Diversification Performance and Stress-Betas

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In a series of earlier articles based upon a 2003 return-covariance matrix, Leibowitz [2004] and Leibowitz and Bova [2005, 2007a] reported that a wide range of the diversified allocations used in practice were found to have risk characteristics that were similar to each other and to a traditional 60/40 structure; that is, total volatilities between 10% and 11%, portfolio to U.S. equity volatility ratios of 60% to 70%, correlations with U.S. equity above 90%, and correlation-based portfolio betas that ranged from 0.55 to 0.65.

With these risk characteristics, correlation-based portfolio betas become an overwhelmingly dominant risk factor, accounting for 90%, or more, of each fund's volatility. To the extent that these theoretical findings hold in practice, traditional and other diversification structures would not really reduce risk. Our findings thus imply that diversification should be viewed as providing benefits over the long term in the form of greater return accumulation and wider divergence of outcomes, rather than as reducing risk in the short term. The 15-year experience from 1993 to 2007 generally confirms that these covariance-based results with regard to the risk structure are correct (Leibowitz and Bova [2008a, 2008b]) and, as predicted, that diversified portfolios generated significantly higher returns over the same 15-year period.

Because the equity beta accounts for over 90% of portfolio volatility, the most serious risk for U.S. institutional funds is a sudden and severe decline in the equity market. In another series of studies beginning in 2007, we conjectured that the correlation tightening and *stress-betas* associated with such a drop in the equity market could hurt diversified portfolios more than traditional portfolios (Leibowitz and Bova [2007b, 2008c, 2008d, and 2008e]). The 2008 market debacle unfortunately provided an opportunity to test our "stress" conjecture. The diversified portfolio's beta was, in fact, proven to be far greater than its 15-year average and much higher than that of the traditional 60/40 portfolio, resulting in 2008 being the first period when diversified portfolios performed materially worse than the traditional 60/40 portfolio.

THEORETICAL BETA-BASED RISKS

Exhibit 1 lists the representative policy portfolios that are used throughout this article. Portfolio B represents the traditional 60/40 portfolio. Portfolio C reflects a typical endowment-type portfolio. One issue that arises with Portfolio C is that the three illiquid asset classes—absolute return, private equity, and venture capital—have pricing indices of problematic quality. Moreover, some of these indices only have quarterly data, which severely limits sample frequency and the ability to

EXHIBIT 1
Sample Portfolio Allocations

	B	C	D
U.S. Equity	60%	20%	30%
U.S. Bonds	40%	20%	25%
International Equity		15%	25%
Emerging Mkt Equity		5%	10%
REITS		10%	10%
Absolute Return		10%	
Venture Capital		10%	
Private Equity			
Total	100%	100%	100%

Source: Morgan Stanley Research.

EXHIBIT 2
Theoretical Risk Projections

	U.S. Equity	B	C	D
Volatility (σ)	16.50%	11.17%	11.07%	11.83%
Volatility/Equity Volatility	1.00	0.68	0.67	0.72
Correlation (ρ)	1.00	0.97	0.91	0.91
Beta to U.S. Equity (β)	1.00	0.65	0.61	0.65
β-Based Volatility	16.50%	10.73%	10.12%	10.74%
β-Based Volatility as % of Total Volatility	100.0%	96.7%	91.4%	90.8%
Expected Real Return	7.25%	5.85%	7.18%	6.50%

Source: Morgan Stanley Research.

examine shorter-term periods. As a result, Portfolio D has been included as a "semi-diversified" portfolio in which all the assets have ample liquidity and more than adequate pricing frequency.

Exhibit 2 summarizes the risk projections for U.S. equity and for the sample portfolios based on the theoretical 2003 return-covariance matrix used in our earlier studies. Covariance matrices, usually expressed in real-return terms, describe the assumed statistical relationships between various asset classes. By implication, the covariance matrix also provides an assumed beta for each asset's sensitivity to movements in the benchmark equity market. This implied beta value can be derived as the product of the asset's equity correlation and the ratio of its volatility to that of equities.

The covariance matrix also provides a basis for segregating each asset's volatility into one component that correlates with equity and a second residual component that does not. Within a portfolio structure, the beta values build on a percentage-weighted basis to add up to the fund's total beta. In contrast, if the residuals can be treated as being independent of each other, they will essentially combine as a sum-of-squares, resulting in low residual volatility at the fund level. This combination of "building" betas and diversifying residuals is the fundamental reason why fund volatility is typically dominated by beta-based volatility.

Focusing on the theoretical risk projections for the three portfolio allocations (Portfolios B, C, and D) provided in Exhibit 2, a number of common features can be observed. For all three allocations, total volatilities range between 11% and 12%, ratios of portfolio volatility to U.S. equity volatility are within 67% to 72%, correlations with U.S. equity are above 90%, and covariance-based betas are in the 0.60 to 0.65 range for all portfolios. The product of the portfolio beta and U.S. equity volatility determines the beta-based volatilities of 10.1% to 10.7%. These beta-based volatilities represent over 90% of total portfolio volatilities, regardless of the level of diversification. Thus, the volatility of all three portfolios is overwhelmingly dominated by their beta volatility.

This key theoretical finding applies well beyond these three portfolios to virtually all U.S. institutional allocations observed in practice. In contrast to the similarity in risk characteristics, the diversified portfolios appear to have higher expected returns, an effect that is also observed across a wide range of portfolio asset allocations.

HISTORICAL RISK CHARACTERISTICS

We now turn to the historical experience of the 1993–2007 period and its three five-year subperiods. The data were based upon the quarterly index values from the sources listed in Exhibit 3. The index values were adjusted for realized inflation in order to obtain empirical real returns that could be compared with the preceding theoretical real returns.

Exhibit 4 shows the portfolio volatilities realized over the period 1993–2007 and the three five-year subperiods. The primary driver of portfolio volatility was the magnitude of equity volatility within each subperiod.

EXHIBIT 3
Index Sources

Asset Class	Index Used
U.S. Equity	S&P 500
U.S. Bonds	Lehman U.S. Aggregate Bond
International Equity	MSCI EAFE
Emerging Mkt Equity	MSCI Emerging
Real Estate	NCREIF Property
Absolute Return	HFR
Venture Capital	Cambridge Associates U.S. Venture Capital
Private Equity	Cambridge Associates U.S. Private Equity

Theoretical Data based on Cambridge Associates Covariance Matrix

Source: Morgan Stanley Research.

EXHIBIT 4
Portfolio Volatilities

	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Volatility	16.50%	9.16%	21.71%	10.54%	15.08%
B	11.17%	6.87%	12.04%	6.79%	9.01%
C	11.07%	5.51%	14.48%	7.74%	10.01%
D	11.83%	6.27%	13.83%	9.47%	10.50%

Source: Morgan Stanley Research.

The higher equity volatility in the subperiod 1998–2002 led to higher portfolio volatilities, but lower equity volatility in the subperiods 1993–1997 and 2003–2007 led to lower portfolio volatilities.

The key point is that, within any given period, the volatilities are quite similar for all three allocations. Thus, as predicted theoretically, diversification does not appear to materially reduce portfolio volatility.

The volatility effect can be further analyzed in terms of the ratio of portfolio volatility to U.S. equity volatility. As shown in Exhibit 5, this volatility ratio was generally quite stable across the different subperiods and also across the various allocations. For Portfolio C, the ratio ranged from 60% to 73%, in line with the theoretical projections of 67%. Portfolios B and D had more variability in their ratios. The 1993–1997 subperiod experienced higher bond volatility and lower equity volatility than normal, leading to the 75% ratio for Portfolio B. For Portfolio D, the 90% ratio from 2003 to 2007 was driven by a combination of lower equity volatility and higher (possibly currency-related) volatility for the other assets.

As shown in Exhibit 6, the three portfolios also had a high correlation with U.S. equity, which enabled the beta volatility to account for a high proportion of the total volatility.

EXHIBIT 5
Ratio of Portfolio Volatility to U.S. Equity Volatility

	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Real Return	7.25%	17.23%	–2.89%	9.42%	7.59%
B	0.68	0.75	0.55	0.64	0.60
C	0.67	0.60	0.67	0.73	0.66
D	0.72	0.68	0.64	0.90	0.70

Source: Morgan Stanley Research.

EXHIBIT 6
Correlations with U.S. Equity

	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Real Return	7.25%	17.23%	–2.89%	9.42%	7.59%
B	0.97	0.81	0.89	0.94	0.89
C	0.91	0.82	0.89	0.92	0.89
D	0.91	0.76	0.97	0.94	0.92

Source: Morgan Stanley Research.

EXHIBIT 7
Portfolio Betas

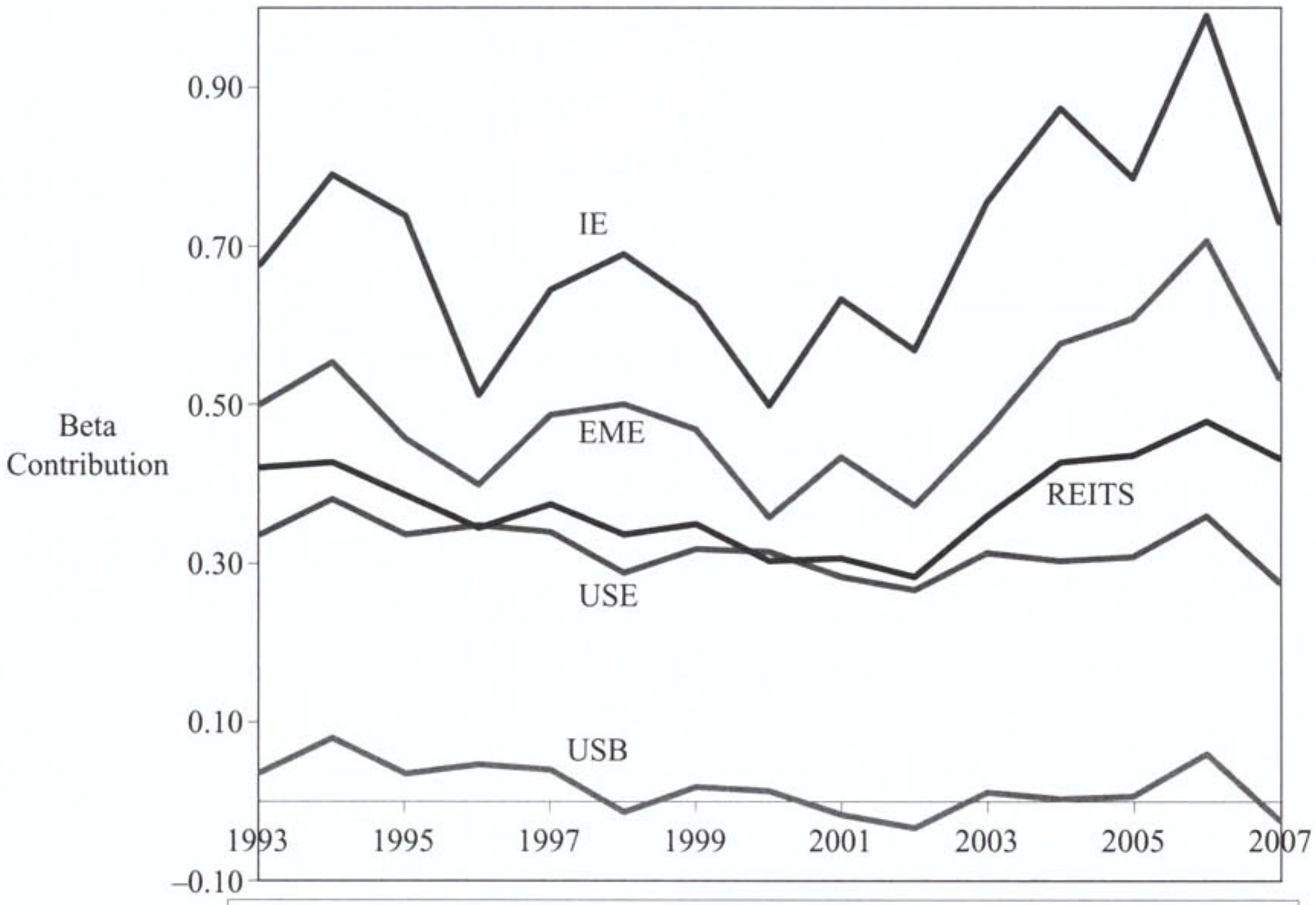
	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Real Return	7.25%	17.23%	–2.89%	9.42%	7.59%
B	0.65	0.61	0.49	0.61	0.53
C	0.61	0.49	0.59	0.68	0.59
D	0.65	0.52	0.62	0.85	0.64

Source: Morgan Stanley Research.

This long-term relationship reinforces the fact that U.S. equity beta is the dominant risk factor in virtually all institutional portfolios.

Exhibit 7 shows the theoretical and realized portfolio betas for the three portfolios. Portfolio C had a beta for the 1993–2007 period of 0.59, quite close to its theoretical beta of 0.61, but there was significant variation within the five-year subperiods; for example, the strong equity markets from 1993 to 1997 led to a correlation "lag" that resulted in a lower beta of 0.49 for Portfolio C. The key message from Exhibit 7, however, is that over longer periods the covariance-based beta estimate appears to be an appropriate indicator of overall portfolio risk in that longer-term beta values were found to be quite consistent with the theoretical projections from the 2003 covariance matrix.

EXHIBIT 8
Portfolio D Beta Contributions



IE = International Equity; EME = Emerging Markets Equity; REITS = Real Estate Investment Trusts; USE = U.S. Equity; and USB = U.S. Bonds

Source: Morgan Stanley Research.

A second outlier result reported in Exhibit 7 is Portfolio D's 0.85 beta between 2003 and 2007. In order to delve more deeply into the cause of this large increase in portfolio beta, Exhibit 8 graphs the beta contribution of each asset (i.e., the asset beta multiplied by its weight in the portfolio). Not surprisingly, U.S. bonds had a negligible effect on the overall portfolio beta. REITS had a relatively minor beta impact prior to 2003, but this changed in the later years. The 2003–2007 subperiod witnessed a particularly large beta contribution from the 35% weight in international equity and emerging market equity, which is evidently the fundamental basis for the surge in Portfolio D's beta over this subperiod. This effect may be partially due to the weaker dollar during this timeframe.

ALPHA AND BETA RETURNS

Although the preceding analysis has been focused on risk factors, the 2003 return-covariance matrix also provided expected real returns for each asset class. As shown in Exhibit 9, these assumptions allowed projected returns to be calculated for each of the portfolios. Moreover, by using the theoretical beta values, these projected real returns can be partitioned into a beta-component associated with U.S. equity and a residual alpha-component.

Because the portfolios have similar beta values, their beta-based returns all fall in the 5.0% to 5.2% range. The structural alphas are quite small for Portfolio B, but increase with diversification. These higher alpha returns provide diversified portfolios with their return advantage over the traditional 60/40 portfolio and they lead to only minimal increases in portfolio volatility.

The structural alphas differ from the active alphas in that the latter result from superior management skill. Structural alphas, as defined in this analysis, arise from assumed investments in asset-class benchmarks and, hence, are fundamentally passive in nature. Exhibit 10 shows the realized portfolio returns and the significant variability in returns across different periods for the three allocations. As with portfolio volatility, the dominance of U.S. equity

EXHIBIT 9
Theoretical Alpha and Beta Returns

	B	C	D
Total Portfolio Return	5.85%	7.18%	6.50%
Less Risk-Free Rate	1.50%	1.50%	1.50%
	4.35%	5.68%	5.00%
Equity Risk Premium of 5.75%			
x B's Beta of 0.65	3.76%		
x C's Beta of 0.61		3.53%	
x D's Beta of 0.65			3.74%
Structural Alpha (Passive)	0.59%	2.15%	1.26%

Source: Morgan Stanley Research.

EXHIBIT 10
Total Portfolio Returns

	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Real Return	7.25%	17.23%	–2.89%	9.42%	7.59%
B	5.85%	12.17%	0.93%	6.24%	6.35%
C	7.18%	14.26%	3.92%	11.65%	9.86%
D	6.50%	10.91%	–0.59%	12.43%	7.42%

Source: Morgan Stanley Research.

EXHIBIT 11
Portfolio Beta Returns

	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Real Return	7.25%	17.23%	–2.89%	9.42%	7.59%
B	5.26%	11.32%	–0.47%	5.66%	5.39%
C	5.03%	9.55%	–0.96%	6.35%	5.01%
D	5.24%	9.90%	–1.07%	8.18%	5.33%

Source: Morgan Stanley Research.

EXHIBIT 12
Realized Alpha Returns

	Theoretical	1993–1997	1998–2002	2003–2007	1993–2007
U.S. Equity Real Return	0.00%	0.00%	0.00%	0.00%	0.00%
B	0.59%	0.86%	1.40%	0.58%	0.96%
C	2.15%	4.71%	4.88%	5.30%	4.85%
D	1.26%	1.01%	0.48%	4.25%	2.09%

Source: Morgan Stanley Research.

plays a major role in determining portfolio returns. In subperiods when U.S. equity performed well, all the portfolios also did well. In contrast, the weak U.S. equity market from 1998 to 2002 drove down all of the portfolios' returns. Within each of the subperiods, however, the returns generally increased with greater levels of diversification (as predicted).

Exhibit 7 showed that the portfolio betas are quite similar, across allocations and across different periods, but, as indicated in Exhibit 11, the beta-based returns clearly depend on the realized U.S. equity returns within each subperiod. It is quite striking that, across the full 15-year period, all the beta returns fell into the 5.0% to 5.4% range (i.e., very close to the theoretical expectations).

One argument for portfolio diversification can be examined by focusing on the realized alpha returns shown in Exhibit 12. For Portfolio C, even though the theoretical alpha return was 2.15%, the actual alpha return was greater than the projection in every subperiod. Moreover, the alpha returns for Portfolio C were roughly stable across the three five-year subperiods. The less-diversified portfolios also had positive alphas, but the alphas were smaller—and more volatile.

STRESS-BETA THEORY

A common saying is that in a serious market decline "all correlations go to one." This statement generally refers to the correlation across various equity-like asset classes, such as U.S. equity, international equity, emerging market equity, private equity, and so on, but not necessarily fixed-income assets. In actuality, all such correlations cannot literally move to one, but under stress they can tighten to higher-than-normal levels. Within a U.S. equity–based beta framework, such correlation tightening would lead to higher-than-normal beta values, or what we call stress-betas.

In a report published in December 2007, we considered how these theoretical stress-betas might impact various portfolio allocations. Our basic finding was that it would be the more-diversified allocations, with the larger number of asset classes, that would be most vulnerable to having portfolio betas rise from normal to higher stress levels.

Recall our earlier findings that, under normal times, virtually all allocations would exhibit roughly the same beta and volatility levels. In adverse markets, however, any correlation tightening would have little impact on the 60/40 portfolio, while the diversified portfolio—with its multiple asset classes—would become much more vulnerable to stress-betas. Combining these results,

we surmised that diversified portfolios would actually be more vulnerable to severe adverse markets than the traditional 60/40 portfolio. This conjecture was quite at odds with the standard intuition that viewed diversification as a protection against such risks.

The initial betas of the majority of diversified portfolios lie in the same 0.55 to 0.65 range as the beta of a traditional 60/40 portfolio. When beta values are unchanged, both portfolio types should experience roughly comparable price declines, but in the presence of correlation tightening, the diversified portfolio's total beta should increase relative to that of the 60/40 portfolio.

To test this premise, we examined the historical record of various portfolio allocations over the 15-year period ending December 31, 2007. This historical period included significant subperiods of market turbulence, but the turbulence tended to be primarily focused on one or more specific factors or subasset classes.

2008 RESULTS AND STRESS-BETAS

The weak equity markets of 2008 provided an (unwelcome) opportunity to test the stress-beta hypothesis with empirical data. To gather enough datapoints to calculate beta values within a single year, we had to use monthly pricing. The need for more-frequent pricing motivated the use of the semi-diversified Portfolio D as the representative portfolio for studying the 2008 market. Exhibit 13 presents a summary of the 2008 results in terms of the various risk characteristics and returns for Portfolios B and D.

For both Portfolios B and D, the correlations and the ratio of portfolio volatility to U.S. equity volatility rose substantially in 2008. The net result was a beta of 0.95 for the semi-diversified Portfolio D, significantly higher than its 15-year average of 0.53, and a beta of 0.64 for Portfolio B. At other times, such as 2006, both portfolios' betas were higher than their 15-year average betas. The truly horrendous markets in 2008 led to a divergence in beta values for Portfolios B and D of a magnitude not seen for any period in the past. The high stress-beta accounts for the 9% underperformance in 2008 of Portfolio D compared to the performance of Portfolio B. This was the first period in which Portfolio D performed materially worse than the traditional 60/40 portfolio. (The returns reported in Exhibit 13 are real returns. On a nominal-return basis, Portfolio D's performance was –31.3% compared to Portfolio B's performance of –22.3%.)

An examination of the individual asset classes held in Portfolio D shows that with the exception of U.S. bonds, the asset class betas in 2008 were all higher than the theoretical projections and the corresponding 15-year betas. Surprisingly, this increase in betas was more a function of tighter correlations than of higher volatility ratios. As a side note, it is quite curious how the volatility ratios of emerging market equity remained steady while the asset class's beta value soared in 2008.

EXHIBIT 13
2008 Risk–Return Results

Correlations	Theoretical	1993–2007	**2008**
U.S. Bonds	0.18	–0.11	**0.26**
International Equity	0.92	0.80	**0.91**
Emerging Mkt Equity	0.75	0.60	**0.84**
REITS	0.55	0.34	**0.81**
B	0.97	0.89	**0.97**
D	0.91	0.92	**0.96**
Volatility/Equity Volatility	**Theoretical**	**1993–2007**	**2008**
U.S. Bonds	0.45	0.28	**0.38**
International Equity	1.18	1.07	**1.32**
Emerging Mkt Equity	1.70	1.74	**1.83**
REITS	0.88	1.01	**2.08**
B	0.68	0.60	**0.64**
D	0.72	0.70	**0.99**
Betas	**Theoretical**	**1993–2007**	**2008**
U.S. Bonds	0.14	–0.03	**0.10**
International Equity	0.77	0.86	**1.20**
Emerging Mkt Equity	0.76	1.04	**1.54**
REITS	0.48	0.34	**1.68**
B	0.65	0.53	**0.64**
D	0.65	0.64	**0.95**
Real Returns	**Theoretical**	**1993–2007**	**2008**
U.S. Equity	7.25%	7.59%	**–36.76%**
U.S. Bonds	3.75%	3.70%	**4.66%**
International Equity	7.25%	7.05%	**–42.87%**
Emerging Mkt Equity	9.25%	9.24%	**–52.97%**
REITS	6.50%	9.40%	**–36.81%**
B	5.85%	6.35%	**–22.07%**
D	6.50%	7.42%	**–31.06%**
D vs. B	0.65%	1.07%	**–8.99%**

Source: Morgan Stanley Research.

CONCLUSION

During "normal times," our theory suggests that diversified and traditional portfolios should share similar portfolio betas. The actual betas of Portfolios B, C, and D over the 1993–2007 period verified this assessment, as they and the portfolios' theoretical beta projections, were all quite similar.

Although diversified and traditional portfolios have similar risks in normal times, in severely declining markets the tightening of correlations should theoretically make diversified portfolios more vulnerable to stress-betas. The year 2008 provided an opportunity to test this hypothesis with empirical data. In 2008, the diversified Portfolio D's beta of 0.95 was indeed far higher than Portfolio B's beta of 0.64 and accounted for the majority of Portfolio D's 9% underperformance relative to Portfolio B with its 60/40 allocation.

Counterpoints to these findings can be made. First, diversified portfolios have sources of expected return above and beyond those associated with the beta relationship. Over time, these incremental returns should accumulate and provide a sizable cushion against beta-based and other forms of risk. Second, the initial correlations embedded in the covariance matrix are based primarily on short-term price changes, but over longer-term periods the correlations may be quite different. For example, the relationship between developed and emerging equity markets may be quite tight in a sudden downward price move. Over the long term, however, regional decoupling could lead the two markets to evolve in very different fashions with an emerging market allocation then serving as a powerful long-term diversifier.

These findings do not apply to all possible types of portfolio diversification—only those with betas greater than 0.5. Certainly, potential diversification structures exist that could lead to lower betas and reduced volatility risks. Such low-beta portfolio diversifications are rarely seen, however, among U.S. institutions. For a variety of reasons, most institutional allocations seem to have portfolio betas of 0.55 to 0.65, placing them squarely in the "beta-dominated" region.

In the short run, the most problematic risk for a typical institutional fund is a sudden, severe decline in asset value. Such an adverse event is almost surely associated with deterioration in the equity market. To the extent that the feared correlation tightening does occur, it may well be the more-diversified funds that—ironically—will experience the higher betas and the lower returns.

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