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ASSET ALLOCATION AND FUND PERFORMANCE OF DEFINED BENEFIT PENSION FUNDS IN THE UNITED STATES BETWEEN 1998-2011

Performance differences among defined benefit pension funds in the U.S. primarily result from differences in the asset allocation decisions they make. Between 1998 and 2011, large corporate sector funds distinguished themselves by having a much higher net return compared to public sector and small and mid-sized corporate sector funds. They achieved this by radically altering their allocations just prior to the Global Financial Crisis. The key decision was a timely increase in their allocation to long duration fixed income funded through a decrease in allocation to U.S. large cap stock. Interestingly, pension funds could have achieved similar results by having a meaningful allocation to equity REITs and/or other real assets (i.e., infrastructure, commodities, etc.) which, on average, they did not have.



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Asset Allocation and Fund Performance of Defined Benefit Pension Funds in the United States between 1998-2011

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1 Executive Summary

Of the \$18.8 trillion of retirement assets in the United States at the end of the third quarter of 2013, \$6.8 trillion was held and managed in traditional defined benefit (DB) pension plans, including endowments and foundations.¹ Millions of Americans rely on returns from these investments for current or future retirement incomes. Funding levels of DB plans came under severe pressure during the Global Financial Crisis, putting in jeopardy the financial security of current and future retirees. In such an environment, the investment allocation decisions of DB pension plan managers take on the utmost importance.

The performance of any investment portfolio is determined primarily by three factors: the allocation of investments across the available asset classes; the total returns generated from investments available within each asset class; and the costs of deploying assets through each investment. With respect to the allocation of investments across the available asset classes, nearly all DB pension plans hold diversified portfolios that include corporate equities and fixed income securities. Many of these plans also invest in other asset classes, including commodities, real estate, timber, infrastructure and private equity. The portfolio allocations, returns, and costs of investing in the available asset classes vary widely across plans, leading to pronounced differences in the investment performance of DB plans.

This study uses realized investment performance information of U.S. DB pension funds over the sample period 1998-2011, rather than investment performance information as measured by broad asset class benchmarks, and examines how that realized performance has been influenced by the asset allocation decisions of the funds. The results are derived from CEM Benchmarking Inc.'s unique database which contains detailed information regarding asset allocation, investment performance and investment expenses for large, global institutional investors beginning in 1990. The starting date for the study is 1998, chosen to coincide with the addition to the database of publicly traded real estate in the form of stock exchange-listed equity REITs. As a separate and distinct investment alternative within the real estate asset class, having information with respect to the investment performance and expense of listed equity REITs provides a more complete comparison of the consequences of portfolio allocations to real estate investment through both listed and private alternatives, not unlike the data available for both listed and private equity investments. The end of the sample period is limited to 2011 for performance comparisons

¹ Retirement assets are reported by the Investment Company Institute as of September 30, 2013. The \$6.8 trillion of retirement assets held in defined benefit plans excludes assets of the Federal employees' defined benefit and defined contribution plans. Another \$5.8 trillion of retirement assets are held in defined contribution plans, including 401(k) plans, and the remaining \$6.2 trillion of retirement assets are held in individual retirement plans, consisting predominantly of individual retirement accounts (IRAs), including traditional, rollover and Roth IRAs.

because that is the last year for which private real estate returns are available after standardizing for the usual lag and appraisal smoothing in the reporting of these investment returns.²

1.1 Asset class performance

Over the 14-year sample period 1998-2011, there were striking differences in performance across asset classes, both year-by-year and over the entire period. As summarized in Table ES1, private equity posted the highest average annual gross total return of 13.31 percent. Listed equity REITs were the second best performing asset class over the period, with an average annual gross total return of 11.82 percent. It is noteworthy that this period includes the experience of the Global Financial Crisis and its aftermath.

Of greater importance to investors, however, are the returns earned net of investment costs and fees, which vary widely across asset classes. Fixed income investments generally had the lowest costs, at 17 basis points per year on average for both U.S. broad fixed income and U.S. long fixed income. Costs for U.S. other fixed income and non-U.S. fixed income were at least twice as high. Listed equity investments, including real estate equity through stock

Table ES1. Standardized aggregate asset class annual net total returns for U.S. public and corporate sector DB pension funds spanning 1998-2011. Private real estate and private equity have been standardized for differences in reporting lag and smoothing (see Section 4). Also included are the average annual gross returns (Gross Ret.), average annual investment costs (Inv. Cost) in basis points, average annual net returns (Net Ret.), annualized average compounded net return (Net Comp. Ret.), standard error on averaged annual net return (Std. Err.), and the standard deviation or volatility of annual net returns (Std. Dev.).

†Average annual gross returns and average annual net returns are the arithmetic average annual gross and net total returns, and do not reflect the effects of compounding.

‡The standard deviation of the aggregate asset class Real Assets: Other has been significantly reduced from that of its components due to imperfect aggregation (*i.e.*, diversification).

Table ES1. Standardized Aggregate Asset Class Net Total Returns for U.S. Public and Corporate DB Pension Funds

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------------------|-----------------|-----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|--------|-----------------|----------------|
| | U.S. Large Cap. | U.S. Small Cap. | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA/Hedge Funds | Private Equity |
| 2011 | 0.81% | -3.08% | -12.61% | 8.51% | 21.80% | 3.89% | 4.56% | 9.23% | 2.74% | -1.47% | 0.37% | -4.38% |
| 2010 | 16.19% | 26.35% | 12.42% | 8.73% | 11.07% | 5.56% | 13.33% | 15.75% | 23.53% | 10.80% | 9.19% | 29.47% |
| 2009 | 29.60% | 33.64% | 39.38% | 11.86% | 4.37% | 13.42% | 19.96% | 23.50% | 29.74% | 5.44% | 14.50% | 38.77% |
| 2008 | -37.97% | -37.66% | -44.40% | 0.02% | 13.96% | -5.55% | -8.80% | -39.70% | -38.63% | -9.26% | -18.26% | -38.89% |
| 2007 | 5.86% | 2.19% | 14.29% | 6.50% | 7.68% | 4.83% | 7.81% | -17.16% | -10.81% | 13.93% | 7.73% | 7.94% |
| 2006 | 14.43% | 14.66% | 25.56% | 4.80% | 2.71% | 5.69% | 7.75% | 13.68% | 34.86% | 14.86% | 10.75% | 29.43% |
| 2005 | 6.74% | 7.17% | 16.72% | 3.15% | 5.99% | 3.32% | 1.88% | 18.17% | 14.15% | 19.19% | 6.87% | 3.18% |
| 2004 | 11.97% | 16.78% | 19.64% | 5.29% | 9.09% | 4.86% | 10.08% | 26.32% | 32.52% | 18.16% | 6.84% | 19.49% |
| 2003 | 30.82% | 43.11% | 37.55% | 6.10% | 6.87% | 8.55% | 17.74% | 14.85% | 33.15% | 9.39% | 13.91% | 28.11% |
| 2002 | -21.45% | -18.94% | -14.12% | 9.38% | 15.23% | 2.29% | 14.01% | 11.52% | 5.29% | 9.32% | -12.87% | -22.46% |
| 2001 | -9.84% | -1.29% | -17.28% | 8.14% | 6.60% | 4.56% | 2.00% | 4.84% | 10.94% | 4.56% | -4.69% | -1.17% |
| 2000 | -5.08% | 0.43% | -12.24% | 11.45% | 16.16% | 6.31% | 4.73% | 3.50% | 25.89% | 18.95% | 1.78% | 3.34% |
| 1999 | 19.11% | 29.10% | 38.24% | -0.68% | -7.86% | 5.52% | 1.21% | 13.90% | 1.07% | 22.30% | 9.59% | 34.78% |
| 1998 | 23.63% | 3.10% | 12.09% | 8.54% | 11.90% | 6.11% | 10.73% | 8.10% | -6.12% | 1.78% | 21.10% | 27.79% |
| Gross Ret.†: | 6.29% | 8.81% | 8.67% | 6.73% | 9.14% | 5.29% | 8.06% | 8.73% | 11.82% | 10.88% | 6.02% | 13.31% |
| Inv. Cost. (bps): | 22.9 | 55.5 | 44.3 | 17.3 | 17.4 | 34.1 | 42.0 | 112.6 | 51.6 | 102.6 | 125.1 | 238.3 |
| Net Ret.†: | 6.06% | 8.25% | 8.23% | 6.56% | 8.97% | 4.95% | 7.64% | 7.61% | 11.31% | 9.85% | 4.77% | 11.10% |
| Net Comp. Ret.: | 4.14% | 6.10% | 5.18% | 6.49% | 8.75% | 4.88% | 7.39% | 6.01% | 9.17% | 9.50% | 4.23% | 8.56% |
| Std. Err.: | 0.01% | 0.02% | 0.01% | 0.01% | 0.06% | 0.01% | 0.04% | 0.03% | 0.05% | 0.89% | 0.06% | 0.07% |
| Std. Dev.: | 18.81% | 20.58% | 24.02% | 3.65% | 6.85% | 3.88% | 7.26% | 16.48% | 20.17% | 8.63%‡ | 10.35% | 22.02% |

² The investment returns of private real estate reported to CEM Benchmarking suffer from both reporting lags and appraisal smoothing, which affect their contemporaneous correlation with the returns of listed equity REITs and other asset classes. This analysis adjusts the reported returns for both reporting lags and appraisal smoothing, and includes these “standardized” returns in Table ES1. After such standardization, the returns of private real estate investments and the returns of listed equity REITs have a contemporaneous correlation of over 85 percent. Such a result is not surprising because both investments primarily own and generate their investment returns from the same underlying assets, income-producing commercial real estate. See Section 4 for a complete discussion with respect to calculating standardized returns.

exchange-listed equity REITs, had the next lowest costs, ranging from 23 basis points per year on average for U.S. large cap equity, to 52 basis points for listed equity REITs and 56 basis points for U.S. small cap equity. Costs for private real estate, other real assets, TAA/hedge funds and private equity were significantly higher, ranging from 103 basis points per year to 238 basis points per year.

After accounting for the costs of investing, listed equity REITs recorded an average annual net return of 11.31 percent, the highest average annual net return of any asset class over the sample period, reflecting a combination of both relatively high gross returns and relatively low investment costs. Private equity investments fell to second place in terms of average annual net total returns as a result of having the highest costs among all 12 investments but still handily outperformed listed equity investments. Private real estate investments, however, trailed listed equity REITs by 370 basis points per year due to their significantly lower gross returns as well as their relatively high investment costs. Listed equity REIT annual net returns were about 20 percent more volatile than private real estate returns over the sample period.³

Unlike private real estate, which underperformed its publicly traded counterpart listed equity REITs over the sample period, private equity outperformed listed equities. After standardizing private equity for approximately one quarter of return reporting lag, the asset class is seen to outperform large cap U.S. stock and small cap U.S. stock by 504 and 285 basis points respectively in terms of average annual net returns. The difference in average annual net return between private equity and, for example, small cap U.S. stocks was driven by significant differences in annual net return in only a handful of years, specifically in 2006 and 1998, when private equity outperformed, and in 2003, when it underperformed. Indeed, after standardizing the annual net returns for reporting lag, public equity and private equity exhibit excellent tracking with correlations to private equity in excess of 0.92 in the case of small cap U.S. stock and 0.96 in the case of large cap U.S. stock.

An intriguing aspect of these findings is that the standardization of returns for private equity and private real estate, both for reporting lags and, in the case of private real estate appraisal smoothing, reveals a high contemporaneous correlation of returns with the corresponding returns from investments in listed markets. This suggests the widespread belief that there are significant diversification benefits available for long-term investors through private assets is largely an artifact of the reporting lags. By simply accounting for lags in the reporting of data, one finds that the returns from private assets were highly correlated with returns from other investments in the portfolio and did not provide significant diversification benefits that weren't available in lower-cost, more liquid alternatives in the universe of investment opportunities.

Comparing asset class performance over the entire sample period, U.S. large cap stock, U.S. small cap stock, non-U.S. stock, and private equity all posted double-digit net total returns during several boom years of the 2000s, but suffered significant losses both in 2002 and during the Global Financial Crisis of 2008. Fixed income neither enjoyed the highs nor suffered the lows, with positive, typically single-digit returns nearly every year. Along with equities, listed equity REITs, private real estate, and other real assets (infrastructure, commodities, etc.) suffered similar, double-digit losses in 2008, but escaped the losses of 2002 associated with bursting of the tech bubble and the 2001 economic recession.

1.2 Asset allocations

As summarized in Table ES2, total stock investments across all corporate and public sector plans constituted the largest asset class over the sample period 1998-2011, accounting for on average 58.0 percent of assets under management (AUM). Total fixed income across all plans was the second-largest asset class, with 31.5 percent of

³ A recent study of private asset returns by CEM Benchmarking Inc. covering the universe of funds (*i.e.*, not limited to U.S. DB pension funds) demonstrated that, after controlling for leverage, regional biases, fund specific reporting lag, and idiosyncratic risk, private real estate underperformed a listed equity REIT benchmark by 120 basis points annually over the period 1995-2011, while private equity outperformed a listed small cap equity benchmark by nine basis points annually over the period 1996-2012. See reference [1] for details of the private equity results.

AUM. The remainder of the average portfolio was invested in alternatives such as private real estate, listed equity REITs, infrastructure, hedge funds and private equity. Ironically, two of the best performing asset classes over the entire sample period – listed equity REITs and other real assets – had the lowest average asset allocations at less than one percent each.

There were major shifts in the asset allocation policies of both corporate sector and public sector plans over the sample period 1998-2011, although portfolio diversification strategies differed somewhat with respect to fund size. As shown in Table ES3, corporate sector plans reduced their average allocations to U.S. large cap equities and U.S. broad fixed income securities by 19.6 percentage points and 10.3 percentage points, respectively, with the largest declines having been among the largest plans, *i.e.*, those with total assets over \$10 billion. Over the same period, allocations to long duration U.S. bonds and hedge funds increased 16.9 percentage points and 5.0 percentage points, respectively, and again most dramatically among the largest plans. The appreciable shift of

Tables ES2 and ES3. Average asset allocation (ES2) and changes in average asset allocation (ES3) for U.S. public and corporate sector DB pension funds from 1998-2011 by size and fund type.

Table ES2. Average Asset Allocation of U.S. Public Sector and U.S. Corporate Sector DB Pension Funds 1998-2011.

| Aggregate Asset Class | Public Sector | | | | Corporate Sector | | | | All |
|--------------------------|---------------|------------|---------|--------|------------------|------------|---------|--------|--------|
| | < \$2B | \$2B-\$10B | > \$10B | All | < \$2B | \$2B-\$10B | > \$10B | All | |
| Stock: U.S. Large Cap | 34.0% | 30.9% | 36.1% | 33.6% | 37.0% | 36.1% | 29.7% | 35.3% | 34.4% |
| Stock: U.S. Small Cap | 7.9% | 6.3% | 3.7% | 5.8% | 8.3% | 5.4% | 3.8% | 6.3% | 6.0% |
| Stock: Non U.S. | 17.4% | 18.5% | 18.0% | 18.0% | 15.9% | 18.4% | 18.7% | 17.5% | 17.6% |
| Fixed Income: U.S. Broad | 26.4% | 24.4% | 24.2% | 24.8% | 21.4% | 19.6% | 17.8% | 19.9% | 22.1% |
| Fixed Income: Long | 0.1% | 0.2% | 0.2% | 0.1% | 5.3% | 6.1% | 7.7% | 6.1% | 3.8% |
| Fixed Income: U.S. Other | 2.0% | 4.8% | 4.1% | 4.0% | 3.2% | 3.1% | 3.8% | 3.3% | 3.6% |
| Fixed Income: Non U.S. | 3.2% | 2.9% | 1.9% | 2.6% | 1.4% | 1.4% | 2.0% | 1.5% | 2.0% |
| Private Real Estate | 3.6% | 4.0% | 4.7% | 4.1% | 2.4% | 2.4% | 4.2% | 2.7% | 3.3% |
| Listed Equity REITs | 1.0% | 0.6% | 0.9% | 0.8% | 0.5% | 0.5% | 0.6% | 0.5% | 0.6% |
| Other Real Assets | 0.3% | 0.8% | 0.2% | 0.5% | 0.3% | 0.5% | 0.5% | 0.4% | 0.4% |
| TAA / Hedge Funds | 2.4% | 3.5% | 1.4% | 2.4% | 2.5% | 3.2% | 4.2% | 3.1% | 2.8% |
| Private Equity | 1.7% | 3.1% | 4.5% | 3.4% | 1.8% | 3.4% | 7.1% | 3.5% | 3.4% |
| Total | 100% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Stock: Total | 59.3% | 55.8% | 57.9% | 57.3% | 61.2% | 59.9% | 52.2% | 59.1% | 58.0% |
| Fixed Income: Total | 31.7% | 32.2% | 30.4% | 31.5% | 31.3% | 30.2% | 31.3% | 30.8% | 31.5% |
| Other: Total | 9.0% | 11.9% | 11.7% | 11.1% | 7.5% | 9.9% | 16.5% | 10.2% | 10.5% |
| Total | 100% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Table ES3. Changes in Asset Allocation of U.S. Public Sector and U.S. Corporate Sector DB Pension Funds 1998-2011.

| Aggregate Asset Class | Public Sector | | | | Corporate Sector | | | | All |
|--------------------------|---------------|------------|---------|--------|------------------|------------|---------|--------|--------|
| | < \$2B | \$2B-\$10B | > \$10B | All | < \$2B | \$2B-\$10B | > \$10B | All | |
| Stock: U.S. Large Cap | -19.6% | -21.8% | -18.5% | -18.7% | -17.0% | -19.3% | -23.7% | -19.6% | -19.2% |
| Stock: U.S. Small Cap | -0.2% | -2.8% | 1.2% | -0.8% | -0.7% | 0.1% | -1.0% | -1.1% | -0.9% |
| Stock: Non U.S. | 11.5% | 13.4% | 10.4% | 11.0% | 1.9% | 1.2% | -0.8% | 1.6% | 5.0% |
| Fixed Income: U.S. Broad | -11.0% | -16.1% | -8.1% | -11.0% | -9.4% | -8.6% | -15.3% | -10.3% | -11.1% |
| Fixed Income: Long | 0.0% | 0.4% | 0.0% | 0.1% | 15.4% | 15.1% | 23.9% | 16.9% | 11.6% |
| Fixed Income: U.S. Other | 3.5% | 5.2% | 4.0% | 4.4% | 2.4% | 2.6% | 2.6% | 2.5% | 3.1% |
| Fixed Income: Non U.S. | 0.7% | 0.9% | -0.1% | -0.2% | 2.1% | 1.1% | 0.6% | 1.4% | 0.7% |
| Private Real Estate | 3.0% | 3.0% | 1.8% | 2.7% | 0.1% | 0.4% | -0.5% | 0.3% | 1.0% |
| Listed Equity REITs | 0.6% | 0.3% | 0.2% | 0.4% | 0.2% | -0.1% | -0.3% | 0.0% | 0.1% |
| Other Real Assets | 1.9% | 2.4% | 0.9% | 1.4% | 0.6% | 1.6% | 1.3% | 1.2% | 1.3% |
| TAA / Hedge Funds | 5.2% | 9.0% | 2.4% | 4.6% | 4.6% | 4.0% | 8.4% | 5.0% | 4.9% |
| Private Equity | 4.4% | 6.1% | 5.7% | 6.0% | -0.2% | 2.1% | 4.8% | 2.1% | 3.5% |
| Total | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Stock: Total | -8.2% | -11.2% | -6.9% | -8.5% | -15.8% | -18.0% | -25.5% | -19.1% | -15.1% |
| Fixed Income: Total | -6.8% | -9.6% | -4.2% | -6.6% | 10.5% | 10.1% | 11.9% | 10.5% | 4.3% |
| Other: Total | 15.1% | 20.8% | 11.0% | 15.1% | 5.3% | 7.9% | 13.6% | 8.6% | 10.8% |
| Total | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

assets among corporate plans from U.S. large cap equities to long duration U.S. bonds is consistent with a liability driven investment (LDI) policy. This shift was not gradual, but emerged rather suddenly circa 2007 among corporate plans of all sizes (see Section 5).

Table ES4. Average annualized compound net returns spanning 1998-2011 by fund type, fund size, and above/below average asset allocation to each aggregate asset class. (Standard errors on the 14-year average compounded net return are shown in brackets to enable comparisons.) The net returns have been calculated from standardized aggregate asset class returns. n/a indicates that for at least one of the 14 years, no funds had the requisite characteristics of the screen. Of the 225 screens appearing in the table, 211 yield full 14-year time series. Of the 144 screens specific to public or corporate sectors, the three fund size ranges, and 24 above/below average asset allocation, 132 yielded complete 14-year time series. Of these 132, those ranked in the top-20 by Z-score are highlighted in green, while those in the bottom-20 are highlighted in red. (See Table 8 for the two lists.)

Table ES4. Average Annualized 14-Year Compound Net Total Returns for U.S. DB Pension Funds Grouped by Type, Size and Above/Below Average Asset Allocation

| | Public Sector | | | | Corporate Sector | | | | | | |
|------------------------------------|------------------------------------|-----------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | < \$2B | \$2B-\$10B | > \$10B | All | < \$2B | \$2B-\$10B | > \$10B | All | All | | |
| Above Average Asset Allocation to: | Stock: U.S. Large Cap | 5.89% (0.24%) | 5.86% (0.17%) | 6.01% (0.16%) | 6.01% (0.11%) | 5.99% (0.24%) | 6.21% (0.24%) | 5.36% (0.37%) | 6.08% (0.16%) | 6.02% (0.10%) | |
| | Stock: U.S. Small Cap | 6.03% (0.21%) | 6.19% (0.17%) | 6.29% (0.21%) | 6.18% (0.12%) | 6.48% (0.28%) | 6.69% (0.28%) | 7.42% (0.33%) | 6.62% (0.20%) | 6.43% (0.12%) | |
| | Stock: Non U.S. | 6.00% (0.21%) | 6.17% (0.18%) | 6.34% (0.14%) | 6.18% (0.10%) | 6.90% (0.45%) | 6.92% (0.26%) | 7.24% (0.25%) | 6.98% (0.20%) | 6.62% (0.12%) | |
| | Fixed Income: U.S. Broad | 6.32% (0.22%) | 6.13% (0.22%) | 6.08% (0.19%) | 6.23% (0.13%) | 6.07% (0.27%) | 6.35% (0.23%) | 7.21% (0.40%) | 6.38% (0.18%) | 6.37% (0.12%) | |
| | Fixed Income: U.S. Long | n/a | n/a | n/a | n/a | 7.71% (0.43%) | 8.42% (0.81%) | n/a | 8.34% (0.53%) | 8.20% (0.46%) | |
| | Fixed Income: U.S. Other | n/a | 6.21% (0.19%) | 5.98% (0.22%) | 6.15% (0.15%) | 6.50% (0.41%) | 6.21% (0.22%) | 7.54% (0.35%) | 6.60% (0.19%) | 6.44% (0.12%) | |
| | Fixed Income: Non U.S. | 5.68% (0.21%) | 6.34% (0.22%) | 6.56% (0.28%) | 6.23% (0.15%) | 6.60% (0.34%) | 7.16% (0.49%) | 7.52% (0.34%) | 7.03% (0.23%) | 6.66% (0.15%) | |
| | Private Real Estate | 5.70% (0.25%) | 6.23% (0.18%) | 6.43% (0.15%) | 6.23% (0.11%) | 6.63% (0.39%) | 6.83% (0.25%) | 7.38% (0.30%) | 6.85% (0.21%) | 6.51% (0.13%) | |
| | Listed Equity REITs | 5.43% (0.26%) | 6.42% (0.34%) | 6.14% (0.17%) | 6.11% (0.16%) | 6.78% (0.34%) | 7.55% (0.38%) | 7.54% (0.34%) | 7.16% (0.23%) | 6.63% (0.15%) | |
| | Other Real Assets | n/a | 6.32% (0.21%) | n/a | 6.29% (0.17%) | n/a | n/a | n/a | n/a | 6.46% (0.18%) | |
| | TAA / Hedge Funds | 5.38% (0.29%) | 6.04% (0.21%) | 6.64% (0.27%) | 6.18% (0.19%) | 6.34% (0.36%) | 7.21% (0.30%) | 6.84% (0.31%) | 6.93% (0.22%) | 6.72% (0.17%) | |
| | Private Equity | n/a | 6.36% (0.22%) | 6.59% (0.14%) | 6.38% (0.13%) | 7.12% (0.51%) | 7.38% (0.32%) | 7.52% (0.25%) | 7.39% (0.22%) | 6.97% (0.15%) | |
| | Below Average Asset Allocation to: | Stock: U.S. Large Cap | 6.08% (0.25%) | 6.51% (0.21%) | 6.47% (0.18%) | 6.39% (0.13%) | 7.24% (0.38%) | 7.58% (0.32%) | 7.89% (0.26%) | 7.54% (0.21%) | 7.18% (0.14%) |
| | | Stock: U.S. Small Cap | 5.95% (0.37%) | 6.37% (0.24%) | 6.12% (0.15%) | 6.19% (0.12%) | 6.65% (0.33%) | 6.92% (0.25%) | 7.51% (0.28%) | 6.96% (0.17%) | 6.75% (0.12%) |
| Stock: Non U.S. | | 6.10% (0.26%) | 6.29% (0.23%) | 6.07% (0.19%) | 6.18% (0.14%) | 6.38% (0.23%) | 6.84% (0.27%) | 7.55% (0.48%) | 6.72% (0.17%) | 6.57% (0.12%) | |
| Fixed Income: U.S. Broad | | 5.15% (0.24%) | 6.42% (0.19%) | 6.35% (0.13%) | 6.21% (0.11%) | 6.98% (0.37%) | 7.37% (0.32%) | 7.78% (0.30%) | 7.34% (0.21%) | 6.88% (0.13%) | |
| Fixed Income: U.S. Long | | 5.91% (0.18%) | 6.23% (0.15%) | 6.20% (0.13%) | 6.17% (0.09%) | 6.19% (0.23%) | 6.54% (0.21%) | 7.12% (0.37%) | 6.46% (0.14%) | 6.35% (0.09%) | |
| Fixed Income: U.S. Other | | 6.00% (0.20%) | 6.23% (0.19%) | 6.30% (0.16%) | 6.20% (0.11%) | 6.52% (0.28%) | 7.16% (0.26%) | 7.61% (0.38%) | 6.95% (0.18%) | 6.70% (0.12%) | |
| Fixed Income: Non U.S. | | 6.23% (0.24%) | 6.18% (0.18%) | 6.05% (0.14%) | 6.19% (0.11%) | 6.56% (0.26%) | 6.75% (0.22%) | 7.59% (0.36%) | 6.75% (0.17%) | 6.62% (0.11%) | |
| Private Real Estate | | 6.13% (0.23%) | 6.27% (0.20%) | 5.91% (0.18%) | 6.15% (0.12%) | 6.57% (0.25%) | 6.87% (0.28%) | 7.86% (0.40%) | 6.84% (0.18%) | 6.70% (0.12%) | |
| Listed Equity REITs | | 6.29% (0.22%) | 6.20% (0.16%) | 6.28% (0.17%) | 6.23% (0.11%) | 6.57% (0.26%) | 6.68% (0.23%) | 7.62% (0.33%) | 6.76% (0.16%) | 6.62% (0.11%) | |
| Other Real Assets | | 5.98% (0.19%) | 6.16% (0.16%) | 6.20% (0.13%) | 6.16% (0.09%) | 6.52% (0.23%) | 6.87% (0.22%) | 7.48% (0.30%) | 6.80% (0.15%) | 6.60% (0.10%) | |
| TAA / Hedge Funds | | 6.09% (0.19%) | 6.15% (0.18%) | 6.16% (0.14%) | 6.17% (0.10%) | 6.53% (0.25%) | 6.74% (0.25%) | 7.98% (0.37%) | 6.78% (0.16%) | 6.57% (0.10%) | |
| Private Equity | | 6.07% (0.18%) | 6.21% (0.18%) | 5.88% (0.18%) | 6.09% (0.11%) | 6.31% (0.22%) | 6.49% (0.24%) | n/a | 6.42% (0.16%) | 6.38% (0.11%) | |
| All | | 6.01% (0.18%) | 6.26% (0.14%) | 6.21% (0.13%) | 6.19% (0.09%) | 6.53% (0.22%) | 6.85% (0.20%) | 7.54% (0.25%) | 6.84% (0.14%) | 6.61% (0.09%) | |

Public sector plans also reduced on average their allocations to U.S. large cap equities (by 18.7 percentage points) and to U.S. broad fixed income (by 11.0 percentage points), although the reductions in both cases were somewhat larger for mid-sized plans. Unlike corporate sector plans, however, the allocation to long duration U.S. bonds among public plans was notably unchanged over the period as public sector plans did not embrace LDI to the degree of their corporate sector counterparts. Public plans on average increased their allocations primarily to non-U.S. equities (by 11.0 percentage points), TAA/hedge funds (by 4.6 percentage points) and private equity (by 6.0 percentage points).

1.3 Realized plan performance

As summarized in the bottom row of Table ES4, large corporate sector plans were the best performing among all major pension fund cohorts classified by fund type and fund size, achieving an average annualized compound net return of 7.54 percent over the period 1998-2011, significantly outperforming the 6.61 percent of all funds combined. The outperformance appears due almost entirely to the shift of assets at the large corporation plans from U.S. large cap stocks into long duration U.S. bonds beginning in 2007, just before the Global Financial Crisis, as many large corporate plans apparently implemented investment policies consistent at least in part with LDI strategies.

Table ES4 also aggregates fund performance for fund cohorts classified by fund type, fund size and whether their asset allocations to the 12 asset classes were above or below the average asset allocation of all funds over the entire 14-year period. Based on their Z-scores, Table ES4 also identifies the top-20 and bottom-20 performing cohorts. Among the top-20 performing cohorts – shown in green – all are corporate sector plans, and 16 of the top-20 are large plans having assets exceeding \$10 billion. Among the bottom-20 performing cohorts – shown in red – 19 are public sector plans, and all but one are either in the large or small cohort. The one corporate sector fund cohort in the bottom-20 is large plans with above average allocations to U.S. large cap stocks.

The average annualized compound net returns by cohort ranged from a high of 8.42 percent for mid-sized corporate sector plans with above average allocations to long duration U.S. bonds to a low of 5.15 percent for small public sector plans with below average allocations to U.S. broad fixed income. A performance difference of 327 basis points per year amounts to a fund either doubling or more than tripling its assets over the 14-year period of our study.

1.4 Impact of asset allocation on plan performance

The net returns realized by any pension fund are affected by the allocation of investments across the available asset classes, the returns generated from investments available within each asset class, and the costs of deploying assets through each investment. As revealed in the data shown above, pension plans have made a wide range of asset allocation choices, and different assets have performed quite differently both year-to-year and over the longer sample period 1998-2011. The impact of any particular asset class on total portfolio returns, of course, must be considered in light of the allocations made to other asset classes and the comparative returns of those other investments. For example, small public sector plans with *above* average allocations to listed equity REITs over the period posted an average annualized compound portfolio net return of 5.43 percent, whereas small public plans with *below* average allocations to listed equity REITs posted an average annualized compound portfolio net return of 6.29 percent, even though listed equity REITs as an asset class posted the highest average annual net total return of 11.31 percent.

The reason for this seeming paradox, of course, is that significantly larger allocations to other asset classes dominated the impact on overall portfolio returns. For small public sector plans with above average allocations to listed equity REITs, the underperformance of assets with much larger allocations over the period more than offset the portfolio gains from the allocation to REITs. To provide a clearer indication of the marginal effect of a particular asset choice on overall portfolio returns, we analyzed the impact on portfolio net total returns that would have been realized from a one percentage point change in the allocations to each asset class.

To determine the potential impact of a shift in asset allocations on portfolio net total returns over the period 1998-2011, Table ES5 provides estimates for each year of the marginal benefit or loss of a one percentage point increase in the portfolio weight for each of the main asset classes, with the average annual impact shown in the bottom row. The estimates reveal that U.S. long duration fixed income, listed equity REITs, and other real assets (infrastructure, commodities, etc.) would have provided the largest marginal increases to total portfolio annualized average net returns of 4.4 basis points, 3.9 basis points, and 3.8 basis points per year, respectively, for each percentage point increase in allocation over a period that includes the Global Financial Crisis. To put this in perspective, an average size U.S. public sector fund having had 1998 assets of a little over \$15 billion and a 14-year compound net total return of approximately 6.19 percent (from Table ES4) would have generated an additional \$180 million in assets over the 14-year period had its investment policy allocated an extra one percentage point of assets to listed equity REITs.

Other portfolio allocation shifts that would have appreciably increased portfolio net total returns over the period include reduced exposure to U.S. large cap equities (2.9 basis points per year for a one percentage point *lower* allocation), increased exposure to private equity (2.8 basis points per year for a one percentage point *higher* allocation), and reduced exposure to TAA/hedge funds (2.1 basis points per year for a one percentage point *lower* allocation).

The average aggregate portfolio in 1998 closely resembled the canonical “60/40” model of allocations to equities and fixed income. Many funds improved their diversification in recent years by increasing their allocations to alternative assets that have provided attractive returns and that have had lower correlations with U.S. large cap equities. Many other funds, however, have not undertaken meaningful portfolio diversification strategies and continue to forego the potential diversification benefits available to them. Assuming that most, if not all, of the investment performance attributes among and between the major asset classes observed in the past remain approximately intact, the analysis presented here demonstrates that embracing more completely the portfolio diversification opportunities available to pension funds should reasonably be expected to increase net portfolio returns and reduce portfolio volatility over the moderate- to long-term investment horizons that are relevant to such funds.

In sum, this study of the actual investment results of U.S. DB pension funds finds that the asset class with the

Table ES5. Estimates in basis points of the marginal benefit or loss to the average annual portfolio net total return resulting from a one percentage point increase in allocation to each of the aggregate asset classes by year. The total impact is an estimate of the benefit (or loss) to the average annualized compound net total returns over the period 1998-2011 of a persistent, one percentage point increase to each of the aggregate asset classes relative to the all fund average allocation. Note that, by symmetry, a one percentage point decrease in allocation has an equal and opposite loss (or benefit).

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|---------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -1.7 | -5.4 | -18.2 | 7.5 | 22.5 | 1.9 | 2.5 | 7.4 | 0.6 | -3.6 | -1.9 | -6.9 |
| 2010 | 3.1 | 13.2 | -1.8 | -6.2 | -3.1 | -8.8 | -0.6 | 1.9 | 9.7 | -3.1 | -5.0 | 16.4 |
| 2009 | 7.3 | 9.9 | 18.6 | -15.5 | -21.6 | -11.5 | -4.4 | -0.8 | 5.5 | -19.0 | -10.2 | 15.3 |
| 2008 | -18.2 | -13.3 | -23.6 | 31.5 | 41.8 | 20.5 | 16.6 | -15.3 | -13.6 | 16.0 | 7.1 | -14.4 |
| 2007 | -1.2 | -4.8 | 9.5 | -0.2 | 1.0 | -1.9 | 1.1 | -24.8 | -17.6 | 7.3 | 1.1 | 1.3 |
| 2006 | -0.1 | 0.2 | 13.8 | -12.1 | -12.0 | -9.1 | -6.8 | -0.8 | 20.6 | 0.4 | -3.8 | 15.4 |
| 2005 | -2.0 | -0.9 | 10.7 | -6.2 | -2.0 | -4.9 | -6.2 | 10.5 | 6.2 | 11.2 | -1.2 | -5.0 |
| 2004 | -0.9 | 4.5 | 8.6 | -9.2 | -3.5 | -8.0 | -2.5 | 14.1 | 20.1 | 5.6 | -5.8 | 7.1 |
| 2003 | 10.0 | 19.8 | 15.6 | -24.1 | -17.9 | -16.7 | -6.9 | -10.0 | 8.7 | -15.2 | -10.8 | 3.7 |
| 2002 | -20.5 | -11.0 | -6.5 | 24.7 | 24.2 | 11.2 | 23.0 | 20.8 | 13.9 | 17.9 | -4.4 | -14.3 |
| 2001 | -9.4 | 2.9 | -15.8 | 16.6 | 10.7 | 8.7 | 6.1 | 9.1 | 15.0 | 8.5 | -0.7 | 2.9 |
| 2000 | -7.9 | 0.7 | -14.4 | 15.8 | 16.5 | 6.6 | 5.0 | 3.8 | 26.2 | 19.2 | 2.0 | 3.7 |
| 1999 | 3.8 | 13.1 | 25.4 | -23.5 | -25.0 | -11.5 | -16.0 | -3.1 | -15.9 | 5.4 | -7.4 | 18.3 |
| 1998 | 13.8 | -13.3 | -4.1 | -9.6 | -3.8 | -9.7 | -5.0 | -7.7 | -21.9 | -13.9 | 5.6 | 12.4 |
| Totals: | -2.9 | 0.2 | -0.4 | 1.4 | 4.4 | -1.0 | 1.6 | 0.4 | 3.9 | 3.8 | -2.1 | 2.8 |

highest average annual gross total return over the period 1998-2011 was private equity, followed by listed equity REITs and other real assets. Investment costs, however, weighed heavily on the returns to private equity, while the low costs of investing in listed equity REITs contributed to REITs having had the highest net returns over the period. Gross returns on private real estate lagged gross returns of listed equity REITs due in part to sector and leverage differences, but the high costs of investing in private real estate widened the gap between net returns even further. Moreover, standardizing returns to correct for reporting lags and appraisal smoothing reveals a high correlation between the returns from REITs and returns from private real estate, and between large and small cap stocks and private equity, demonstrating that much of the diversification thought to be gained through private markets is largely an artifact of the valuation process.

The following sections of the paper describe in more detail the CEM Benchmarking Inc. database (Section 2); the methodology for aggregating detailed investment data into high-level asset classes (Section 3); the net return characteristics by aggregate asset class, including the standardization adjustments to account for private market reporting lags and appraisal smoothing (Section 4); asset allocations according to type and size of plan, as well as their trends over time (Section 5); and fund performance by type, size and allocation (Section 6). Section 7 concludes.

2 The CEM Database: An Overview

The CEM database contains detailed information regarding asset allocation, investment costs, and investment returns, both gross and net of costs, for over 900 large institutional investors, some as far back as 1990. Participating funds include defined benefit (DB) pension funds, defined contribution (DC) pension funds, sovereign wealth funds and endowment funds situated in Australia, Canada, the Netherlands, the U.S., the U.K., et al. Funds participate in the CEM investment benchmarking service in order to benchmark their investment costs against their peers. While some funds enter and exit the database over time, the database remains largely free of bias with respect to investment return performance [2] because performance does not motivate fund participation.

A particularly valuable attribute of the CEM database is the detailed investment cost data that support comparative studies of asset class returns net of investment costs, the true measure of returns received by investors. The costs collected include (but are not limited to) manager base fees, manager-of-manager fees, commitment fees and performance fees, along with the usual costs associated with running an investment team (salaries and benefits for staff, travel, research, IT, etc.). Where costs cannot be separated from returns, they are netted from 'gross' returns. This level of detail allows for a separation of those costs directly associated with an investment and those not directly associated with an investment (*e.g.*, oversight costs of the pension fund, actuarial costs, etc.). The net returns studied here are net only of those costs directly associated with an investment.

Prior studies of DB pension fund performance using the CEM database have focused on a number of topics, including: abnormal returns of domestic equity [2], outperformance of large funds relative to small funds by virtue of increased focus on alternatives including private equity and private real estate [3], outperformance of large funds relative to benchmarks of large funds due to market timing and security selection [4], and value added by large funds through private markets [5], noting that larger funds invest primarily in direct real estate but also are more likely than smaller funds to hold complementary investments in REITs, whereas smaller funds are more likely than larger funds to invest only in direct real estate.

This study's focus is on the connections between asset allocation and fund performance of U.S. public sector and corporate sector DB pension funds spanning 1998-2011. We chose 1998 as the starting point for our study as it coincides with the introduction of several new asset classes in the CEM Benchmarking Inc. database - among them stock exchange-listed equity REITs and hedge funds - which were previously included with other, broader, asset classes within the database. Thus, the analysis is more in tune with the myriad of asset classes available to pension funds today.

Summary data for total fund holdings are shown for U.S. public sector DB funds in Table 1A and for U.S. corporate sector DB funds in Table 1B. The holdings for a particular fund and year represent the average holdings over that year and not the holdings at year end. When funds choose not to provide their average holdings over a year, CEM estimates the average by averaging the start- and end-of-year holdings. A comparison of the two tables shows that the average public sector plan is significantly larger than the average corporate sector plan within the database.

Summary data for total fund net returns on investments are shown for public sector funds in Table 2A (left-hand set of columns) and for corporate sector funds in Table 2B (left-hand set of columns). Total fund net returns are net of all investment costs but are a composite measure of returns from physical assets, which is of primary concern for our study, as well as from overlay strategies (derivatives), which are not. A comparison of the two tables demonstrates that the smaller, corporate sector funds outperformed their larger, public sector counterparts over the period 1998-2011 by a significant margin, 6.22 percent vs. 5.55 percent, or 67 basis points, with the outperformance concentrated in a handful of years (1999, 2002, 2008, and 2011).

To remove from total fund net returns the performance component derived from overlays - in order to compare returns arising from asset allocation alone - net returns for each fund are re-calculated from their reported asset class net returns along with their weightings. Summary data for calculated total fund, physical asset only, net returns are shown for public sector funds in Table 2A (middle set of columns) and for private sector funds in Table 2B (middle set of columns). Here again we observe outperformance of corporate sector funds over their public sector counterparts, 6.91 percent vs. 6.33 percent, or 58 basis points.

The third set of columns in Tables 2A and 2B show the final set of calculated, physical asset only, net returns that

Tables 1A and 1B. Assets under management (AUM) for U.S. public sector pension funds (top) and U.S. corporate sector pension funds (bottom) in the CEM database between 1998 and 2011. AUM are expressed in millions of dollars. (The 2007 increase in corporate sector DB funds was a result of a partnership between CEM and an external organization).

Table 1A. Assets Under Management: U.S. Public Sector DB Pension Funds

| Year | # | Avg. | Std. Dev. | Min. | Q1 | Med. | Q3 | Max. | Total |
|------|----|----------|-----------|-------|---------|----------|----------|-----------|-------------|
| 2011 | 59 | \$30,360 | \$42,765 | \$867 | \$4,747 | \$13,224 | \$35,744 | \$225,228 | \$1,791,240 |
| 2010 | 69 | \$23,752 | \$36,904 | \$813 | \$3,098 | \$9,547 | \$23,992 | \$215,814 | \$1,638,888 |
| 2009 | 68 | \$21,151 | \$33,329 | \$320 | \$2,746 | \$7,720 | \$21,682 | \$195,277 | \$1,438,268 |
| 2008 | 72 | \$24,622 | \$39,946 | \$117 | \$2,985 | \$8,359 | \$22,659 | \$222,415 | \$1,772,784 |
| 2007 | 80 | \$21,893 | \$39,146 | \$621 | \$2,735 | \$7,260 | \$21,519 | \$244,224 | \$1,751,440 |
| 2006 | 70 | \$23,503 | \$37,180 | \$422 | \$3,427 | \$7,842 | \$22,232 | \$216,422 | \$1,645,210 |
| 2005 | 71 | \$18,764 | \$33,047 | \$393 | \$2,502 | \$6,186 | \$17,659 | \$194,502 | \$1,332,244 |
| 2004 | 75 | \$17,713 | \$30,497 | \$369 | \$2,354 | \$5,591 | \$15,592 | \$175,296 | \$1,328,475 |
| 2003 | 75 | \$15,355 | \$25,423 | \$325 | \$2,173 | \$5,372 | \$14,389 | \$147,383 | \$1,151,625 |
| 2002 | 74 | \$14,805 | \$25,158 | \$223 | \$1,629 | \$5,120 | \$14,221 | \$142,563 | \$1,095,570 |
| 2001 | 83 | \$15,237 | \$26,403 | \$147 | \$1,821 | \$5,460 | \$13,472 | \$158,116 | \$1,264,671 |
| 2000 | 80 | \$17,268 | \$30,780 | \$502 | \$2,006 | \$5,595 | \$12,859 | \$167,867 | \$1,381,440 |
| 1999 | 83 | \$16,050 | \$28,422 | \$305 | \$1,586 | \$4,868 | \$12,316 | \$161,527 | \$1,332,150 |
| 1998 | 68 | \$15,185 | \$25,993 | \$290 | \$1,542 | \$5,184 | \$12,831 | \$139,921 | \$1,032,580 |

Table 1B. Assets Under Management: U.S. Corporate Sector DB Pension Funds

| Year | # | Avg. | Std. Dev. | Min. | Q1 | Med. | Q3 | Max. | Total |
|------|-----|---------|-----------|-------|---------|---------|---------|-----------|-----------|
| 2011 | 123 | \$7,695 | \$12,475 | \$37 | \$1,624 | \$3,174 | \$8,321 | \$93,529 | \$946,485 |
| 2010 | 120 | \$7,274 | \$12,058 | \$34 | \$1,381 | \$2,778 | \$7,742 | \$85,991 | \$872,880 |
| 2009 | 122 | \$6,552 | \$11,417 | \$160 | \$1,296 | \$2,527 | \$6,563 | \$86,296 | \$799,344 |
| 2008 | 129 | \$6,321 | \$12,101 | \$78 | \$1,266 | \$2,479 | \$5,820 | \$94,962 | \$815,409 |
| 2007 | 121 | \$7,178 | \$12,920 | \$90 | \$1,688 | \$3,155 | \$7,402 | \$102,587 | \$868,538 |
| 2006 | 64 | \$9,422 | \$17,293 | \$424 | \$1,864 | \$3,721 | \$9,189 | \$117,534 | \$603,008 |
| 2005 | 69 | \$8,865 | \$14,270 | \$375 | \$1,984 | \$3,597 | \$9,024 | \$89,299 | \$611,685 |
| 2004 | 79 | \$7,509 | \$12,939 | \$37 | \$1,591 | \$3,344 | \$7,300 | \$85,437 | \$593,211 |
| 2003 | 73 | \$7,165 | \$12,311 | \$56 | \$1,367 | \$2,567 | \$6,031 | \$77,223 | \$523,045 |
| 2002 | 68 | \$7,386 | \$11,540 | \$82 | \$1,559 | \$2,857 | \$7,002 | \$62,327 | \$502,248 |
| 2001 | 81 | \$6,885 | \$11,759 | \$26 | \$1,318 | \$2,884 | \$6,525 | \$71,636 | \$557,685 |
| 2000 | 73 | \$7,540 | \$13,168 | \$123 | \$1,207 | \$2,483 | \$7,015 | \$76,600 | \$550,420 |
| 1999 | 86 | \$5,898 | \$10,875 | \$128 | \$1,116 | \$1,933 | \$5,336 | \$74,550 | \$507,228 |
| 1998 | 92 | \$5,359 | \$10,158 | \$117 | \$997 | \$1,902 | \$4,064 | \$69,425 | \$493,028 |

Tables 2A and 2B. Average annual total fund returns net of all investment costs, average annual calculated physical-asset-only net returns, and average annual standardized physical-asset only net returns for U.S. public sector DB pension funds (Table 2A) and for U.S. corporate sector pension funds (Table 2B). 'Total Fund' net returns include returns from both physical assets (stocks, bonds, etc.) and overlays (derivatives); it is a fund's true time weighted annual return achieved from all investment activity. 'Physical Asset Only' net returns are the net returns calculated from each fund's average asset class allocations and each fund's average asset class true time weighted net return, and therefore excludes overlays. 'Standardized Physical Asset Only' net returns are calculated in identical fashion as 'Physical Asset Only' net returns with the exception that each fund's private real estate and private equity net returns are standardized for reporting lag and appraisal smoothing (See Section 4).

In-year standard errors are the standard deviations divided by the square root of the sample size. They indicate the 68% confidence interval around the in-year average (two standard errors provides the 95% confidence level). The average annualized 14-year compound net returns are shown at the bottom of the tables together with the standard error on the estimate, and the standard deviation of the annual returns (sometimes referred to as the volatility). We stress that the calculation is approximate because it ignores correlations between asset class weights and returns which accumulate between episodes of rebalancing. As such, the difference between total and calculated net returns should not be wholly attributed to returns from overlays. (The 2007 increase in corporate sector DB funds was a result of a partnership between CEM and an external organization).

Table 2A. Return Histories for U.S. Public Sector DB Pension Funds

| Year | # | Total Fund Net Returns | | | Physical Asset Only Net Returns | | | Standardized Physical Asset Only Net Returns | | |
|--------------------|----|------------------------|-----------|-----------|---------------------------------|-----------|-----------|--|-----------|-----------|
| | | Avg. | Std. Err. | Std. Dev. | Avg. | Std. Err. | Std. Dev. | Avg. | Std. Err. | Std. Dev. |
| 2011 | 59 | 0.93% | 0.21% | 1.59% | 1.05% | 0.21% | 1.58% | -0.21% | 0.21% | 1.61% |
| 2010 | 69 | 13.34% | 0.20% | 1.62% | 13.02% | 0.20% | 1.62% | 14.32% | 0.23% | 1.91% |
| 2009 | 68 | 19.95% | 0.52% | 4.26% | 21.56% | 0.52% | 4.28% | 26.77% | 0.40% | 3.29% |
| 2008 | 72 | -27.06% | 0.33% | 2.76% | -24.33% | 0.40% | 3.42% | -27.46% | 0.43% | 3.67% |
| 2007 | 80 | 8.42% | 0.19% | 1.70% | 8.39% | 0.20% | 1.81% | 6.38% | 0.19% | 1.69% |
| 2006 | 70 | 14.12% | 0.18% | 1.54% | 14.34% | 0.21% | 1.72% | 14.50% | 0.22% | 1.83% |
| 2005 | 71 | 8.46% | 0.20% | 1.72% | 8.64% | 0.23% | 1.94% | 8.07% | 0.20% | 1.66% |
| 2004 | 75 | 12.00% | 0.15% | 1.32% | 12.11% | 0.16% | 1.37% | 12.58% | 0.18% | 1.54% |
| 2003 | 75 | 22.96% | 0.33% | 2.89% | 23.53% | 0.33% | 2.82% | 24.25% | 0.33% | 2.86% |
| 2002 | 74 | -8.81% | 0.31% | 2.71% | -7.61% | 0.29% | 2.51% | -7.60% | 0.30% | 2.57% |
| 2001 | 83 | -4.23% | 0.27% | 2.44% | -3.81% | 0.27% | 2.48% | -3.36% | 0.27% | 2.45% |
| 2000 | 80 | 0.17% | 0.42% | 3.80% | 0.82% | 0.41% | 3.67% | -0.05% | 0.43% | 3.82% |
| 1999 | 83 | 14.38% | 0.45% | 4.10% | 16.12% | 0.51% | 4.67% | 16.16% | 0.51% | 4.65% |
| 1998 | 68 | 15.15% | 0.41% | 3.36% | 15.78% | 0.42% | 3.50% | 15.81% | 0.43% | 3.53% |
| Comp. Avg.: | | 5.55% | 0.09% | 12.76% | 6.33% | 0.09% | 12.40% | 6.19% | 0.09% | 13.63% |

Table 2B. Return Histories for U.S. Corporate Sector DB Pension Funds

| Year | # | Total Fund Net Returns | | | Physical Asset Only Net Returns | | | Standardized Physical Asset Only Net Returns | | |
|--------------------|-----|------------------------|-------|-----------|---------------------------------|-----------|-----------|--|-----------|-----------|
| | | Avg. | Std. | Std. Dev. | Avg. | Std. Err. | Std. Dev. | Avg. | Std. Err. | Std. Dev. |
| 2011 | 123 | 5.34% | 0.54% | 5.99% | 4.94% | 0.52% | 5.72% | 4.18% | 0.51% | 5.71% |
| 2010 | 120 | 13.45% | 0.18% | 1.92% | 13.13% | 0.18% | 2.01% | 14.14% | 0.20% | 2.23% |
| 2009 | 122 | 18.07% | 0.60% | 6.61% | 19.80% | 0.56% | 6.14% | 23.55% | 0.51% | 5.69% |
| 2008 | 129 | -23.82% | 0.77% | 8.72% | -21.50% | 0.74% | 8.36% | -23.68% | 0.74% | 8.41% |
| 2007 | 121 | 8.92% | 0.20% | 2.18% | 8.84% | 0.20% | 2.19% | 7.43% | 0.21% | 2.29% |
| 2006 | 64 | 13.81% | 0.20% | 1.61% | 14.03% | 0.23% | 1.82% | 14.16% | 0.24% | 1.90% |
| 2005 | 69 | 8.73% | 0.22% | 1.87% | 8.70% | 0.22% | 1.83% | 8.18% | 0.18% | 1.53% |
| 2004 | 79 | 12.22% | 0.18% | 1.59% | 12.27% | 0.19% | 1.65% | 12.65% | 0.20% | 1.81% |
| 2003 | 73 | 23.87% | 0.37% | 3.17% | 24.54% | 0.37% | 3.16% | 25.25% | 0.37% | 3.17% |
| 2002 | 68 | -10.44% | 0.40% | 3.28% | -9.42% | 0.39% | 3.18% | -9.59% | 0.39% | 3.20% |
| 2001 | 81 | -4.98% | 0.32% | 2.88% | -4.89% | 0.28% | 2.56% | -4.34% | 0.27% | 2.45% |
| 2000 | 73 | 1.14% | 0.67% | 5.76% | 1.87% | 0.80% | 6.86% | 0.71% | 0.75% | 6.42% |
| 1999 | 86 | 16.88% | 0.74% | 6.82% | 19.30% | 1.15% | 10.65% | 19.25% | 1.14% | 10.57% |
| 1998 | 92 | 14.89% | 0.34% | 3.29% | 15.56% | 0.37% | 3.58% | 15.75% | 0.38% | 3.69% |
| Comp. Avg.: | | 6.22% | 0.13% | 12.32% | 6.91% | 0.14% | 12.14% | 6.84% | 0.14% | 12.97% |

summarize the performance data used for the remainder of the study. The returns from the asset classes comprising private real estate and private equity have been standardized to account for reporting lags in private equity and private real estate, as well as appraisal smoothing in private real estate, so that meaningful comparisons can be made between asset classes accessible through both private and publicly traded markets, as we discuss in detail in Section 4. Despite differences in methodology, corporate sector funds are again seen to outperform their public sector counterparts, 6.84 percent to 6.19 percent, or 65 bps. The fact that the differences in overall, long-run returns are consistent, independent of how they are calculated (67 basis points, 59 basis points, or 65 basis points) serves to demonstrate that differences in asset allocation are the main driver of differences in performance.

We remark that a comparison of returns from one set of funds or asset classes to another requires error estimates on the averages (since the averages are statistics derived from distributions which may have quite different shapes). To aid comparisons, we calculate the standard error for each year – the standard deviation of the sample divided by the square root of the sample size – and propagate the errors via standard methods for calculated quantities (e.g., average annualized returns). The standard errors provided in our tables are 1σ errors (i.e., one standard error represents the range of values over which we have 67 percent confidence and two standard errors represents the range over which we have 95 percent confidence, etc.). It is important to note that the error on an average annualized net return is not a function of the volatility. The distinction here is an important one: the error estimate we use is the error on ‘what has happened’ while an error estimate based on the volatility would be an error estimate on a prediction of ‘what will happen’. In this article we make no claims about ‘what will happen’, only claims on ‘what has happened’.

3 Asset Class Aggregation and Net Return Characteristics

The CEM global database included 186 distinct asset classes as of 2011, of which U.S. pension funds reported actively investing in 104. Each of the distinct asset classes is defined by an asset type, an investment style (i.e., whether an investment is actively managed or managed passively to track an index), and whether the investments are managed by staff of the fund (internal) or by contracted third parties that are not directly employed by the fund (external). In the case of privately traded assets, the latter division is more complex, and includes whether assets are managed in-house, as co-investments, as fund-of-funds, by limited partnerships, or by wholly owned operating subsidiaries.

To make the study of net return performance manageable, we have aggregated the 104 asset classes actively used by U.S. pension funds into a much smaller set of 12 *aggregate asset classes*. A complete discussion of asset class aggregation, as well as a complete list of distinct asset classes included in the CEM global database and applicable to U.S. funds, appears in Appendix A. Here we provide only those details necessary for the topic at hand.

Our aggregation is based on four factors. The first three factors are centered on fitting the net return series for each of CEM’s global database asset classes to a simple linear model:

$$r_a = \alpha + \beta r_r,$$

where r_a is the net return of the asset class, r_r is the net return of a reference asset class, and α and β are the usual ‘excess return’ and ‘correlated volatility’ parameters used in investment benchmarking. (The implied meaning of the terms is not necessarily applicable here, but the model is useful nonetheless.) We have solved the equation using linear least squares for all 104 x 104 pairs of asset classes, yielding estimates of α , β , and the correlation coefficient ρ .

In general, we look to the linear model to illustrate three desirable qualities in the returns of an asset class and a reference asset class if they are to be aggregated together without meaningful distortion of the data. These three qualities are:

1. The ‘excess return’ parameter α should be near zero: if α is either large positive or large negative, then aggregation of the two asset classes will average out markedly different series of returns.
2. The ‘correlated volatility’ parameter β should be close to one: if β is not close to one, then aggregation of the two asset classes will average out markedly different series of returns while also causing a suppression of the volatility through diversification.
3. The correlation coefficient ρ should be close to one: if ρ is significantly less than one then the model fails to describe the relationship between the two series of net returns and estimates of α and β cannot be trusted.

A fourth factor is an *ad-hoc* one, based on data checking. For a handful of asset classes, none of the above criteria is strictly met, yet other widely-recognized characteristics of each of these asset classes imply that each one should belong to a particular aggregate asset class. All twelve private equity asset classes, for example, fall into this fourth category because they do not clearly align with the three qualities specified above. A detailed analysis, summarized later, demonstrates that, after standardization, the private equity aggregate asset classes in fact do align with all three qualities specified above.

Tables A1, A2 and A3 in Appendix A show the regression parameters α , β and ρ for 2,601 (51 x 51) pairs of asset classes. (We have not included in the tables those asset classes which had few invested assets and so would not meaningfully contribute to the net returns of any of the aggregate asset classes)⁴.

Along the top and sides of Tables 1-3 in Appendix A we list the 12 aggregate asset classes we use going forward. These 12 classes are:

1. Stock: U.S. large cap (*e.g.*, large cap equities appearing in the S&P 500)
2. Stock: U.S. small cap (*e.g.*, Russell 2000 small cap equities + mid cap equities)
3. Stock: non U.S. (*e.g.*, non U.S. equities such as EAFE and emerging market equities)
4. Fixed income: U.S. broad (*e.g.*, investment grade U.S. corporate bonds, U.S. Treasuries)
5. Fixed income: U.S. long bonds (*e.g.*, strategies dedicated to long duration bonds)
6. Fixed income: U.S. other (*e.g.*, non-investment grade bonds, mortgages, cash)
7. Fixed income: non U.S. (*e.g.*, non U.S. bonds)
8. Real Assets: Stock exchange-listed equity REITs (publicly traded real estate)
9. Real Assets: Private real estate (*e.g.*, direct real estate holdings, real estate limited partnerships)
10. Real Assets: Other (*e.g.*, commodities, infrastructure, natural resources)
11. Hedge funds / TAA (*e.g.*, hedge funds and tactical asset allocation teams)
12. Private equity (*e.g.*, venture capital, diversified private equity, private equity fund of funds)

Some salient features of our aggregation are the aggregations of fixed income: broad, fixed income: U.S. other, fixed income: non U.S., real assets: other, and private equity. Looking first at the 4 x 4 pairings of U.S. investment grade fixed income in Table 2 of Appendix A, where the asset class has been subdivided by active/passive investment styles and internal/external management, the β 's deviate significantly from one, especially between internal passive and external active mandates. These deviations are all caused by investment returns from 2008 when, for example, external active mandates suffered large losses in comparison with internal passive mandates, likely due to over-exposure to credits (which suffered large losses) by external active bond managers relative to their internal passive bond manager counterparts. Removing the 2008 data point results in small α 's, β 's near 1, and near perfect correlation, so we aggregated these four asset classes into a single aggregate asset class, fixed income: U.S. broad.

⁴ The curious reader may notice the lack of symmetry in three tables appearing in Appendix A (as well as in Tables 4A, 4B and 4C), where one might expect the ‘excess return’ α resulting from a regression of the returns from asset class 1 vs. the returns of asset class 2 to be equal and opposite to α' from a regression of the returns from asset class 2 vs. the returns from asset class 1. However, even where the correspondence between two asset classes is perfect and $\rho = 1$, $\alpha' = -\alpha/\beta$ and $\beta' = 1/\beta$. In realistic situations where $\rho \sim 1$, this quasi-symmetry is observed; where the correspondence is poor and $\rho \sim 0$ no quasi-symmetry should be expected.

Second, we aggregated TIPs, high yield bonds, mortgages and cash into a fixed income: U.S. other aggregate asset class. This aggregation leads to a relatively diverse aggregate asset class, but such a grouping is reasonably appropriate in order to limit the number of fixed income aggregate asset classes used in the analysis. We have checked that this aggregation is relatively robust with respect to our conclusions, and we note that this aggregate asset class is significantly less volatile than its components through diversification effects.

Third, fixed income: EAFE and fixed income: global show all the traits of a good asset aggregation, while fixed income: emerging does not. However, as emerging market fixed income represents less than 0.5 percent of the holdings of U.S. DB pension funds, we included the return data into a fixed income: non-U.S. aggregate asset class, with little impact on our conclusions.

Fourth, commodities, infrastructure, and other real assets have been rolled into a single aggregate asset class despite not sharing much in the way of similar net returns, akin to the situation experienced with fixed income U.S. other. Our choice is again driven by the importance of using a manageable number of meaningful aggregate asset classes in the analysis, together with the fact that total allocations to these asset classes are small. With an average allocation of 0.43 percent of assets under management, it is the smallest of the 12 aggregate asset classes we have defined. We remark that this aggregate asset class is significantly less volatile than its components through diversification effects.

Finally, the various private equity asset classes are the least to conform to the three desirable qualities we seek to identify using the linear model. As we will show later, however, the low correlation between the private equity asset classes owes largely to the significant reporting lag of net returns. When the data are standardized by removing the lag, private equity net returns are very similar to the net returns of the asset class stock: U.S. small cap, with $\alpha = 0.03$, $\beta = 0.98$, and $\rho = 0.92$.

4 Net Returns by Aggregate Asset Class of U.S. DB Pension Funds

Having aggregated assets into 12 manageable classes, we turn to the net returns of these aggregated asset classes. Aggregate asset class annual net returns for each fund are calculated as weighted averages of the component net returns, with weights equal to the fund's holdings in each component. These annual average aggregate net returns are then averaged over all funds invested in the aggregate asset class. We first look at net returns, as reported to CEM, covering 1998-2011. We then standardize the private real estate and private equity net returns in order to meaningfully compare them to the other aggregate asset classes and to each other. To standardize the returns, we adjust for the lags and smoothing embedded in the reported net returns that often result from the use of appraisals rather than current market prices. Finally, we present the standardized net returns covering 1998-2011 from which meaningful comparisons between aggregate asset classes can be made.

4.1 Reported net returns

The as reported average annual net returns for the 12 aggregate asset classes are shown in Figure 1, along with a summary of the results in Table 3. Also provided at the bottom of Table 3 are statistics summarizing the full time period. First is average annual gross return (Gross Ret.), followed by average annual investment cost (Inv. Cost.) and the average annual net return (Net Ret.). These three statistics are all simple averages of the data which insures that average gross return less average investment cost equals average net return. Following this is the average annualized compound net return (Net Comp. Ret.), the standard error on this estimate (Std. Err.), and the population standard deviation of the average annual returns, sometimes referred to as the volatility (Std. Dev.).

When comparing multi-year performance of the aggregate asset classes, neither the simple average net return nor the average annualized compound net return are perfect measures of performance with respect to the contribution of each aggregate asset class to a pension funds' portfolio net return. The vast majority of funds rebalance their portfolios more frequently than annually. Therefore, the magnitude of the contributions to total fund net return attributable to each aggregate asset class falls somewhere between the two measures.

Figure 1. Aggregate asset class annual net returns as reported to CEM Benchmarking by U.S. public and corporate sector DB pension funds spanning 1998-2011. The data have *not* been standardized for reporting lag (private real estate, private equity) or appraisal smoothing (private real estate).

Figure 1. As Reported Aggregate Asset Class Returns for U.S. Public and Corporate Sector DB Pension Funds

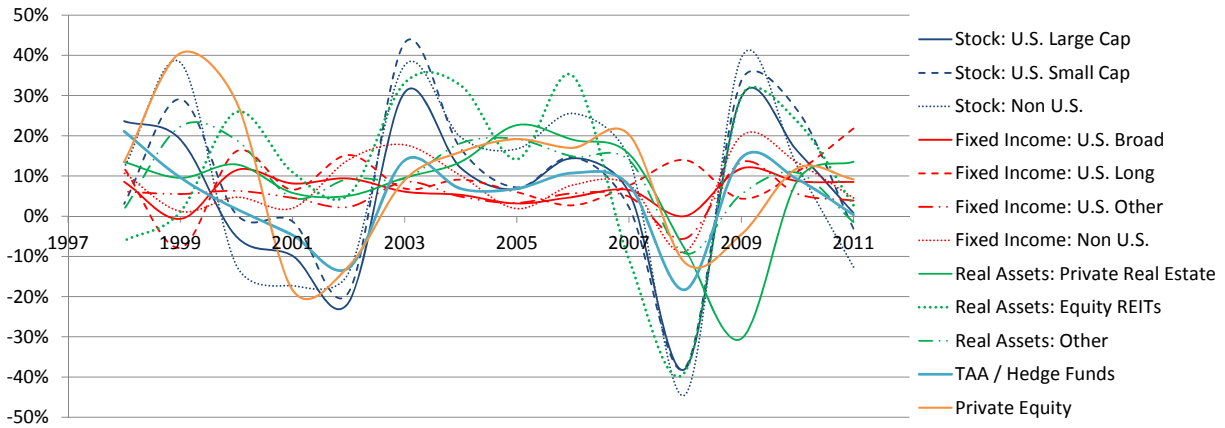


Table 3. Aggregate asset class annual net returns as reported to CEM Benchmarking by U.S. public and corporate sector DB pension funds spanning 1998-2011. Also included are the average annual gross returns (Gross Ret.), average annual investment costs (Inv. Cost) in basis points, average annual net returns (Net Ret.), annualized average compounded net returns (Net Comp. Ret.), standard error on averaged annual net returns (Std. Err.), and the standard deviation or volatility (Std. Dev.).

†Average annual gross returns and average annual net returns are the arithmetic average annual gross and net returns, and do not reflect the effects of compounding.

‡The standard deviation of the aggregate asset class Real Assets: Other has been significantly reduced from that of its components due to imperfect aggregation (*i.e.*, diversification).

Table 3. As Reported Aggregate Asset Class Net Returns for U.S. Public and Corporate Sector DB Pension Funds

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------------------|-----------------|-----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|--------|-----------------|----------------|
| | U.S. Large Cap. | U.S. Small Cap. | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA/Hedge Funds | Private Equity |
| 2011 | 0.81% | -3.08% | -12.61% | 8.51% | 21.80% | 3.89% | 4.56% | 13.55% | 2.74% | -1.47% | 0.37% | 9.18% |
| 2010 | 16.19% | 26.35% | 12.42% | 8.73% | 11.07% | 5.56% | 13.33% | 8.80% | 23.53% | 10.80% | 9.19% | 11.92% |
| 2009 | 29.60% | 33.64% | 39.38% | 11.86% | 4.37% | 13.42% | 19.96% | -30.47% | 29.74% | 5.44% | 14.50% | -4.54% |
| 2008 | -37.97% | -37.66% | -44.40% | 0.02% | 13.96% | -5.55% | -8.80% | -8.29% | -38.63% | -9.26% | -18.26% | -11.61% |
| 2007 | 5.86% | 2.19% | 14.29% | 6.50% | 7.68% | 4.83% | 7.81% | 15.46% | -10.81% | 13.93% | 7.73% | 20.27% |
| 2006 | 14.43% | 14.66% | 25.56% | 4.80% | 2.71% | 5.69% | 7.75% | 19.00% | 34.86% | 14.86% | 10.75% | 17.00% |
| 2005 | 6.74% | 7.17% | 16.72% | 3.15% | 5.99% | 3.32% | 1.88% | 22.66% | 14.15% | 19.19% | 6.87% | 19.17% |
| 2004 | 11.97% | 16.78% | 19.64% | 5.29% | 9.09% | 4.86% | 10.08% | 13.52% | 32.52% | 18.16% | 6.84% | 15.99% |
| 2003 | 30.82% | 43.11% | 37.55% | 6.10% | 6.87% | 8.55% | 17.74% | 9.56% | 33.15% | 9.39% | 13.91% | 8.99% |
| 2002 | -21.45% | -18.94% | -14.12% | 9.38% | 15.23% | 2.29% | 14.01% | 5.07% | 5.29% | 9.32% | -12.87% | -12.46% |
| 2001 | -9.84% | -1.29% | -17.28% | 8.14% | 6.60% | 4.56% | 2.00% | 5.82% | 10.94% | 4.56% | -4.69% | -18.32% |
| 2000 | -5.08% | 0.43% | -12.24% | 11.45% | 16.16% | 6.31% | 4.73% | 12.87% | 25.89% | 18.95% | 1.78% | 28.45% |
| 1999 | 19.11% | 29.10% | 38.24% | -0.68% | -7.86% | 5.52% | 1.21% | 9.54% | 1.07% | 22.30% | 9.59% | 40.52% |
| 1998 | 23.63% | 3.10% | 12.09% | 8.54% | 11.90% | 6.11% | 10.73% | 13.46% | -6.12% | 1.78% | 21.10% | 13.54% |
| Gross Ret.†: | 6.29% | 8.81% | 8.67% | 6.73% | 9.14% | 5.29% | 8.06% | 9.02% | 11.82% | 10.88% | 6.02% | 12.08% |
| Inv. Cost. (bps): | 22.9 | 55.5 | 44.3 | 17.3 | 17.4 | 34.1 | 42.0 | 112.6 | 51.6 | 102.6 | 125.1 | 238.3 |
| Net Ret.†: | 6.06% | 8.25% | 8.23% | 6.56% | 8.97% | 4.95% | 7.64% | 7.89% | 11.31% | 9.85% | 4.77% | 9.86% |
| Net Comp. Ret.: | 4.14% | 6.10% | 5.18% | 6.49% | 8.75% | 4.88% | 7.39% | 6.99% | 9.17% | 9.50% | 4.23% | 8.67% |
| Std. Err.: | 0.01% | 0.02% | 0.01% | 0.01% | 0.06% | 0.01% | 0.04% | 0.02% | 0.05% | 0.89% | 0.06% | 0.07% |
| Std. Dev.: | 18.81% | 20.58% | 24.02% | 3.65% | 6.85% | 3.88% | 7.26% | 12.73% | 20.17% | 8.63%‡ | 10.35% | 15.92% |

Of the aggregate asset classes, private equity recorded the highest average annual gross return at 12.08 percent, followed by real assets: listed equity REITs at 11.82 percent and real assets: other at 10.88 percent. After accounting for investment costs, however, real assets: listed equity REITs showed by far the highest average annual net return at 11.31 percent, followed by private equity at 9.86 percent and real assets: other at 9.85

percent⁵. In terms of average annualized compound net returns, real assets: other led at 9.50 percent, followed by real assets: listed equity REITs at 9.17 percent and fixed income: long bonds at 8.75 percent.

Notable in these results are both the outperformance of listed equity REITs compared with non-listed private real estate and the outperformance of private equity relative to large and small cap U.S. stock. Listed equity REITs outperformed private real estate by 342 basis points per year on an average annual net returns basis and 218 basis points per year on an annualized compound net returns basis. Private equity outperformed publicly traded small cap stocks by 161 basis points per year on an average annual net return basis and 257 basis points per year on an annualized compound net return basis. These results are consistent with the findings of other researchers despite significant differences in sample period and methodology, suggesting that the results may be quite general.⁶ Annual net returns from listed equity REITs were nearly 60 percent more volatile than net returns from private real estate, and net returns from listed small cap stocks were about 30 percent more volatile than net returns from private equity. However, net returns from both private equity and private real estate are affected by reporting lag, and in the case of private real estate, appraisal smoothing as well. Standardizing the returns of private market assets by accounting for these effects significantly changes these 'as reported' results.

4.2 Private real estate and REITs: reporting lag and appraisal smoothing

The data presented in Figure 1, and summarized in Table 3, show that private real estate net returns reacted differently than nearly every other asset class to the Global Financial Crisis. Where every other asset class (except long bonds) reported an immediate and pronounced loss in 2008, private real estate reported a much smaller loss in 2008 followed by a much larger loss in 2009 comparable to the losses reported by most other aggregate asset classes in 2008. This behavior is consistent with the data being subject to a lagged return and appraisal smoothing.

In Figure 2A, we show the as reported annual average net returns for the four listed equity REIT asset classes (internal active, internal passive, external active, external passive) together with as reported annual average net returns for four of the five private real estate asset classes (internal active, external active, fund-of-funds, and limited partnerships). (The return series for operating subsidiaries is insufficient to complete the analysis). Table 4A shows the 'excess return' parameters α , the 'correlated volatility' parameters β , and the correlation coefficient ρ for the as reported data. From the data it is evident that the as reported net returns from the four REIT asset classes are strongly correlated with one another, and similarly as reported net returns for the private real estate asset classes are also all correlated with one another. However, the two sets of net return series for listed equity REITs and private real estate appear not at all closely related.

The shapes of the curves appearing in Figure 2A suggest that private real estate returns stated in one year are actually the returns experienced in the prior year, not surprising given that the primary component of private real estate return volatilities are realized by fluctuations in property values, and property values are typically appraised on an annual basis. Removing this lag is a simple matter of offsetting the private real estate net returns by a year and results in the net return curves shown in Figure 2B. Restated fit parameters α , β , and ρ are displayed in Table 4B. All of the parameters between listed equity REITs and private real estate change significantly, especially the correlation coefficients which increase around eight fold. Clearly, the two sets of net returns are far more correlated than the as reported data reveal, and offer proof that the as reported private real estate data are

⁵ The standard error on the returns for the aggregate asset class real assets: other is much larger than for the other aggregate asset classes due to both imperfect aggregation (*i.e.*, greater relative disparity between returns of the asset classes being aggregated) and because of small sample size (*i.e.*, few funds have allocations to the asset class).

⁶ In the case of private real estate, Pagliari et. al. [7] found that on an as reported basis REITs outperformed the NCREIF private real estate index by 279 basis points over the period 1993-2001. In the case of private equity, Higson and Stucke [9] found that liquidated private equity funds outperformed the S&P 500 by 450 basis points over the period 1980-2000 while Harris et. al. [10] concluded that private equity leverage buyout funds outperformed the S&P 500 by "more than 3% annually" over the period 1984-2008.

lagged. Were the data not lagged, REIT returns would foreshadow private real estate returns, providing a “tell” on future market movements, which is unrealistic.

While applying a simple lag increases the correlation coefficient between listed equity REITs and private real estate, further improvements are made from de-smoothing private real estate returns. Smoothing refers to the well-known attribute of reported investment performance of private real estate where return series are serially correlated (*i.e.*, returns from one period are correlated with returns from prior periods). The effect is easily removed [6, 7] by applying a transfer function:

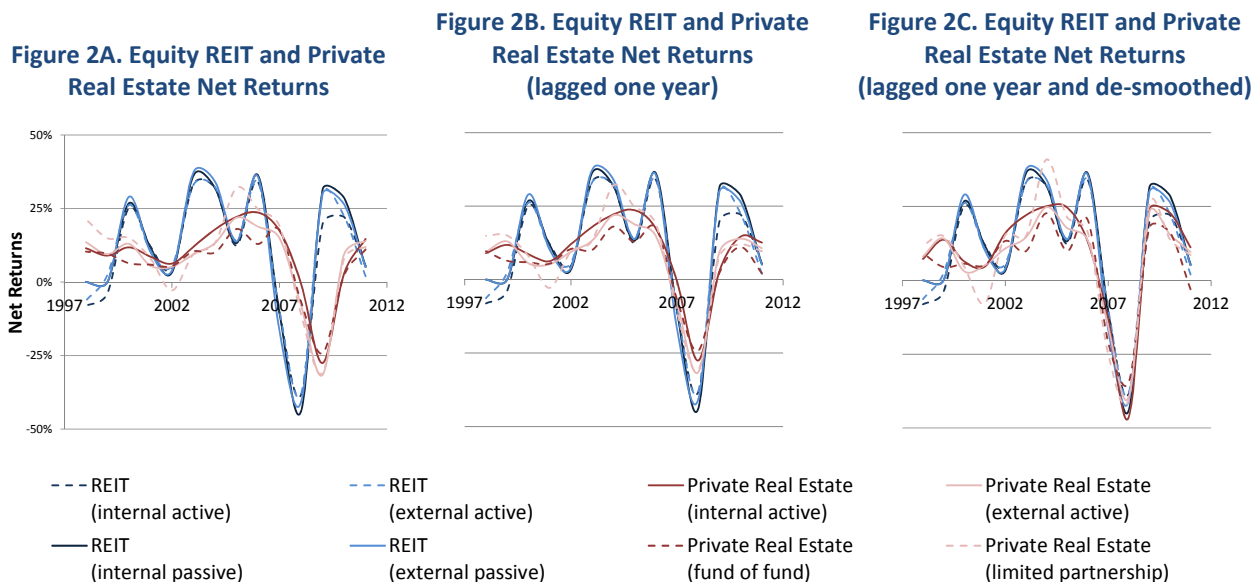
$$r_y = \gamma r_y^* + (1 - \gamma)r_{y-1}$$

where r_y^* is the actual (but unreported) return, r_y and r_{y-1} are the appraised returns that are reported during years y and $y - 1$, respectively, and γ is a smoothing parameter that takes a value between zero and one reflecting the appraiser’s confidence. The equation describes a smoothed return equal to a weighted average of the actual return (presumably known by the appraiser) and the appraised return of the prior period.

Since γ is an attribute of the appraiser, we should in principle determine its value on a fund-by-fund basis (or even a year-to-year and fund-by-fund basis). However, a sizeable fraction of the funds in the CEM dataset have not participated in the benchmarking service for all 14 years covered in this study, preventing such an analysis. Rather, we apply a constant γ to each of the four private real estate asset classes in order to estimate the actual returns of private real estate.

First, using parameters typical of other studies (0.3 – 0.5) is clearly unsatisfactory. For example, using $\gamma = 0.4$ results in a de-smoothed volatility for private real estate that is about 50 percent greater than that of listed equity

Figures 2A, 2B, and 2C. Listed equity REIT net returns and private real estate net returns for different management styles; internal passive (REITs only), internal active, external passive (REITs only), external active, fund of funds (private real estate only), and limited partnerships (private real estate only). Figure 2A shows data without adjustment. Figure 2B shows the same REIT data with private real estate net returns lagged one year (compare Table 5A with Table 5B where the correlation between REITs and private real estate increases 8-fold from this adjustment). Figure 2C shows the same REIT data with de-smoothed private real estate returns, also lagged one year. De-smoothing increases the correlation of net returns between REITs and private real estate and serves to eliminate serial correlation observed in the private real estate data. Note that: (i) near complete 2012 private real estate returns have been incorporated into Figures 2B and 2C; (ii) CEM does not have internal passive or external passive REIT returns for 1998 or 1999.



REITs, and produces losses in 2008 as large as 68 percent, which is unrealistic.

Another possible method of estimating γ is to maximize the correlation of net returns with listed equity REITs. Doing so yields estimates of $\gamma = 0.59, 0.75, 0.63,$ and 0.68 for private real estate managed internally, externally, by fund-of-funds, and by limited partnerships, respectively. For the entire private real estate aggregate asset class (which includes operating subsidiaries), maximizing correlation to the entire listed equity REIT aggregate asset class yields an estimate of $\gamma = 0.73$.

Further evidence that these parameters are reasonable is found in an analysis of serial correlation. While a full examination of serial correlation of the asset classes is far too large a subject to tackle here, we simply note that, whereas average annual listed equity REIT net returns show no serial correlation with the minimal lag of a year, private real estate does, strongly suggesting that the private real estate return data are substantially smoothed. Furthermore, the parameters quoted in the prior paragraph eliminate serial correlation of private real estate returns with this minimal lag of a year.

Table 4A, 4B, and 4C. Regression parameters α , β , and ρ between aggregate asset class net returns (horizontal) and reference aggregate asset class net returns (vertical) for listed equity REITs and private real estate. Table 4A shows regression parameters using as reported equity REITs and private real estate net returns. Table 4B shows regression parameters using private real estate net returns lagged one year and as reported equity REIT net returns. Table 4C shows regression parameters using de-smoothed, one-year lagged private real estate net returns and as reported equity REIT net returns. Asset class labels IP, IA, EP, EA, FF, and LP stand for the investment styles internal passive, internal active, external passive, external active, fund-of-funds, and limited partnerships respectively. See text for discussion.

Table 4A. Listed Equity REITs versus As Reported Private Real Estate

| | | Excess Return α | | | | | | | | Correlated Volatility β | | | | | | | | Correlation Coefficient ρ | | | | | | | |
|-----------------|-------|------------------------|-------|-------|-------|---------------------|-------|-------|-------|-------------------------------|------|------|-------|---------------------|------|------|------|--------------------------------|------|------|------|---------------------|------|------|------|
| | | REITs | | | | Private Real Estate | | | | REITs | | | | Private Real Estate | | | | REITs | | | | Private Real Estate | | | |
| | | IP | IA | EP | EA | IA | EA | FF | LP | IP | IA | EP | EA | IA | EA | FF | LP | IP | IA | EP | EA | IA | EA | FF | LP |
| Priv. Real Est. | REITs | 0.0% | 0.3% | -0.1% | 0.7% | 8.7% | 6.0% | 5.4% | 6.2% | 1.00 | 0.87 | 1.00 | 0.90 | 0.03 | 0.08 | 0.02 | 0.13 | 1.00 | 0.99 | 0.99 | 1.00 | 0.05 | 0.13 | 0.05 | 0.18 |
| | IA | 0.0% | 0.0% | -0.2% | 1.4% | 8.4% | 6.6% | 5.9% | 8.1% | 1.12 | 1.00 | 1.13 | 1.00 | 0.09 | 0.12 | 0.05 | 0.13 | 0.99 | 1.00 | 0.99 | 0.99 | 0.15 | 0.18 | 0.10 | 0.17 |
| | EP | 0.3% | 0.4% | 0.0% | 0.9% | 8.7% | 6.1% | 5.5% | 6.3% | 0.99 | 0.87 | 1.00 | 0.90 | 0.03 | 0.08 | 0.02 | 0.12 | 0.99 | 0.99 | 1.00 | 0.99 | 0.05 | 0.13 | 0.04 | 0.17 |
| | EA | -0.7% | -1.1% | -0.9% | 0.0% | 9.0% | 7.3% | 6.4% | 8.7% | 1.09 | 0.97 | 1.10 | 1.00 | 0.02 | 0.05 | 0.00 | 0.07 | 1.00 | 0.99 | 0.99 | 1.00 | 0.03 | 0.07 | 0.00 | 0.09 |
| | FF | 13.4% | 7.8% | 13.2% | 10.9% | 0.0% | -1.7% | -1.2% | -1.3% | 0.09 | 0.24 | 0.09 | 0.05 | 1.00 | 1.02 | 0.82 | 1.17 | 0.05 | 0.15 | 0.05 | 0.03 | 1.00 | 0.97 | 0.96 | 0.93 |
| | LP | 12.6% | 7.8% | 12.5% | 10.5% | 2.2% | 0.0% | 0.3% | 0.6% | 0.21 | 0.28 | 0.21 | 0.11 | 0.91 | 1.00 | 0.78 | 1.14 | 0.13 | 0.18 | 0.13 | 0.07 | 0.97 | 1.00 | 0.97 | 0.96 |
| | IA | 13.6% | 8.8% | 13.6% | 11.4% | 2.1% | 0.1% | 0.0% | 0.7% | 0.10 | 0.19 | 0.08 | -0.01 | 1.12 | 1.20 | 1.00 | 1.38 | 0.05 | 0.10 | 0.04 | 0.00 | 0.96 | 0.97 | 1.00 | 0.94 |
| | EA | 12.1% | 7.9% | 12.0% | 10.2% | 2.2% | 0.1% | 0.3% | 0.0% | 0.26 | 0.22 | 0.25 | 0.12 | 0.74 | 0.81 | 0.64 | 1.00 | 0.18 | 0.17 | 0.17 | 0.09 | 0.93 | 0.96 | 0.94 | 1.00 |

Table 4B. Listed Equity REITs versus One Year Lagged Private Real Estate

| | | Excess Return α | | | | | | | | Correlated Volatility β | | | | | | | | Correlation Coefficient ρ | | | | | | | |
|-----------------|-------|------------------------|-------|-------|------|---------------------|-------|-------|-------|-------------------------------|------|------|------|---------------------|------|------|------|--------------------------------|------|------|------|---------------------|------|------|------|
| | | REITs | | | | Private Real Estate | | | | REITs | | | | Private Real Estate | | | | REITs | | | | Private Real Estate | | | |
| | | IP | IA | EP | EA | IA | EA | FF | LP | IP | IA | EP | EA | IA | EA | FF | LP | IP | IA | EP | EA | IA | EA | FF | LP |
| Priv. Real Est. | REITs | 0.0% | 0.3% | -0.1% | 0.7% | 1.7% | -1.5% | -0.7% | -1.4% | 1.00 | 0.87 | 1.00 | 0.90 | 0.48 | 0.54 | 0.43 | 0.59 | 1.00 | 0.99 | 0.99 | 1.00 | 0.81 | 0.87 | 0.87 | 0.82 |
| | IA | 0.0% | 0.0% | -0.2% | 1.4% | 4.0% | 2.0% | 1.6% | 2.8% | 1.12 | 1.00 | 1.13 | 1.00 | 0.49 | 0.52 | 0.43 | 0.56 | 0.99 | 1.00 | 0.99 | 0.99 | 0.78 | 0.79 | 0.81 | 0.73 |
| | EP | 0.3% | 0.4% | 0.0% | 0.9% | 1.8% | -1.3% | -0.6% | -1.4% | 0.99 | 0.87 | 1.00 | 0.90 | 0.47 | 0.54 | 0.42 | 0.59 | 0.99 | 0.99 | 1.00 | 0.99 | 0.80 | 0.87 | 0.87 | 0.84 |
| | EA | -0.7% | -1.1% | -0.9% | 0.0% | 3.3% | 1.0% | 1.0% | 1.7% | 1.09 | 0.97 | 1.10 | 1.00 | 0.48 | 0.53 | 0.42 | 0.57 | 1.00 | 0.99 | 0.99 | 1.00 | 0.76 | 0.80 | 0.80 | 0.74 |
| | FF | 2.4% | -1.3% | 2.3% | 0.6% | 0.0% | -1.9% | -1.4% | -1.9% | 1.42 | 1.28 | 1.41 | 1.27 | 1.00 | 1.02 | 0.82 | 1.16 | 0.81 | 0.78 | 0.80 | 0.76 | 1.00 | 0.97 | 0.95 | 0.94 |
| | LP | 5.3% | 1.3% | 5.1% | 2.8% | 2.3% | 0.0% | 0.3% | 0.3% | 1.47 | 1.23 | 1.47 | 1.26 | 0.92 | 1.00 | 0.78 | 1.13 | 0.87 | 0.79 | 0.87 | 0.80 | 0.97 | 1.00 | 0.95 | 0.96 |
| | IA | 5.0% | 1.0% | 4.8% | 2.8% | 2.2% | 0.1% | 0.0% | 0.3% | 1.75 | 1.54 | 1.76 | 1.53 | 1.13 | 1.19 | 1.00 | 1.36 | 0.87 | 0.81 | 0.87 | 0.80 | 0.95 | 0.95 | 1.00 | 0.94 |
| | EA | 6.2% | 2.0% | 5.9% | 3.5% | 2.5% | 0.2% | 0.4% | 0.0% | 1.19 | 0.97 | 1.21 | 0.99 | 0.77 | 0.83 | 0.65 | 1.00 | 0.82 | 0.73 | 0.84 | 0.74 | 0.94 | 0.96 | 0.94 | 1.00 |

Table 4C. Listed Equity REITs versus De-Smoothed, One Year Lagged, Private Real Estate

| | | Excess Return α | | | | | | | | Correlated Volatility β | | | | | | | | Correlation Coefficient ρ | | | | | | | |
|-----------------|-------|------------------------|-------|-------|------|---------------------|-------|-------|-------|-------------------------------|------|------|------|---------------------|------|------|------|--------------------------------|------|------|------|---------------------|------|------|------|
| | | REITs | | | | Private Real Estate | | | | REITs | | | | Private Real Estate | | | | REITs | | | | Private Real Estate | | | |
| | | IP | IA | EP | EA | IA | EA | FF | LP | IP | IA | EP | EA | IA | EA | FF | LP | IP | IA | EP | EA | IA | EA | FF | LP |
| Priv. Real Est. | REITs | 0.0% | 0.3% | -0.1% | 0.7% | -2.8% | -3.7% | -3.9% | -4.7% | 1.00 | 0.87 | 1.00 | 0.90 | 0.79 | 0.69 | 0.66 | 0.80 | 1.00 | 0.99 | 0.99 | 1.00 | 0.88 | 0.89 | 0.91 | 0.83 |
| | IA | 0.0% | 0.0% | -0.2% | 1.4% | 1.4% | 0.6% | -0.6% | 0.4% | 1.12 | 1.00 | 1.13 | 1.00 | 0.76 | 0.65 | 0.65 | 0.76 | 0.99 | 1.00 | 0.99 | 0.99 | 0.81 | 0.79 | 0.84 | 0.75 |
| | EP | 0.3% | 0.4% | 0.0% | 0.9% | -2.5% | -3.5% | -3.8% | -4.7% | 0.99 | 0.87 | 1.00 | 0.90 | 0.78 | 0.68 | 0.66 | 0.81 | 0.99 | 0.99 | 1.00 | 0.99 | 0.87 | 0.88 | 0.91 | 0.85 |
| | EA | -0.7% | -1.1% | -0.9% | 0.0% | -0.3% | -0.9% | -1.9% | -1.4% | 1.09 | 0.97 | 1.10 | 1.00 | 0.79 | 0.68 | 0.66 | 0.80 | 1.00 | 0.99 | 0.99 | 1.00 | 0.83 | 0.83 | 0.86 | 0.78 |
| | FF | 5.9% | 2.3% | 5.8% | 3.7% | 0.0% | -0.6% | -1.0% | -1.0% | 1.01 | 0.87 | 1.00 | 0.91 | 1.00 | 0.86 | 0.77 | 1.00 | 0.88 | 0.81 | 0.87 | 0.83 | 1.00 | 0.98 | 0.92 | 0.93 |
| | LP | 7.2% | 3.2% | 7.0% | 4.5% | 1.0% | 0.0% | -0.5% | -0.5% | 1.18 | 0.97 | 1.18 | 1.03 | 1.13 | 1.00 | 0.90 | 1.19 | 0.89 | 0.79 | 0.88 | 0.83 | 0.98 | 1.00 | 0.94 | 0.96 |
| | IA | 7.5% | 3.7% | 7.3% | 5.2% | 2.3% | 1.1% | 0.0% | 0.7% | 1.25 | 1.09 | 1.26 | 1.12 | 1.14 | 1.02 | 1.00 | 1.23 | 0.91 | 0.84 | 0.91 | 0.86 | 0.92 | 0.94 | 1.00 | 0.92 |
| | EA | 8.5% | 4.3% | 8.2% | 5.6% | 2.2% | 1.0% | 0.2% | 0.0% | 0.89 | 0.74 | 0.91 | 0.78 | 0.86 | 0.77 | 0.71 | 1.00 | 0.83 | 0.75 | 0.85 | 0.78 | 0.93 | 0.96 | 0.92 | 1.00 |

Using these de-smoothing parameters on lagged private real estate data produces the annual net return time series shown in Figure 2C, with restated parameters α , β , and ρ appearing in Table 4C. The data demonstrates that, once private real estate net returns have been standardized for reporting lag and smoothing: (i) listed equity REIT returns are highly correlated with private real estate returns, since $\rho \sim 1$; (ii) listed equity REITs significantly outperform private real estate, since $\alpha > 0$; and (iii) listed equity REIT annual returns remain more volatile than private real estate, since $\beta > 1$.

4.3 Private equity and small cap U.S. stock: reporting lag

Private equity net returns show similar symptoms of reporting lag as do private real estate net returns, but there does not appear to be any noticeable smoothing of the private equity net returns. To see the lag, we first look at Table 3 in Appendix A, which reveals only moderate correlations between private equity and other asset classes. Intuitively, we expect that private equity net returns should correlate best with small cap U.S. equities, but Table 3 shows correlation coefficients among the various private equity and small cap stock asset classes of between only 0.30 and 0.60.

In Figure 3A we show a comparison of the aggregated private equity net returns with average annualized Russell 2000 index returns, calculated from the daily return series. The contemporaneous correlation between the two series is 0.31 which is not statistically significant. By contrast, the correlation between the annualized Russell 2000 net return series and our aggregated small cap U.S. stock series is in excess of 0.98.

By varying the starting date for annualizing the Russell 2000 returns, different annualized return series are obtained. As shown in Figure 3B, a plot of the correlation coefficient calculated by varying the starting date displays a peak at 80 days, at which the correlation between private equity and Russell 2000 returns exceeds 0.86, strongly suggestive that the reported net returns for private equity incorporate a lag relative to market pricing of roughly this length. A plot of the annualized Russell 2000 return series with the starting date lagged by 80 days is also shown in Figure 3A for direct visual comparison.

The same analysis for seven of twelve CEM private equity asset classes for which there are sufficiently long time series all show similar behaviour, with apparent lags of 80, 43, 80, 80, 92, 88, and 107 days. For all of these series a strong peak is observed in the correlation vs. lag, with the exception of internal active private equity: other (which

Figure 3A (left) and 3B (right). Figure 3A shows the annual reported private equity net returns vs. annual returns of the Russell 2000 small cap index, both with no lag and lagged 80 days (~ one quarter). As shown in Figure 3B, the correlation coefficient increases from 0.36 to 0.86 when the data are lagged 80 days.

Figure 3A. Comparison of Private Equity and Russell 2000 Net Returns

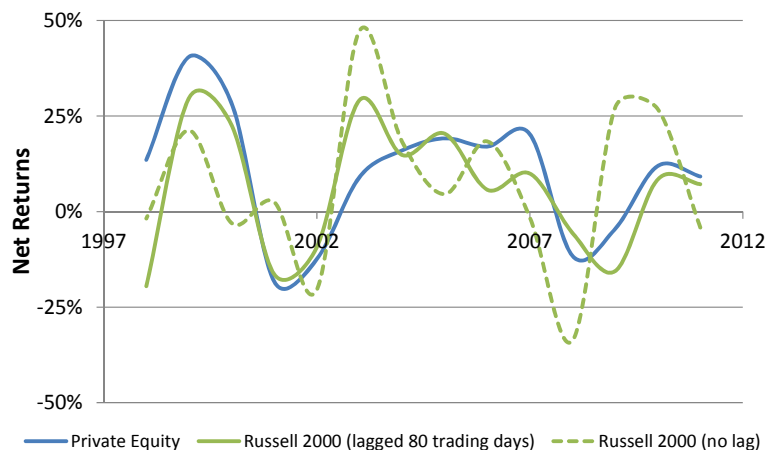
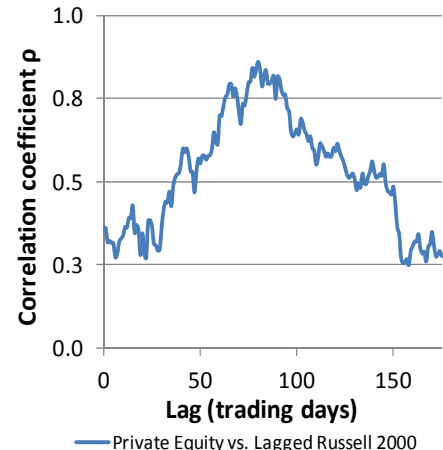


Figure 3B. Correlation vs. Lag



shows the lag of 43 days). Thus, while it is possible that internal active private equity: other does not incorporate a reporting lag, a lack of reporting lag for all of the other series seems impossible to reconcile with the data.

4.4 Standardized Net Returns

The discussion of reporting lag and appraisal smoothing in private real estate and private equity implies that the as reported net returns data appearing in Figure 1 and Table 3 are not the most informative returns for comparing average annual net returns across the aggregate asset classes, except for those returns from publicly traded assets. The reason for this should be clear: private real estate returns for, say, 2011 are actually an appraisal smoothed 2010 return (reflecting the reporting lag), which is itself a blend of actual returns from prior years (reflecting appraisal smoothing). Standardizing the 1998-2011 reported private real estate returns is straightforward, and with additional 2012 reported private real estate returns⁷ yields aggregate asset class return series covering 1998-2011. Doing so increases the correlation between the average annual net returns of our private real estate aggregate asset class and the average annual net returns of our listed equity REIT aggregate asset class from less than 0.11 to more than 0.85, but changes the average net return for private real estate over the same period only marginally, from 7.89 percent to 7.61 percent. The average annualized compound net return changes are more significant, moving from 6.99 percent to 6.01 percent due to the increased volatility resulting from de-smoothing of the data.

Standardizing the reported private equity returns is not as straightforward. For private equity, standardizing the reported returns is simplified by the fact that the data do not appear to suffer from appraisal smoothing, but is complicated by the fact that the reporting lag cannot be expressed in terms of calendar years. To standardize the reported private equity returns, we adjust the annualized private equity returns by the amount that annualized Russell 2000 daily returns are offset when the appropriate reporting lag is introduced. Doing so: (i) increases the correlation between private equity and U.S. small cap stock net returns from 0.44 to 0.92; (ii) increases the correlation between private equity and U.S. large cap stock net returns from 0.48 to 0.96; (iii) increases the average net return for private equity from 9.86 percent to 11.10 percent; and (iv) only marginally alters the average annualized compound net return, from 8.67 percent to 8.56 percent.

The standardized net returns used in the remainder of this study are shown in Figure 4 and Table 5. The aggregate asset class with the highest average annual net return remains listed equity REITs at 11.31 percent, followed by private equity at 11.10 percent and real assets: other at 9.85 percent. In terms of average annualized compound net return, real assets: other was highest at 9.50 percent, followed by listed equity REITs at 9.17 percent and fixed income: long bonds at 8.75 percent.

A comparison of the investment performance of listed equity REITs and standardized private real estate between 1998 and 2011 shows that REITs outperformed private real estate by 370 basis points on a simple average annual basis, and by 316 basis points on an average annualized compound basis, a significant disparity given DB pension funds' preference for investing in real estate through private markets, as discussed further in the following section. Indeed, the difference is nearly 75 times the standard error on the difference, making it extremely unlikely that the observed difference from 1998-2011 is a result of a bias within our sample (95 percent confidence at two times the standard error, 99 percent confidence at three times the standard error, etc.). We remark that our estimate of the difference (and our confidence placed on it) is an estimate of the difference in the return actually experienced by the universe of U.S. DB pension funds over the period (*i.e.*, what has happened) and not an estimate of future performance (*i.e.*, what will happen).

There are several possible reasons for the average difference in returns from publicly traded and private market real estate investments as experienced by U.S. DB pension funds. Likely reasons include geographical and property

⁷ At the time of our analysis, as reported returns for private real estate in 2012 were 99 percent complete, enabling our study to cover the sample period 1998-2011 after taking into account the one year of reporting lag for this aggregate asset class.

sector differences in the underlying real estate investments, as well as differences in the use of leverage. Indeed, prior studies [7, 8] of listed equity REIT and private real estate returns have emphasized the need to adjust for these differences in order to compare the performance of the underlying physical assets (*i.e.*, the properties). Still, while our results are not dissimilar from these other studies, even given the vastly different time periods studied,

Figure 4. Standardized aggregate asset class annual net returns for U.S. public and corporate sector DB pension funds spanning 1998-2011. Private real estate has been standardized for a one-year lag and appraisal smoothing while private equity has been standardized for approximately 80 days of lag (see Sections 4.2 and 4.3 for details).

Figure 4. Standardized Aggregate Asset Class Net Returns for U.S. Public and Corporate Sector DB Pension Funds

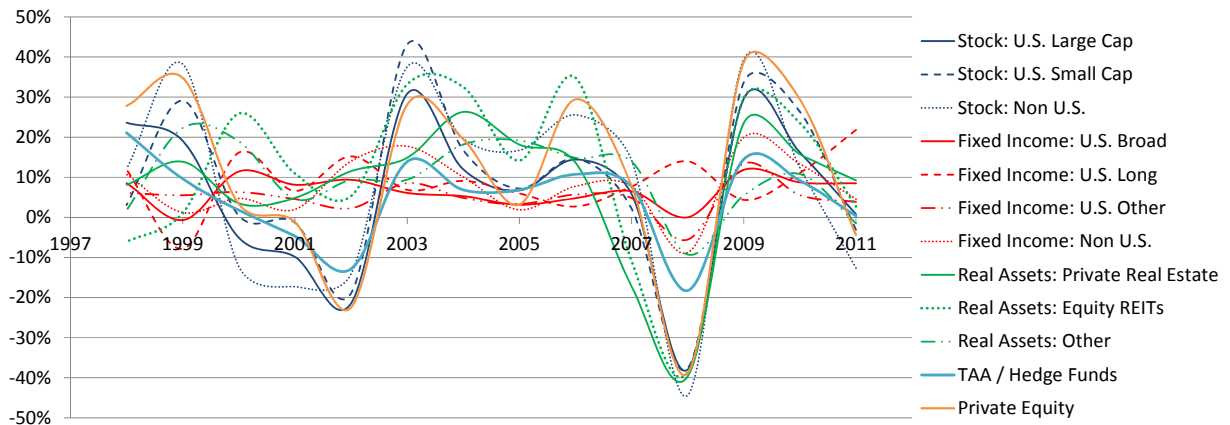


Table 5. Standardized aggregate asset class annual net returns for U.S. public and corporate sector DB pension funds spanning 1998-2011. (Private real estate and private equity reported returns have been standardized for differences in reporting lag and smoothing. See Sections 4.2 and 4.3). Also included are the average annual gross returns (Gross Ret.), average annual investment costs (Inv. Cost) in basis points, average annual net returns (Net Ret.), annualized average compounded net returns (Net Comp. Ret.), standard error on average annual net returns (Std. Err.), and the standard deviation or volatility (Std. Dev.).

†Average annual gross returns and average annual net returns are the arithmetic average annual gross and net returns, and do not reflect the effects of compounding.

‡The standard deviation of the aggregate asset class Real Assets: Other has been significantly reduced from that of its components due to imperfect aggregation (*i.e.*, diversification).

Table 5. Standardized Aggregate Asset Class Net Returns for U.S. Public and Corporate Sector DB Pension Funds

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------------------|-----------------|-----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|--------|-----------------|----------------|
| | U.S. Large Cap. | U.S. Small Cap. | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA/Hedge Funds | Private Equity |
| 2011 | 0.81% | -3.08% | -12.61% | 8.51% | 21.80% | 3.89% | 4.56% | 9.23% | 2.74% | -1.47% | 0.37% | -4.38% |
| 2010 | 16.19% | 26.35% | 12.42% | 8.73% | 11.07% | 5.56% | 13.33% | 15.75% | 23.53% | 10.80% | 9.19% | 29.47% |
| 2009 | 29.60% | 33.64% | 39.38% | 11.86% | 4.37% | 13.42% | 19.96% | 23.50% | 29.74% | 5.44% | 14.50% | 38.77% |
| 2008 | -37.97% | -37.66% | -44.40% | 0.02% | 13.96% | -5.55% | -8.80% | -39.70% | -38.63% | -9.26% | -18.26% | -38.89% |
| 2007 | 5.86% | 2.19% | 14.29% | 6.50% | 7.68% | 4.83% | 7.81% | -17.16% | -10.81% | 13.93% | 7.73% | 7.94% |
| 2006 | 14.43% | 14.66% | 25.56% | 4.80% | 2.71% | 5.69% | 7.75% | 13.68% | 34.86% | 14.86% | 10.75% | 29.43% |
| 2005 | 6.74% | 7.17% | 16.72% | 3.15% | 5.99% | 3.32% | 1.88% | 18.17% | 14.15% | 19.19% | 6.87% | 3.18% |
| 2004 | 11.97% | 16.78% | 19.64% | 5.29% | 9.09% | 4.86% | 10.08% | 26.32% | 32.52% | 18.16% | 6.84% | 19.49% |
| 2003 | 30.82% | 43.11% | 37.55% | 6.10% | 6.87% | 8.55% | 17.74% | 14.85% | 33.15% | 9.39% | 13.91% | 28.11% |
| 2002 | -21.45% | -18.94% | -14.12% | 9.38% | 15.23% | 2.29% | 14.01% | 11.52% | 5.29% | 9.32% | -12.87% | -22.46% |
| 2001 | -9.84% | -1.29% | -17.28% | 8.14% | 6.60% | 4.56% | 2.00% | 4.84% | 10.94% | 4.56% | -4.69% | -1.17% |
| 2000 | -5.08% | 0.43% | -12.24% | 11.45% | 16.16% | 6.31% | 4.73% | 3.50% | 25.89% | 18.95% | 1.78% | 3.34% |
| 1999 | 19.11% | 29.10% | 38.24% | -0.68% | -7.86% | 5.52% | 1.21% | 13.90% | 1.07% | 22.30% | 9.59% | 34.78% |
| 1998 | 23.63% | 3.10% | 12.09% | 8.54% | 11.90% | 6.11% | 10.73% | 8.10% | -6.12% | 1.78% | 21.10% | 27.79% |
| Gross Ret. †: | 6.29% | 8.81% | 8.67% | 6.73% | 9.14% | 5.29% | 8.06% | 8.73% | 11.82% | 10.88% | 6.02% | 13.31% |
| Inv. Cost. (bps): | 22.9 | 55.5 | 44.3 | 17.3 | 17.4 | 34.1 | 42.0 | 112.6 | 51.6 | 102.6 | 125.1 | 238.3 |
| Net Ret. †: | 6.06% | 8.25% | 8.23% | 6.56% | 8.97% | 4.95% | 7.64% | 7.61% | 11.31% | 9.85% | 4.77% | 11.10% |
| Net Comp. Ret.: | 4.14% | 6.10% | 5.18% | 6.49% | 8.75% | 4.88% | 7.39% | 6.01% | 9.17% | 9.50% | 4.23% | 8.56% |
| Std. Err.: | 0.01% | 0.02% | 0.01% | 0.01% | 0.06% | 0.01% | 0.04% | 0.03% | 0.05% | 0.89% | 0.06% | 0.07% |
| Std. Dev.: | 18.81% | 20.58% | 24.02% | 3.65% | 6.85% | 3.88% | 7.26% | 16.48% | 20.17% | 8.63%‡ | 10.35% | 22.02% |

our focus here is not on the causes of investment performance differences between aggregate asset classes but rather the actual comparative performance of aggregate asset classes independent of how they achieved the returns that they did.

5 Asset Allocation by U.S. Defined Benefit Pension Funds

The allocation of assets by U.S. DB pension funds has changed significantly over the 14-year period 1998-2011, and varies by plan size and by whether the plan is in the public sector or in the corporate sector. The eight panels in Figure 5 show the fund average asset allocations to the 12 aggregate asset classes used here between 1998 and 2011 for public sector funds and private sector funds with total holdings less than \$2 billion (small funds), between \$2 billion and \$10 billion (mid-sized funds), and in excess of \$10 billion (large funds). To aid the discussion, we summarize in Table 6A the average allocations and in Table 6B the average net change in asset allocations over the full sample period for the same eight categories of funds.

The clearest asset allocation features common to all plan type/size categories include:

1. U.S. large cap stock: largest (34.4 percent) and steadily decreasing allocation (-1.4 percentage points per year)
2. U.S. small cap stock: flat, almost unchanging allocation (-0.1 percentage points per year)
3. Non U.S. stock: approximately equal allocation on average (17.6 percent)
4. U.S. broad fixed income: second largest (22.1 percent) and decreasing allocation (-0.8 percentage points per year)
5. U.S. long bonds: no common features
6. U.S. other fixed income: steadily increasing allocation (+0.2 percentage points per year)
7. Non U.S. fixed income: steady allocation
8. Private real estate: no common features
9. Listed equity REITs: second smallest (0.6 percent) and unchanging allocation
10. Other real assets: smallest (0.4 percent) and increasing allocation (+0.1 percentage points per year)
11. TAA / hedge funds: increasing allocation (+0.4 percentage points per year)
12. Private equity: no common features

We expect that features common to funds cannot be the cause of differences in fund performance, as discussed in the next section. However, we note that one commonality was clearly detrimental to both public sector funds and corporate sector funds, large and small; two of the three highest returning aggregate asset classes (listed equity REITs and other real assets) were also the two that saw the lowest allocations.

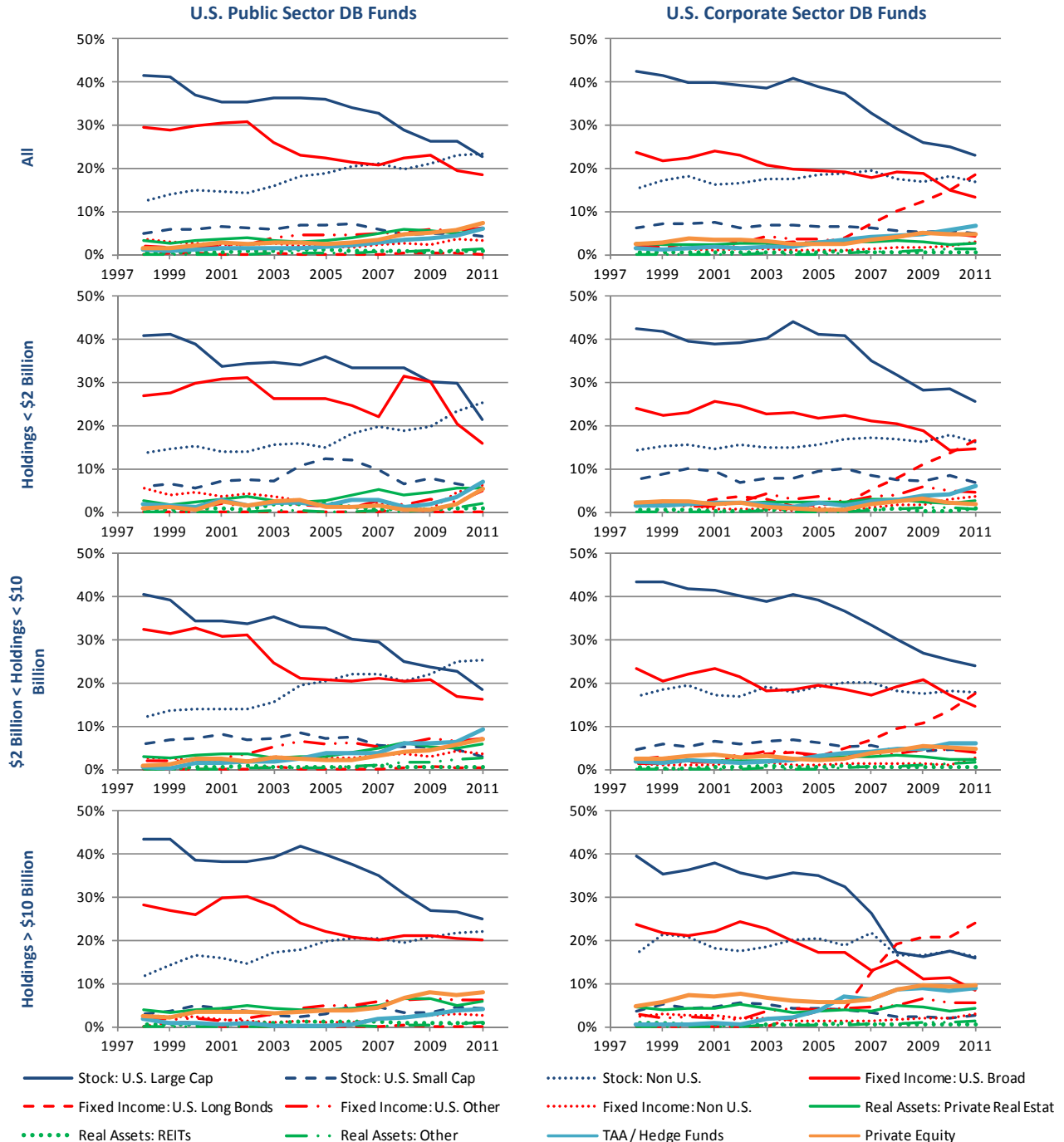
The clearest asset allocation features which differentiate public and corporate sector funds include:

1. U.S. large cap stock: higher allocation by corporate funds (35.3 percent) vs. public funds (33.6 percent)
2. U.S. small cap stock: higher allocation by corporate funds (6.3 percent) vs. public funds (5.8 percent)
3. Non U.S. stock: nearly steady allocation for corporate funds (+0.1 percentage points per year) vs. increasing allocation for public funds (+0.8 percentage points per year)
4. U.S. broad fixed income: much lower allocation by corporate funds (19.9 percent) vs. public funds (24.8 percent)
5. U.S. long bonds: much higher allocation by corporate funds (6.1 percent) that is increasing sharply (+1.2 percentage points per year) vs. public funds (0.1 percent) which are steady
6. U.S. other fixed income: lower allocation by corporate funds (3.3 percent) vs. public funds (4.0 percent)
7. Non U.S. fixed income: lower allocation by corporate funds (1.5 percent) vs. public funds (2.6 percent)
8. Private real estate: lower allocation by corporate funds (2.7 percent) that is steady vs. higher allocation by public funds (4.1 percent) that is increasing (+0.2 percentage points per year)
9. Listed equity REITs: lower allocation for corporate funds (0.5 percent) vs. public funds (0.8 percent)
10. Other real assets: no differentiating features
11. TAA / hedge funds: higher allocation by corporate funds (3.1 percent) vs. public funds (2.4 percent)

12. Private equity: corporate funds allocation increasing slower (+0.1 percentage points per year) vs. public funds (+0.4 percentage points per year)

Several of these asset allocation differences can be expected to benefit public funds versus corporate funds, and vice versa. For example, a lower average allocation to U.S. large cap stock by public sector funds (33.6 percent) was clearly an advantage relative to the higher average allocation by corporate sector funds (35.3 percent), as U.S.

Figure 5. Asset allocation time series for U.S. DB pension funds segmented by fund type (public sector/corporate sector), and fund size (all, holdings less than \$2 billion, holdings between \$2 billion and \$10 billion, and holdings in excess of \$10 billion).



large cap stocks averaged a net return of 6.06 percent per year, appreciably below the equally weighted aggregate asset class average net return of 7.94 percent per year. By contrast, a higher average allocation to U.S. broad fixed income by public sector funds (24.8 percent) was clearly detrimental relative to the lower average allocation by corporate sector funds (19.9 percent), as U.S. broad fixed income averaged a net return of only 6.56 percent per year, below the aggregate asset class average of 7.94 percent per year.

Lastly, the clearest asset allocation features differentiating funds by size category include:

1. U.S. large cap stock: corporate funds with > \$10 billion in holdings had the lowest average allocation (29.7 percent)
2. U.S. small cap stock: decreasing allocations with increasing fund size
3. Non U.S. stock: corporate and public funds with < \$2 billion in holdings had the lowest allocations (15.9 percent and 17.4 percent, respectively)

Tables 6A and 6B. Average asset allocation (Table 6A) and changes in average asset allocation for U.S. public and corporate sector DB pension funds from 1998-2011 by size and fund type (Table 6B).

Table 6A. Average asset allocation of U.S. public sector and U.S. corporate sector DB pension funds 1998-2011.

| Aggregate Asset Class | Public Sector | | | | Corporate Sector | | | | All |
|--------------------------|---------------|---------------|---------------|---------------|------------------|---------------|---------------|---------------|---------------|
| | < \$2B | \$2B-\$10B | > \$10B | All | < \$2B | \$2B-\$10B | > \$10B | All | |
| Stock: U.S. Large Cap | 34.0% | 30.9% | 36.1% | 33.6% | 37.0% | 36.1% | 29.7% | 35.3% | 34.4% |
| Stock: U.S. Small Cap | 7.9% | 6.3% | 3.7% | 5.8% | 8.3% | 5.4% | 3.8% | 6.3% | 6.0% |
| Stock: Non U.S. | 17.4% | 18.5% | 18.0% | 18.0% | 15.9% | 18.4% | 18.7% | 17.5% | 17.6% |
| Fixed Income: U.S. Broad | 26.4% | 24.4% | 24.2% | 24.8% | 21.4% | 19.6% | 17.8% | 19.9% | 22.1% |
| Fixed Income: Long | 0.1% | 0.2% | 0.2% | 0.1% | 5.3% | 6.1% | 7.7% | 6.1% | 3.8% |
| Fixed Income: U.S. Other | 2.0% | 4.8% | 4.1% | 4.0% | 3.2% | 3.1% | 3.8% | 3.3% | 3.6% |
| Fixed Income: Non U.S. | 3.2% | 2.9% | 1.9% | 2.6% | 1.4% | 1.4% | 2.0% | 1.5% | 2.0% |
| Private Real Estate | 3.6% | 4.0% | 4.7% | 4.1% | 2.4% | 2.4% | 4.2% | 2.7% | 3.3% |
| Listed Equity REITs | 1.0% | 0.6% | 0.9% | 0.8% | 0.5% | 0.5% | 0.6% | 0.5% | 0.6% |
| Other Real Assets | 0.3% | 0.8% | 0.2% | 0.5% | 0.3% | 0.5% | 0.5% | 0.4% | 0.4% |
| TAA / Hedge Funds | 2.4% | 3.5% | 1.4% | 2.4% | 2.5% | 3.2% | 4.2% | 3.1% | 2.8% |
| Private Equity | 1.7% | 3.1% | 4.5% | 3.4% | 1.8% | 3.4% | 7.1% | 3.5% | 3.4% |
| Total | 100% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Stock: Total | 59.3% | 55.8% | 57.9% | 57.3% | 61.2% | 59.9% | 52.2% | 59.1% | 58.0% |
| Fixed Income: Total | 31.7% | 32.2% | 30.4% | 31.5% | 31.3% | 30.2% | 31.3% | 30.8% | 31.5% |
| Other: Total | 9.0% | 11.9% | 11.7% | 11.1% | 7.5% | 9.9% | 16.5% | 10.2% | 10.5% |
| Total | 100% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

Table 6B. Changes in asset allocation of U.S. public sector and U.S. corporate sector DB pension funds 1998-2011.

| Aggregate Asset Class | Public Sector | | | | Corporate Sector | | | | All |
|--------------------------|---------------|-------------|-------------|-------------|------------------|-------------|-------------|-------------|-------------|
| | < \$2B | \$2B-\$10B | > \$10B | All | < \$2B | \$2B-\$10B | > \$10B | All | |
| Stock: U.S. Large Cap | -19.6% | -21.8% | -18.5% | -18.7% | -17.0% | -19.3% | -23.7% | -19.6% | -19.2% |
| Stock: U.S. Small Cap | -0.2% | -2.8% | 1.2% | -0.8% | -0.7% | 0.1% | -1.0% | -1.1% | -0.9% |
| Stock: Non U.S. | 11.5% | 13.4% | 10.4% | 11.0% | 1.9% | 1.2% | -0.8% | 1.6% | 5.0% |
| Fixed Income: U.S. Broad | -11.0% | -16.1% | -8.1% | -11.0% | -9.4% | -8.6% | -15.3% | -10.3% | -11.1% |
| Fixed Income: Long | 0.0% | 0.4% | 0.0% | 0.1% | 15.4% | 15.1% | 23.9% | 16.9% | 11.6% |
| Fixed Income: U.S. Other | 3.5% | 5.2% | 4.0% | 4.4% | 2.4% | 2.6% | 2.6% | 2.5% | 3.1% |
| Fixed Income: Non U.S. | 0.7% | 0.9% | -0.1% | -0.2% | 2.1% | 1.1% | 0.6% | 1.4% | 0.7% |
| Private Real Estate | 3.0% | 3.0% | 1.8% | 2.7% | 0.1% | 0.4% | -0.5% | 0.3% | 1.0% |
| Listed Equity REITs | 0.6% | 0.3% | 0.2% | 0.4% | 0.2% | -0.1% | -0.3% | 0.0% | 0.1% |
| Other Real Assets | 1.9% | 2.4% | 0.9% | 1.4% | 0.6% | 1.6% | 1.3% | 1.2% | 1.3% |
| TAA / Hedge Funds | 5.2% | 9.0% | 2.4% | 4.6% | 4.6% | 4.0% | 8.4% | 5.0% | 4.9% |
| Private Equity | 4.4% | 6.1% | 5.7% | 6.0% | -0.2% | 2.1% | 4.8% | 2.1% | 3.5% |
| Total | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Stock: Total | -8.2% | -11.2% | -6.9% | -8.5% | -15.8% | -18.0% | -25.5% | -19.1% | -15.1% |
| Fixed Income: Total | -6.8% | -9.6% | -4.2% | -6.6% | 10.5% | 10.1% | 11.9% | 10.5% | 4.3% |
| Other: Total | 15.1% | 20.8% | 11.0% | 15.1% | 5.3% | 7.9% | 13.6% | 8.6% | 10.8% |
| Total | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

4. U.S. broad fixed income: decreasing allocations with increasing fund size
5. U.S. long bonds: increasing allocations and larger annual increases for corporate funds with increasing fund size
6. U.S. other fixed income: no differentiating features
7. Non U.S. fixed income: decreasing allocations with increasing fund size for public funds
8. Private real estate: increasing allocations with increasing fund size
9. Listed equity REITs: no differentiating features
10. Other real assets: no differentiating features
11. TAA / hedge funds: increasing allocations and larger annual increases with increasing fund size (with the exception of public funds with > \$10 billion in holdings)
12. Private equity: increasing allocations and larger annual increases with increasing fund size

Like the previous list, these differences can be expected to benefit large funds relative to small ones, and vice versa. For larger funds, for example, an increased allocation to private equity was advantageous because private equity averaged a net return of 11.10 percent, considerably higher than the equally weighted aggregate asset class average of 7.94 percent.

6 Fund Performance by Fund Type, Size, and Asset Allocation

As demonstrated, the asset allocation of funds varies considerably by fund type and by fund size. Together with the variability in returns by asset class, this leads to markedly different fund performance. By further subdividing the data by whether funds have above/below average asset allocation to each of the aggregate asset classes, we can draw conclusions regarding the gross features of funds which performed well, and those that did not.

In Table 7 we show the average annualized compound net returns for funds grouped by size, by fund type, and above/below average asset allocation to each of the 12 aggregate asset classes. The net return series have been standardized for reporting lag and appraisal smoothing in the case of private real estate, and for reporting lag in the case of private equity. Also included in the table are “All” categories for comparison (*i.e.*, all corporate funds, all public funds, all corporate and public funds). The size groupings – under \$2 billion (small funds), between \$2 billion and \$10 billion (mid-sized funds), and over \$10 billion (large funds) – are chosen such that we have an approximately even distribution of the number of funds within each size/fund type group. With the two fund types, three fund sizes, and 12 above average and 12 below average asset allocations to each of the aggregate asset classes, there are 144 groupings of funds (excluding “All” types).

Also included in the table within parentheses are calculated standard errors. The errors are useful when making comparisons between averages, since the averages are derived from distributions with varying characteristics (*e.g.*, width, number of funds per year/etc.). To make comparisons between the groups and the all funds average we utilize a Z-score:

$$Z = \frac{r_{group} - r_{all}}{\sqrt{\Delta_{group}^2 + \Delta_{all}^2}}$$

where $r_{group,all}$ are the group and all fund compound net returns, and $\Delta_{group,all}$ are the group and all fund standard errors. This Z-score measures the distance between the average return of a group and the all fund average in terms of the number of standard errors on the difference (*i.e.*, Z=1 implies that the group return is one standard error greater than the all group, a difference significant at the 68 percent level, Z=2 implies that the group return is two standard errors greater than the all group, a difference significant at the 95 percent level, etc.).

From the data, one can first conclude that large corporate sector funds were the best performing group. Their 14-year average annualized compound net return of 7.54 percent exceeded the all fund average annualized compounded net return of 6.61 percent by more than three times the error on the difference (*i.e.*, Z=3.5, >99 percent confidence). Small corporate funds performed slightly worse (6.53 percent) than the all fund average, and

medium sized corporate funds (6.85 percent) performed slightly better than the all fund average, but the differences are not statistically significant (Z=-0.3 and Z=1.1, respectively). Public sector funds all displayed poorer overall performance than the all fund average, at 6.01 percent for small funds, 6.26 percent for medium-sized funds, and 6.21 percent for large funds, differences which are all statistically significant (Z=-3.0, -2.1, and -2.6, respectively, for small, medium, and large funds).

Table 7. Average annualized compound net returns spanning 1998-2011 by fund type, fund size, and above/below average asset allocation to each aggregate asset class (standard errors on the 14-year average compounded net returns are shown in parentheses to enable comparisons). The net returns have been calculated from standardized aggregate asset class returns. "n/a" indicates that for at least one of the 14 years, no funds had the requisite characteristics of the screen. Of the 225 screens appearing in the table, 211 yield full 14-year time series. Of the 144 screens specific to public or corporate sectors, the three fund size ranges, and 24 above/below average asset allocation, 132 yielded complete 14-year time series. Of these 132, those ranked in the top-20 by Z-score are highlighted in green, while those in the bottom-20 are highlighted in red (see Table 8 for the two lists).

Table 7. Average Annualized 14-year Compound Net Returns for U.S. DB Pension Funds Grouped by Type, Size and Above/Below Average Asset Allocation

| | Public Sector | | | | Corporate Sector | | | | | | |
|------------------------------------|------------------------------------|-----------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | < \$2B | \$2B-\$10B | > \$10B | All | < \$2B | \$2B-\$10B | > \$10B | All | All | | |
| Above Average Asset Allocation to: | Stock: U.S. Large Cap | 5.89% (0.24%) | 5.86% (0.17%) | 6.01% (0.16%) | 6.01% (0.11%) | 5.99% (0.24%) | 6.21% (0.24%) | 5.36% (0.37%) | 6.08% (0.16%) | 6.02% (0.10%) | |
| | Stock: U.S. Small Cap | 6.03% (0.21%) | 6.19% (0.17%) | 6.29% (0.21%) | 6.18% (0.12%) | 6.48% (0.28%) | 6.69% (0.28%) | 7.42% (0.33%) | 6.62% (0.20%) | 6.43% (0.12%) | |
| | Stock: Non U.S. | 6.00% (0.21%) | 6.17% (0.18%) | 6.34% (0.14%) | 6.18% (0.10%) | 6.90% (0.45%) | 6.92% (0.26%) | 7.24% (0.25%) | 6.98% (0.20%) | 6.62% (0.12%) | |
| | Fixed Income: U.S. Broad | 6.32% (0.22%) | 6.13% (0.22%) | 6.08% (0.19%) | 6.23% (0.13%) | 6.07% (0.27%) | 6.35% (0.23%) | 7.21% (0.40%) | 6.38% (0.18%) | 6.37% (0.12%) | |
| | Fixed Income: U.S. Long | n/a | n/a | n/a | n/a | 7.71% (0.43%) | 8.42% (0.81%) | n/a | 8.34% (0.53%) | 8.20% (0.46%) | |
| | Fixed Income: U.S. Other | n/a | 6.21% (0.19%) | 5.98% (0.22%) | 6.15% (0.15%) | 6.50% (0.41%) | 6.21% (0.22%) | 7.54% (0.35%) | 6.60% (0.19%) | 6.44% (0.12%) | |
| | Fixed Income: Non U.S. | 5.68% (0.21%) | 6.34% (0.22%) | 6.56% (0.28%) | 6.23% (0.15%) | 6.60% (0.34%) | 7.16% (0.49%) | 7.52% (0.34%) | 7.03% (0.23%) | 6.66% (0.15%) | |
| | Private Real Estate | 5.70% (0.25%) | 6.23% (0.18%) | 6.43% (0.15%) | 6.23% (0.11%) | 6.63% (0.39%) | 6.83% (0.25%) | 7.38% (0.30%) | 6.85% (0.21%) | 6.51% (0.13%) | |
| | Listed Equity REITs | 5.43% (0.26%) | 6.42% (0.34%) | 6.14% (0.17%) | 6.11% (0.16%) | 6.78% (0.34%) | 7.55% (0.38%) | 7.54% (0.34%) | 7.16% (0.23%) | 6.63% (0.15%) | |
| | Other Real Assets | n/a | 6.32% (0.21%) | n/a | 6.29% (0.17%) | n/a | n/a | n/a | n/a | 6.46% (0.18%) | |
| | TAA / Hedge Funds | 5.38% (0.29%) | 6.04% (0.21%) | 6.64% (0.27%) | 6.18% (0.19%) | 6.34% (0.36%) | 7.21% (0.30%) | 6.84% (0.31%) | 6.93% (0.22%) | 6.72% (0.17%) | |
| | Private Equity | n/a | 6.36% (0.22%) | 6.59% (0.14%) | 6.38% (0.13%) | 7.12% (0.51%) | 7.38% (0.32%) | 7.52% (0.25%) | 7.39% (0.22%) | 6.97% (0.15%) | |
| | Below Average Asset Allocation to: | Stock: U.S. Large Cap | 6.08% (0.25%) | 6.51% (0.21%) | 6.47% (0.18%) | 6.39% (0.13%) | 7.24% (0.38%) | 7.58% (0.32%) | 7.89% (0.26%) | 7.54% (0.21%) | 7.18% (0.14%) |
| | | Stock: U.S. Small Cap | 5.95% (0.37%) | 6.37% (0.24%) | 6.12% (0.15%) | 6.19% (0.12%) | 6.65% (0.33%) | 6.92% (0.25%) | 7.51% (0.28%) | 6.96% (0.17%) | 6.75% (0.12%) |
| | | Stock: Non U.S. | 6.10% (0.26%) | 6.29% (0.23%) | 6.07% (0.19%) | 6.18% (0.14%) | 6.38% (0.23%) | 6.84% (0.27%) | 7.55% (0.48%) | 6.72% (0.17%) | 6.57% (0.12%) |
| Fixed Income: U.S. Broad | | 5.15% (0.24%) | 6.42% (0.19%) | 6.35% (0.13%) | 6.21% (0.11%) | 6.98% (0.37%) | 7.37% (0.32%) | 7.78% (0.30%) | 7.34% (0.21%) | 6.88% (0.13%) | |
| Fixed Income: U.S. Long | | 5.91% (0.18%) | 6.23% (0.15%) | 6.20% (0.13%) | 6.17% (0.09%) | 6.19% (0.23%) | 6.54% (0.21%) | 7.12% (0.37%) | 6.46% (0.14%) | 6.35% (0.09%) | |
| Fixed Income: U.S. Other | | 6.00% (0.20%) | 6.23% (0.19%) | 6.30% (0.16%) | 6.20% (0.11%) | 6.52% (0.28%) | 7.16% (0.26%) | 7.61% (0.38%) | 6.95% (0.18%) | 6.70% (0.12%) | |
| Fixed Income: Non U.S. | | 6.23% (0.24%) | 6.18% (0.18%) | 6.05% (0.14%) | 6.19% (0.11%) | 6.56% (0.26%) | 6.75% (0.22%) | 7.59% (0.36%) | 6.75% (0.17%) | 6.62% (0.11%) | |
| Private Real Estate | | 6.13% (0.23%) | 6.27% (0.20%) | 5.91% (0.18%) | 6.15% (0.12%) | 6.57% (0.25%) | 6.87% (0.28%) | 7.86% (0.40%) | 6.84% (0.18%) | 6.70% (0.12%) | |
| Listed Equity REITs | | 6.29% (0.22%) | 6.20% (0.16%) | 6.28% (0.17%) | 6.23% (0.11%) | 6.57% (0.26%) | 6.68% (0.23%) | 7.62% (0.33%) | 6.76% (0.16%) | 6.62% (0.11%) | |
| Other Real Assets | | 5.98% (0.19%) | 6.16% (0.16%) | 6.20% (0.13%) | 6.16% (0.09%) | 6.52% (0.23%) | 6.87% (0.22%) | 7.48% (0.30%) | 6.80% (0.15%) | 6.60% (0.10%) | |
| TAA / Hedge Funds | | 6.09% (0.19%) | 6.15% (0.18%) | 6.16% (0.14%) | 6.17% (0.10%) | 6.53% (0.25%) | 6.74% (0.25%) | 7.98% (0.37%) | 6.78% (0.16%) | 6.57% (0.10%) | |
| Private Equity | | 6.07% (0.18%) | 6.21% (0.18%) | 5.88% (0.18%) | 6.09% (0.11%) | 6.31% (0.22%) | 6.49% (0.24%) | n/a | 6.42% (0.16%) | 6.38% (0.11%) | |
| All | | 6.01% (0.18%) | 6.26% (0.14%) | 6.21% (0.13%) | 6.19% (0.09%) | 6.53% (0.22%) | 6.85% (0.20%) | 7.54% (0.25%) | 6.84% (0.14%) | 6.61% (0.09%) | |

In Tables 8A and 8B, respectively, we list the top-20 and bottom-20 performing fund cohorts among the 144 groups segmented by fund type, fund size, and above/below average asset allocation in order to illustrate broad features of the data. (The fund cohorts listed in Tables 8A and 8B are highlighted in green/top-20 and red/bottom-20 in Table 7). It is immediately clear that corporate funds populate the entire top-20 list (and for the most part large funds), whereas public funds make up all but one of the bottom-20 list. This is unsurprising given our prior discussion of outperformance of large corporate funds. Also unsurprising is the presence at the top of the list those funds with *below* average allocations to U.S. large cap stock and *below* average allocations to TAA / hedge funds, as these were the worst performing asset classes.

One instructive feature about the lists in Table 8A and 8B is the contrast between above/below average allocations to listed equity REITs. Near the top of Table 8A, ranking number 7, are large corporate sector funds with below

Tables 8A and 8B. Top-20 and bottom-20 average annualized compound net returns determined by Z-score for screens using fund type (public or corporate), size (below \$2 billion in holdings, between \$2 billion in holdings and \$10 billion in holdings, and above \$10 billion in holdings), and for above or below average asset allocation to the 12 aggregate asset classes considered in this study. Only the 132 of the 144 screens returning full 14-year time series are considered.

Table 8A. Top-20 Average Annualized 14-Year Compound Net Return Groups for U.S. DB Pension Funds

| Rank | Type | Holdings (H) | Asset Allocation Style | Return (Std. Err.) | Z-Score |
|------|-----------|------------------|--|--------------------|---------|
| 1 | Corporate | H > \$10B | Below Average Stock: U.S. Large Cap | 7.89% (0.26%) | 4.7 |
| 2 | Corporate | H > \$10B | Below Average Fixed Income: U.S. Broad | 7.78% (0.30%) | 3.7 |
| 3 | Corporate | H > \$10B | Below Average TAA / Hedge Funds | 7.98% (0.37%) | 3.5 |
| 4 | Corporate | H > \$10B | Above Average Private Equity | 7.52% (0.25%) | 3.4 |
| 5 | Corporate | H > \$10B | Below Average Stock: U.S. Small Cap | 7.51% (0.28%) | 3.0 |
| 6 | Corporate | H > \$10B | Below Average Private Real Estate | 7.86% (0.40%) | 3.0 |
| 7 | Corporate | H > \$10B | Below Average Listed Equity REITs | 7.62% (0.33%) | 3.0 |
| 8 | Corporate | \$2B < H < \$10B | Below Average Stock: U.S. Large Cap | 7.58% (0.32%) | 2.9 |
| 9 | Corporate | H > \$10B | Below Average Other Real Assets | 7.48% (0.30%) | 2.8 |
| 10 | Corporate | H > \$10B | Below Average Fixed Income: Non U.S. | 7.59% (0.36%) | 2.7 |
| 11 | Corporate | H > \$10B | Above Average Listed Equity REITs | 7.54% (0.34%) | 2.6 |
| 12 | Corporate | H > \$10B | Above Average Fixed Income: Non U.S. | 7.52% (0.34%) | 2.6 |
| 13 | Corporate | H > \$10B | Below Average Fixed Income: U.S. Other | 7.61% (0.38%) | 2.5 |
| 14 | Corporate | H > \$10B | Above Average Fixed Income: U.S. Other | 7.54% (0.35%) | 2.5 |
| 15 | Corporate | \$2B > H | Above Average Fixed Income: U.S. Long | 7.71% (0.43%) | 2.5 |
| 16 | Corporate | H > \$10B | Above Average Private Real Estate | 7.38% (0.30%) | 2.4 |
| 17 | Corporate | H > \$10B | Above Average Stock: Non U.S. | 7.24% (0.25%) | 2.4 |
| 18 | Corporate | \$2B < H < \$10B | Above Average Listed Equity REITs | 7.55% (0.38%) | 2.4 |
| 19 | Corporate | H > \$10B | Above Average Stock: U.S. Small Cap | 7.42% (0.33%) | 2.4 |
| 20 | Corporate | \$2B < H < \$10B | Above Average Private Equity | 7.38% (0.32%) | 2.3 |

Table 8A. Bottom-20 Average Annualized 14-Year Compound Net Return Groups for U.S. DB Pension Funds

| Rank | Type | Holdings (H) | Asset Allocation Style | Return (Std. Err.) | Z-Score |
|------|-----------|------------------|--|--------------------|---------|
| 113 | Public | H > \$10B | Below Average Stock: Non U.S. | 6.07% (0.19%) | -2.6 |
| 114 | Public | \$2B > H | Below Average Private Equity | 6.07% (0.18%) | -2.7 |
| 115 | Public | \$2B > H | Above Average Stock: Non U.S. | 6.00% (0.21%) | -2.7 |
| 116 | Public | H > \$10B | Below Average TAA / Hedge Funds | 6.16% (0.14%) | -2.8 |
| 117 | Public | \$2B > H | Above Average Stock: U.S. Large Cap | 5.89% (0.24%) | -2.8 |
| 118 | Public | \$2B > H | Below Average Fixed Income: U.S. Other | 6.00% (0.20%) | -2.9 |
| 119 | Public | H > \$10B | Below Average Stock: U.S. Small Cap | 6.12% (0.15%) | -2.9 |
| 120 | Public | \$2B > H | Below Average Other Real Assets | 5.98% (0.19%) | -3.1 |
| 121 | Public | H > \$10B | Above Average Stock: U.S. Large Cap | 6.01% (0.16%) | -3.2 |
| 122 | Corporate | H > \$10B | Above Average Stock: U.S. Large Cap | 5.36% (0.37%) | -3.3 |
| 123 | Public | H > \$10B | Below Average Fixed Income: Non U.S. | 6.05% (0.14%) | -3.4 |
| 124 | Public | H > \$10B | Below Average Private Real Estate | 5.91% (0.18%) | -3.5 |
| 125 | Public | \$2B > H | Above Average Private Real Estate | 5.70% (0.25%) | -3.5 |
| 126 | Public | \$2B > H | Below Average Fixed Income: U.S. Long | 5.91% (0.18%) | -3.6 |
| 127 | Public | H > \$10B | Below Average Private Equity | 5.88% (0.18%) | -3.6 |
| 128 | Public | \$2B < H < \$10B | Above Average Stock: U.S. Large Cap | 5.86% (0.17%) | -3.9 |
| 129 | Public | \$2B > H | Above Average TAA / Hedge Funds | 5.38% (0.29%) | -4.0 |
| 130 | Public | \$2B > H | Above Average Fixed Income: Non U.S. | 5.68% (0.21%) | -4.1 |
| 131 | Public | \$2B > H | Above Average Listed Equity REITs | 5.43% (0.26%) | -4.3 |
| 132 | Public | \$2B > H | Below Average Fixed Income: U.S. Broad | 5.15% (0.24%) | -5.7 |

average allocations to REITs, whereas at the bottom of Table 8B, ranking number 131, are small public sector funds with above average allocations to REITs. Since REITs were the best performing asset class over the period of the analysis, one should suspect that the top-20 performance of the funds ranked number 7 is *not* a result of their below average allocation to REITs, and, similarly, that the bottom-20 performance of funds ranked number 131 is *not* due to their above average allocation to REITs. Rather, the disparity in overall portfolio net returns is caused by differences in the allocations of these funds to other asset classes and not to differences in their allocations to REITs. Indeed, for every deviation from the average fund in allocation to one aggregate asset class, there must be one or more offsetting deviations in asset allocations to the other aggregate asset classes, since combined allocations must sum to 100 percent.

In what follows, we discuss the impacts of differences in average asset allocations for each of the six fund type / size type fund cohorts in order to elucidate the source of differences in net returns. In addition, since these discussions only serve to explain ‘what happened’ over the sample period 1998-2011, we quantify the expected marginal effect of a one percentage point change in the asset allocation to each aggregate asset class in order to explain ‘what could have happened’.

6.1 How Funds Invested: Large Corporate Sector Funds

From 1998 through 2011, the large segment of corporate sector U.S. DB pension funds had an annualized average compound net return of 7.54 percent. This overall net return is significantly greater than the all fund average of 6.61 percent (*i.e.*, $Z=3.5$, >99 percent confidence). What features of their asset allocations were responsible for the outperformance?

Table 9A shows the annual differences in asset allocations between this group of funds and the all fund average. The most noticeable differences in asset allocation are within long duration U.S. fixed income, where this group was overweight from 2004 onwards, and large cap U.S. stock, where they were underweight for nearly the entire period. Also notable is the fund cohort’s propensity to be overweight private equity and underweight small cap U.S. stock and broad U.S. fixed income. Being overweight long duration U.S. fixed income and underweight shorter duration broad U.S. fixed income is indicative of a LDI style of investing (*i.e.*, matching the durations of assets and liabilities).

While these asset allocation differences are notable, they do not quantify the sources of underperformance. To do so, we estimate the marginal contribution of differences in asset allocation to differences in average annual net returns. This analysis is based on a calculation of \hat{r}_i^y , the net returns a cohort of funds would have achieved in year y if, in turn, each asset class i were instead equal to the all fund universe average. We calculate \hat{r}_i^y using:

$$\hat{r}_i^y = r_i^y \Delta w_i^y + \sum_{j \neq i} r_j^y \Delta w_j^y$$

where Δw_i^y is the change in asset allocation to aggregate asset class i in year y . The equation is completely general, and we have freedom to choose the responses by the other asset classes, Δw_j^y , to the change Δw_i^y subject to the constraint that $\Delta w_i^y = -\sum_{j \neq i} \Delta w_j^y$ (*i.e.*, the total change in asset allocation must be zero). We have chosen to set the responses to be proportional to the asset allocations themselves in order to preserve the weights relative to one and another.

The results of the analysis for large corporate sector funds are displayed in Table 9B. The largest impacts occurred during the Global Financial Crisis of 2008 where above-average exposure to long duration U.S. fixed income added nearly 520 basis points to the annual net return. Also important was the below-average exposure to large cap U.S. stock in 2008, which contributed another 267 basis points to the annual net return. When combined, the total estimated impact of asset allocation differences to the 2008 net return relative to the all fund average was 683 basis points. The actual difference of 657 basis points suggests that, at least in 2008, outperformance of large corporate sector funds was entirely due to differences in asset allocation.

Tables 9A and 9B. Differences in asset allocations relative to the all fund average (9A) and impacts of differences in asset allocation on net returns in basis points (9B) for large (greater than \$10 billion AUM) corporate sector DB pension funds. Total impacts in 9B are the total impacts of differences in asset allocation for each aggregate asset class in basis points on 14-year annualized compound net returns relative to the all fund average.

**Table 9A. Difference in Asset Allocation Relative to the All Fund Average:
Large Corporate Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -7.0% | -2.1% | -2.8% | -6.7% | 11.4% | 0.5% | -0.1% | 0.5% | -0.1% | 0.0% | 2.5% | 4.1% |
| 2010 | -7.9% | -3.2% | -2.2% | -5.2% | 11.3% | 0.4% | -0.6% | 0.3% | -0.1% | 0.0% | 3.1% | 4.1% |
| 2009 | -9.7% | -2.8% | -1.9% | -9.0% | 12.7% | 0.9% | 0.1% | 0.8% | -0.1% | 0.0% | 4.5% | 4.6% |
| 2008 | -12.0% | -3.0% | -1.8% | -5.2% | 12.5% | 0.5% | -0.3% | 0.7% | -0.2% | 0.0% | 4.6% | 4.2% |
| 2007 | -6.4% | -2.9% | 1.7% | -6.1% | 8.3% | 0.5% | -0.4% | -0.3% | -0.2% | 0.0% | 2.9% | 2.9% |
| 2006 | -3.1% | -3.0% | -1.1% | -3.3% | 2.5% | 0.4% | 0.0% | 0.5% | -0.1% | 0.0% | 4.1% | 3.1% |
| 2005 | -2.5% | -2.4% | 1.6% | -3.7% | 2.2% | -0.1% | -0.2% | 0.6% | -0.3% | 0.3% | 1.3% | 3.2% |
| 2004 | -3.1% | -2.4% | 2.5% | -1.7% | 0.6% | 0.0% | -0.1% | 0.6% | -0.4% | 0.3% | 0.3% | 3.4% |
| 2003 | -3.3% | -1.1% | 1.8% | -0.6% | -1.6% | -0.3% | 0.0% | 1.3% | -0.4% | 0.2% | 0.1% | 3.8% |
| 2002 | -1.4% | -0.6% | 2.2% | -2.9% | -1.5% | -1.0% | -0.1% | 1.8% | -0.2% | 0.0% | -1.0% | 4.8% |
| 2001 | 0.3% | -2.4% | 2.8% | -5.1% | -0.9% | 0.0% | 1.0% | 1.3% | 0.0% | 0.0% | -0.8% | 3.8% |
| 2000 | -2.0% | -2.1% | 4.4% | -5.1% | -0.9% | 0.5% | 0.3% | 1.3% | 0.1% | 0.0% | -0.9% | 4.3% |
| 1999 | -5.8% | -1.3% | 5.8% | -3.6% | -1.2% | 0.4% | 0.8% | 1.4% | 0.4% | 0.0% | -0.5% | 3.5% |
| 1998 | -2.6% | -2.0% | 2.9% | -2.6% | -0.9% | 1.0% | -0.1% | 2.0% | 0.3% | 0.0% | -0.9% | 2.8% |
| Avg.: | -4.7% | -2.2% | 1.1% | -4.3% | 3.9% | 0.3% | 0.0% | 0.9% | -0.1% | 0.0% | 1.4% | 3.8% |

**Table 9B. Impacts on Physical Asset Only Net Returns in Basis Points of Difference in Asset Allocation:
Large Corporate Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|------------|--|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | 28.8 | 16.1 | 56.3 | -31.2 | 262.2 | -0.2 | 0.0 | 2.5 | 0.2 | 0.1 | -10.8 | -39.3 |
| 2010 | -23.3 | -40.8 | 3.5 | 29.8 | -38.5 | -3.3 | 0.3 | 0.7 | -1.2 | 0.1 | -15.7 | 71.6 |
| 2009 | -90.1 | -33.9 | -40.8 | 101.7 | -280.5 | -8.1 | -0.1 | 1.3 | -0.7 | 0.0 | -36.7 | 86.7 |
| 2008 | 266.5 | 55.6 | 53.9 | -119.1 | 517.5 | 6.8 | -3.1 | -14.8 | 3.3 | -0.4 | 6.5 | -89.4 |
| 2007 | 12.2 | 15.2 | 15.7 | 5.3 | 4.0 | -1.4 | -0.2 | 8.1 | 3.6 | -0.3 | 1.5 | 2.1 |
| 2006 | 0.9 | -0.1 | -14.7 | 39.4 | -31.3 | -3.8 | 0.2 | -0.5 | -1.5 | 0.0 | -17.0 | 48.5 |
| 2005 | 5.8 | 2.7 | 17.3 | 23.0 | -5.1 | 0.4 | 1.1 | 5.8 | -1.6 | 3.1 | -1.8 | -17.2 |
| 2004 | 4.9 | -9.6 | 20.9 | 16.2 | -2.6 | 0.2 | 0.2 | 8.6 | -7.8 | 1.4 | -1.6 | 23.6 |
| 2003 | -30.1 | -20.9 | 28.7 | 14.4 | 27.8 | 5.8 | 0.3 | -13.9 | -3.5 | -3.3 | -0.9 | 13.8 |
| 2002 | 26.1 | 5.4 | -11.7 | -74.1 | -37.1 | -12.5 | -2.2 | 39.7 | -3.5 | 0.1 | 3.1 | -65.3 |
| 2001 | -2.3 | -9.0 | -42.8 | -84.8 | -10.4 | 0.3 | 6.9 | 13.2 | 0.5 | 0.0 | -0.1 | 15.0 |
| 2000 | 12.4 | -3.5 | -62.2 | -81.1 | -15.3 | 3.9 | 2.0 | 6.3 | 2.8 | -0.9 | -2.6 | 20.9 |
| 1999 | 0.2 | -13.3 | 141.2 | 91.1 | 32.0 | -6.0 | -15.1 | -7.7 | -6.7 | -0.1 | 4.3 | 57.4 |
| 1998 | -33.4 | 26.3 | -13.0 | 24.2 | 3.5 | -9.9 | 0.4 | -15.8 | -7.5 | 0.2 | -5.0 | 35.5 |
| Subtotals: | 21.3 | 1.3 | 10.5 | -10.3 | 46.7 | -1.8 | -0.6 | 3.0 | -1.5 | 0.0 | -4.8 | 6.9 |
| Total: | 70.6 bps of 92.6 bps of average annualized net return outperformance is explained by differences in asset allocation | | | | | | | | | | | |

The total impact for each aggregate asset class appearing in the bottom row of Table 9B, \hat{r}_i , represents the total effect on the annualized average compound net return caused by differences in allocation to each of the aggregate asset classes. We calculate it from the difference in annualized compounded net returns achieved with the quoted impacts, and the actual annualized compounded net return achieved from each year's net return r^y . That is:

$$\hat{r}_i = \left[\prod_{y=1998}^{2011} (1 + r^y + \hat{r}_i^y) \right]^{\frac{1}{14}} - \left[\prod_{y=1998}^{2011} (1 + r^y) \right]^{\frac{1}{14}}$$

Tables 10A and 10B. Differences in asset allocations relative to the all fund average (10A) and impacts of differences in asset allocation on net returns in basis points (10B) for large (greater than \$10 billion AUM) public sector DB pension funds. Total impacts in 10B are the total impacts of differences in asset allocation for each aggregate asset class in basis points on 14-year annualized compound net returns relative to the all fund average.

**Table 10A. Difference in Asset Allocation Relative to the All Fund Average:
Large Public Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | 2.1% | -0.4% | 2.9% | 5.0% | -12.5% | 1.3% | -0.5% | 2.1% | 0.2% | -0.3% | -2.3% | 2.5% |
| 2010 | 1.0% | -0.9% | 1.9% | 3.8% | -9.4% | 1.3% | 0.4% | 1.5% | 0.3% | -0.6% | -1.6% | 2.1% |
| 2009 | 0.8% | -1.8% | 2.5% | 1.0% | -7.8% | 0.8% | 0.9% | 2.5% | 0.4% | -0.5% | -1.8% | 2.9% |
| 2008 | 1.7% | -1.9% | 1.2% | 0.8% | -6.3% | 1.6% | 0.5% | 2.1% | 0.2% | -0.4% | -2.0% | 2.4% |
| 2007 | 2.3% | -1.6% | 0.5% | 1.0% | -4.3% | 1.8% | 0.0% | 1.2% | 0.3% | -0.5% | -1.8% | 1.1% |
| 2006 | 2.2% | -1.8% | 0.6% | 0.5% | -1.9% | 0.9% | -0.4% | 0.8% | 0.3% | -0.1% | -2.4% | 1.3% |
| 2005 | 2.6% | -3.6% | 0.9% | 1.2% | -1.4% | 0.7% | -0.4% | 0.8% | 0.3% | -0.2% | -2.2% | 1.1% |
| 2004 | 3.2% | -4.5% | -0.1% | 2.4% | -1.4% | 0.2% | -0.3% | 1.1% | 0.4% | -0.2% | -1.5% | 0.7% |
| 2003 | 1.8% | -3.5% | 0.3% | 4.6% | -1.6% | -1.0% | -0.9% | 1.5% | 0.1% | -0.2% | -1.3% | 0.2% |
| 2002 | 1.1% | -2.5% | -0.6% | 2.9% | -1.5% | -0.6% | -0.6% | 1.5% | 0.3% | -0.1% | -0.7% | 0.8% |
| 2001 | 0.6% | -2.9% | 0.5% | 2.5% | -0.9% | -0.4% | -0.1% | 1.2% | 0.1% | -0.1% | -1.0% | 0.4% |
| 2000 | 0.5% | -1.7% | 0.0% | -0.2% | 0.2% | 0.2% | 0.2% | 1.0% | 0.1% | 0.0% | -0.7% | 0.4% |
| 1999 | 2.1% | -2.8% | -1.5% | 1.7% | -0.2% | -0.1% | 0.1% | 0.8% | 0.0% | 0.0% | -0.2% | 0.1% |
| 1998 | 1.4% | -2.5% | -2.6% | 2.0% | -0.9% | 0.4% | 0.2% | 1.3% | 0.1% | 0.0% | 0.2% | 0.3% |
| Avg.: | 1.7% | -2.3% | 0.5% | 2.1% | -3.6% | 0.5% | -0.1% | 1.4% | 0.2% | -0.2% | -1.4% | 1.2% |

**Table 10B. Impacts on Physical Asset Only Net Returns in Basis Points of Difference in Asset Allocation:
Large Public Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|------------|--|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | 3.5 | 1.1 | -45.3 | 55.8 | -278.5 | 5.8 | -2.7 | 21.5 | 0.6 | 0.4 | -1.9 | -10.7 |
| 2010 | 2.8 | -11.4 | -4.3 | -26.6 | 29.8 | -11.6 | -0.4 | 2.5 | 3.1 | 1.9 | 8.2 | 35.2 |
| 2009 | 3.6 | -13.6 | 41.0 | -19.4 | 173.0 | -11.4 | -5.8 | -7.9 | 1.4 | 11.0 | 21.6 | 38.7 |
| 2008 | -24.9 | 18.4 | -24.5 | 30.1 | -267.4 | 37.5 | 9.0 | -26.4 | -2.6 | -7.5 | -20.3 | -28.1 |
| 2007 | -1.7 | 7.1 | 5.3 | 0.2 | -5.8 | -2.9 | 0.0 | -29.8 | -5.4 | -3.5 | -2.5 | 1.8 |
| 2006 | -2.0 | 0.6 | 7.6 | -6.4 | 23.3 | -9.0 | 2.9 | -1.1 | 6.7 | 0.0 | 10.2 | 19.2 |
| 2005 | -5.8 | 3.5 | 10.1 | -7.4 | 2.9 | -3.7 | 2.4 | 8.9 | 2.1 | -1.9 | 2.7 | -5.8 |
| 2004 | -3.2 | -19.5 | -0.5 | -22.6 | 5.0 | -1.4 | 0.6 | 15.3 | 8.6 | -1.0 | 8.5 | 5.1 |
| 2003 | 21.2 | -69.6 | 5.4 | -111.7 | 26.3 | 16.4 | 5.2 | -13.5 | 1.1 | 3.4 | 12.8 | 1.0 |
| 2002 | -23.0 | 27.4 | 4.0 | 72.0 | -34.8 | -6.2 | -14.0 | 31.9 | 3.6 | -1.4 | 3.3 | -11.3 |
| 2001 | -5.9 | -7.6 | -7.9 | 41.9 | -9.5 | -3.1 | -0.6 | 10.7 | 1.8 | -0.6 | 0.8 | 1.1 |
| 2000 | -3.9 | -1.0 | -0.2 | -3.7 | 4.1 | 1.3 | 1.1 | 3.7 | 2.7 | -0.9 | -1.3 | 1.5 |
| 1999 | 11.5 | -38.3 | -40.0 | -38.9 | 3.6 | 0.9 | -2.1 | -1.8 | 0.7 | -0.2 | 1.2 | 1.5 |
| 1998 | 19.7 | 33.2 | 11.2 | -20.5 | 3.6 | -3.7 | -1.3 | -10.7 | -2.0 | 0.2 | 1.3 | 3.8 |
| Subtotals: | -2.1 | -3.0 | -4.1 | 0.4 | -35.7 | 2.0 | -0.2 | 0.1 | 1.5 | -0.4 | 2.0 | 1.9 |
| Total: | -37.9 bps of -40.9 bps of average annualized net return underperformance is explained by differences in asset allocation | | | | | | | | | | | |

It is important to recognize that the sum of the total impacts will not, in general, equal the actual difference in annualized average net returns. This is due to variability in performance within aggregate asset classes (e.g., large corporate funds had better private equity returns than small corporate funds, in large part due to differences in costs) and correlations between performance in aggregate asset classes and asset allocations (i.e., typically, funds which allocate more to an asset class have better returns, due in part to lower costs through economies of scale).

The largest total impact of asset allocation differences for large U.S. corporate sector funds were clear; a tendency to be underweight large cap U.S. stock alone contributed 21 basis points to the 93 basis points total outperformance of large corporate sector DB pension funds relative to the all average, while the decision to increase allocations to long duration bonds in and after 2007 contributed another 47 basis points. The other differences in asset allocations were, by comparison, immaterial.

We remark that the calculated impacts help to validate the disparity in net returns experienced by large corporate sector DB funds when they are further grouped on being above and below average with respect to their asset allocation to each aggregate asset class. For example, those with above average allocations to large cap U.S. stock did poorly, while those with below average allocation to large cap U.S. stock did well. While not shown here, this difference in net return was amplified by differences in allocation to long duration fixed income; large corporate funds that had below average allocations to large cap U.S. stock were the same large corporate sector funds that invested (heavily) in long duration fixed beginning in 2007, while large corporate funds that had above average allocations to large cap U.S. stock did not.

6.2 How Funds Invested: Large Public Sector Funds

Over the sample period 1998-2011, large public sector U.S. DB pension funds had an average annualized compound net return of 6.21 percent, 41 basis points below and significantly different from the all fund average ($Z=-2.6$). This difference was almost entirely driven by differences in asset allocation. The differences in asset allocation relative to the all fund average are shown in Table 10A, and the impacts of those differences are shown in Table 10B.

The most important difference in asset allocation for large public sector U.S. DB pension funds was their propensity to be underweight long duration U.S. fixed income, especially following 2007 when large corporate sector DB funds began a push towards LDI style investing. Other differences in asset allocation were the consistent underweighting of small cap U.S. stock and TAA/hedge funds relative to the average fund. Conversely, this fund cohort was overweight broad U.S. fixed income and large cap U.S. stock, on average.

The impacts of these differences in asset allocation are shown in Table 10B. Of the -41 basis points total deficit in net return relative to the average fund, almost all of it (-36 basis points) was due to under-exposure to long duration U.S. bonds. Indeed, only differences in non-U.S. stock allocations led to more than one-tenth the impact generated from allocation differences in U.S. long duration fixed income. Furthermore, the sum of the total impacts, -38 basis points, is almost identical to the actual difference, -41 bps, which demonstrates that the slight underperformance of large U.S. public sector DB pension funds from 1998-2011 can almost entirely be attributed to differences in asset allocation, and that the only differences of importance were differences in U.S. long duration fixed income.

As revealed in Table 7, an interesting contrast within this group of funds is between those funds with an above average allocation to either private real estate (6.43 percent average annualized net return) or private equity (6.59 percent average annualized net return) and those funds with a below average allocation to private real estate (5.91 percent average annualized net return) and private equity (5.88 percent average annualized net return). The contrasts in overall performances are, in fact, not driven by differences in allocations to either private real estate or private equity. Instead, the contrasts are mostly due to the fact that large public sector funds with above average allocations to private assets also had below average allocations to large cap U.S. stock, while the converse was true for large public sector funds with below average allocations to private assets. In both cases, the difference in allocations to large cap U.S. stock was the driver of differences in total net returns.

6.3 How Funds Invested: Mid-sized Corporate Sector Funds

From 1998 through 2011, the group of mid-sized U.S. corporate sector DB pension funds had an annualized average compound net return of 6.85 percent, above but not significantly different than the all fund average ($Z=1.1$). Differences in asset allocation for this segment of funds relative to the all fund average are shown in Table 11A.

The most notable differences in the asset allocations for mid-sized corporate funds relative to the average fund were a persistent slight over-exposure to large cap U.S. stock and long duration U.S. fixed income, and an under-exposure to broad U.S. fixed income. The impact of these differences on total net returns is summarized in Table

Tables 11A and 11B. Differences in asset allocations relative to the all fund average (11A) and impacts of differences in asset allocation on net returns in basis points (11B) for mid-sized (greater than \$2 billion AUM, less than \$10 billion AUM) corporate sector DB pension funds. Total impacts in 11B are the total impacts of differences in asset allocation for each aggregate asset class in basis points on 14-year annualized compound net returns relative to the all fund average.

**Table 11A. Difference in Asset Allocation Relative to the All Fund Average:
Mid-Sized Corporate Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | 1.1% | -0.1% | -1.1% | -0.4% | 5.0% | -1.1% | -0.6% | -1.4% | -0.2% | 0.3% | -0.4% | -1.0% |
| 2010 | -0.1% | -0.6% | -1.6% | 0.6% | 4.0% | -0.5% | -1.5% | -1.0% | -0.1% | 0.2% | 0.8% | -0.1% |
| 2009 | 0.7% | -1.0% | -0.9% | 0.6% | 2.6% | -1.0% | -0.5% | -1.0% | 0.0% | 0.1% | 0.2% | 0.3% |
| 2008 | 1.2% | -0.8% | 0.0% | -1.3% | 3.0% | -0.9% | -0.7% | -1.0% | -0.2% | 0.1% | 0.6% | 0.0% |
| 2007 | 0.6% | -0.4% | 0.0% | -1.7% | 2.5% | -1.1% | -0.2% | -0.9% | -0.1% | 0.2% | 0.7% | 0.3% |
| 2006 | 1.1% | -1.5% | 0.3% | -2.1% | 3.0% | -0.7% | 0.1% | -0.6% | -0.2% | 0.0% | 0.8% | -0.2% |
| 2005 | 1.8% | -0.6% | 0.4% | -1.6% | 1.7% | -0.7% | -0.6% | -0.3% | -0.3% | 0.0% | 0.6% | -0.3% |
| 2004 | 2.0% | 0.0% | 0.2% | -3.1% | 2.4% | -0.3% | -0.5% | -0.6% | -0.2% | -0.1% | 0.4% | -0.2% |
| 2003 | 1.3% | 0.2% | 2.5% | -5.2% | 2.0% | 0.1% | -0.2% | -0.9% | 0.0% | -0.1% | 0.1% | 0.3% |
| 2002 | 3.2% | -0.4% | 1.4% | -5.7% | 2.2% | 0.6% | -0.1% | -1.3% | 0.0% | 0.0% | 0.0% | 0.1% |
| 2001 | 3.8% | -0.5% | 1.8% | -4.0% | 0.7% | -0.3% | -0.8% | -1.1% | -0.1% | 0.0% | 0.1% | 0.3% |
| 2000 | 3.7% | -1.4% | 2.8% | -4.3% | 1.0% | -0.2% | -1.3% | -1.0% | -0.2% | 0.0% | 0.6% | 0.2% |
| 1999 | 2.3% | -0.7% | 2.8% | -4.7% | 1.8% | -0.3% | -1.0% | -0.6% | -0.2% | 0.0% | 0.5% | 0.4% |
| 1998 | 1.2% | -1.1% | 2.6% | -2.9% | 1.6% | -0.5% | -1.0% | -0.9% | 0.0% | 0.0% | 0.5% | 0.5% |
| Avg.: | 1.7% | -0.6% | 0.8% | -2.6% | 2.4% | -0.5% | -0.6% | -0.9% | -0.1% | 0.0% | 0.4% | 0.0% |

**Table 11B. Impacts on Physical Asset Only Net Returns in Basis Points of Difference in Asset Allocation:
Mid-Sized Corporate Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|------------|---|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -3.4 | 0.6 | 22.0 | -2.6 | 113.0 | -0.8 | -0.9 | -9.0 | 0.1 | -1.3 | 1.3 | 7.7 |
| 2010 | -0.2 | -8.1 | 2.4 | -3.8 | -11.9 | 4.7 | 0.5 | -2.2 | -0.5 | -0.5 | -3.6 | -2.4 |
| 2009 | 5.9 | -10.2 | -18.1 | -8.6 | -56.1 | 10.7 | 1.8 | 0.1 | 0.0 | -0.9 | -1.5 | 4.6 |
| 2008 | -23.5 | 11.6 | -0.4 | -39.3 | 127.2 | -16.9 | -10.5 | 16.5 | 2.7 | 1.6 | 3.6 | -0.3 |
| 2007 | -1.1 | 2.0 | 0.3 | 1.0 | 1.9 | 2.5 | -0.2 | 21.2 | 1.4 | 1.2 | 0.6 | 0.3 |
| 2006 | 0.2 | -0.6 | 3.5 | 23.9 | -36.8 | 6.3 | -0.4 | 0.4 | -3.3 | 0.0 | -3.0 | -3.9 |
| 2005 | -4.0 | 0.6 | 4.8 | 10.0 | -3.7 | 3.4 | 3.6 | -3.3 | -1.5 | -0.4 | -0.7 | 1.7 |
| 2004 | -2.0 | 0.2 | 1.5 | 27.7 | -8.7 | 2.7 | 1.2 | -7.9 | -4.5 | -0.6 | -2.3 | -1.2 |
| 2003 | 10.7 | 2.9 | 37.4 | 125.3 | -39.8 | -1.9 | 1.7 | 10.4 | -0.3 | 1.2 | -1.7 | 0.6 |
| 2002 | -62.3 | 3.4 | -7.2 | -138.6 | 56.4 | 7.2 | -1.3 | -28.4 | 0.7 | -0.8 | -0.1 | -0.8 |
| 2001 | -31.6 | -1.9 | -26.0 | -68.1 | 8.1 | -2.8 | -5.5 | -11.1 | -2.1 | 0.0 | 0.0 | 1.3 |
| 2000 | -24.3 | -2.4 | -38.6 | -69.6 | 18.1 | -1.3 | -7.6 | -4.6 | -4.6 | -0.9 | 1.8 | 1.0 |
| 1999 | 4.0 | -8.4 | 68.3 | 111.8 | -47.3 | 4.3 | 17.2 | 2.7 | 3.4 | -0.1 | -4.2 | 6.5 |
| 1998 | 16.4 | 15.1 | -12.9 | 28.9 | -6.9 | 5.1 | 5.7 | 7.3 | -0.2 | 0.2 | 2.6 | 5.6 |
| Subtotals: | -10.4 | 0.8 | 1.5 | -6.3 | 14.8 | 1.0 | -0.2 | -0.7 | -0.6 | -0.1 | -0.3 | 1.4 |
| Total: | 0.8 bps of 24.0 bps of average annualized net return outperformance is explained by differences in asset allocation | | | | | | | | | | | |

11B. Even the slight over-exposure to large cap U.S. stock had a materially negative effect, while the differences in exposures to broad and long duration U.S. fixed income on balance combined to largely cancel the negative effect of the above average-allocation for large cap U.S. stock. Ultimately, however, differences in asset allocation had little to do with this group's difference in net return, unsurprising since the difference in net return isn't statistically significant.

When mid-sized U.S. corporate DB funds are further grouped by being above/below average in allocation to each aggregate asset class, an apparent contradiction arises since funds with above-average allocations to TAA/hedge funds perform somewhat better than the all fund average (7.21 percent, Z=1.9), despite poor net returns from the aggregate asset class. The better than average return by those funds with above-average allocation to TAA/hedge

Tables 12A and 12B. Differences in asset allocations relative to the all fund average (12A) and impacts of differences in asset allocation on net returns in basis points (12B) for mid-sized (greater than \$2 billion AUM, less than \$10 billion AUM) public sector DB pension funds. Total impacts in 12B are the total impacts of differences in asset allocation for each aggregate asset class in basis points on 14-year annualized compound net returns relative to the all fund average.

**Table 12A. Difference in Asset Allocation Relative to the All Fund Average:
Mid-Sized Public Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -4.3% | -1.6% | 6.2% | 1.3% | -12.1% | 2.2% | 0.6% | 2.1% | -0.1% | 1.2% | 3.0% | 1.5% |
| 2010 | -2.7% | -0.6% | 5.0% | 0.2% | -9.2% | 1.3% | 1.7% | 1.6% | -0.1% | 1.0% | 1.1% | 0.7% |
| 2009 | -2.5% | 0.0% | 3.7% | 0.6% | -7.4% | 1.5% | 1.1% | 1.4% | 0.0% | 0.6% | 1.6% | -0.6% |
| 2008 | -4.1% | 0.2% | 2.3% | 0.2% | -6.3% | 1.5% | 1.8% | 1.8% | 0.0% | 0.9% | 1.9% | -0.2% |
| 2007 | -3.3% | -0.5% | 1.9% | 2.0% | -4.3% | 1.1% | 1.5% | 1.0% | 0.1% | 0.6% | 0.3% | -0.3% |
| 2006 | -5.3% | 0.6% | 2.2% | -0.1% | -1.9% | 2.3% | 1.2% | 0.3% | -0.2% | 0.4% | 0.9% | -0.4% |
| 2005 | -4.8% | 0.5% | 1.6% | -0.3% | -1.4% | 1.9% | 1.2% | 0.0% | -0.3% | 0.3% | 1.3% | -0.2% |
| 2004 | -5.5% | 1.7% | 1.8% | -0.4% | -1.4% | 2.3% | 1.1% | 0.2% | -0.3% | 0.2% | 0.8% | -0.4% |
| 2003 | -2.2% | 0.8% | -1.2% | 1.2% | -0.8% | 1.2% | 1.0% | -0.1% | -0.2% | 0.1% | 0.1% | -0.1% |
| 2002 | -3.5% | 0.8% | -1.3% | 4.1% | -1.5% | 1.0% | 0.1% | 0.4% | 0.2% | 0.2% | 0.3% | -0.9% |
| 2001 | -3.2% | 1.1% | -1.5% | 3.4% | -0.9% | 0.8% | 0.2% | 0.5% | 0.0% | 0.1% | -0.1% | -0.5% |
| 2000 | -4.0% | 0.6% | -2.7% | 6.5% | -0.9% | 0.4% | -0.2% | 0.4% | -0.1% | 0.1% | 0.2% | -0.5% |
| 1999 | -2.1% | 0.3% | -2.1% | 6.2% | -1.2% | 0.2% | 0.5% | 0.2% | -0.1% | 0.1% | -0.8% | -1.1% |
| 1998 | -1.7% | 0.3% | -2.2% | 6.3% | -0.9% | 0.1% | 0.3% | 0.1% | -0.2% | 0.1% | -1.0% | -1.1% |
| Avg.: | -3.5% | 0.3% | 1.0% | 2.2% | -3.6% | 1.3% | 0.9% | 0.7% | -0.1% | 0.4% | 0.7% | -0.3% |

**Table 12B. Impacts on Physical Asset Only Net Returns in Basis Points of Difference in Asset Allocation:
Mid-Sized Public Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|------------|---|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -9.3 | 3.5 | -96.6 | 14.6 | -276.5 | 11.5 | 3.2 | 22.9 | -0.3 | -0.6 | 4.5 | -5.4 |
| 2010 | -8.0 | -8.1 | -9.7 | -1.2 | 25.8 | -11.2 | -0.9 | 3.1 | -0.6 | -3.1 | -5.5 | 11.5 |
| 2009 | -13.2 | 0.2 | 66.0 | -9.5 | 156.3 | -19.0 | -6.2 | -3.0 | 0.2 | -11.5 | -18.5 | -8.3 |
| 2008 | 61.2 | -2.0 | -50.5 | 5.7 | -257.6 | 34.8 | 33.4 | -25.1 | -0.3 | 16.1 | 17.5 | 2.4 |
| 2007 | 3.6 | 2.3 | 19.1 | -0.3 | -4.5 | -2.1 | 1.9 | -23.9 | -2.3 | 4.4 | 0.3 | -0.5 |
| 2006 | 0.8 | 0.1 | 31.0 | 1.2 | 22.5 | -21.4 | -8.6 | -0.3 | -4.9 | 0.1 | -3.5 | -5.4 |
| 2005 | 9.6 | -0.5 | 17.8 | 1.7 | 2.8 | -9.8 | -7.8 | 0.0 | -1.7 | 3.3 | -1.7 | 1.2 |
| 2004 | 4.9 | 7.7 | 15.5 | 3.9 | 5.0 | -19.2 | -2.7 | 2.6 | -5.7 | 1.3 | -4.5 | -2.5 |
| 2003 | -23.4 | 17.0 | -18.7 | -29.5 | 13.1 | -19.9 | -6.4 | 0.7 | -1.6 | -1.1 | -1.5 | -0.5 |
| 2002 | 73.7 | -10.4 | 10.0 | 100.9 | -33.6 | 9.7 | 2.4 | 7.9 | 2.3 | 3.2 | -1.6 | 13.6 |
| 2001 | 32.7 | 2.3 | 25.5 | 55.4 | -8.8 | 6.2 | 1.2 | 4.3 | 0.6 | 0.8 | 0.2 | -1.0 |
| 2000 | 36.3 | -0.3 | 41.0 | 101.5 | -13.4 | 2.2 | -0.6 | 1.1 | -3.0 | 2.0 | 0.2 | -1.2 |
| 1999 | -12.8 | 4.0 | -54.8 | -144.6 | 27.6 | -2.1 | -6.6 | -0.3 | 2.0 | 0.9 | 4.6 | -21.9 |
| 1998 | -24.5 | -3.5 | 7.2 | -59.7 | 2.7 | -1.3 | -1.3 | -0.4 | 4.0 | -0.8 | -6.4 | -14.8 |
| Subtotals: | 13.1 | 0.6 | -1.9 | 6.6 | -35.9 | -0.9 | 1.4 | -1.3 | -0.8 | 1.8 | -0.3 | -1.9 |
| Total: | -19.4 bps of -35.3bps of average annualized net return underperformance is explained by differences in asset allocation | | | | | | | | | | | |

funds was, in fact, not driven by differences in allocation to TAA/hedge funds, which was actually detrimental, but by differences in allocation to non U.S. stock and long duration U.S. fixed income.

It is also instructive to compare the impacts of allocations to large cap U.S. stock for this cohort of funds to the previous cohort, large public plans. Over the whole period, both funds were over-exposed on average by the same amount, 1.7 percent, yet the total impacts differed by nearly five-fold (-10.4 basis points vs. -2.1 basis points). The difference illustrates two important features of this analysis, market timing and interactions within the total portfolio. Large public plans were mostly overweight large cap U.S. stock from 2004 through 2007 (timing), when returns for the aggregate asset class were largely positive, but not more so than the weighted average of the cohort's other investments (interactions). The result is a slight negative impact due to allocation differences in large cap U.S. stock. By contrast, mid-sized corporate plans were mostly overweight large cap U.S. stock from

Tables 13A and 13B. Differences in asset allocations relative to the all fund average (13A) and impacts of differences in asset allocation on net returns in basis points (13B) for small (less than \$2 billion AUM) corporate sector DB pension funds. Total impacts in 13B are the total impacts of differences in asset allocation for each aggregate asset class in basis points on 14-year annualized compound net returns relative to the all fund average.

**Table 13A. Difference in Asset Allocation Relative to the All Fund Average:
Small Corporate Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | 2.7% | 2.1% | -2.9% | -0.4% | 4.1% | -0.6% | 0.6% | -1.2% | 0.1% | -0.7% | -0.2% | -3.7% |
| 2010 | 3.2% | 3.1% | -1.9% | -2.5% | 4.0% | -0.2% | 0.4% | -1.5% | -0.2% | -0.2% | -1.2% | -2.9% |
| 2009 | 2.2% | 2.2% | -2.0% | -1.2% | 3.2% | 0.3% | -0.2% | -1.5% | -0.2% | 0.0% | -0.8% | -1.9% |
| 2008 | 2.6% | 2.4% | -1.4% | 0.1% | 1.2% | -0.4% | -0.2% | -1.2% | 0.0% | -0.2% | -1.1% | -1.9% |
| 2007 | 2.2% | 2.3% | -2.7% | 2.0% | 0.9% | -0.3% | -0.7% | -0.8% | -0.1% | -0.3% | -0.9% | -1.7% |
| 2006 | 5.3% | 3.2% | -2.9% | 2.2% | 0.0% | -1.8% | -1.0% | -1.2% | -0.2% | -0.3% | -1.4% | -2.0% |
| 2005 | 3.7% | 2.8% | -3.2% | 0.7% | 0.2% | -0.4% | -0.4% | -0.8% | -0.2% | -0.2% | -0.3% | -1.9% |
| 2004 | 5.5% | 1.2% | -2.9% | 1.5% | -0.3% | -1.1% | -1.0% | -0.5% | -0.1% | -0.1% | -0.5% | -1.7% |
| 2003 | 2.8% | 1.5% | -1.8% | -0.7% | 1.5% | 0.2% | -1.3% | -0.4% | -0.3% | 0.0% | 0.3% | -1.7% |
| 2002 | 2.2% | 0.8% | 0.4% | -2.4% | 2.3% | -0.1% | -1.3% | -1.2% | -0.4% | 0.0% | 0.6% | -0.8% |
| 2001 | 1.3% | 2.5% | -0.8% | -1.6% | 2.0% | -0.4% | -1.1% | -0.8% | -0.2% | 0.0% | 0.5% | -1.4% |
| 2000 | 1.3% | 3.6% | -0.8% | -3.2% | 0.8% | -0.3% | -0.6% | -0.8% | 0.0% | 0.0% | 0.3% | -0.4% |
| 1999 | 0.6% | 2.4% | -0.4% | -2.7% | 0.8% | 0.1% | -0.9% | -0.3% | 0.1% | 0.0% | 0.3% | 0.1% |
| 1998 | 0.5% | 1.9% | 0.1% | -2.1% | 0.4% | 0.1% | -0.9% | -0.3% | 0.0% | 0.0% | 0.1% | 0.1% |
| Avg.: | 2.6% | 2.3% | -1.7% | -0.7% | 1.5% | -0.3% | -0.6% | -0.9% | -0.1% | -0.1% | -0.3% | -1.5% |

**Table 13B. Impacts on Physical Asset Only Net Returns in Basis Points of Difference in Asset Allocation:
Small Corporate Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|------------|--|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -9.1 | -14.8 | 54.9 | -2.6 | 91.3 | -0.3 | 0.7 | -7.4 | -0.1 | 3.3 | 0.6 | 28.9 |
| 2010 | 9.9 | 41.3 | 3.6 | 15.0 | -13.5 | 1.5 | -0.3 | -2.8 | -2.3 | 0.5 | 6.2 | -46.7 |
| 2009 | 18.3 | 24.0 | -38.7 | 17.6 | -69.6 | -2.9 | 0.7 | 0.1 | -1.3 | -0.2 | 7.6 | -30.2 |
| 2008 | -50.4 | -33.8 | 32.5 | 2.9 | 49.9 | -8.0 | -2.6 | 19.2 | -0.4 | -2.5 | -7.6 | 26.9 |
| 2007 | -2.3 | -11.0 | -25.0 | -0.1 | 1.1 | 0.5 | -0.9 | 20.5 | 2.3 | -2.0 | -1.1 | -2.4 |
| 2006 | 4.9 | 2.8 | -40.3 | -25.3 | 0.2 | 14.7 | 5.9 | 0.3 | -3.8 | -0.3 | 4.4 | -31.7 |
| 2005 | -5.7 | -1.5 | -34.0 | -4.2 | -0.3 | 1.9 | 2.4 | -8.2 | -1.4 | -2.6 | 0.2 | 8.5 |
| 2004 | -2.2 | 6.1 | -25.1 | -13.5 | 0.8 | 8.5 | 2.2 | -7.8 | -1.8 | -0.4 | 2.7 | -12.7 |
| 2003 | 28.6 | 29.4 | -27.5 | 17.6 | -26.6 | -3.3 | 8.8 | 4.1 | -2.3 | 0.0 | -3.1 | -5.9 |
| 2002 | -42.9 | -8.5 | -2.2 | -60.9 | 58.0 | -1.1 | -29.5 | -26.6 | -6.2 | -0.8 | -2.3 | 10.5 |
| 2001 | -12.2 | 7.7 | 13.1 | -25.8 | 22.2 | -3.2 | -6.5 | -7.5 | -3.3 | -0.1 | -0.3 | -4.0 |
| 2000 | -10.0 | 3.0 | 11.3 | -48.9 | 14.2 | -2.2 | -3.0 | -3.1 | 0.4 | 0.1 | 0.6 | -1.6 |
| 1999 | 1.6 | 36.0 | -9.5 | 64.2 | -21.0 | -1.3 | 15.3 | 0.9 | -1.6 | -0.1 | -2.1 | 2.6 |
| 1998 | 6.6 | -26.1 | -0.6 | 19.6 | -1.5 | -1.1 | 4.3 | 2.6 | -0.6 | 0.2 | 0.8 | 1.2 |
| Subtotals: | -7.4 | 1.6 | -4.0 | -5.0 | 11.4 | 0.0 | -0.9 | -1.0 | -1.6 | -0.4 | 0.1 | -2.3 |
| Total: | -9.6 bps of -8.1 bps of average annualized net return underperformance is explained by differences in asset allocation | | | | | | | | | | | |

2000-2002 (timing), when returns from the asset class were negative and significantly worse than the weighted average of the cohort's other investments (interactions). The result here is a large negative impact due to allocation differences in large cap U.S. stock.

6.4 How Funds Invested: Mid-sized Public Sector Funds

Over the sample period 1998-2011, mid-sized U.S. public sector DB plans had an average annualized compound net return of 6.26 percent, about two standard errors below the all fund average. The differences in asset allocation relative to the all fund average, shown in Table 12A are, thematically, opposite of their mid-sized corporate sector peers; below average allocations to large cap U.S. stock and U.S. long bonds.

Tables 14A and 14B. Differences in asset allocations relative to the all fund average (14A) and impacts of differences in asset allocation on net returns in basis points (14B) for small (less than \$2 billion AUM) public sector DB pension funds. Total impacts in 14B are the total impacts of differences in asset allocation for each aggregate asset class in basis points on 14-year annualized compound net returns relative to the all fund average.

**Table 14A. Difference in Asset Allocation Relative to the All Fund Average:
Small Public Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|-------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -1.6% | 0.9% | 6.2% | 1.0% | -12.5% | -0.2% | 3.1% | 1.9% | 0.4% | 0.6% | 0.6% | -0.3% |
| 2010 | 4.5% | 1.2% | 3.6% | 3.8% | -9.6% | -2.7% | 1.9% | 2.0% | 0.4% | -0.2% | -1.9% | -3.1% |
| 2009 | 4.1% | 2.8% | 1.6% | 10.1% | -8.0% | -2.6% | -1.2% | 0.6% | -0.1% | -0.3% | -2.6% | -4.4% |
| 2008 | 4.3% | 1.4% | 0.4% | 11.1% | -5.4% | -2.9% | -1.3% | -0.5% | 0.3% | -0.7% | -2.8% | -3.8% |
| 2007 | 0.6% | 3.7% | -0.3% | 2.9% | -4.3% | -1.5% | 0.3% | 1.5% | -0.1% | -0.1% | -0.7% | -2.0% |
| 2006 | -2.3% | 5.2% | -1.5% | 4.4% | -1.9% | -2.7% | -0.3% | 0.4% | 0.4% | -0.3% | 0.2% | -1.5% |
| 2005 | -1.4% | 5.7% | -3.8% | 5.1% | -1.4% | -2.8% | 0.3% | -0.3% | 1.1% | -0.2% | -1.1% | -1.4% |
| 2004 | -4.7% | 3.8% | -1.8% | 4.7% | -1.4% | -2.5% | 1.1% | -0.3% | 0.9% | 0.0% | 0.3% | 0.0% |
| 2003 | -2.7% | 1.0% | -1.0% | 2.8% | -1.6% | -1.4% | 1.7% | -0.3% | 1.0% | 0.2% | 0.6% | -0.4% |
| 2002 | -2.8% | 1.4% | -1.3% | 4.1% | -1.5% | -1.1% | 2.2% | 0.3% | 0.0% | -0.1% | 0.1% | -1.2% |
| 2001 | -3.8% | 0.2% | -1.5% | 3.5% | -0.9% | 0.1% | 1.9% | -0.1% | 0.3% | -0.1% | 1.0% | -0.7% |
| 2000 | 0.6% | -1.1% | -1.1% | 3.4% | -0.9% | -0.6% | 2.4% | -0.3% | 0.2% | 0.0% | -0.2% | -2.4% |
| 1999 | 0.0% | -0.1% | -1.2% | 2.4% | -1.2% | -0.2% | 1.7% | -0.7% | 0.1% | 0.0% | 0.5% | -1.1% |
| 1998 | -1.2% | 0.2% | -0.4% | 0.8% | -0.9% | -0.5% | 3.1% | -0.2% | -0.1% | 0.0% | 0.4% | -1.2% |
| Avg.: | -0.5% | 1.9% | -0.2% | 4.3% | -3.7% | -1.5% | 1.2% | 0.3% | 0.3% | -0.1% | -0.4% | -1.7% |

**Table 14B. Impacts on Physical Asset Only Net Returns in Basis Points of Difference in Asset Allocation:
Small Public Sector U.S. DB Pension Funds**

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|------------|--|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -3.7 | -2.0 | -95.5 | 11.2 | -286.3 | -1.0 | 18.2 | 20.4 | 1.4 | -0.3 | 1.0 | 1.1 |
| 2010 | 13.7 | 15.4 | -7.7 | -25.6 | 28.7 | 23.2 | -1.5 | 3.7 | 3.6 | 0.6 | 9.4 | -49.5 |
| 2009 | 25.4 | 25.2 | 27.5 | -193.6 | 166.5 | 31.3 | 6.6 | -1.2 | -0.4 | 5.0 | 28.5 | -60.1 |
| 2008 | -78.7 | -18.1 | -9.1 | 415.8 | -217.6 | -59.9 | -22.0 | 6.5 | -3.4 | -11.5 | -21.6 | 50.5 |
| 2007 | -0.2 | -15.9 | -3.5 | 1.5 | -6.8 | 1.9 | 0.5 | -36.5 | 1.1 | -0.7 | -1.2 | -3.7 |
| 2006 | -0.7 | 2.5 | -20.9 | -54.7 | 21.9 | 23.7 | 2.1 | -0.2 | 8.8 | -0.2 | -0.5 | -22.7 |
| 2005 | 2.0 | -3.1 | -40.1 | -31.3 | 2.2 | 12.3 | -1.5 | -3.0 | 7.4 | -2.3 | 0.8 | 6.2 |
| 2004 | 4.7 | 17.7 | -14.7 | -46.4 | 5.1 | 20.1 | -2.8 | -3.6 | 19.0 | 0.1 | -1.6 | -0.3 |
| 2003 | -26.8 | 20.4 | -16.2 | -69.4 | 27.1 | 22.3 | -11.5 | 2.8 | 9.2 | -2.3 | -6.9 | -1.6 |
| 2002 | 61.2 | -17.1 | 10.2 | 98.4 | -33.5 | -10.5 | 50.0 | 5.5 | 0.1 | -1.5 | -0.4 | 19.1 |
| 2001 | 39.1 | 0.4 | 24.5 | 56.5 | -8.8 | 1.1 | 10.0 | -0.8 | 4.3 | -0.5 | -1.7 | -1.3 |
| 2000 | -5.1 | -0.3 | 16.5 | 54.5 | -14.1 | -3.7 | 11.6 | -1.2 | 5.6 | -0.9 | -0.3 | -7.6 |
| 1999 | -0.1 | -1.3 | -32.4 | -54.5 | 28.3 | 2.3 | -26.1 | 1.5 | -1.7 | -0.2 | -3.0 | -21.8 |
| 1998 | -16.5 | -2.7 | 1.5 | -7.7 | 3.1 | 5.0 | -14.9 | 1.2 | 2.2 | 0.2 | 2.2 | -14.9 |
| Subtotals: | -0.5 | 0.2 | -11.5 | 30.7 | -30.8 | 2.0 | 1.7 | 0.0 | 3.8 | -1.4 | -0.6 | -4.6 |
| Total: | -11.1bps of -60.3bps of average annualized net return underperformance is explained by differences in asset allocation | | | | | | | | | | | |

Given the three cases described already, the impacts of these asset allocation decisions, shown in Table 12B, should not be surprising; the positive impacts of being underweight large cap U.S. stock are opposed by the negative impacts of being underweight U.S. long bonds. Due to timing of the latter choice, however, the impact was greatly magnified such that the total impact of being underweight U.S. long bonds was about three times as important as the choice to be underweight U.S. large cap stocks, resulting in net underperformance.

Where this group of funds was overweight to compensate for being underweight U.S. large cap stock and U.S. long bonds, essentially every other asset class, proved to be immaterial by comparison.

6.5 How Funds Invested: Small Corporate Sector Funds

From 1998 through 2011, small U.S. corporate sector DB funds had an average annualized compound net return of 6.53 percent, only eight basis points below the all fund average ($Z=-0.3$). Despite the similarity, the allocation was quite different from the average, as shown in Table 13A. Indeed, small corporate fund asset allocations were similar to mid-sized corporate funds, with the exception that they invested more in small cap U.S. stock and less in non-U.S. stock than their mid-sized counterparts. These choices, however, proved to be largely offsetting (see Table 13B).

The main difference between small corporate funds and mid-sized corporate funds was a matter of simple timing. A comparison of Tables 11A and 11B with Table 13A and 13B shows that small corporate plans were late in adopting LDI investing strategies, on average, and gained less from U.S. long bonds in 2008 than did mid-sized corporate plans.

6.6 How Funds Invested: Small Public Sector Funds

Small public sector plans were the worst performing plans of the six fund type/size cohorts, with average annualized net returns of 6.01 percent, nearly three standard errors below the all fund average of 6.61 percent (*i.e.*, $Z=-3$). However, when examining the group's differences in asset allocation to the all fund averages, shown in Table 14A, or the impacts of the differences, shown in Table 14B, it is not readily apparent that differences in asset allocation were the primary cause of this underperformance. Indeed, the sum of the total impacts suggests that this cohort of funds should have underperformed the all fund average by only 11 basis points rather than the realized 60 basis points.

The cause of the underperformance was not asset allocation but, rather, underperformance within asset classes relative to the all fund average. While an in depth discussion of the reasons for this underperformance are beyond the scope of this research, we note here that small public sector plans underperformed the all fund average within small cap U.S. equities by 115 basis points, private real estate by 109 basis points, and private equity by an astounding 407 basis points. In these cases the differences are, at least in part, due to higher investment costs relative to the other fund type/size cohorts.

6.7 How Funds Invest: The 1 Percentage Point Change

The impacts on net returns arising from differences in asset allocation of small, mid-sized, and large public and corporate sector pension funds places each aggregate asset class on an unequal footing; impacts will be larger where deviations in asset allocations from the all fund average allocation are largest. In order to place each aggregate asset class on a more equal footing, we calculate the potential marginal impacts that arise from a one percentage point increase to each aggregate asset class relative to the all fund average.

The marginal impacts on annual net returns that result from a one percentage point increase to each aggregate asset class are shown in Table 15. (We do not show the impacts of a one percentage point decrease since, by symmetry, they are equal and opposite). The estimates reveal that one percentage point increases in allocations to U.S. long bonds, listed equity REITs, and other real assets would have provided the largest marginal increases to total portfolio annualized average net returns of 4.4 basis points, 3.9 basis points, and 3.8 basis points per year, respectively, over a period that includes the Global Financial Crisis. To put this in perspective, an average size U.S. public sector fund having had 1998 assets of a little over \$15 billion and a 14-year compound net total return of approximately 6.19 percent (from Table 7) would have generated an additional \$180 million in assets over the 14-year period had its investment policy allocated an extra one percentage point of assets to listed equity REITs.

Table 15. Estimates in basis points of the marginal benefit or loss to the average annual portfolio net total return resulting from a one percentage point increase in allocation to each of the aggregate asset classes by year. The total impact is an estimate of the benefit (or loss) to the average annualized compound net total returns over the period 1998-2011 of a persistent, one percentage point increase to each of the aggregate asset classes relative to the all fund average allocation. Note that a one percentage point decrease in allocation has an equal and opposite loss (or benefit).

Table 15. Marginal Impacts to Average Annualized Compound Net Returns by a One Percentage Point Increase in Allocation

| Year | Stock | | | Fixed Income | | | | Real Assets | | | Other | |
|---------|----------------|----------------|----------|--------------|-----------|------------|----------|---------------------|---------------------|-------|-------------------|----------------|
| | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad | U.S. Long | U.S. Other | Non U.S. | Private Real Estate | Listed Equity REITs | Other | TAA / Hedge Funds | Private Equity |
| 2011 | -1.7 | -5.4 | -18.2 | 7.5 | 22.5 | 1.9 | 2.5 | 7.4 | 0.6 | -3.6 | -1.9 | -6.9 |
| 2010 | 3.1 | 13.2 | -1.8 | -6.2 | -3.1 | -8.8 | -0.6 | 1.9 | 9.7 | -3.1 | -5.0 | 16.4 |
| 2009 | 7.3 | 9.9 | 18.6 | -15.5 | -21.6 | -11.5 | -4.4 | -0.8 | 5.5 | -19.0 | -10.2 | 15.3 |
| 2008 | -18.2 | -13.3 | -23.6 | 31.5 | 41.8 | 20.5 | 16.6 | -15.3 | -13.6 | 16.0 | 7.1 | -14.4 |
| 2007 | -1.2 | -4.8 | 9.5 | -0.2 | 1.0 | -1.9 | 1.1 | -24.8 | -17.6 | 7.3 | 1.1 | 1.3 |
| 2006 | -0.1 | 0.2 | 13.8 | -12.1 | -12.0 | -9.1 | -6.8 | -0.8 | 20.6 | 0.4 | -3.8 | 15.4 |
| 2005 | -2.0 | -0.9 | 10.7 | -6.2 | -2.0 | -4.9 | -6.2 | 10.5 | 6.2 | 11.2 | -1.2 | -5.0 |
| 2004 | -0.9 | 4.5 | 8.6 | -9.2 | -3.5 | -8.0 | -2.5 | 14.1 | 20.1 | 5.6 | -5.8 | 7.1 |
| 2003 | 10.0 | 19.8 | 15.6 | -24.1 | -17.9 | -16.7 | -6.9 | -10.0 | 8.7 | -15.2 | -10.8 | 3.7 |
| 2002 | -20.5 | -11.0 | -6.5 | 24.7 | 24.2 | 11.2 | 23.0 | 20.8 | 13.9 | 17.9 | -4.4 | -14.3 |
| 2001 | -9.4 | 2.9 | -15.8 | 16.6 | 10.7 | 8.7 | 6.1 | 9.1 | 15.0 | 8.5 | -0.7 | 2.9 |
| 2000 | -7.9 | 0.7 | -14.4 | 15.8 | 16.5 | 6.6 | 5.0 | 3.8 | 26.2 | 19.2 | 2.0 | 3.7 |
| 1999 | 3.8 | 13.1 | 25.4 | -23.5 | -25.0 | -11.5 | -16.0 | -3.1 | -15.9 | 5.4 | -7.4 | 18.3 |
| 1998 | 13.8 | -13.3 | -4.1 | -9.6 | -3.8 | -9.7 | -5.0 | -7.7 | -21.9 | -13.9 | 5.6 | 12.4 |
| Totals: | -2.9 | 0.2 | -0.4 | 1.4 | 4.4 | -1.0 | 1.6 | 0.4 | 3.9 | 3.8 | -2.1 | 2.8 |

However, given our discussion on asset allocation in Section 5, the potential positive impacts of increased exposure to listed equity REITs and other real assets went unrealized by most U.S. DB pension funds as both equity REITs and other real assets had the lowest allocations of any aggregate asset class considered.

The aggregate asset class with the fourth largest impact was U.S. large cap stocks which, for each one percentage point decrease in allocation provided a 2.9 basis points marginal increase to total portfolio annualized average net returns, almost equal and opposite to the 2.8 basis points marginal increase to total portfolio annualized average net returns for each one percentage point increase to private equity.

The aggregate asset class with the fourth largest impact was U.S. large cap stocks which, for each one percentage point decrease in allocation provided a 2.9 basis points marginal increase to total portfolio annualized average net returns, almost equal and

7 Discussion and Conclusions

In this study we have analyzed the net return performance of U.S. DB pension funds for the period spanning 1998-2011. To do so effectively, we have recognized the necessity of standardizing the net returns of private equity and private real estate by placing them at common points in the market cycle with respect to publicly traded assets. This standardization removes from the analysis a bias which would have resulted from how returns from privately traded investments are reported.

Standardizing the time series of net returns reveals some interesting observations. The excess returns from publicly traded equity REITs when compared with real estate investments in private markets over the sample period was 370 basis points (316 basis points compounded), but came with 22 percent more volatility. Furthermore, after standardization of the private real estate net return series for reporting lag and appraisal smoothing, the net returns from the two aggregate asset classes are seen to have been highly correlated. The use of leverage by listed equity REITs likely accounts in part for the fact that REITs were the best performing aggregate asset class from among all 12 aggregate asset classes included in the analysis and that REITs significantly

outperformed private real estate over the sample period. However, the returns reported for private real estate investments typically also incorporate the use of some amount of leverage, and differences in the use of leverage are unlikely to explain all of the outperformance by REITs.

When standardized to account for reporting lag, the converse is true with respect to net returns for private equity and equity investments in public markets. In particular, net returns from private equity outperformed large cap U.S. stock by 504 basis points (442 basis points compounded) and small cap U.S. stock by 285 basis points (246 basis points compounded) yet had similar volatilities.

In terms of fund performance, our study demonstrates that large U.S. corporate sector DB pension funds significantly outperformed the all fund average in terms of physical asset only net returns. The cause of the outperformance was a dramatic and timely move which saw a reduction in asset allocation to large cap U.S. stocks and an increase in asset allocation to long duration bonds circa 2007. While small and mid-sized corporate funds followed this trend, they did not do so to the same degree.

The biggest source of differences in fund performance is found in how funds deployed their assets. By quantifying the effects on net returns made by changes in asset allocation, we find that two of the largest positive impacts on net returns could have been made by increasing pension fund allocations to other real assets (infrastructure, commodities, etc.) and listed equity REITs, yet these assets had the smallest allocations of any aggregate asset class over the sample period 1998-2011. Thus, their potential impact was largely unrealized. The other large impacts to net fund performance were found in decreased allocations to large cap U.S. stock and increased allocations to long duration bonds and private equity. This is exactly what large corporate sector funds did and explains their outperformance over the sample period.

8 Acknowledgement

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Appendix A: Asset Class Aggregation and Performance Measures

As of 2011, the CEM Benchmarking Inc. included 186 different asset classes in its global database, of which 104 are applicable to U.S. funds. Publicly traded asset classes used by CEM are differentiated on whether they are managed internally or externally and whether the mandate is actively or passively managed. Privately traded asset classes, by contrast, cannot be managed passively and are instead differentiated based on whether they are managed internally, externally, by operating subsidiaries, by limited partnerships, as co-investments, or by means of fund-of-funds. The full list of asset classes defined by CEM and applicable to U.S. participating funds is listed below:

- Stock: U.S. broad (if large, medium, and small cap stock cannot be differentiated)
- Stock: U.S. large cap
- Stock: U.S. small cap (includes mid cap)
- Stock: EAFE
- Stock: Emerging
- Stock: All country world ex-U.S.
- Stock: Global (approximately 30 percent U.S. 70 percent non U.S.)
- Stock: Employer stock
- Stock: Other
- Fixed income: U.S. investment grade
- Fixed income: U.S. long bonds
- Fixed income: U.S. TIPS
- Fixed income: High yield
- Fixed income: Mortgages (not mortgage backed bonds)
- Fixed income: EAFE
- Fixed income: Emerging
- Fixed income: Global
- Fixed income: Other
- Fixed income: Cash
- Real assets: Commodities
- Real assets: Listed equity REITs
- Real assets: Private real estate
- Real Assets: Infrastructure
- Real Assets: Natural resources (privately traded)
- Real Assets: Other
- Tactical asset allocation (funded TAA programs)
- Hedge Funds
- Private equity: Diversified
- Private equity: Venture capital
- Private equity: Leveraged buy out
- Private equity: Other

To make studying the performance of asset classes manageable, we have aggregated the 104 asset classes, including the above asset types further divided by investment style, into a much smaller set of 12 *aggregate asset classes* based on four primary factors. The first three factors are centered on fitting net return series for each of the asset classes to a simple linear model:

$$r_a = \alpha + \beta r_r$$

where r_a is the net return of the asset class, r_r is the net return of a reference asset class, and α and β are the usual 'excess return' and 'correlated volatility' parameters used in investment benchmarking. (The implied meaning of the terms is not necessarily applicable here, but the model is useful nonetheless). We have solved the equation using linear least squares for all 104 x 104 pairs of asset classes, yielding estimates of α , β , and the correlation coefficient ρ .

We look to the linear model to illustrate three desirable qualities in the returns of an asset class and a reference asset class if they are to be aggregated. These three qualities include:

1. The 'excess return' parameter α should be near zero: if α is either large positive or large negative, then aggregation of the two asset classes will average out markedly different series of returns.
2. The 'correlated volatility' parameter β should be close to one: if β is not close to one, then aggregation of the two asset classes will average out markedly different series of returns while also causing a suppression of the volatility through diversification.
3. The correlation coefficient ρ should be close to one: if ρ is significantly less than one, the model fails to describe the relationship between the two series of net returns and estimates of α and β cannot be trusted.

A fourth factor we use is an *ad-hoc* one, based on data checking. For a handful of asset classes, none of the above criteria is strictly met, yet other widely-recognized characteristics of each of these asset classes imply that each one should belong to a particular aggregate asset class. All of the private equity asset classes, for example, fall into this fourth category because they do not clearly align with the three qualities specified above prior to standardizing the data for smoothing and reporting lag.

Tables A1, A2 and A3 show the linear regression parameters α , β , and ρ for 2,601 (51 x 51) pairs of asset classes (a subset of the full 10,816 pairs). Along the top and sides of the tables we list the 12 aggregate asset classes we use going forward. These 12 classes are:

- Stock: U.S. large cap (*e.g.*, large cap equities appearing in the S&P 500)
- Stock: U.S. small cap (*e.g.*, Russell 2000 small cap equities + mid cap equities)
- Stock: Non U.S. (*e.g.*, non US equities such as EAFE and emerging market equities)
- Fixed income: U.S. broad (*e.g.*, investment grade U.S. corporate bonds, U.S. treasuries)
- Fixed income: U.S. long bonds (*e.g.*, strategies dedicated to long duration bonds)
- Fixed income: U.S. other (*e.g.*, non-investment grade bonds, mortgages, cash)
- Fixed income: Non U.S. (*e.g.*, non US bonds)
- Real assets: Listed equity REITs (publicly traded real estate)
- Real assets: Private real estate (*e.g.*, direct real estate holdings, real estate limited partnerships)
- Real assets: Other (*e.g.*, commodities, infrastructure, natural resources)
- Hedge funds / TAA (*e.g.*, hedge funds and tactical asset allocation teams)
- Private equity (*e.g.*, venture capital, diversified private equity, private equity fund of funds)

We have removed from the tables in Appendix A those asset classes which were sparsely populated, and so do not meaningfully contribute to the aggregated asset classes. Where these omitted results are notable, we discuss them here.

A.1 Stock

Beginning with the 18 x 18 stock pairings, it is evident that we may aggregate these into three aggregate asset classes rather easily, stock: large cap, stock: small cap, and stock: non-U.S. The four stock: U.S. broad and four stock: U.S. large cap all have α 's less than one percent in magnitude, β 's between 0.91 and 1.07, and ρ 's > 0.98, and as such, these eight asset classes may safely be aggregated without distorting the data. Similar considerations apply to the 4 x 4 small cap stock pairings, and the 6 x 6 non-U.S. stock pairings shown. Deviations between these three aggregate asset classes are strong enough to prevent aggregation into a single category of stock; for example, the large α 's of small cap U.S. stock over large cap U.S. stock, or the large β 's of non-U.S. stock over large cap U.S. stock.

A.2 Fixed income

Fixed income is more problematic. Even within the 4 x 4 pairings of U.S. investment grade fixed income, their β 's deviate significantly from one, especially between internal passive and external active mandates. However, these deviations are all caused by outlier data from 2008 when, for example, external active mandates suffered large losses in comparison with internal passive mandates. The cause of this deviation is likely an over-exposure to credits (which crashed) by external active bond managers relative to internal passive bond managers. Removing the data point results in β 's near 1 and near perfect correlation, and so we aggregate these four assets into a single aggregate asset class, fixed income: U.S. broad.

Long bonds show clear hallmarks of being a single aggregate asset class, displaying a high degree of similarity in returns with each other, but not with any other asset classes, and so are aggregated together in fixed income: long bonds asset class. Fixed income: EAFE and fixed income: global also show the traits of a good asset aggregation, while fixed income: emerging does not. However, as emerging market fixed income represents less than 0.5 percent of the holdings of U.S. DB pension funds, we roll the data into a fixed income: non-U.S. aggregate asset class, confident that it does not alter our conclusions.

Finally, we have aggregated TIPs, high yield bonds, mortgages and cash into a fixed income: U.S. other aggregate asset class. This aggregation is not ideal, but is required in order to limit the number of fixed income aggregate asset classes. We have checked that this aggregation does not fundamentally alter our conclusions. However, we remark that this aggregate asset class is significantly less volatile than its components through diversification effects.

A.3 Real assets

The four listed equity REIT asset classes all fit comfortably into a single aggregate asset class, despite external active managers performing somewhat worse than the others, while also taking on more risk. Furthermore, while listed equity REITs have a high degree of correlation with U.S. large cap and small cap stocks, they also display significant and large α 's (on average 9.2 percent and 5.6 percent, respectively) suggesting large outperformance of REITs relative to U.S. equities from 1998 through 2011.

Private real estate and listed equity REITs show little in common despite the fact that the two share very similar underlying assets. We defer discussion of this phenomenon to Section 4 where we analyze the smoothing and reporting lag in private assets. We simply note here that the four types of private real estate behave similarly, and can safely be aggregated.

Commodities, infrastructure, and other real assets are rolled into a single aggregate asset class despite not sharing much in the way of similar net returns, akin to the situation experienced with fixed income U.S. other. The choice is driven by the need for a manageable number of aggregate asset classes, together with the fact that allocation to these asset classes is small at 0.43 percent of all holdings on average, the smallest of any aggregate asset class we define here.

A.4 TAA / Hedge Funds

Hedge funds and TAA programs are all highly correlated ($\rho \sim 0.9$ on average), and display moderate excess returns, to U.S. stocks, large and small cap. Indeed, internal active TAA programs could well be considered equivalent to U.S. stock. External active TAA programs, hedge funds, and hedge funds-of-funds, by contrast, have low β 's with respect to U.S. stock and are highly similar in their performance, allowing for aggregation that does not bias our results. We include all four aggregate asset classes in one aggregate asset class called TAA / hedge funds, noting that the dissimilar species, internal active TAA programs, make up only about 0.06 percent of the aggregated asset class on average.

A.5 Private equity

The final aggregate asset class, private equity, includes a number of asset classes that are the least to conform to the three desirable qualities we seek to identify using the linear model. As we show in Section 4, however, the low correlation between the private equity asset classes results largely from the significant reporting lag, although no obvious signs of appraisal smoothing. When the lag is removed from the data, private equity net returns are very similar to the net returns of small cap U.S. stock, with $\alpha = 0.03$, $\beta = 0.98$, $\rho = 0.92$.

Appendix A Table A1. Excess return α from fitting α from fitting net returns between fine grained CEM asset classes to reference asset classes. Dark borders indicate the coarse grained aggregate asset classes used in the present study. Color code is a guide to the eye (white indicates parameters which are in the acceptable range for good aggregation, red below acceptable, and blue above acceptable).

| Reference Asset Class | Asset Class | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----------------------------|-----------------------|-----------------------|-----------------|------------------------|------------------------|----------------------|-------|---------------------|-------------------|-------------------|------------------|--------------------|-----------------------|----------------------|-------------|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | Stock: U.S. Large Cap | Stock: U.S. Small Cap | Stock: Non U.S. | Fixed Inc.: U.S. Broad | Fixed Inc.: U.S. Other | Fixed Inc.: Non U.S. | REITs | Private Real Estate | Other Real Assets | TAA / Hedge Funds | Hedge Funds (ea) | Hedge Funds (FofF) | Diversified PE (FofF) | Venture Cap. PE (ea) | LBO PE (ea) | Other PE (ea) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Stock: U.S. Large cap (ea) | 0.0 | -0.4 | -0.3 | -0.2 | -0.8 | -0.3 | -0.6 | 3.1 | 3.4 | 2.0 | 3.0 | -0.7 | 0.1 | 0.5 | 0.8 | 7.2 | 6.6 | 6.4 | 6.2 | 9.8 | 9.9 | 8.4 | 8.9 | 8.0 | 7.4 | 6.6 | 6.0 | 8.3 | 10.7 | 10.7 | 7.3 | 8.5 | 7.7 | 8.7 | 6.2 | 10.0 | 8.9 | 2.1 | 2.1 | 1.8 | 0.2 | 7.6 | 5.7 | 5.2 | 5.5 | 6.5 | 6.4 |

Appendix A Table A2. Correlated volatility β from fitting as reported net returns between fine grained CEM asset classes to reference asset classes. Dark borders indicate the coarse grained aggregate asset classes used in the present study. Color code is a guide to the eye (white indicates parameters which are in the acceptable range for good aggregation, red below acceptable, and blue above acceptable).

| Stock: U.S. Large Cap | Asset Class | | | | | | | | | | Private Real Estate | | | | | | | | | | TAA / Hedge Funds | | | | | | | | | | Private Equity | | | | | | | | | | | | | | | | | | |
|------------------------|-----------------------|------|-----------------------|------|-----------------|------|------------------------|------|------------------------|------|----------------------|------|-------|------|-----------------|------|-----------------|-------|-----------------|-------|-------------------|-------|----------------|------|----------|------|----------|------|------------------|------|--------------------|------|-----------------------|-------|----------------------|------|-------------|-------|---------------|-------|---------------|------|------|------|------|------|------|------|------|
| | Stock: U.S. Large Cap | | Stock: U.S. Small Cap | | Stock: Non U.S. | | Fixed Inc.: U.S. Broad | | Fixed Inc.: U.S. Other | | Fixed Inc.: Non U.S. | | REITs | | Private RE (1a) | | Private RE (1b) | | Private RE (1c) | | Other Real Assets | | Nat. Res. (ea) | | TAA (1a) | | TAA (ea) | | Hedge Funds (ea) | | Hedge Funds (foff) | | Diversified PE (foff) | | Venture Cap. PE (ea) | | LBO PE (ea) | | Other PE (1a) | | Other PE (ea) | | | | | | | | |
| Stock: U.S. Large Cap | 1.00 | 0.95 | 1.02 | 1.09 | 1.00 | 1.07 | 1.04 | 0.93 | 0.90 | 0.98 | 1.14 | 1.29 | 1.16 | 1.17 | 1.14 | 1.24 | 1.24 | -0.11 | 0.00 | -0.04 | 0.06 | -0.23 | -0.16 | 0.02 | 0.03 | 0.02 | 0.08 | 0.09 | 0.41 | 0.97 | 0.93 | 0.64 | -0.04 | 0.02 | 0.13 | 0.02 | 0.15 | -0.05 | 1.12 | 0.65 | 0.49 | 0.42 | 0.45 | 0.41 | 0.45 | 0.39 | 0.29 | 0.39 | |
| Stock: U.S. Small Cap | 1.04 | 1.00 | 1.05 | 1.07 | 1.06 | 1.06 | 1.07 | 1.01 | 0.97 | 1.03 | 1.17 | 1.24 | 1.21 | 1.21 | 1.14 | 1.20 | 1.29 | -0.10 | 0.01 | -0.04 | 0.07 | -0.23 | -0.16 | 0.04 | 0.04 | 0.03 | 0.02 | 0.09 | 0.30 | 0.45 | 1.03 | 0.68 | 0.99 | 0.71 | -0.01 | 0.06 | 0.13 | 0.02 | 0.15 | -0.04 | 1.17 | 0.69 | 0.50 | 0.44 | 0.50 | 0.46 | 0.41 | 0.36 | 0.43 |
| Stock: Non U.S. | 0.98 | 0.93 | 1.00 | 1.00 | 1.01 | 1.00 | 1.01 | 0.90 | 0.87 | 0.95 | 1.12 | 1.17 | 1.14 | 1.15 | 1.12 | 1.21 | 1.20 | -0.10 | 0.00 | -0.04 | 0.06 | -0.22 | -0.16 | 0.03 | 0.03 | 0.02 | 0.09 | 0.38 | 0.37 | 0.55 | 0.92 | 0.62 | -0.03 | 0.03 | 0.15 | 0.03 | 0.15 | -0.04 | 1.09 | 0.64 | 0.49 | 0.42 | 0.44 | 0.40 | 0.45 | 0.39 | 0.30 | 0.38 | |
| Fixed Inc.: U.S. Broad | 0.97 | 0.92 | 0.98 | 1.00 | 0.99 | 0.99 | 1.00 | 0.84 | 0.90 | 0.96 | 1.10 | 1.14 | 1.16 | 1.13 | 1.11 | 1.21 | 1.20 | -0.10 | 0.01 | -0.04 | 0.07 | -0.22 | -0.16 | 0.03 | 0.04 | 0.03 | 0.09 | 0.30 | 0.43 | 0.95 | 0.60 | 0.91 | 0.67 | 0.01 | 0.12 | 0.01 | 0.12 | 0.01 | 0.15 | -0.06 | 1.09 | 0.63 | 0.47 | 0.42 | 0.44 | 0.41 | 0.38 | 0.32 | 0.37 |
| Fixed Inc.: U.S. Other | 0.97 | 0.91 | 0.99 | 1.00 | 0.98 | 1.00 | 0.99 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.11 | -0.01 | -0.04 | 0.05 | -0.22 | -0.16 | 0.02 | 0.02 | 0.03 | 0.01 | 0.09 | 0.35 | 0.55 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | |
| Fixed Inc.: Non U.S. | 0.97 | 0.92 | 0.98 | 0.99 | 0.99 | 1.00 | 0.99 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.10 | 0.00 | -0.04 | 0.06 | -0.21 | -0.15 | 0.03 | 0.03 | 0.01 | 0.08 | 0.30 | 0.43 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | | |
| REITs | 0.97 | 0.91 | 0.99 | 0.99 | 1.00 | 0.98 | 1.00 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.10 | 0.00 | -0.04 | 0.06 | -0.21 | -0.15 | 0.03 | 0.03 | 0.01 | 0.08 | 0.30 | 0.43 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | | |
| Private Real Estate | 0.97 | 0.91 | 0.99 | 0.99 | 1.00 | 0.98 | 1.00 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.10 | 0.00 | -0.04 | 0.06 | -0.21 | -0.15 | 0.03 | 0.03 | 0.01 | 0.08 | 0.30 | 0.43 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | | |
| Other Real Assets | 0.96 | 0.91 | 0.98 | 0.99 | 0.98 | 0.99 | 1.00 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.10 | 0.00 | -0.04 | 0.06 | -0.21 | -0.15 | 0.03 | 0.03 | 0.01 | 0.08 | 0.30 | 0.43 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | | |
| TAA / Hedge Funds | 0.96 | 0.91 | 0.98 | 0.99 | 0.98 | 0.99 | 1.00 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.10 | 0.00 | -0.04 | 0.06 | -0.21 | -0.15 | 0.03 | 0.03 | 0.01 | 0.08 | 0.30 | 0.43 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | | |
| Private Equity | 0.96 | 0.91 | 0.98 | 0.99 | 0.98 | 0.99 | 1.00 | 0.87 | 0.85 | 0.92 | 1.12 | 1.15 | 1.12 | 1.13 | 1.10 | 1.19 | 1.19 | -0.10 | 0.00 | -0.04 | 0.06 | -0.21 | -0.15 | 0.03 | 0.03 | 0.01 | 0.08 | 0.30 | 0.43 | 0.91 | 0.91 | 0.58 | -0.03 | 0.15 | 0.04 | 0.14 | -0.04 | 1.08 | 0.65 | 0.45 | 0.45 | 0.40 | 0.45 | 0.39 | 0.38 | 0.38 | | | |

Reference Asset Class

