	-0.30	0.67	1.00