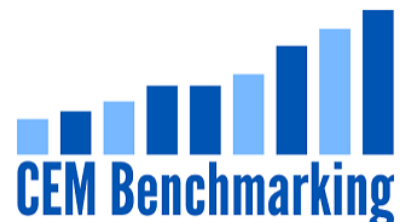


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**October 2020**

**ASSET ALLOCATION AND FUND  
PERFORMANCE OF DEFINED BENEFIT  
PENSION FUNDS IN THE UNITED  
STATES, 1998-2018**



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# Asset Allocation and Fund Performance of Defined Benefit Pension Funds in the United States, 1998-2018

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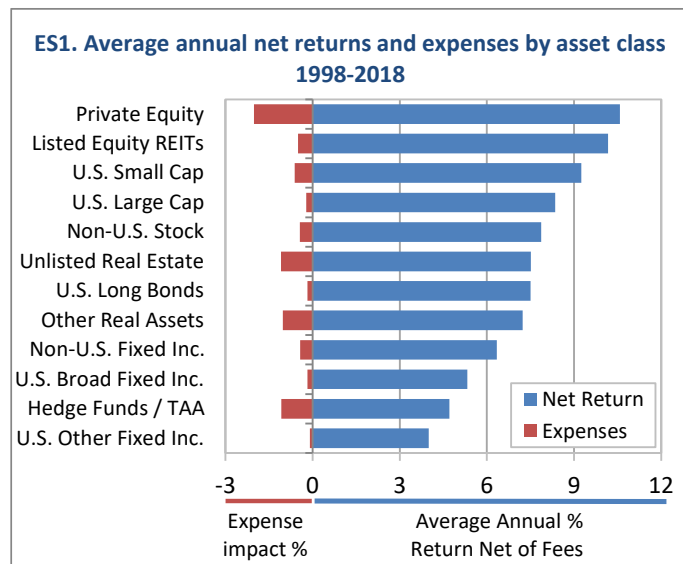
## 2020 Executive Summary

### Introduction

- Of the \$27.1 trillion of retirement assets in the United States at the end of 2018, approximately \$5.7 trillion were held in public sector defined benefit (DB) funds and \$2.9 trillion were held in corporate sector DB funds (see Reference 1). Because millions of Americans rely on these pensions for their retirement security, the investment allocation decisions of these pension funds are of critical importance.
- This study provides a comprehensive look at investment allocations and realized investment performance across aggregate asset classes using a unique and proprietary dataset covering over 200 public and private sector pensions over a 21-year period, with nearly \$3.9 trillion in combined assets under management (AUM) at the end of 2018 (see Reference 2 for a detailed description of methodology). One of the unique benefits of the dataset is that it provides the actual realized performance net of investment costs of the assets chosen by plan managers and trustees.

### Asset returns

- This study compares annual average returns net of all investment costs across 12 aggregate asset classes with appropriate adjustments for reporting lags associated with illiquid asset classes (e.g., unlisted real estate and private equity).
- Over the 21-year period covered by this study<sup>2</sup> there were striking differences in performance across aggregate asset classes. Exhibit ES1 summarizes arithmetic average annual net returns and average annual investment costs (both in percentage points) for the 12 asset classes covered in the study.
- Private equity had the highest average gross return over the period, averaging 12.6 percent. Private equity had the highest



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<sup>2</sup> The study commences in 1998 since this is the year hedge fund and listed REIT data were first collected by CEM Benchmarking.

average net return as well, estimated as 10.6 percent, much lower than the gross return because of the impact of expenses. Listed equity REITs had the second highest gross return over the period, averaging 10.7 percent and the second highest average net return of 10.2 percent as well.

- The two worst performing asset classes were hedge funds / tactical asset allocation (TAA) strategies and U.S. other fixed income. U.S. other fixed income however includes cash. If cash is excluded from U.S. other fixed income as an aggregate asset class, then hedge funds/TAA was the worst performing asset class with a 21-year arithmetic average annual net return of 4.7 percent.

## Asset Allocations

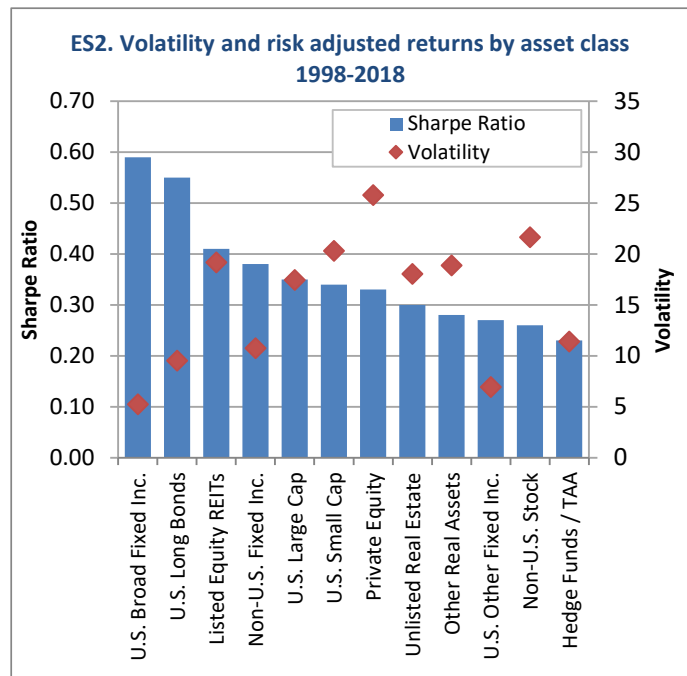
- The most material decrease in asset allocation was the decrease in allocation to U.S. large cap stocks. In 1998 over 42 percent of U.S. DB pension funds holdings were dedicated to U.S. large cap stocks. By 2018 this had fallen to less than 16 percent.
- The most material increase in asset allocation was the increase in allocation to U.S. long bonds. In 1998, the allocation to U.S. long bonds was less than 1 percent whereas today it is over 21 percent. This increase was largely confined to corporate sector pension funds.
- Although they had the second highest arithmetic average annual net return of 10.2 percent and the second highest compound average annual net return of 8.6 percent over the period, listed equity REITs were the least used asset class covered in the study. Allocations to listed equity REITs averaged just 0.6 percent of total assets. Unlisted real estate by contrast had a 3.8 percent allocation on average while having had an arithmetic average annual net return of 7.5 percent and a compound average annual net return of 6.3 percent.

## Total fund returns

- Large corporate-sector plans (> \$10 billion in AUM) outperformed over the 21-year period (average compound net return of 7.3 percent) due to a timely increase in allocation to long duration fixed income just before the financial crisis of 2008.
- Small public-sector plans (< \$2 billion in AUM) underperformed (average compound net return of 6.5 percent) because of persistent underperformance in hedge funds, unlisted real estate, and private equity. The underperformance is due, in part, to the use of expensive fund-of-funds.

## Volatility and Risk Adjusted Returns

- The study also compared volatilities and risk adjusted returns using the Sharpe ratio across asset classes. The data are summarized in Exhibit ES2.
- Two fixed income aggregate asset classes had the highest Sharpe ratios reflecting their extremely low volatilities, albeit with modest returns.
- Hedge funds / TAA had the lowest Sharpe ratios reflecting moderate volatility and poor returns.
- After adjusting for reporting lags, private equity was the most volatile aggregate asset class by far at 25.8 percent. The large volatility reflects both the large standard deviation of average returns across years (market risk) as well as the large dispersion of returns between funds within years (idiosyncratic risk). The study shows that market risk of private equity at 19.8 percent is however comparable to U.S.



small cap stocks at 19.0 percent.

- After adjusting for reporting lags, the study found that listed equity REITs and unlisted real estate had comparable volatilities. Listed equity REITs and unlisted real estate had the 4<sup>th</sup> and 6<sup>th</sup> most volatile net returns with volatilities of 19.2 percent and 18.0 percent respectively.

## Correlations

- The study also compared correlations of annual returns among the 12 asset classes as summarized in Exhibit ES3.
- The broadest group of highly correlated aggregate asset classes were equity asset classes together with hedge funds / TAA; this includes U.S. large cap stock, U.S. small cap stock, non-U.S. stocks, hedge funds, TAA, and private equity. The high correlation of listed equities to private equity only emerged after accounting for reporting lags. Correlations in this group ranged from 0.79 to 0.92.
- Listed equity REITs and unlisted real estate were highly correlated as well once reporting lags in unlisted real estate were accounted for. The correlation between the two asset classes is 0.84, among the highest of all. The high correlation is not surprising given both asset classes invest in fundamentally the same assets.
- Both listed equity REITs and unlisted real estate are not highly correlated to any other aggregate asset classes.
- Long duration U.S. bonds were anti-correlated to equity asset classes (including hedge funds / TAA and private equity), but positively correlated to U.S. broad fixed income.

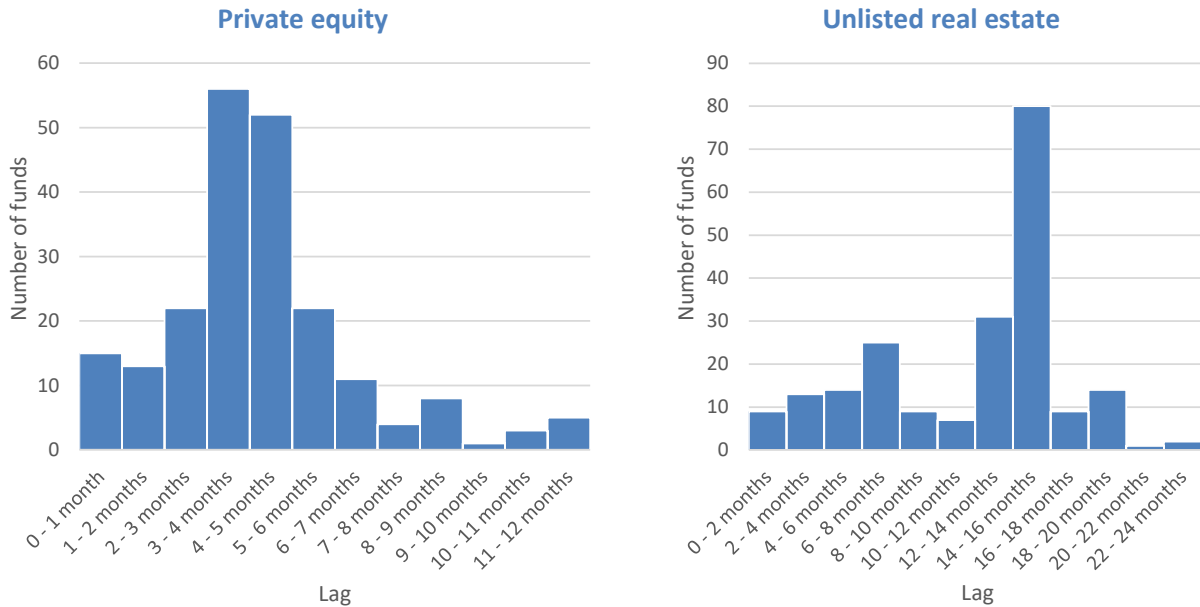
## Reporting lags for illiquid assets

- Reporting lag is the time between when an underlying asset changes value and when that change in value is reported to the pension fund or investor. Illiquid assets like unlisted real estate and private equity have reporting lags.
- The unique CEM dataset allows adjustment for illiquid asset reporting lag at the individual pension fund level. Typically, this type of adjustment is made using a single assumption applied to all investment returns in an illiquid asset class.
- In addition to improving the accuracy of the returns, volatilities and correlations, adjusting for reporting lag at the fund portfolio level allows the observation of the distribution of reporting lags across funds. The distributions are shown in Exhibit ES4.
- The distribution of reporting lags associated with private equity is clustered around 3 to 5 months.
- The distribution of reporting lags for unlisted real estate shows no such clustering and has a bimodal distribution with peaks at 6-8 months and a stronger peak at 14-16 months.

**ES3. Correlations between aggregate asset classes: 1998-2018**

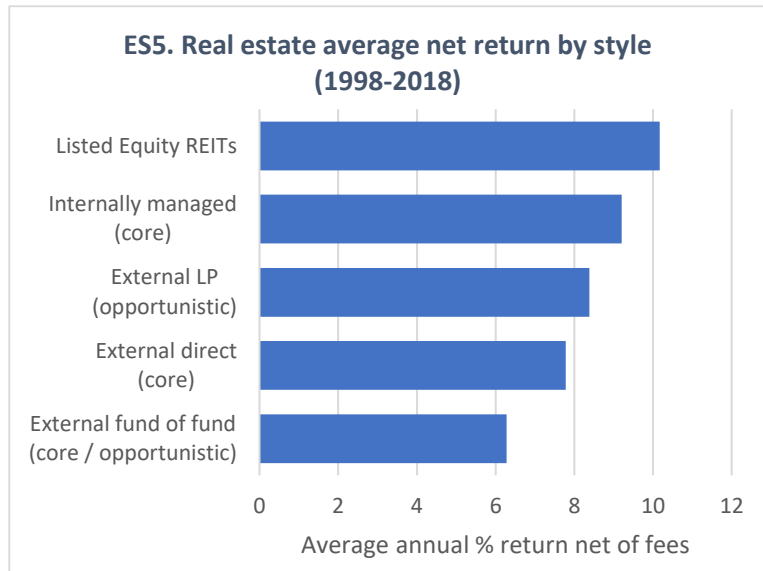
|                             | Stock:<br>U.S.<br>Large<br>Cap | Stock:<br>U.S.<br>Small<br>Cap | Stock:<br>Non U.S. | Hedge<br>Funds<br>/ TAA | Private<br>Equity | Fixed<br>Income:<br>U.S.<br>Broad | Fixed<br>Income:<br>Long<br>Duration | Fixed<br>Income:<br>U.S.<br>Other | Fixed<br>Income:<br>Non U.S. | Unlisted<br>Real<br>Estate | Listed<br>Equity<br>REITs | Other<br>Real<br>Assets |
|-----------------------------|--------------------------------|--------------------------------|--------------------|-------------------------|-------------------|-----------------------------------|--------------------------------------|-----------------------------------|------------------------------|----------------------------|---------------------------|-------------------------|
| Stock: U.S. Large Cap       | n/a                            | 0.92                           | 0.89               | 0.92                    | 0.85              | 0.05                              | -0.31                                | 0.64                              | 0.53                         | 0.45                       | 0.54                      | 0.08                    |
| Stock: U.S. Small Cap       |                                | n/a                            | 0.88               | 0.79                    | 0.89              | 0.04                              | -0.38                                | 0.68                              | 0.55                         | 0.54                       | 0.64                      | 0.00                    |
| Stock: Non U.S.             |                                |                                | n/a                | 0.85                    | 0.90              | 0.05                              | -0.38                                | 0.70                              | 0.61                         | 0.49                       | 0.57                      | -0.08                   |
| Hedge Funds / TAA           |                                |                                |                    | n/a                     | 0.80              | 0.19                              | -0.21                                | 0.72                              | 0.55                         | 0.41                       | 0.52                      | -0.16                   |
| Private Equity              |                                |                                |                    |                         | n/a               | -0.01                             | -0.44                                | 0.68                              | 0.46                         | 0.51                       | 0.51                      | -0.14                   |
| Fixed Income: U.S. Broad    |                                |                                |                    |                         |                   | n/a                               | 0.69                                 | 0.65                              | 0.70                         | 0.33                       | 0.47                      | -0.35                   |
| Fixed Income: Long Duration |                                |                                |                    |                         |                   |                                   | n/a                                  | 0.03                              | 0.26                         | 0.02                       | 0.04                      | -0.12                   |
| Fixed Income: U.S. Other    |                                |                                |                    |                         |                   |                                   |                                      | n/a                               | 0.82                         | 0.61                       | 0.69                      | -0.36                   |
| Fixed Income: Non U.S.      |                                |                                |                    |                         |                   |                                   |                                      |                                   | n/a                          | 0.43                       | 0.63                      | -0.22                   |
| Unlisted Real Estate        |                                |                                |                    |                         |                   |                                   |                                      |                                   |                              | n/a                        | 0.84                      | -0.06                   |
| Listed Equity REITs         |                                |                                |                    |                         |                   |                                   |                                      |                                   |                              |                            | n/a                       | -0.13                   |
| Other Real Assets           |                                |                                |                    |                         |                   |                                   |                                      |                                   |                              |                            |                           | n/a                     |

## ES4 Distribution of reporting lag



## Real estate performance by implementation style

- Unlisted real estate net returns by year and by implementation style are provided in Appendix B (see Reference 3 for a description of the methodology).
- As shown in ES5, real estate internally managed by funds outperformed more expensive external LP real estate (i.e., opportunistic real estate managed by a GP sometimes called private equity real estate). External direct real estate (core real estate) underperforms external LP opportunistic real estate but outperforms real estate held in a fund-of-fund.
- All styles of unlisted real estate underperform listed equity REITs by between 1-4 percent depending on style, primarily driven by differences in investment fees (see ES5).
- Core real estate had the lowest volatility of all real estate implementation styles.
- Listed equity REITs provided the highest Sharpe ratio of all real estate implementation styles.



## Summary

- Aggregate asset class net returns, standardized to remove reporting lags in unlisted real estate and private equity, are summarized in Exhibit ES6.

## ES6. Standardized aggregate asset class net returns for U.S. DB pension funds (in percent)

| Year               | Stock          |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|--------------------|----------------|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                    | U.S. Large Cap | U.S. Small Cap | Non-U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non-U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| 2018               | -5.36          | -10.74         | -13.16   | -0.52        | -5.24           | -0.36      | -3.59    | 0.68                 | -4.20               | -0.84 | -1.98             | -15.20         |
| 2017               | 21.45          | 16.24          | 27.77    | 4.66         | 11.20           | 2.98       | 9.46     | 3.89                 | 7.96                | 6.20  | 5.90              | 13.47          |
| 2016               | 11.56          | 17.40          | 5.06     | 4.14         | 7.50            | 5.25       | 8.73     | 14.68                | 4.88                | 8.99  | 2.42              | 22.06          |
| 2015               | 0.67           | -3.72          | -3.25    | -0.13        | -3.51           | -0.90      | -3.35    | -3.12                | 1.74                | -9.88 | -1.05             | 4.88           |
| 2014               | 12.52          | 5.03           | -1.78    | 6.91         | 19.39           | 1.79       | 2.85     | 29.00                | 20.19               | 2.37  | 4.75              | 2.87           |
| 2013               | 33.38          | 38.39          | 17.84    | -2.09        | -7.72           | 1.35       | -0.39    | -1.49                | 3.99                | 2.88  | 9.10              | 25.64          |
| 2012               | 16.27          | 16.00          | 17.72    | 7.14         | 10.51           | 5.41       | 11.54    | 14.86                | 20.55               | 3.84  | 7.54              | 16.29          |
| 2011               | 0.90           | -3.08          | -12.71   | 8.48         | 22.17           | 3.61       | 3.77     | -1.44                | 2.05                | -1.53 | 0.80              | -6.99          |
| 2010               | 16.22          | 26.41          | 12.45    | 8.61         | 11.03           | 5.10       | 13.62    | -2.46                | 23.51               | 10.93 | 9.26              | 20.69          |
| 2009               | 29.52          | 33.41          | 39.57    | 11.88        | 4.18            | 13.13      | 20.38    | 27.88                | 29.89               | 5.65  | 14.84             | 41.12          |
| 2008               | -38.10         | -37.65         | -44.44   | 0.07         | 13.96           | -5.39      | -8.67    | -25.99               | -38.20              | -9.66 | -17.84            | -29.58         |
| 2007               | 5.81           | 2.24           | 14.30    | 6.51         | 7.66            | 4.89       | 7.88     | -10.00               | -10.75              | 14.40 | 8.07              | 3.26           |
| 2006               | 14.67          | 14.68          | 25.72    | 4.80         | 2.67            | 5.68       | 7.79     | 27.47                | 34.75               | 14.86 | 11.03             | 24.81          |
| 2005               | 6.75           | 7.21           | 16.72    | 3.15         | 5.99            | 3.32       | 1.93     | 12.44                | 14.16               | 19.19 | 7.44              | 6.45           |
| 2004               | 12.02          | 16.76          | 19.62    | 5.29         | 9.07            | 4.92       | 10.31    | 12.17                | 32.43               | 18.18 | 7.42              | 17.21          |
| 2003               | 30.80          | 43.17          | 37.56    | 6.11         | 6.87            | 8.12       | 18.10    | 29.16                | 33.09               | 9.56  | 15.61             | 27.95          |
| 2002               | -21.45         | -19.33         | -14.12   | 9.38         | 15.21           | 2.35       | 14.11    | -1.42                | 5.17                | 9.24  | -12.17            | -20.23         |
| 2001               | -9.94          | -1.27          | -17.36   | 8.17         | 6.57            | 4.54       | 2.11     | -0.59                | 10.94               | 4.44  | -5.02             | -9.48          |
| 2000               | -5.21          | 0.27           | -12.45   | 11.42        | 16.14           | 6.33       | 4.65     | 33.87                | 26.58               | 18.95 | 1.50              | 5.07           |
| 1999               | 19.19          | 29.88          | 38.33    | -0.63        | -7.89           | 5.56       | 1.24     | 12.25                | 1.23                | 22.30 | 10.12             | 56.09          |
| 1998               | 23.59          | 2.94           | 11.80    | 8.50         | 11.90           | 6.19       | 10.64    | -14.03               | -6.39               | 1.75  | 21.09             | 15.81          |
| Arit. Gross Ret.:  | 8.57           | 9.86           | 8.31     | 5.50         | 7.69            | 4.08       | 6.77     | 8.60                 | 10.67               | 8.25  | 5.78              | 12.60          |
| Avg. Invest. Cost: | 0.22           | 0.61           | 0.44     | 0.17         | 0.18            | 0.09       | 0.43     | 1.08                 | 0.50                | 1.03  | 1.08              | 2.02           |
| Arit. Net Ret.:    | 8.35           | 9.25           | 7.87     | 5.33         | 7.51            | 3.99       | 6.34     | 7.51                 | 10.17               | 7.23  | 4.71              | 10.58          |
| Comp. Net Ret.:    | 6.79           | 7.45           | 5.54     | 5.25         | 7.19            | 3.93       | 6.10     | 6.36                 | 8.64                | 6.87  | 4.31              | 8.76           |
| Std. Dev.:         | 17.16          | 19.01          | 21.13    | 3.98         | 8.11            | 3.59       | 7.17     | 15.56                | 17.26               | 8.67  | 8.81              | 19.78          |
| Volatility:        | 17.45          | 20.29          | 21.63    | 5.23         | 9.53            | 6.92       | 10.74    | 18.03                | 19.17               | 18.88 | 11.39             | 25.78          |
| Sharpe Ratio:      | 0.35           | 0.34           | 0.26     | 0.59         | 0.55            | 0.27       | 0.38     | 0.30                 | 0.41                | 0.28  | 0.23              | 0.33           |

## References

[1] “2019 Investment Company Fact Book – A Review of Trends and Activities in the Investment Company Industry”, 59<sup>th</sup> edition, p 160.

[2] This update adds 2015, 2016, and 2017 statistics to the executive summary of the previously published report “Asset Allocation and Fund Performance of Defined Benefit Pension Funds in the United States, 1998-2014”. In so doing, historical unlisted real estate and private equity net returns, standardized to remove reporting lag, have been restated. Please see the full article for details at:

<https://www.cembenchmarking.com/insights.html>

[3] Alexander D. Beath and Chris Flynn, “Real Estate Performance by Investment Style”, December 2018. Full article available at:

<https://www.cembenchmarking.com/insights.html>

## Appendix A: Supplemental tables

The following tables were included in the original version of this paper (i.e., Reference 2) and are included here, updated with 2015, 2016 and 2017 data. Table numbering has been retained from Reference 2.

Tables 1A and 1B. Assets under management (AUM) for U.S. public sector (top) and corporate sector (bottom) pension funds by year expressed in \$millions (USD) within the CEM database. Statistics shown are the number of funds (#), annual average (avg.), population standard deviations (std. dev.), minimum (min.), 25th percentile (Q1), 50th percentile (med.), 75th percentile (Q3), maximum (max.) and the total of the in-year average AUM. Any differences from earlier versions of this manuscript are caused by either data revisions, data exclusions, or new data submissions. (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 (in \$millions USD)**

| Year | #  | Avg.     | Std. Dev. | Min.    | Q1      | Med.     | Q3       | Max.      | Total       |
|------|----|----------|-----------|---------|---------|----------|----------|-----------|-------------|
| 2018 | 57 | \$50,198 | \$67,628  | \$598   | \$6,399 | \$23,186 | \$73,245 | \$354,843 | \$2,811,109 |
| 2017 | 60 | \$46,482 | \$62,497  | \$1,299 | \$7,360 | \$21,329 | \$59,551 | \$326,388 | \$2,788,900 |
| 2016 | 60 | \$40,987 | \$56,787  | \$595   | \$5,667 | \$16,863 | \$48,490 | \$296,294 | \$2,459,212 |
| 2015 | 62 | \$40,256 | \$55,249  | \$1,198 | \$5,481 | \$16,512 | \$46,318 | \$292,427 | \$2,495,849 |
| 2014 | 62 | \$38,600 | \$54,629  | \$837   | \$5,390 | \$16,075 | \$42,904 | \$287,947 | \$2,393,191 |
| 2013 | 64 | \$33,828 | \$48,252  | \$989   | \$5,903 | \$14,763 | \$39,599 | \$263,404 | \$2,164,985 |
| 2012 | 68 | \$31,244 | \$43,229  | \$927   | \$5,295 | \$13,667 | \$36,827 | \$235,389 | \$2,124,617 |
| 2011 | 68 | \$30,068 | \$41,631  | \$867   | \$6,271 | \$13,072 | \$34,583 | \$225,228 | \$2,044,656 |
| 2010 | 73 | \$23,804 | \$36,400  | \$813   | \$3,080 | \$9,871  | \$23,795 | \$215,814 | \$1,737,684 |
| 2009 | 73 | \$21,410 | \$32,703  | \$320   | \$3,081 | \$8,632  | \$21,596 | \$195,277 | \$1,562,899 |
| 2008 | 72 | \$25,508 | \$40,166  | \$710   | \$3,306 | \$8,858  | \$24,107 | \$222,213 | \$1,836,579 |
| 2007 | 80 | \$22,364 | \$39,052  | \$621   | \$2,808 | \$7,500  | \$22,592 | \$243,745 | \$1,789,094 |
| 2006 | 69 | \$23,801 | \$37,362  | \$422   | \$3,293 | \$7,842  | \$22,175 | \$216,422 | \$1,642,253 |
| 2005 | 72 | \$18,868 | \$32,835  | \$393   | \$2,596 | \$6,324  | \$17,865 | \$194,502 | \$1,358,529 |
| 2004 | 76 | \$17,827 | \$30,330  | \$369   | \$2,350 | \$5,678  | \$16,034 | \$175,296 | \$1,354,833 |
| 2003 | 74 | \$15,849 | \$25,427  | \$325   | \$2,126 | \$5,571  | \$15,256 | \$146,841 | \$1,172,830 |
| 2002 | 74 | \$15,205 | \$25,304  | \$314   | \$2,061 | \$5,016  | \$13,684 | \$142,563 | \$1,125,203 |
| 2001 | 83 | \$15,400 | \$26,473  | \$147   | \$1,826 | \$5,466  | \$13,058 | \$158,116 | \$1,278,235 |
| 2000 | 80 | \$17,134 | \$30,773  | \$502   | \$2,284 | \$5,449  | \$12,713 | \$167,867 | \$1,370,738 |
| 1999 | 83 | \$15,911 | \$27,745  | \$305   | \$1,588 | \$4,947  | \$12,294 | \$161,527 | \$1,320,607 |
| 1998 | 69 | \$15,124 | \$25,913  | \$292   | \$1,552 | \$4,963  | \$11,671 | \$139,930 | \$1,043,527 |

**Table 1B. Assets Under Management: U.S. Corporate Sector DB Pension Funds (in \$millions USD)**

| Year | #   | Avg.     | Std. Dev. | Min.  | Q1      | Med.    | Q3       | Max.      | Total       |
|------|-----|----------|-----------|-------|---------|---------|----------|-----------|-------------|
| 2018 | 99  | \$10,731 | \$12,982  | \$224 | \$2,249 | \$4,750 | \$13,120 | \$58,263  | \$1,062,325 |
| 2017 | 97  | \$9,987  | \$12,382  | \$223 | \$2,008 | \$4,552 | \$12,688 | \$57,599  | \$968,694   |
| 2016 | 100 | \$10,071 | \$12,416  | \$327 | \$1,991 | \$5,393 | \$12,428 | \$54,857  | \$1,007,070 |
| 2015 | 101 | \$9,771  | \$11,979  | \$474 | \$2,221 | \$5,074 | \$12,099 | \$56,534  | \$986,860   |
| 2014 | 97  | \$10,302 | \$12,569  | \$469 | \$2,749 | \$5,354 | \$12,335 | \$58,866  | \$999,256   |
| 2013 | 112 | \$9,073  | \$12,184  | \$152 | \$2,187 | \$3,994 | \$11,660 | \$59,191  | \$1,016,147 |
| 2012 | 120 | \$8,031  | \$11,366  | \$47  | \$1,879 | \$3,518 | \$9,859  | \$61,469  | \$963,749   |
| 2011 | 124 | \$7,579  | \$12,512  | \$37  | \$1,573 | \$3,153 | \$8,282  | \$93,529  | \$939,748   |
| 2010 | 121 | \$7,162  | \$12,005  | \$34  | \$1,434 | \$2,529 | \$7,432  | \$85,991  | \$866,645   |
| 2009 | 122 | \$6,475  | \$11,381  | \$160 | \$1,258 | \$2,494 | \$6,437  | \$86,296  | \$789,957   |
| 2008 | 130 | \$6,268  | \$12,043  | \$78  | \$1,185 | \$2,423 | \$5,728  | \$94,962  | \$814,814   |
| 2007 | 121 | \$7,093  | \$12,703  | \$90  | \$1,630 | \$3,141 | \$7,355  | \$102,587 | \$858,221   |
| 2006 | 64  | \$9,154  | \$16,144  | \$424 | \$1,864 | \$3,721 | \$9,189  | \$105,719 | \$585,882   |
| 2005 | 69  | \$8,988  | \$14,764  | \$375 | \$1,972 | \$3,588 | \$8,950  | \$92,692  | \$620,189   |
| 2004 | 78  | \$7,525  | \$12,941  | \$37  | \$1,592 | \$3,276 | \$7,031  | \$85,437  | \$586,963   |
| 2003 | 71  | \$7,089  | \$11,992  | \$55  | \$1,362 | \$2,678 | \$6,277  | \$73,289  | \$503,314   |
| 2002 | 69  | \$7,159  | \$11,506  | \$82  | \$1,397 | \$2,783 | \$6,451  | \$62,327  | \$494,000   |
| 2001 | 81  | \$6,750  | \$11,741  | \$26  | \$1,270 | \$2,664 | \$6,103  | \$71,398  | \$546,710   |
| 2000 | 72  | \$7,471  | \$13,257  | \$123 | \$1,144 | \$2,402 | \$6,833  | \$76,600  | \$537,927   |
| 1999 | 85  | \$5,835  | \$10,932  | \$128 | \$1,080 | \$1,908 | \$4,749  | \$74,550  | \$495,979   |
| 1998 | 91  | \$5,385  | \$10,363  | \$120 | \$979   | \$1,928 | \$3,904  | \$71,850  | \$490,017   |



Table 2. Annual average net returns by aggregate asset class as reported to CEM (in percent). Summary statistics include the arithmetic average return, the compound average net return, the standard deviation of annual average net returns, the volatility (which includes the effects of in-year standard deviation of annual average net returns), and the sharp ratio (the risk-free rate of return used are 3-month T-bills).

Table 2. As reported aggregate asset class net returns for U.S. DB pension funds (in percent)

| Year               | Stock          |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|--------------------|----------------|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                    | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| 2018               | -5.36          | -10.74         | -13.16   | -0.52        | -5.24           | -0.36      | -3.59    | 6.79                 | -4.20               | -0.84 | -1.98             | 14.49          |
| 2017               | 21.45          | 16.24          | 27.77    | 4.66         | 11.20           | 2.98       | 9.46     | 7.05                 | 7.96                | 6.20  | 5.90              | 15.38          |
| 2016               | 11.56          | 17.40          | 5.06     | 4.14         | 7.50            | 5.25       | 8.73     | 8.00                 | 4.88                | 8.99  | 2.42              | 8.87           |
| 2015               | 0.67           | -3.72          | -3.25    | -0.13        | -3.51           | -0.90      | -3.35    | 12.74                | 1.74                | -9.88 | -1.05             | 8.39           |
| 2014               | 12.52          | 5.03           | -1.78    | 6.91         | 19.39           | 1.79       | 2.85     | 12.73                | 20.19               | 2.37  | 4.75              | 15.37          |
| 2013               | 33.38          | 38.39          | 17.84    | -2.09        | -7.72           | 1.35       | -0.39    | 12.00                | 3.99                | 2.88  | 9.10              | 15.43          |
| 2012               | 16.27          | 16.00          | 17.72    | 7.14         | 10.51           | 5.41       | 11.54    | 9.74                 | 20.55               | 3.84  | 7.54              | 11.91          |
| 2011               | 0.90           | -3.08          | -12.71   | 8.48         | 22.17           | 3.61       | 3.77     | 13.37                | 2.05                | -1.53 | 0.80              | 10.53          |
| 2010               | 16.22          | 26.41          | 12.45    | 8.61         | 11.03           | 5.10       | 13.62    | 9.01                 | 23.51               | 10.93 | 9.26              | 12.42          |
| 2009               | 29.52          | 33.41          | 39.57    | 11.88        | 4.18            | 13.13      | 20.38    | -29.69               | 29.89               | 5.65  | 14.84             | -3.97          |
| 2008               | -38.10         | -37.65         | -44.44   | 0.07         | 13.96           | -5.39      | -8.67    | -8.14                | -38.20              | -9.66 | -17.84            | -10.79         |
| 2007               | 5.81           | 2.24           | 14.30    | 6.51         | 7.66            | 4.89       | 7.88     | 15.42                | -10.75              | 14.40 | 8.07              | 20.46          |
| 2006               | 14.67          | 14.68          | 25.72    | 4.80         | 2.67            | 5.68       | 7.79     | 19.08                | 34.75               | 14.86 | 11.03             | 16.99          |
| 2005               | 6.75           | 7.21           | 16.72    | 3.15         | 5.99            | 3.32       | 1.93     | 23.12                | 14.16               | 19.19 | 7.44              | 18.94          |
| 2004               | 12.02          | 16.76          | 19.62    | 5.29         | 9.07            | 4.92       | 10.31    | 13.51                | 32.43               | 18.18 | 7.42              | 15.64          |
| 2003               | 30.80          | 43.17          | 37.56    | 6.11         | 6.87            | 8.12       | 18.10    | 9.63                 | 33.09               | 9.56  | 15.61             | 9.02           |
| 2002               | -21.45         | -19.33         | -14.12   | 9.38         | 15.21           | 2.35       | 14.11    | 5.22                 | 5.17                | 9.24  | -12.17            | -12.19         |
| 2001               | -9.94          | -1.27          | -17.36   | 8.17         | 6.57            | 4.54       | 2.11     | 6.00                 | 10.94               | 4.44  | -5.02             | -18.19         |
| 2000               | -5.21          | 0.27           | -12.45   | 11.42        | 16.14           | 6.33       | 4.65     | 12.63                | 26.58               | 18.95 | 1.50              | 28.98          |
| 1999               | 19.19          | 29.88          | 38.33    | -0.63        | -7.89           | 5.56       | 1.24     | 9.91                 | 1.23                | 22.30 | 10.12             | 33.76          |
| 1998               | 23.59          | 2.94           | 11.80    | 8.50         | 11.90           | 6.19       | 10.64    | 13.81                | -6.39               | 1.75  | 21.09             | 13.51          |
| Arit. Gross Ret.:  | 8.57           | 9.86           | 8.31     | 5.50         | 7.69            | 4.08       | 6.77     | 9.75                 | 10.67               | 8.25  | 5.78              | 12.73          |
| Avg. Invest. Cost: | 0.22           | 0.61           | 0.44     | 0.17         | 0.18            | 0.09       | 0.43     | 1.08                 | 0.50                | 1.03  | 1.08              | 2.02           |
| Arit. Net Ret.:    | 8.35           | 9.25           | 7.87     | 5.33         | 7.51            | 3.99       | 6.34     | 8.66                 | 10.17               | 7.23  | 4.71              | 10.71          |
| Comp. Net Ret.:    | 6.79           | 7.45           | 5.54     | 5.25         | 7.19            | 3.93       | 6.10     | 8.06                 | 8.64                | 6.87  | 4.31              | 9.97           |
| Std. Dev.:         | 17.16          | 19.01          | 21.13    | 3.98         | 8.11            | 3.59       | 7.17     | 10.42                | 17.26               | 8.67  | 8.81              | 12.41          |
| Volatility:        | 17.46          | 20.29          | 21.64    | 5.22         | 9.55            | 6.99       | 10.75    | 13.36                | 19.18               | 18.65 | 11.41             | 21.07          |
| Sharpe Ratio:      | 0.35           | 0.34           | 0.26     | 0.59         | 0.55            | 0.26       | 0.38     | 0.50                 | 0.41                | 0.28  | 0.23              | 0.41           |

Table 4A. Arithmetic average annualized returns in percent by aggregate asset class for selected multi-year time spans. Unlisted real estate and private equity have been standardized for reporting lag. Maximum values within each time span are highlighted in green while lows are highlighted in red.

| Time Span      | Table 4A. Annualized arithmetic average net return by time span (in percent) |                |          |              |                 |            |          |                      |                     |       |                   |                |
|----------------|--|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                | Stock  |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|                | U.S. Large Cap   | U.S. Small Cap | Non U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| <b>3-year</b>  |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2016 – 2018    | 9.21   | 7.63           | 6.55     | 2.76         | 4.49            | 2.62       | 4.87     | 6.42                 | 2.88                | 4.78  | 2.11              | 6.78           |
| 2015 – 2017    | 11.23  | 9.97           | 9.86     | 2.89         | 5.06            | 2.44       | 4.94     | 5.15                 | 4.86                | 1.77  | 2.42              | 13.47          |
| 2014 – 2016    | 8.25   | 6.24           | 0.01     | 3.64         | 7.80            | 2.04       | 2.74     | 13.52                | 8.94                | 0.49  | 2.04              | 9.94           |
| 2013 – 2015    | 15.53  | 13.23          | 4.27     | 1.56         | 2.72            | 0.74       | -0.30    | 8.13                 | 8.64                | -1.54 | 4.27              | 11.13          |
| 2012 – 2014    | 20.72  | 19.80          | 11.26    | 3.99         | 7.39            | 2.85       | 4.67     | 14.12                | 14.91               | 3.03  | 7.13              | 14.93          |
| 2011 – 2013    | 16.85  | 17.10          | 7.62     | 4.51         | 8.32            | 3.46       | 4.97     | 3.98                 | 8.86                | 1.73  | 5.81              | 11.65          |
| 2010 – 2012    | 11.13  | 13.11          | 5.82     | 8.08         | 14.57           | 4.71       | 9.64     | 3.65                 | 15.37               | 4.42  | 5.87              | 10.00          |
| 2009 – 2011    | 15.55  | 18.91          | 13.11    | 9.66         | 12.46           | 7.28       | 12.59    | 8.00                 | 18.48               | 5.02  | 8.30              | 18.28          |
| 2008 – 2010    | 2.55   | 7.39           | 2.53     | 6.85         | 9.73            | 4.28       | 8.44     | -0.19                | 5.07                | 2.31  | 2.08              | 10.74          |
| 2007 – 2009    | -0.92  | -0.67          | 3.14     | 6.15         | 8.60            | 4.21       | 6.53     | -2.70                | -6.36               | 3.46  | 1.69              | 4.93           |
| 2006 – 2008    | -5.87  | -6.91          | -1.47    | 3.79         | 8.10            | 1.73       | 2.33     | -2.84                | -4.73               | 6.53  | 0.42              | -0.50          |
| 2005 – 2007    | 9.08   | 8.04           | 18.91    | 4.82         | 5.44            | 4.63       | 5.87     | 9.97                 | 12.72               | 16.15 | 8.85              | 11.51          |
| 2004 – 2006    | 11.15  | 12.88          | 20.69    | 4.41         | 5.91            | 4.64       | 6.68     | 17.36                | 27.11               | 17.41 | 8.63              | 16.16          |
| 2003 – 2005    | 16.52  | 22.38          | 24.63    | 4.85         | 7.31            | 5.45       | 10.11    | 17.92                | 26.56               | 15.64 | 10.16             | 17.20          |
| 2002 – 2004    | 7.12   | 13.53          | 14.35    | 6.93         | 10.39           | 5.13       | 14.17    | 13.30                | 23.56               | 12.32 | 3.62              | 8.31           |
| 2001 – 2003    | -0.20  | 7.52           | 2.03     | 7.89         | 9.55            | 5.00       | 11.44    | 9.05                 | 16.40               | 7.74  | -0.53             | -0.59          |
| 2000 – 2002    | -12.20   | -6.78          | -14.64   | 9.66         | 12.64           | 4.41       | 6.96     | 10.62                | 14.23               | 10.87 | -5.23             | -8.21          |
| 1999 – 2001    | 1.34   | 9.63           | 2.84     | 6.32         | 4.94            | 5.47       | 2.67     | 15.18                | 12.92               | 15.23 | 2.20              | 17.22          |
| 1998 – 2000    | 12.52  | 11.03          | 12.56    | 6.43         | 6.72            | 6.03       | 5.51     | 10.70                | 7.14                | 14.33 | 10.90             | 25.66          |
| <b>5-year</b>  |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2014 – 2018    | 8.17   | 4.84           | 2.93     | 3.01         | 5.87            | 1.75       | 2.82     | 9.02                 | 6.11                | 1.37  | 2.01              | 5.62           |
| 2013 – 2017    | 15.92  | 14.67          | 9.13     | 2.70         | 5.37            | 2.09       | 3.46     | 8.59                 | 7.75                | 2.11  | 4.22              | 13.79          |
| 2012 – 2016    | 14.88  | 14.62          | 7.12     | 3.19         | 5.23            | 2.58       | 3.87     | 10.78                | 10.27               | 1.64  | 4.55              | 14.35          |
| 2011 – 2015    | 12.75  | 10.52          | 3.56     | 4.06         | 8.17            | 2.25       | 2.88     | 7.56                 | 9.70                | -0.46 | 4.23              | 8.54           |
| 2010 – 2014    | 15.86  | 16.55          | 6.71     | 5.81         | 11.08           | 3.45       | 6.28     | 7.69                 | 14.06               | 3.70  | 6.29              | 11.70          |
| 2009 – 2013    | 19.26  | 22.22          | 14.98    | 6.81         | 8.03            | 5.72       | 9.78     | 7.47                 | 16.00               | 4.36  | 8.31              | 19.35          |
| 2008 – 2012    | 4.96   | 7.02           | 2.52     | 7.24         | 12.37           | 4.37       | 8.13     | 2.57                 | 7.56                | 1.85  | 2.92              | 8.31           |
| 2007 – 2011    | 2.87   | 4.27           | 1.84     | 7.11         | 11.80           | 4.27       | 7.40     | -2.40                | 1.30                | 3.96  | 3.02              | 5.70           |
| 2006 – 2010    | 5.62   | 7.82           | 9.52     | 6.37         | 7.90            | 4.68       | 8.20     | 3.38                 | 7.84                | 7.24  | 5.07              | 12.06          |
| 2005 – 2009    | 3.73   | 3.98           | 10.37    | 5.28         | 6.89            | 4.33       | 5.86     | 6.36                 | 5.97                | 8.89  | 4.71              | 9.21           |
| 2004 – 2008    | 0.23   | 0.65           | 6.38     | 3.96         | 7.87            | 2.68       | 3.85     | 3.22                 | 6.48                | 11.39 | 3.22              | 4.43           |
| 2003 – 2007    | 14.01  | 16.81          | 22.78    | 5.17         | 6.45            | 5.39       | 9.20     | 14.25                | 20.74               | 15.24 | 9.91              | 15.94          |
| 2002 – 2006    | 8.56   | 12.50          | 17.10    | 5.75         | 7.96            | 4.88       | 10.45    | 15.96                | 23.92               | 14.20 | 5.87              | 11.24          |
| 2001 – 2005    | 3.64   | 9.31           | 8.48     | 6.42         | 8.74            | 4.65       | 9.31     | 10.35                | 19.16               | 12.12 | 2.65              | 4.38           |
| 2000 – 2004    | 1.24   | 7.92           | 2.65     | 8.07         | 10.77           | 5.25       | 9.86     | 14.64                | 21.64               | 12.07 | 1.47              | 4.10           |
| 1999 – 2003    | 2.68   | 10.54          | 6.39     | 6.89         | 7.38            | 5.38       | 8.04     | 14.65                | 15.40               | 12.90 | 2.01              | 11.88          |
| 1998 – 2002    | 1.23   | 2.50           | 1.24     | 7.37         | 8.39            | 4.99       | 6.55     | 6.02                 | 7.51                | 11.34 | 3.10              | 9.45           |
| <b>10-year</b> |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2009 – 2018    | 13.71  | 13.53          | 8.95     | 4.91         | 6.95            | 3.74       | 6.30     | 8.25                 | 11.06               | 2.86  | 5.16              | 12.48          |
| 2008 – 2017    | 10.44  | 10.84          | 5.82     | 4.97         | 8.87            | 3.23       | 5.79     | 5.58                 | 7.66                | 1.98  | 3.57              | 11.05          |
| 2007 – 2016    | 8.88   | 9.44           | 4.48     | 5.15         | 8.52            | 3.42       | 5.64     | 4.19                 | 5.79                | 2.80  | 3.79              | 10.03          |
| 2006 – 2015    | 9.19   | 9.17           | 6.54     | 5.22         | 8.04            | 3.47       | 5.54     | 5.47                 | 8.77                | 3.39  | 4.65              | 10.30          |
| 2005 – 2014    | 9.79   | 10.26          | 8.54     | 5.55         | 8.99            | 3.89       | 6.07     | 7.03                 | 10.01               | 6.29  | 5.50              | 10.46          |
| 2004 – 2013    | 9.74   | 11.44          | 10.68    | 5.38         | 7.95            | 4.20       | 6.82     | 5.34                 | 11.24               | 7.87  | 5.76              | 11.89          |
| 2003 – 2012    | 9.49   | 11.91          | 12.65    | 6.20         | 9.41            | 4.88       | 8.66     | 8.41                 | 14.15               | 8.54  | 6.42              | 12.12          |
| 2002 – 2011    | 5.71   | 8.38           | 9.47     | 6.43         | 9.88            | 4.57       | 8.92     | 6.78                 | 12.61               | 9.08  | 4.44              | 8.47           |
| 2001 – 2010    | 4.63   | 8.56           | 9.00     | 6.40         | 8.32            | 4.67       | 8.76     | 6.87                 | 13.50               | 9.68  | 3.86              | 8.22           |
| 2000 – 2009    | 2.49   | 5.95           | 6.51     | 6.68         | 8.83            | 4.79       | 7.86     | 10.50                | 13.81               | 10.48 | 3.09              | 6.66           |
| 1999 – 2008    | 1.45   | 5.60           | 6.39     | 5.43         | 7.63            | 4.03       | 5.94     | 8.94                 | 10.94               | 12.14 | 2.61              | 8.15           |
| 1998 – 2007    | 7.62   | 9.65           | 12.01    | 6.27         | 7.42            | 5.19       | 7.88     | 10.13                | 14.12               | 13.29 | 6.51              | 12.69          |
| <b>15-year</b> |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2004 – 2018    | 9.22   | 9.24           | 8.10     | 4.59         | 7.26            | 3.38       | 5.48     | 6.57                 | 9.53                | 5.71  | 4.51              | 9.80           |
| 2003 – 2017    | 11.63  | 12.83          | 11.48    | 5.04         | 8.07            | 3.95       | 6.93     | 8.47                 | 12.02               | 6.40  | 5.69              | 12.68          |
| 2002 – 2016    | 8.77   | 10.46          | 8.68     | 5.35         | 8.33            | 3.91       | 7.24     | 8.12                 | 11.83               | 6.60  | 4.48              | 10.43          |
| 2001 – 2015    | 7.34   | 9.22           | 7.19     | 5.62         | 8.27            | 3.86       | 6.80     | 7.10                 | 12.23               | 6.30  | 3.98              | 8.33           |
| 2000 – 2014    | 6.94   | 9.48           | 6.58     | 6.39         | 9.58            | 4.34       | 7.33     | 9.56                 | 13.89               | 8.22  | 4.15              | 8.34           |
| 1999 – 2013    | 7.39   | 11.14          | 9.25     | 5.89         | 7.76            | 4.59       | 7.22     | 8.45                 | 12.63               | 9.55  | 4.51              | 11.89          |
| 1998 – 2012    | 6.74   | 8.78           | 8.85     | 6.59         | 9.07            | 4.92       | 7.96     | 7.61                 | 11.93               | 9.47  | 5.31              | 11.23          |
| <b>21-year</b> |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 1998 – 2018    | 8.35   | 9.25           | 7.87     | 5.33         | 7.51            | 3.99       | 6.34     | 7.51                 | 10.17               | 7.23  | 4.71              | 10.58          |

Table 4B. Compound average annualized returns in percent by aggregate asset class for selected multi-year time spans. Unlisted real estate and private equity have been standardized for reporting lag. Maximum values within each time span are highlighted in green while lows are highlighted in red.

| Time Span      | Table 4B. Annualized compound average net return by time span (in percent) |                |          |              |                 |            |          |                      |                     |       |                   |                |
|----------------|--|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                | Stock  |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|                | U.S. Large Cap   | U.S. Small Cap | Non U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| <b>3-year</b>  |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2016 – 2018    | 8.64   | 6.80           | 5.24     | 2.73         | 4.24            | 2.60       | 4.69     | 6.25                 | 2.75                | 4.70  | 2.06              | 5.51           |
| 2015 – 2017    | 10.90  | 9.53           | 9.10     | 2.87         | 4.87            | 2.41       | 4.78     | 4.89                 | 4.83                | 1.42  | 2.39              | 13.25          |
| 2014 – 2016    | 8.12   | 5.88           | -0.06    | 3.60         | 7.39            | 2.01       | 2.62     | 12.74                | 8.65                | 0.18  | 2.01              | 9.61           |
| 2013 – 2015    | 14.75  | 11.85          | 3.84     | 1.49         | 2.06            | 0.74       | -0.33    | 7.17                 | 8.34                | -1.72 | 4.18              | 10.67          |
| 2012 – 2014    | 20.39  | 19.02          | 10.86    | 3.90         | 6.78            | 2.83       | 4.55     | 13.43                | 14.64               | 3.03  | 7.12              | 14.55          |
| 2011 – 2013    | 16.10  | 15.87          | 6.59     | 4.40         | 7.60            | 3.44       | 4.86     | 3.70                 | 8.56                | 1.70  | 5.75              | 10.77          |
| 2010 – 2012    | 10.89  | 12.43          | 4.94     | 8.08         | 14.45           | 4.70       | 9.56     | 3.36                 | 14.97               | 4.29  | 5.80              | 9.29           |
| 2009 – 2011    | 14.95  | 17.79          | 11.07    | 9.65         | 12.22           | 7.20       | 12.38    | 7.13                 | 17.86               | 4.89  | 8.14              | 16.57          |
| 2008 – 2010    | -2.33  | 1.69           | -4.46    | 6.74         | 9.65            | 4.00       | 7.70     | -2.63                | -0.29               | 1.92  | 1.02              | 6.25           |
| 2007 – 2009    | -5.33  | -5.26          | -3.94    | 6.04         | 8.53            | 3.93       | 5.85     | -5.20                | -10.52              | 2.97  | 0.65              | 0.86           |
| 2006 – 2008    | -9.10  | -9.91          | -7.23    | 3.76         | 8.00            | 1.60       | 2.03     | -5.31                | -9.42               | 5.88  | -0.47             | -3.18          |
| 2005 – 2007    | 9.01   | 7.92           | 18.81    | 4.81         | 5.42            | 4.62       | 5.83     | 8.86                 | 11.14               | 16.13 | 8.83              | 11.12          |
| 2004 – 2006    | 11.10  | 12.81          | 20.63    | 4.41         | 5.88            | 4.64       | 6.62     | 17.15                | 26.77               | 17.39 | 8.62              | 15.91          |
| 2003 – 2005    | 16.08  | 21.47          | 24.30    | 4.84         | 7.30            | 5.43       | 9.91     | 17.67                | 26.25               | 15.56 | 10.09             | 16.87          |
| 2002 – 2004    | 4.80   | 10.48          | 12.22    | 6.91         | 10.33           | 5.10       | 14.13    | 12.62                | 22.84               | 12.25 | 2.94              | 6.16           |
| 2001 – 2003    | -2.55  | 4.47           | -0.80    | 7.88         | 9.48            | 4.98       | 11.23    | 8.17                 | 15.80               | 7.72  | -1.20             | -2.60          |
| 2000 – 2002    | -12.47   | -7.22          | -14.67   | 9.65         | 12.56           | 4.39       | 6.83     | 9.47                 | 13.88               | 10.71 | -5.40             | -8.80          |
| 1999 – 2001    | 0.58   | 8.74           | 0.03     | 6.19         | 4.46            | 5.47       | 2.66     | 14.32                | 12.44               | 14.96 | 2.01              | 14.08          |
| 1998 – 2000    | 11.77  | 10.26          | 10.63    | 6.30         | 6.18            | 6.03       | 5.44     | 8.91                 | 6.25                | 13.97 | 10.61             | 23.84          |
| <b>5-year</b>  |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2014 – 2018    | 7.75   | 4.26           | 2.07     | 2.97         | 5.47            | 1.73       | 2.67     | 8.43                 | 5.81                | 1.15  | 1.96              | 4.85           |
| 2013 – 2017    | 15.41  | 13.81          | 8.49     | 2.64         | 4.91            | 2.07       | 3.34     | 7.96                 | 7.56                | 1.90  | 4.17              | 13.43          |
| 2012 – 2016    | 14.40  | 13.76          | 6.73     | 3.13         | 4.78            | 2.55       | 3.73     | 10.15                | 9.96                | 1.44  | 4.49              | 13.99          |
| 2011 – 2015    | 12.13  | 9.49           | 2.85     | 3.97         | 7.49            | 2.23       | 2.76     | 6.86                 | 9.36                | -0.60 | 4.16              | 7.95           |
| 2010 – 2014    | 15.40  | 15.61          | 5.99     | 5.73         | 10.55           | 3.44       | 6.14     | 7.01                 | 13.69               | 3.62  | 6.24              | 11.03          |
| 2009 – 2013    | 18.69  | 21.28          | 13.71    | 6.70         | 7.58            | 5.65       | 9.54     | 6.82                 | 15.47               | 4.28  | 8.21              | 18.28          |
| 2008 – 2012    | 1.80   | 3.40           | -2.17    | 7.16         | 12.22           | 4.20       | 7.65     | 0.89                 | 4.05                | 1.60  | 2.24              | 5.34           |
| 2007 – 2011    | -0.10  | 0.83           | -2.74    | 7.04         | 11.64           | 4.10       | 6.94     | -3.91                | -2.02               | 3.59  | 2.34              | 2.87           |
| 2006 – 2010    | 2.49   | 4.28           | 4.62     | 6.30         | 7.82            | 4.51       | 7.75     | 1.16                 | 3.58                | 6.83  | 4.34              | 9.10           |
| 2005 – 2009    | 0.76   | 0.90           | 5.40     | 5.21         | 6.82            | 4.16       | 5.44     | 4.07                 | 1.96                | 8.37  | 3.99              | 6.40           |
| 2004 – 2008    | -2.13  | -1.76          | 2.20     | 3.94         | 7.81            | 2.60       | 3.61     | 1.38                 | 2.36                | 10.83 | 2.61              | 2.52           |
| 2003 – 2007    | 13.67  | 16.01          | 22.51    | 5.17         | 6.43            | 5.37       | 9.08     | 13.32                | 19.33               | 15.19 | 9.87              | 15.52          |
| 2002 – 2006    | 7.10   | 10.64          | 15.70    | 5.73         | 7.88            | 4.86       | 10.31    | 15.40                | 23.31               | 14.13 | 5.41              | 9.71           |
| 2001 – 2005    | 2.04   | 7.38           | 6.39     | 6.40         | 8.69            | 4.63       | 9.12     | 9.81                 | 18.61               | 11.98 | 2.16              | 2.88           |
| 2000 – 2004    | -0.35  | 5.95           | 0.45     | 8.05         | 10.70           | 5.23       | 9.70     | 13.71                | 21.09               | 11.93 | 1.01              | 2.62           |
| 1999 – 2003    | 0.89   | 8.23           | 3.41     | 6.81         | 7.02            | 5.36       | 7.83     | 13.72                | 14.75               | 12.70 | 1.51              | 8.66           |
| 1998 – 2002    | -0.25  | 1.32           | -0.79    | 7.28         | 8.01            | 4.98       | 6.43     | 4.83                 | 6.95                | 11.05 | 2.46              | 6.52           |
| <b>10-year</b> |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2009 – 2018    | 13.09  | 12.45          | 7.73     | 4.82         | 6.52            | 3.67       | 6.05     | 7.63                 | 10.53               | 2.70  | 5.04              | 11.36          |
| 2008 – 2017    | 8.39   | 8.48           | 3.02     | 4.88         | 8.50            | 3.13       | 5.47     | 4.36                 | 5.79                | 1.75  | 3.20              | 9.31           |
| 2007 – 2016    | 6.90   | 7.10           | 1.88     | 5.06         | 8.15            | 3.32       | 5.32     | 2.88                 | 3.80                | 2.51  | 3.41              | 8.29           |
| 2006 – 2015    | 7.20   | 6.85           | 3.73     | 5.13         | 7.66            | 3.36       | 5.23     | 3.97                 | 6.43                | 3.05  | 4.25              | 8.53           |
| 2005 – 2014    | 7.83   | 8.00           | 5.69     | 5.47         | 8.67            | 3.80       | 5.79     | 5.53                 | 7.67                | 5.97  | 5.11              | 8.69           |
| 2004 – 2013    | 7.78   | 9.15           | 7.80     | 5.31         | 7.70            | 4.11       | 6.53     | 4.07                 | 8.71                | 7.50  | 5.38              | 10.12          |
| 2003 – 2012    | 7.57   | 9.53           | 9.48     | 6.16         | 9.29            | 4.79       | 8.36     | 6.92                 | 11.43               | 8.18  | 5.99              | 10.32          |
| 2002 – 2011    | 3.43   | 5.62           | 6.08     | 6.38         | 9.74            | 4.48       | 8.61     | 5.30                 | 9.92                | 8.73  | 3.86              | 6.23           |
| 2001 – 2010    | 2.27   | 5.81           | 5.50     | 6.35         | 8.26            | 4.57       | 8.43     | 5.39                 | 10.84               | 9.37  | 3.25              | 5.95           |
| 2000 – 2009    | 0.20   | 3.39           | 2.89     | 6.62         | 8.74            | 4.69       | 7.55     | 8.78                 | 11.11               | 10.14 | 2.49              | 4.49           |
| 1999 – 2008    | -0.63  | 3.11           | 2.80     | 5.36         | 7.41            | 3.97       | 5.70     | 7.37                 | 8.38                | 11.76 | 2.06              | 5.55           |
| 1998 – 2007    | 6.49   | 8.42           | 10.24    | 6.22         | 7.22            | 5.18       | 7.75     | 8.99                 | 12.97               | 13.10 | 6.10              | 10.93          |
| <b>15-year</b> |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2004 – 2018    | 7.77   | 7.50           | 5.85     | 4.52         | 6.95            | 3.31       | 5.23     | 5.50                 | 7.74                | 5.34  | 4.22              | 8.33           |
| 2003 – 2017    | 10.12  | 10.94          | 9.15     | 4.97         | 7.81            | 3.87       | 6.66     | 7.27                 | 10.13               | 6.04  | 5.38              | 11.34          |
| 2002 – 2016    | 6.97   | 8.27           | 6.29     | 5.28         | 8.06            | 3.83       | 6.96     | 6.89                 | 9.93                | 6.24  | 4.07              | 8.76           |
| 2001 – 2015    | 5.45   | 7.02           | 4.61     | 5.55         | 8.00            | 3.78       | 6.51     | 5.88                 | 10.35               | 5.94  | 3.55              | 6.61           |
| 2000 – 2014    | 5.03   | 7.31           | 3.91     | 6.32         | 9.34            | 4.27       | 7.08     | 8.19                 | 11.96               | 7.92  | 3.73              | 6.62           |
| 1999 – 2013    | 5.43   | 8.84           | 6.31     | 5.81         | 7.47            | 4.53       | 6.96     | 7.19                 | 10.69               | 9.21  | 4.07              | 9.63           |
| 1998 – 2012    | 4.90   | 6.72           | 5.94     | 6.53         | 8.86            | 4.85       | 7.72     | 6.22                 | 9.92                | 9.13  | 4.80              | 9.04           |
| <b>21-year</b> |  |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 1998 – 2018    | 6.79   | 7.45           | 5.54     | 5.25         | 7.19            | 3.93       | 6.10     | 6.36                 | 8.64                | 6.87  | 4.31              | 8.76           |

Table 4C. Annualized volatility in percent by aggregate asset class for selected multi-year time spans. Unlisted real estate and private equity have been standardized for reporting lag. Maximum values within each time span are highlighted in green while lows are highlighted in red.

| Time Span      | Table 4C. Annualized volatility by time span (in percent) |                |          |              |                 |            |          |                      |                     |       |                   |                |
|----------------|---|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                | Stock   |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|                | U.S. Large Cap  | U.S. Small Cap | Non U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| <b>3-year</b>  |   |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2016 – 2018    | 11.33   | 13.64          | 16.99    | 3.08         | 7.38            | 6.18       | 7.08     | 8.64                 | 6.20                | 9.71  | 5.43              | 17.98          |
| 2015 – 2017    | 8.84  | 10.55          | 13.41    | 2.86         | 6.58            | 4.46       | 7.14     | 9.37                 | 4.31                | 13.13 | 4.73              | 10.66          |
| 2014 – 2016    | 5.72  | 9.56           | 4.41     | 4.00         | 10.20           | 4.15       | 6.49     | 14.32                | 9.70                | 13.83 | 4.44              | 12.48          |
| 2013 – 2015    | 13.67   | 18.47          | 10.22    | 4.86         | 12.64           | 3.01       | 6.10     | 15.76                | 9.93                | 13.65 | 6.44              | 13.78          |
| 2012 – 2014    | 9.29  | 14.30          | 9.80     | 5.36         | 12.16           | 4.33       | 7.95     | 13.59                | 10.43               | 10.14 | 5.38              | 13.41          |
| 2011 – 2013    | 13.43   | 17.29          | 14.74    | 6.25         | 13.29           | 4.87       | 8.47     | 9.91                 | 10.72               | 11.73 | 6.87              | 16.65          |
| 2010 – 2012    | 7.51  | 12.66          | 13.53    | 4.11         | 7.29            | 5.07       | 10.27    | 11.68                | 12.28               | 11.99 | 6.76              | 15.64          |
| 2009 – 2011    | 12.07   | 16.66          | 21.90    | 5.82         | 10.99           | 10.38      | 14.06    | 17.90                | 15.30               | 15.24 | 9.47              | 23.04          |
| 2008 – 2010    | 29.42   | 32.43          | 35.37    | 7.95         | 11.76           | 13.05      | 19.07    | 25.12                | 32.75               | 24.48 | 16.78             | 32.47          |
| 2007 – 2009    | 28.20   | 29.64          | 35.58    | 7.76         | 11.66           | 13.38      | 17.19    | 25.20                | 30.51               | 25.67 | 16.59             | 31.97          |
| 2006 – 2008    | 23.19   | 22.68          | 30.91    | 5.24         | 9.85            | 8.67       | 11.89    | 24.67                | 31.93               | 30.16 | 14.95             | 25.35          |
| 2005 – 2007    | 4.44  | 6.34           | 5.98     | 1.79         | 2.73            | 4.64       | 5.46     | 20.17                | 20.25               | 20.70 | 4.86              | 14.39          |
| 2004 – 2006    | 3.70  | 4.99           | 4.77     | 1.43         | 3.28            | 2.89       | 6.11     | 14.95                | 11.92               | 22.89 | 4.71              | 14.08          |
| 2003 – 2005    | 10.57   | 15.99          | 9.92     | 2.06         | 2.43            | 5.91       | 9.77     | 14.62                | 12.34               | 16.27 | 7.98              | 16.38          |
| 2002 – 2004    | 21.73   | 26.18          | 21.69    | 2.60         | 4.14            | 6.53       | 8.34     | 14.61                | 15.60               | 16.96 | 16.90             | 25.29          |
| 2001 – 2003    | 22.60   | 27.37          | 25.52    | 2.37         | 4.49            | 6.41       | 10.49    | 15.93                | 14.31               | 16.82 | 17.25             | 25.21          |
| 2000 – 2002    | 7.92  | 12.36          | 5.28     | 2.78         | 4.66            | 4.11       | 8.63     | 18.20                | 11.56               | 20.59 | 12.79             | 27.51          |
| 1999 – 2001    | 13.85   | 20.74          | 26.43    | 5.94         | 9.98            | 3.29       | 7.70     | 16.47                | 13.32               | 22.05 | 8.95              | 43.06          |
| 1998 – 2000    | 14.02   | 19.77          | 22.29    | 6.02         | 10.54           | 3.89       | 9.38     | 21.75                | 17.80               | 18.57 | 9.90              | 40.09          |
| <b>5-year</b>  |   |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2014 – 2018    | 9.69  | 11.60          | 14.00    | 3.79         | 9.82            | 5.15       | 6.93     | 13.10                | 9.42                | 12.57 | 5.18              | 15.19          |
| 2013 – 2017    | 11.19   | 14.72          | 12.38    | 4.23         | 10.49           | 4.00       | 7.04     | 13.20                | 8.13                | 12.58 | 5.72              | 12.65          |
| 2012 – 2016    | 10.80   | 14.69          | 9.61     | 4.61         | 10.47           | 4.55       | 7.76     | 13.13                | 10.13               | 12.06 | 5.76              | 12.78          |
| 2011 – 2015    | 12.19   | 15.98          | 12.58    | 5.69         | 12.92           | 4.35       | 7.83     | 13.96                | 10.95               | 13.19 | 6.42              | 14.68          |
| 2010 – 2014    | 10.62   | 15.19          | 12.47    | 5.55         | 11.58           | 4.66       | 9.80     | 14.50                | 11.64               | 11.91 | 6.49              | 15.58          |
| 2009 – 2013    | 11.80   | 15.44          | 17.26    | 6.63         | 11.80           | 8.84       | 12.78    | 15.19                | 13.90               | 12.99 | 8.10              | 18.99          |
| 2008 – 2012    | 23.52   | 25.90          | 29.07    | 6.85         | 10.95           | 10.59      | 15.56    | 20.86                | 26.68               | 20.50 | 13.65             | 27.08          |
| 2007 – 2011    | 22.89   | 25.61          | 28.79    | 6.79         | 11.04           | 10.83      | 15.25    | 20.46                | 26.75               | 21.80 | 13.84             | 27.08          |
| 2006 – 2010    | 23.30   | 25.56          | 29.00    | 6.25         | 9.56            | 10.70      | 14.90    | 24.02                | 29.94               | 24.95 | 13.95             | 26.98          |
| 2005 – 2009    | 22.73   | 23.83          | 29.15    | 6.16         | 9.41            | 10.47      | 13.91    | 24.81                | 29.06               | 25.70 | 13.63             | 26.73          |
| 2004 – 2008    | 19.56   | 20.18          | 25.90    | 4.19         | 7.81            | 7.06       | 10.39    | 22.32                | 29.26               | 26.51 | 12.38             | 22.43          |
| 2003 – 2007    | 9.28  | 14.91          | 9.01     | 1.86         | 2.84            | 5.75       | 7.88     | 18.10                | 19.59               | 19.63 | 7.10              | 16.00          |
| 2002 – 2006    | 17.14   | 20.52          | 17.49    | 2.63         | 4.65            | 5.29       | 8.83     | 15.81                | 14.28               | 19.97 | 13.63             | 21.68          |
| 2001 – 2005    | 18.23   | 21.61          | 21.41    | 2.76         | 3.98            | 5.32       | 9.62     | 15.26                | 13.80               | 17.88 | 14.18             | 22.34          |
| 2000 – 2004    | 18.62   | 22.32          | 22.42    | 3.12         | 4.51            | 5.52       | 9.21     | 16.70                | 14.28               | 19.59 | 14.15             | 28.00          |
| 1999 – 2003    | 19.83   | 25.79          | 26.66    | 4.96         | 8.81            | 5.42       | 10.64    | 16.62                | 14.80               | 19.21 | 14.46             | 38.34          |
| 1998 – 2002    | 18.04   | 20.03          | 22.32    | 4.95         | 8.95            | 4.12       | 9.42     | 18.31                | 14.40               | 19.04 | 15.12             | 38.07          |
| <b>10-year</b> |   |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2009 – 2018    | 12.14   | 16.18          | 16.83    | 5.72         | 10.91           | 7.50       | 10.85    | 14.20                | 12.86               | 12.87 | 7.49              | 18.52          |
| 2008 – 2017    | 19.21   | 21.41          | 22.59    | 6.13         | 11.28           | 8.09       | 12.30    | 17.72                | 19.72               | 17.01 | 10.48             | 21.31          |
| 2007 – 2016    | 18.88   | 21.51          | 21.62    | 6.13         | 11.25           | 8.35       | 12.22    | 18.41                | 20.72               | 17.65 | 10.63             | 21.61          |
| 2006 – 2015    | 18.94   | 21.36          | 22.55    | 6.08         | 11.36           | 8.25       | 12.19    | 19.75                | 22.56               | 20.32 | 10.86             | 21.79          |
| 2005 – 2014    | 18.75   | 20.95          | 22.50    | 5.87         | 10.75           | 8.12       | 12.03    | 20.33                | 22.50               | 20.20 | 10.70             | 21.91          |
| 2004 – 2013    | 18.75   | 20.95          | 22.42    | 5.72         | 10.01           | 8.14       | 12.02    | 19.21                | 23.40               | 21.17 | 10.77             | 22.08          |
| 2003 – 2012    | 18.44   | 21.69          | 23.79    | 5.12         | 8.53            | 8.54       | 12.35    | 20.38                | 24.31               | 21.16 | 11.43             | 22.56          |
| 2002 – 2011    | 20.42   | 23.57          | 25.01    | 5.19         | 8.69            | 8.53       | 12.55    | 20.46                | 24.24               | 21.52 | 13.81             | 24.68          |
| 2001 – 2010    | 20.95   | 23.68          | 25.49    | 4.83         | 7.33            | 8.45       | 12.55    | 20.42                | 23.99               | 21.84 | 14.12             | 25.06          |
| 2000 – 2009    | 20.81   | 23.17          | 26.29    | 5.08         | 7.63            | 8.38       | 11.96    | 21.55                | 24.20               | 22.90 | 13.98             | 27.49          |
| 1999 – 2008    | 19.73   | 23.68          | 26.29    | 4.82         | 8.33            | 6.44       | 10.72    | 20.49                | 23.62               | 23.16 | 13.48             | 31.63          |
| 1998 – 2007    | 15.70   | 19.05          | 20.14    | 3.89         | 6.71            | 5.00       | 8.78     | 18.66                | 18.42               | 19.44 | 12.29             | 29.38          |
| <b>15-year</b> |   |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2004 – 2018    | 16.31   | 18.63          | 20.35    | 5.28         | 9.99            | 7.38       | 10.76    | 17.50                | 20.01               | 18.99 | 9.45              | 20.27          |
| 2003 – 2017    | 16.66   | 19.69          | 20.76    | 5.12         | 9.42            | 7.46       | 11.14    | 18.31                | 20.62               | 18.98 | 9.95              | 19.83          |
| 2002 – 2016    | 18.32   | 21.23          | 21.19    | 5.23         | 9.57            | 7.50       | 11.44    | 18.44                | 20.67               | 19.22 | 11.76             | 21.64          |
| 2001 – 2015    | 18.89   | 21.44          | 22.19    | 5.25         | 9.56            | 7.43       | 11.54    | 18.52                | 20.66               | 19.97 | 12.11             | 22.15          |
| 2000 – 2014    | 19.13   | 21.44          | 22.64    | 5.26         | 9.20            | 7.38       | 11.31    | 19.53                | 20.87               | 20.18 | 12.11             | 24.30          |
| 1999 – 2013    | 19.40   | 22.69          | 24.01    | 5.53         | 9.63            | 7.37       | 11.59    | 18.90                | 21.02               | 20.67 | 12.25             | 28.55          |
| 1998 – 2012    | 18.72   | 21.61          | 23.92    | 5.10         | 8.69            | 7.37       | 11.50    | 19.75                | 21.75               | 20.52 | 12.87             | 28.71          |
| <b>21-year</b> |   |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 1998 – 2018    | 17.45   | 20.29          | 21.63    | 5.23         | 9.53            | 6.92       | 10.74    | 18.03                | 19.17               | 18.88 | 11.39             | 25.78          |

Table 4D. Sharpe ratios by aggregate asset class for selected multi-year time spans. The risk-free rates used are the total returns from 3-month U.S. treasury bills. Unlisted real estate and private equity have been standardized for reporting lag. Maximum values within each time span are highlighted in green while lows are highlighted in red.

| Time Span      | Table 4D. Sharpe ratios by time span |                |          |              |                 |            |          |                      |                     |       |                   |                |
|----------------|--------------------------------------|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                | Stock                                |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|                | U.S. Large Cap                       | U.S. Small Cap | Non U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| <b>3-year</b>  |                                      |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2016 – 2018    | 0.69                                 | 0.46           | 0.32     | 0.49         | 0.44            | 0.25       | 0.51     | 0.60                 | 0.28                | 0.38  | 0.19              | 0.31           |
| 2015 – 2017    | 1.27                                 | 0.92           | 0.72     | 0.92         | 0.74            | 0.46       | 0.65     | 0.51                 | 1.07                | 0.10  | 0.44              | 1.23           |
| 2014 – 2016    | 1.43                                 | 0.64           | -0.03    | 0.87         | 0.75            | 0.46       | 0.40     | 0.93                 | 0.90                | 0.02  | 0.42              | 0.79           |
| 2013 – 2015    | 1.13                                 | 0.71           | 0.41     | 0.31         | 0.21            | 0.22       | -0.06    | 0.51                 | 0.86                | -0.12 | 0.65              | 0.80           |
| 2012 – 2014    | 2.22                                 | 1.38           | 1.14     | 0.73         | 0.60            | 0.64       | 0.58     | 1.03                 | 1.42                | 0.29  | 1.31              | 1.11           |
| 2011 – 2013    | 1.25                                 | 0.98           | 0.51     | 0.71         | 0.62            | 0.69       | 0.57     | 0.39                 | 0.82                | 0.14  | 0.83              | 0.69           |
| 2010 – 2012    | 1.47                                 | 1.03           | 0.42     | 1.94         | 1.98            | 0.90       | 0.93     | 0.30                 | 1.24                | 0.36  | 0.85              | 0.63           |
| 2009 – 2011    | 1.28                                 | 1.13           | 0.59     | 1.63         | 1.12            | 0.69       | 0.89     | 0.44                 | 1.20                | 0.32  | 0.86              | 0.79           |
| 2008 – 2010    | 0.06                                 | 0.20           | 0.05     | 0.70         | 0.77            | 0.25       | 0.38     | -0.04                | 0.12                | 0.06  | 0.07              | 0.30           |
| 2007 – 2009    | -0.12                                | -0.11          | 0.02     | 0.43         | 0.52            | 0.12       | 0.23     | -0.20                | -0.28               | 0.04  | -0.05             | 0.07           |
| 2006 – 2008    | -0.45                                | -0.51          | -0.19    | -0.06        | 0.39            | -0.29      | -0.16    | -0.29                | -0.28               | 0.08  | -0.26             | -0.19          |
| 2005 – 2007    | 1.10                                 | 0.58           | 2.47     | 0.35         | 0.37            | 0.06       | 0.30     | 0.28                 | 0.41                | 0.57  | 0.94              | 0.50           |
| 2004 – 2006    | 2.27                                 | 1.80           | 4.19     | 0.61         | 0.63            | 0.50       | 0.55     | 0.99                 | 2.02                | 0.62  | 1.24              | 0.95           |
| 2003 – 2005    | 1.31                                 | 1.24           | 2.18     | 1.13         | 1.91            | 0.58       | 0.80     | 1.08                 | 1.91                | 0.86  | 1.01              | 0.91           |
| 2002 – 2004    | 0.26                                 | 0.46           | 0.59     | 2.26         | 2.29            | 0.56       | 1.53     | 0.80                 | 1.40                | 0.64  | 0.13              | 0.27           |
| 2001 – 2003    | -0.11                                | 0.18           | -0.02    | 2.14         | 1.38            | 0.38       | 0.78     | 0.39                 | 0.93                | 0.31  | -0.17             | -0.12          |
| 2000 – 2002    | -2.54                                | -0.98          | -3.46    | 1.89         | 1.68            | 0.07       | 0.29     | 0.38                 | 0.98                | 0.33  | -0.77             | -0.46          |
| 1999 – 2001    | -0.28                                | 0.21           | -0.09    | 0.20         | -0.03           | 0.09       | -0.33    | 0.63                 | 0.60                | 0.46  | -0.34             | 0.28           |
| 1998 – 2000    | 0.49                                 | 0.28           | 0.31     | 0.17         | 0.12            | 0.14       | 0.00     | 0.24                 | 0.10                | 0.48  | 0.53              | 0.50           |
| <b>5-year</b>  |                                      |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2014 – 2018    | 0.75                                 | 0.35           | 0.16     | 0.58         | 0.51            | 0.21       | 0.31     | 0.63                 | 0.56                | 0.06  | 0.25              | 0.32           |
| 2013 – 2017    | 1.40                                 | 0.98           | 0.73     | 0.58         | 0.49            | 0.46       | 0.46     | 0.63                 | 0.91                | 0.15  | 0.69              | 1.07           |
| 2012 – 2016    | 1.36                                 | 0.99           | 0.73     | 0.67         | 0.49            | 0.54       | 0.48     | 0.81                 | 1.00                | 0.13  | 0.77              | 1.12           |
| 2011 – 2015    | 1.04                                 | 0.65           | 0.28     | 0.70         | 0.63            | 0.50       | 0.36     | 0.54                 | 0.88                | -0.04 | 0.65              | 0.58           |
| 2010 – 2014    | 1.48                                 | 1.08           | 0.53     | 1.03         | 0.95            | 0.72       | 0.63     | 0.52                 | 1.20                | 0.30  | 0.95              | 0.74           |
| 2009 – 2013    | 1.62                                 | 1.43           | 0.86     | 1.01         | 0.67            | 0.63       | 0.76     | 0.48                 | 1.14                | 0.32  | 1.01              | 1.01           |
| 2008 – 2012    | 0.18                                 | 0.24           | 0.07     | 0.91         | 1.08            | 0.35       | 0.47     | 0.09                 | 0.26                | 0.06  | 0.16              | 0.28           |
| 2007 – 2011    | 0.06                                 | 0.10           | 0.01     | 0.74         | 0.89            | 0.24       | 0.37     | -0.19                | -0.01               | 0.11  | 0.10              | 0.15           |
| 2006 – 2010    | 0.13                                 | 0.20           | 0.24     | 0.54         | 0.53            | 0.19       | 0.37     | 0.04                 | 0.17                | 0.19  | 0.18              | 0.35           |
| 2005 – 2009    | 0.03                                 | 0.04           | 0.25     | 0.32         | 0.39            | 0.11       | 0.19     | 0.13                 | 0.10                | 0.23  | 0.12              | 0.23           |
| 2004 – 2008    | -0.16                                | -0.13          | 0.12     | 0.16         | 0.54            | -0.09      | 0.05     | 0.00                 | 0.11                | 0.31  | -0.01             | 0.05           |
| 2003 – 2007    | 1.06                                 | 0.85           | 1.99     | 0.83         | 0.87            | 0.37       | 0.71     | 0.60                 | 0.86                | 0.62  | 0.91              | 0.78           |
| 2002 – 2006    | 0.36                                 | 0.48           | 0.84     | 0.98         | 0.99            | 0.44       | 0.85     | 0.87                 | 1.51                | 0.59  | 0.25              | 0.41           |
| 2001 – 2005    | 0.07                                 | 0.31           | 0.28     | 1.38         | 1.40            | 0.41       | 0.67     | 0.51                 | 1.16                | 0.54  | 0.02              | 0.09           |
| 2000 – 2004    | -0.09                                | 0.21           | -0.01    | 1.96         | 1.83            | 0.39       | 0.66     | 0.71                 | 1.27                | 0.46  | -0.10             | 0.04           |
| 1999 – 2003    | -0.05                                | 0.26           | 0.10     | 0.60         | 0.40            | 0.29       | 0.37     | 0.67                 | 0.77                | 0.49  | -0.12             | 0.21           |
| 1998 – 2002    | -0.19                                | -0.10          | -0.15    | 0.55         | 0.42            | 0.12       | 0.20     | 0.08                 | 0.21                | 0.36  | -0.10             | 0.13           |
| <b>10-year</b> |                                      |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2009 – 2018    | 1.08                                 | 0.80           | 0.50     | 0.77         | 0.59            | 0.44       | 0.54     | 0.55                 | 0.81                | 0.19  | 0.62              | 0.64           |
| 2008 – 2017    | 0.51                                 | 0.48           | 0.23     | 0.72         | 0.75            | 0.34       | 0.43     | 0.28                 | 0.36                | 0.09  | 0.29              | 0.49           |
| 2007 – 2016    | 0.41                                 | 0.39           | 0.17     | 0.68         | 0.68            | 0.30       | 0.38     | 0.17                 | 0.23                | 0.11  | 0.27              | 0.41           |
| 2006 – 2015    | 0.40                                 | 0.36           | 0.23     | 0.60         | 0.58            | 0.26       | 0.34     | 0.21                 | 0.33                | 0.10  | 0.30              | 0.41           |
| 2005 – 2014    | 0.42                                 | 0.40           | 0.31     | 0.61         | 0.66            | 0.27       | 0.36     | 0.26                 | 0.37                | 0.24  | 0.36              | 0.40           |
| 2004 – 2013    | 0.41                                 | 0.45           | 0.40     | 0.58         | 0.60            | 0.29       | 0.41     | 0.19                 | 0.40                | 0.29  | 0.37              | 0.45           |
| 2003 – 2012    | 0.40                                 | 0.45           | 0.45     | 0.74         | 0.82            | 0.34       | 0.53     | 0.32                 | 0.50                | 0.32  | 0.39              | 0.45           |
| 2002 – 2011    | 0.18                                 | 0.27           | 0.30     | 0.74         | 0.84            | 0.29       | 0.53     | 0.23                 | 0.43                | 0.33  | 0.18              | 0.26           |
| 2001 – 2010    | 0.10                                 | 0.25           | 0.25     | 0.72         | 0.75            | 0.25       | 0.48     | 0.21                 | 0.45                | 0.33  | 0.10              | 0.23           |
| 2000 – 2009    | -0.03                                | 0.12           | 0.13     | 0.68         | 0.75            | 0.20       | 0.38     | 0.35                 | 0.44                | 0.33  | 0.00              | 0.13           |
| 1999 – 2008    | -0.10                                | 0.09           | 0.11     | 0.39         | 0.47            | 0.08       | 0.22     | 0.27                 | 0.31                | 0.38  | -0.07             | 0.15           |
| 1998 – 2007    | 0.24                                 | 0.30           | 0.40     | 0.60         | 0.51            | 0.26       | 0.42     | 0.33                 | 0.54                | 0.49  | 0.22              | 0.30           |
| <b>15-year</b> |                                      |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 2004 – 2018    | 0.47                                 | 0.41           | 0.33     | 0.57         | 0.57            | 0.27       | 0.37     | 0.29                 | 0.40                | 0.23  | 0.33              | 0.41           |
| 2003 – 2017    | 0.60                                 | 0.57           | 0.49     | 0.68         | 0.70            | 0.34       | 0.49     | 0.39                 | 0.51                | 0.27  | 0.43              | 0.56           |
| 2002 – 2016    | 0.39                                 | 0.42           | 0.35     | 0.71         | 0.71            | 0.33       | 0.50     | 0.36                 | 0.50                | 0.28  | 0.26              | 0.41           |
| 2001 – 2015    | 0.29                                 | 0.34           | 0.25     | 0.71         | 0.67            | 0.29       | 0.43     | 0.29                 | 0.50                | 0.24  | 0.19              | 0.30           |
| 2000 – 2014    | 0.24                                 | 0.33           | 0.19     | 0.79         | 0.79            | 0.30       | 0.45     | 0.38                 | 0.56                | 0.31  | 0.17              | 0.25           |
| 1999 – 2013    | 0.25                                 | 0.38           | 0.28     | 0.59         | 0.53            | 0.29       | 0.40     | 0.32                 | 0.48                | 0.35  | 0.17              | 0.33           |
| 1998 – 2012    | 0.21                                 | 0.27           | 0.25     | 0.67         | 0.67            | 0.28       | 0.43     | 0.25                 | 0.41                | 0.33  | 0.20              | 0.30           |
| <b>21-year</b> |                                      |                |          |              |                 |            |          |                      |                     |       |                   |                |
| 1998 – 2018    | 0.35                                 | 0.34           | 0.26     | 0.59         | 0.55            | 0.27       | 0.38     | 0.30                 | 0.41                | 0.28  | 0.23              | 0.33           |

Table 6. Average asset allocation for U.S. DB pension funds by year. Summary statistics include the average over all years, the absolute change (i.e., 2017 value - 1998 value), the absolute change per year, and the trend per year inferred from linear least-squares regression.

Table 6. Average asset allocation of U.S. DB pension funds by year (in percent)

| Year                    | Stock          |                |          | Fixed Income |                 |            |          | Real Assets          |                     |       | Other             |                |
|-------------------------|----------------|----------------|----------|--------------|-----------------|------------|----------|----------------------|---------------------|-------|-------------------|----------------|
|                         | U.S. Large Cap | U.S. Small Cap | Non U.S. | U.S. Broad   | U.S. Long Bonds | U.S. Other | Non U.S. | Unlisted Real Estate | Listed Equity REITs | Other | Hedge Funds / TAA | Private Equity |
| 2018                    | 15.52          | 3.38           | 20.95    | 12.71        | 21.31           | 4.51       | 2.68     | 5.19                 | 0.78                | 1.39  | 5.77              | 5.83           |
| 2017                    | 16.96          | 3.59           | 21.76    | 11.07        | 19.36           | 5.01       | 2.60     | 4.95                 | 0.74                | 1.74  | 6.62              | 5.61           |
| 2016                    | 17.46          | 3.73           | 20.72    | 11.68        | 17.00           | 5.29       | 3.26     | 5.29                 | 0.60                | 1.67  | 7.37              | 5.94           |
| 2015                    | 18.18          | 3.07           | 20.46    | 12.74        | 16.94           | 4.88       | 2.77     | 4.91                 | 0.73                | 1.36  | 8.26              | 5.70           |
| 2014                    | 18.70          | 3.38           | 20.90    | 12.11        | 16.43           | 4.84       | 2.89     | 4.46                 | 0.62                | 1.39  | 8.36              | 5.93           |
| 2013                    | 20.94          | 4.03           | 20.92    | 13.13        | 14.63           | 4.89       | 2.58     | 4.20                 | 0.56                | 1.37  | 7.13              | 5.63           |
| 2012                    | 21.59          | 4.47           | 18.86    | 15.12        | 14.44           | 4.78       | 2.31     | 4.06                 | 0.55                | 1.36  | 6.60              | 5.86           |
| 2011                    | 22.62          | 4.80           | 18.92    | 14.88        | 13.17           | 5.07       | 2.82     | 3.72                 | 0.62                | 1.30  | 6.40              | 5.67           |
| 2010                    | 25.50          | 5.52           | 19.87    | 17.04        | 9.65            | 4.98       | 2.15     | 3.36                 | 0.50                | 1.18  | 5.14              | 5.11           |
| 2009                    | 25.83          | 5.19           | 18.25    | 20.44        | 7.83            | 5.65       | 1.90     | 3.89                 | 0.48                | 0.94  | 4.57              | 5.03           |
| 2008                    | 28.91          | 5.17           | 18.13    | 20.64        | 6.55            | 4.53       | 1.92     | 4.29                 | 0.66                | 0.71  | 4.14              | 4.34           |
| 2007                    | 32.76          | 6.10           | 20.07    | 19.24        | 4.12            | 4.03       | 1.69     | 3.82                 | 0.73                | 0.57  | 3.48              | 3.39           |
| 2006                    | 35.53          | 6.84           | 19.74    | 20.53        | 1.79            | 3.95       | 1.34     | 3.54                 | 0.86                | 0.31  | 2.89              | 2.67           |
| 2005                    | 37.40          | 6.81           | 18.60    | 21.14        | 1.35            | 4.09       | 1.53     | 3.03                 | 0.88                | 0.22  | 2.43              | 2.52           |
| 2004                    | 38.60          | 6.75           | 17.92    | 21.63        | 1.38            | 4.17       | 1.42     | 2.73                 | 0.84                | 0.19  | 1.70              | 2.67           |
| 2003                    | 38.12          | 6.26           | 16.79    | 23.73        | 1.60            | 3.56       | 1.80     | 2.87                 | 0.75                | 0.23  | 1.39              | 2.88           |
| 2002                    | 37.39          | 6.10           | 15.39    | 27.19        | 1.37            | 2.42       | 2.01     | 3.32                 | 0.55                | 0.08  | 1.43              | 2.74           |
| 2001                    | 37.77          | 7.18           | 15.33    | 27.44        | 0.82            | 1.64       | 1.77     | 2.98                 | 0.53                | 0.06  | 1.50              | 2.98           |
| 2000                    | 38.18          | 6.65           | 16.37    | 26.41        | 0.87            | 1.54       | 2.21     | 2.87                 | 0.52                | 0.05  | 1.30              | 3.04           |
| 1999                    | 41.24          | 6.57           | 15.63    | 25.42        | 1.09            | 1.61       | 2.12     | 2.55                 | 0.46                | 0.03  | 1.09              | 2.19           |
| 1998                    | 42.11          | 5.63           | 13.63    | 26.67        | 0.90            | 1.96       | 2.40     | 2.90                 | 0.36                | 0.01  | 1.46              | 1.97           |
| <b>Average:</b>         | 29.11          | 5.30           | 18.53    | 19.09        | 8.22            | 3.97       | 2.20     | 3.76                 | 0.63                | 0.77  | 4.24              | 4.18           |
| <b>Absolute change:</b> | -26.60         | -2.25          | 7.32     | -13.96       | 20.41           | 2.55       | 0.29     | 2.28                 | 0.42                | 1.39  | 4.31              | 3.85           |
| <b>Change per year:</b> | -1.27          | -0.11          | 0.35     | -0.66        | 0.97            | 0.12       | 0.01     | 0.11                 | 0.02                | 0.07  | 0.21              | 0.18           |
| <b>Trend per year:</b>  | -1.46          | -0.19          | 0.33     | -0.89        | 1.13            | 0.18       | 0.05     | 0.13                 | 0.01                | 0.10  | 0.38              | 0.22           |

Table 8A and 8B. Average annual total fund returns by year with population standard deviations ( $\sigma$ ) and standard errors ( $\sigma/\sqrt{n}$ ) for U.S. public sector (top) and corporate sector (bottom) pension funds spanning 1998-2018. (For details see section 3.4. of Ref. 1.)

Summary statistics include the arithmetic average net return (6.94% 'as-reported' for public sector funds), the standard error on the arithmetic average net return (0.06% 'as-reported' for public sector funds), the standard deviation of the average annual net returns (11.14% 'as-reported' for public sector funds), the compound average of annual average net returns (6.29% 'as-reported' for public sector funds), the standard error on the compound average net return (0.06% 'as-reported' for public sector funds), and lastly the average volatility (11.42% 'as-reported' for public sector funds).

Table 8A. Net returns by year: U.S. public sector DB pension funds (in percent)

| Year                         | #  | As-reported |           |           | Physical-asset-only |           |           | Standardized physical-asset-only |           |           |
|------------------------------|----|-------------|-----------|-----------|---------------------|-----------|-----------|----------------------------------|-----------|-----------|
|                              |    | Avg.        | Std. Err. | Std. Dev. | Avg.                | Std. Err. | Std. Dev. | Avg.                             | Std. Err. | Std. Dev. |
| 2018                         | 57 | -3.01       | 0.26      | 1.96      | -3.12               | 0.27      | 2.05      | -6.15                            | 0.17      | 1.29      |
| 2017                         | 60 | 15.54       | 0.23      | 1.82      | 15.87               | 0.27      | 2.10      | 15.70                            | 0.28      | 2.20      |
| 2016                         | 60 | 7.83        | 0.13      | 0.97      | 7.59                | 0.11      | 0.82      | 8.88                             | 0.15      | 1.19      |
| 2015                         | 62 | 0.32        | 0.20      | 1.54      | 0.56                | 0.15      | 1.20      | -0.51                            | 0.15      | 1.21      |
| 2014                         | 62 | 6.61        | 0.22      | 1.70      | 6.72                | 0.20      | 2.01      | 6.69                             | 0.20      | 2.03      |
| 2013                         | 64 | 15.40       | 0.40      | 3.21      | 16.13               | 0.47      | 3.73      | 16.03                            | 0.45      | 3.59      |
| 2012                         | 68 | 13.10       | 0.14      | 1.12      | 12.97               | 0.15      | 1.25      | 13.40                            | 0.16      | 1.35      |
| 2011                         | 68 | 0.99        | 0.19      | 1.60      | 1.27                | 0.20      | 1.65      | -0.71                            | 0.21      | 1.70      |
| 2010                         | 73 | 13.34       | 0.19      | 1.59      | 13.10               | 0.18      | 1.50      | 13.29                            | 0.23      | 1.95      |
| 2009                         | 73 | 19.96       | 0.49      | 4.22      | 21.24               | 0.52      | 4.41      | 27.06                            | 0.43      | 3.67      |
| 2008                         | 72 | -26.99      | 0.33      | 2.82      | -24.11              | 0.44      | 3.76      | -26.39                           | 0.46      | 3.89      |
| 2007                         | 80 | 8.43        | 0.19      | 1.70      | 8.39                | 0.20      | 1.79      | 6.50                             | 0.17      | 1.56      |
| 2006                         | 69 | 14.16       | 0.18      | 1.48      | 14.46               | 0.20      | 1.62      | 15.11                            | 0.23      | 1.94      |
| 2005                         | 72 | 8.42        | 0.20      | 1.71      | 8.62                | 0.23      | 1.95      | 7.82                             | 0.18      | 1.53      |
| 2004                         | 76 | 11.98       | 0.15      | 1.32      | 12.14               | 0.15      | 1.35      | 12.30                            | 0.16      | 1.43      |
| 2003                         | 74 | 22.95       | 0.34      | 2.89      | 23.70               | 0.31      | 2.69      | 24.67                            | 0.33      | 2.81      |
| 2002                         | 74 | -8.76       | 0.31      | 2.63      | -7.53               | 0.28      | 2.42      | -7.92                            | 0.29      | 2.51      |
| 2001                         | 83 | -4.30       | 0.26      | 2.41      | -3.88               | 0.27      | 2.48      | -3.85                            | 0.26      | 2.41      |
| 2000                         | 80 | 0.06        | 0.43      | 3.86      | 0.75                | 0.42      | 3.72      | 0.89                             | 0.42      | 3.74      |
| 1999                         | 83 | 14.56       | 0.45      | 4.14      | 16.33               | 0.52      | 4.71      | 16.65                            | 0.54      | 4.91      |
| 1998                         | 69 | 15.10       | 0.41      | 3.37      | 15.55               | 0.42      | 3.45      | 14.88                            | 0.45      | 3.71      |
| <b>Arithmetic Avg. Ret.:</b> |    | 6.94        | 0.06      | 11.14     | 7.46                | 0.07      | 10.85     | 7.35                             | 0.07      | 11.92     |
| <b>Compound Avg. Ret.:</b>   |    | 6.29        | 0.06      | n/a       | 6.86                | 0.07      | n/a       | 6.63                             | 0.07      | n/a       |
| <b>Avg. Volatility:</b>      |    | 11.42       | n/a       | n/a       | 11.17               | n/a       | n/a       | 12.21                            | n/a       | n/a       |

Table 8B. Net returns by year: U.S. corporate sector DB pension funds (in percent)

| Year                         | #   | As-reported |           |           | Physical-asset-only |           |           | Standardized physical-asset-only |           |           |
|------------------------------|-----|-------------|-----------|-----------|---------------------|-----------|-----------|----------------------------------|-----------|-----------|
|                              |     | Avg.        | Std. Err. | Std. Dev. | Avg.                | Std. Err. | Std. Dev. | Avg.                             | Std. Err. | Std. Dev. |
| 2018                         | 99  | -4.36       | 0.22      | 2.16      | -4.68               | 0.23      | 2.27      | -6.23                            | 0.21      | 2.12      |
| 2017                         | 97  | 15.01       | 0.31      | 3.10      | 14.99               | 0.31      | 3.09      | 14.87                            | 0.32      | 3.14      |
| 2016                         | 100 | 7.61        | 0.23      | 2.28      | 7.65                | 0.18      | 1.81      | 8.40                             | 0.20      | 1.95      |
| 2015                         | 101 | -1.22       | 0.15      | 1.48      | -1.20               | 0.15      | 1.52      | -1.74                            | 0.13      | 1.28      |
| 2014                         | 97  | 10.13       | 0.36      | 3.57      | 10.04               | 0.35      | 3.47      | 9.82                             | 0.35      | 3.42      |
| 2013                         | 112 | 10.52       | 0.65      | 6.85      | 11.63               | 0.62      | 6.61      | 11.70                            | 0.62      | 6.61      |
| 2012                         | 120 | 12.95       | 0.17      | 1.84      | 12.83               | 0.16      | 1.80      | 13.30                            | 0.17      | 1.85      |
| 2011                         | 124 | 5.55        | 0.55      | 6.15      | 5.24                | 0.53      | 5.91      | 3.82                             | 0.55      | 6.13      |
| 2010                         | 121 | 13.53       | 0.18      | 1.93      | 13.17               | 0.18      | 1.93      | 13.35                            | 0.15      | 1.69      |
| 2009                         | 122 | 18.24       | 0.60      | 6.65      | 19.96               | 0.55      | 6.12      | 24.21                            | 0.53      | 5.85      |
| 2008                         | 130 | -23.77      | 0.76      | 8.70      | -21.35              | 0.73      | 8.36      | -22.86                           | 0.72      | 8.26      |
| 2007                         | 121 | 8.94        | 0.20      | 2.18      | 8.85                | 0.19      | 2.06      | 7.33                             | 0.18      | 1.98      |
| 2006                         | 64  | 13.79       | 0.20      | 1.62      | 14.26               | 0.21      | 1.67      | 14.77                            | 0.23      | 1.80      |
| 2005                         | 69  | 8.72        | 0.22      | 1.87      | 8.75                | 0.22      | 1.81      | 8.05                             | 0.18      | 1.48      |
| 2004                         | 78  | 12.23       | 0.18      | 1.56      | 12.33               | 0.19      | 1.66      | 12.43                            | 0.20      | 1.75      |
| 2003                         | 71  | 23.96       | 0.37      | 3.14      | 24.59               | 0.38      | 3.19      | 25.66                            | 0.39      | 3.28      |
| 2002                         | 69  | -10.51      | 0.39      | 3.25      | -9.59               | 0.36      | 2.98      | -10.00                           | 0.36      | 2.97      |
| 2001                         | 81  | -4.94       | 0.32      | 2.88      | -4.87               | 0.28      | 2.54      | -4.64                            | 0.27      | 2.47      |
| 2000                         | 72  | 1.02        | 0.67      | 5.66      | 1.88                | 0.85      | 7.21      | 1.47                             | 0.77      | 6.57      |
| 1999                         | 85  | 16.89       | 0.74      | 6.81      | 18.54               | 0.75      | 6.94      | 19.12                            | 0.76      | 7.03      |
| 1998                         | 91  | 14.94       | 0.34      | 3.28      | 15.57               | 0.37      | 3.55      | 14.84                            | 0.39      | 3.77      |
| <b>Arithmetic Avg. Ret.:</b> |     | 7.11        | 0.09      | 10.80     | 7.55                | 0.09      | 10.66     | 7.51                             | 0.09      | 11.38     |
| <b>Compound Avg. Ret.:</b>   |     | 6.51        | 0.10      | n/a       | 6.98                | 0.10      | n/a       | 6.86                             | 0.10      | n/a       |
| <b>Avg. Volatility:</b>      |     | 11.60       | n/a       | n/a       | 11.47               | n/a       | n/a       | 12.13                            | n/a       | n/a       |

Tables 9A and 9B. Standardized physical-asset-only net returns by year for U.S. public sector pension funds (top) and corporate sector pension fund (bottom) by size cohort. For comparison, the averages of all six cohorts' average net returns are 7.76 percent (arithmetic) and 7.09 percent (compound).

Tables 9A. Standardized physical-asset-only net returns by year for U.S. public sector pension funds by size (in percent)

| Year                     | Less than \$2 billion AUM |            |            |            | \$2 billion to \$10 billion AUM |            |            |            | More than \$10 billion AUM |            |            |            |
|--------------------------|---------------------------|------------|------------|------------|---------------------------------|------------|------------|------------|----------------------------|------------|------------|------------|
|                          | Avg.                      | Std. Err.  | Std. Dev.  | #          | Avg.                            | Std. Err.  | Std. Dev.  | #          | Avg.                       | Std. Err.  | Std. Dev.  | #          |
| 2018                     | -6.48                     | 0.42       | 0.95       | 5          | -6.15                           | 0.39       | 1.45       | 14         | -6.10                      | 0.20       | 1.25       | 38         |
| 2017                     | 15.83                     | 0.48       | 0.96       | 4          | 15.99                           | 0.71       | 2.85       | 16         | 15.58                      | 0.31       | 1.96       | 40         |
| 2016                     | 8.68                      | 0.23       | 0.52       | 5          | 8.66                            | 0.23       | 0.93       | 17         | 9.00                       | 0.22       | 1.33       | 38         |
| 2015                     | -0.67                     | 0.46       | 1.03       | 5          | -1.16                           | 0.34       | 1.35       | 16         | -0.23                      | 0.17       | 1.06       | 41         |
| 2014                     | 6.23                      | 0.66       | 1.75       | 7          | 6.58                            | 0.86       | 3.21       | 14         | 6.80                       | 0.23       | 1.46       | 41         |
| 2013                     | 18.29                     | 1.14       | 3.41       | 9          | 14.90                           | 1.22       | 4.87       | 16         | 15.97                      | 0.43       | 2.66       | 39         |
| 2012                     | 13.58                     | 0.43       | 1.37       | 10         | 12.90                           | 0.33       | 1.26       | 15         | 13.53                      | 0.20       | 1.34       | 43         |
| 2011                     | -1.42                     | 0.44       | 1.33       | 9          | -0.72                           | 0.34       | 1.54       | 20         | -0.54                      | 0.29       | 1.81       | 39         |
| 2010                     | 12.73                     | 0.80       | 3.09       | 15         | 13.46                           | 0.28       | 1.26       | 21         | 13.41                      | 0.26       | 1.59       | 37         |
| 2009                     | 26.60                     | 1.04       | 3.89       | 14         | 27.53                           | 0.63       | 3.24       | 26         | 26.88                      | 0.67       | 3.86       | 33         |
| 2008                     | -26.36                    | 1.02       | 3.06       | 9          | -26.44                          | 0.56       | 3.08       | 30         | -26.36                     | 0.81       | 4.67       | 33         |
| 2007                     | 6.09                      | 0.42       | 1.59       | 14         | 6.63                            | 0.32       | 1.78       | 31         | 6.55                       | 0.22       | 1.30       | 35         |
| 2006                     | 14.22                     | 0.44       | 1.52       | 12         | 14.38                           | 0.34       | 1.74       | 26         | 16.06                      | 0.32       | 1.80       | 31         |
| 2005                     | 7.16                      | 0.37       | 1.42       | 15         | 7.93                            | 0.24       | 1.33       | 31         | 8.06                       | 0.33       | 1.70       | 26         |
| 2004                     | 11.94                     | 0.37       | 1.50       | 16         | 12.28                           | 0.23       | 1.34       | 33         | 12.54                      | 0.28       | 1.45       | 27         |
| 2003                     | 24.13                     | 0.53       | 2.18       | 17         | 25.38                           | 0.54       | 3.05       | 32         | 24.14                      | 0.54       | 2.68       | 25         |
| 2002                     | -7.22                     | 0.57       | 2.43       | 18         | -7.76                           | 0.46       | 2.66       | 33         | -8.71                      | 0.44       | 2.13       | 23         |
| 2001                     | -3.14                     | 0.58       | 2.67       | 21         | -3.55                           | 0.43       | 2.56       | 35         | -4.80                      | 0.30       | 1.56       | 27         |
| 2000                     | 0.73                      | 0.77       | 3.38       | 19         | 1.54                            | 0.75       | 4.48       | 36         | 0.07                       | 0.49       | 2.43       | 25         |
| 1999                     | 15.65                     | 0.86       | 4.24       | 24         | 16.62                           | 0.86       | 4.88       | 32         | 17.56                      | 1.02       | 5.31       | 27         |
| 1998                     | 14.34                     | 0.92       | 4.21       | 21         | 14.40                           | 0.66       | 3.42       | 27         | 16.03                      | 0.71       | 3.24       | 21         |
| <b>Arith. Avg. Ret.:</b> | 7.19                      | 0.15       | 11.83      | <i>n/a</i> | 7.30                            | 0.12       | 11.93      | <i>n/a</i> | 7.40                       | 0.10       | 12.08      | <i>n/a</i> |
| <b>Comp. Avg. Ret.:</b>  | 6.48                      | 0.15       | <i>n/a</i> | <i>n/a</i> | 6.58                            | 0.12       | <i>n/a</i> | <i>n/a</i> | 6.66                       | 0.10       | <i>n/a</i> | <i>n/a</i> |
| <b>Avg. Volatility:</b>  | 12.08                     | <i>n/a</i> | <i>n/a</i> | <i>n/a</i> | 12.24                           | <i>n/a</i> | <i>n/a</i> | <i>n/a</i> | 12.33                      | <i>n/a</i> | <i>n/a</i> | <i>n/a</i> |

Tables 9B. Standardized physical-asset-only net returns by year for U.S. corporate sector pension funds by size (in percent)

| Year                     | Less than \$2 billion AUM |            |            |            | \$2 billion to \$10 billion AUM |            |            |            | More than \$10 billion AUM |            |            |            |
|--------------------------|---------------------------|------------|------------|------------|---------------------------------|------------|------------|------------|----------------------------|------------|------------|------------|
|                          | Avg.                      | Std. Err.  | Std. Dev.  | #          | Avg.                            | Std. Err.  | Std. Dev.  | #          | Avg.                       | Std. Err.  | Std. Dev.  | #          |
| 2018                     | -4.66                     | 0.81       | 3.46       | 18         | -6.73                           | 0.18       | 1.21       | 44         | -6.41                      | 0.29       | 1.72       | 36         |
| 2017                     | 13.91                     | 0.76       | 3.74       | 24         | 15.69                           | 0.42       | 2.61       | 38         | 14.63                      | 0.50       | 2.98       | 35         |
| 2016                     | 7.50                      | 0.51       | 2.54       | 25         | 8.71                            | 0.29       | 1.84       | 39         | 8.68                       | 0.22       | 1.31       | 36         |
| 2015                     | -2.08                     | 0.31       | 1.42       | 21         | -1.92                           | 0.20       | 1.31       | 44         | -1.33                      | 0.17       | 1.03       | 36         |
| 2014                     | 10.43                     | 1.46       | 5.45       | 14         | 9.84                            | 0.44       | 3.07       | 48         | 9.53                       | 0.46       | 2.70       | 35         |
| 2013                     | 11.68                     | 1.53       | 7.97       | 27         | 11.98                           | 0.88       | 6.33       | 52         | 11.28                      | 1.00       | 5.74       | 33         |
| 2012                     | 13.33                     | 0.36       | 2.09       | 34         | 13.32                           | 0.21       | 1.62       | 58         | 13.21                      | 0.37       | 1.96       | 28         |
| 2011                     | 4.18                      | 1.01       | 6.46       | 41         | 3.77                            | 0.83       | 6.38       | 59         | 3.33                       | 0.97       | 4.74       | 24         |
| 2010                     | 13.42                     | 0.28       | 1.85       | 44         | 13.34                           | 0.23       | 1.72       | 55         | 13.20                      | 0.26       | 1.22       | 22         |
| 2009                     | 24.24                     | 0.88       | 6.38       | 52         | 24.39                           | 0.79       | 5.77       | 53         | 23.58                      | 1.01       | 4.16       | 17         |
| 2008                     | -22.81                    | 1.11       | 8.56       | 59         | -24.68                          | 0.93       | 6.84       | 54         | -17.28                     | 2.13       | 8.79       | 17         |
| 2007                     | 6.95                      | 0.35       | 2.22       | 40         | 7.40                            | 0.24       | 1.93       | 63         | 7.90                       | 0.32       | 1.34       | 18         |
| 2006                     | 14.03                     | 0.36       | 1.53       | 18         | 14.73                           | 0.30       | 1.75       | 35         | 16.12                      | 0.48       | 1.60       | 11         |
| 2005                     | 7.16                      | 0.28       | 1.18       | 18         | 8.21                            | 0.24       | 1.47       | 38         | 8.83                       | 0.35       | 1.25       | 13         |
| 2004                     | 11.98                     | 0.29       | 1.34       | 22         | 12.50                           | 0.28       | 1.85       | 44         | 13.01                      | 0.52       | 1.82       | 12         |
| 2003                     | 24.37                     | 0.49       | 2.57       | 27         | 26.63                           | 0.67       | 3.83       | 33         | 25.93                      | 0.45       | 1.49       | 11         |
| 2002                     | -9.72                     | 0.71       | 3.78       | 28         | -10.24                          | 0.43       | 2.33       | 30         | -10.06                     | 0.59       | 1.97       | 11         |
| 2001                     | -4.16                     | 0.38       | 2.16       | 33         | -4.87                           | 0.45       | 2.66       | 35         | -5.23                      | 0.69       | 2.50       | 13         |
| 2000                     | 1.96                      | 1.10       | 6.15       | 31         | 0.90                            | 1.44       | 7.64       | 28         | 1.52                       | 1.30       | 4.67       | 13         |
| 1999                     | 16.96                     | 0.98       | 6.47       | 44         | 21.17                           | 1.36       | 7.34       | 29         | 22.11                      | 1.57       | 5.44       | 12         |
| 1998                     | 14.55                     | 0.60       | 4.14       | 48         | 15.60                           | 0.55       | 3.18       | 27         | 13.72                      | 1.00       | 3.17       | 10         |
| <b>Arith. Avg. Ret.:</b> | 7.29                      | 0.17       | 10.99      | <i>n/a</i> | 7.61                            | 0.14       | 11.94      | <i>n/a</i> | 7.92                       | 0.19       | 10.91      | <i>n/a</i> |
| <b>Comp. Avg. Ret.:</b>  | 6.69                      | 0.18       | <i>n/a</i> | <i>n/a</i> | 6.89                            | 0.15       | <i>n/a</i> | <i>n/a</i> | 7.34                       | 0.20       | <i>n/a</i> | <i>n/a</i> |
| <b>Avg. Volatility:</b>  | 11.87                     | <i>n/a</i> | <i>n/a</i> | <i>n/a</i> | 12.62                           | <i>n/a</i> | <i>n/a</i> | <i>n/a</i> | 11.46                      | <i>n/a</i> | <i>n/a</i> | <i>n/a</i> |



## Appendix B: Real estate performance by implementation style

The data appearing in Table 10 'Real estate net returns by implementation style, U.S. DB pension funds' originally appeared in a separate publication, 'Real estate performance by implementation style' published in December 2018 by CEM Benchmarking. In this version we have added 2017 and 2018 data to the original 1998-2016 data, and the data for unlisted real estate for the entire period has been updated to reflect improvements to the estimates of reporting lag for each implementation style. For questions regarding the methodology we invite the reader to read the original publication at: <https://www.cembenchmarking.com/insights.html>

**Table 10. Real estate fund-weighted annual average net returns for U.S. public and corporate sector defined benefit plans in the CEM Benchmarking database 1998-2018 by style. For a description of styles see Reference 3. Net return data for unlisted real estate have been standardized to remove reporting lag on a fund-by-fund basis. For a detailed description of the methodology see Reference 2.**

| Year                         | Unlisted real estate styles |                        |                             |                                       |                              | Listed equity REITs (primarily core) |
|------------------------------|-----------------------------|------------------------|-----------------------------|---------------------------------------|------------------------------|--------------------------------------|
|                              | Internal (core)             | External direct (core) | External LP (opportunistic) | External fund-of-fund (opportunistic) | Total (core & opportunistic) |                                      |
| 2018                         | -2.34                       | 0.13                   | -1.08                       | 0.05                                  | 0.68                         | -4.20                                |
| 2017                         | 7.62                        | 6.07                   | 5.92                        | 6.44                                  | 3.89                         | 7.96                                 |
| 2016                         | 10.98                       | 11.18                  | 10.59                       | 6.21                                  | 14.68                        | 4.88                                 |
| 2015                         | 2.46                        | 0.43                   | 1.07                        | -0.18                                 | -3.12                        | 1.74                                 |
| 2014                         | 29.61                       | 26.47                  | 26.81                       | 23.34                                 | 29.00                        | 20.19                                |
| 2013                         | 0.13                        | -1.01                  | -1.19                       | -2.25                                 | -1.49                        | 3.99                                 |
| 2012                         | 18.76                       | 15.69                  | 15.62                       | 9.78                                  | 14.86                        | 20.55                                |
| 2011                         | -4.72                       | -3.04                  | -3.99                       | -4.50                                 | -1.44                        | 2.05                                 |
| 2010                         | 8.98                        | 5.59                   | 10.84                       | 8.00                                  | -2.46                        | 23.51                                |
| 2009                         | 32.35                       | 30.95                  | 31.78                       | 35.56                                 | 27.88                        | 29.89                                |
| 2008                         | -25.19                      | -27.93                 | -35.46                      | -32.41                                | -25.99                       | -38.20                               |
| 2007                         | -8.61                       | -12.40                 | -6.87                       | -10.71                                | -10.00                       | -10.75                               |
| 2006                         | 34.74                       | 28.33                  | 33.63                       | 22.84                                 | 27.47                        | 34.75                                |
| 2005                         | 12.12                       | 8.83                   | 20.28                       | 3.16                                  | 12.44                        | 14.16                                |
| 2004                         | 16.63                       | 16.14                  | 13.66                       | 14.02                                 | 12.17                        | 32.43                                |
| 2003                         | 33.82                       | 25.93                  | 26.83                       | 30.03                                 | 29.16                        | 33.09                                |
| 2002                         | -2.26                       | -0.26                  | -12.06                      | -2.85                                 | -1.42                        | 5.17                                 |
| 2001                         | 6.37                        | 2.95                   | 3.85                        | -0.21                                 | -0.59                        | 10.94                                |
| 2000                         | 32.77                       | 31.85                  | 34.48                       | 30.54                                 | 33.87                        | 26.58                                |
| 1999                         | 9.02                        | 10.03                  | 17.19                       | 10.08                                 | 12.25                        | 1.23                                 |
| 1998                         | -19.98                      | -12.45                 | -15.82                      | -15.06                                | -14.03                       | -6.39                                |
| Net arit <sup>1</sup> . avg. | 9.20                        | 7.78                   | 8.38                        | 6.28                                  | 7.51                         | 10.17                                |
| Net geo <sup>2</sup> . avg.  | 7.88                        | 6.66                   | 6.84                        | 5.03                                  | 6.36                         | 8.64                                 |
| Stdev <sup>3</sup> .         | 16.72                       | 15.22                  | 17.50                       | 15.90                                 | 15.56                        | 17.26                                |
| Volatility <sup>4</sup>      | 19.08                       | 17.78                  | 19.61                       | 18.38                                 | 18.03                        | 19.17                                |
| Sharpe ratio <sup>5</sup>    | 0.37                        | 0.31                   | 0.32                        | 0.22                                  | 0.30                         | 0.41                                 |

1. Net arithmetic average return is the simple average of fund-weighted annual averages appearing in the table. The returns are net of all direct investment management expenses.

2. Net geometric average return is the compound average of fund-weighted averages appearing in the table. The returns are net of all direct investment management expenses.

3. Standard deviation is the population standard deviation of fund-weighted averages appearing in the table.

4. Volatility is the standard deviation that an individual fund can expect to experience. It is larger than the standard deviation because it includes the effects of idiosyncratic risk (i.e., in-year fund-to-fund dispersion of annual returns due to differences in investments).

5. Sharpe ratio is the excess return over the risk-free rate (taken here to be 3-month U.S. treasury bills) divided by the volatility.

**Table 11. Fund-weighted average allocations to real estate for U.S. public and corporate sector defined benefit plans in the CEM Benchmarking database 1998-2018 by style. For a description of styles see Reference 3. Allocations are shown as a percent of total fund net asset value (NAV).**

| Year                         | Unlisted real estate styles |                        |                             |                                       |                              | Listed equity REITs (primarily core) |
|------------------------------|-----------------------------|------------------------|-----------------------------|---------------------------------------|------------------------------|--------------------------------------|
|                              | Internal (core)             | External direct (core) | External LP (opportunistic) | External fund-of-fund (opportunistic) | Total (core & opportunistic) |                                      |
| 2018                         | 0.16                        | 3.17                   | 1.75                        | 0.11                                  | 5.19                         | 0.78                                 |
| 2017                         | 0.15                        | 2.90                   | 1.78                        | 0.12                                  | 4.95                         | 0.74                                 |
| 2016                         | 0.12                        | 2.71                   | 2.30                        | 0.16                                  | 5.29                         | 0.60                                 |
| 2015                         | 0.09                        | 2.58                   | 2.10                        | 0.14                                  | 4.91                         | 0.73                                 |
| 2014                         | 0.07                        | 2.37                   | 1.85                        | 0.18                                  | 4.46                         | 0.62                                 |
| 2013                         | 0.09                        | 2.29                   | 1.67                        | 0.16                                  | 4.20                         | 0.56                                 |
| 2012                         | 0.11                        | 2.29                   | 1.52                        | 0.14                                  | 4.06                         | 0.55                                 |
| 2011                         | 0.10                        | 2.18                   | 1.24                        | 0.20                                  | 3.72                         | 0.62                                 |
| 2010                         | 0.09                        | 2.12                   | 1.00                        | 0.15                                  | 3.36                         | 0.50                                 |
| 2009                         | 0.13                        | 2.49                   | 0.99                        | 0.28                                  | 3.89                         | 0.48                                 |
| 2008                         | 0.14                        | 3.04                   | 0.81                        | 0.29                                  | 4.29                         | 0.66                                 |
| 2007                         | 0.11                        | 2.94                   | 0.52                        | 0.24                                  | 3.82                         | 0.73                                 |
| 2006                         | 0.16                        | 2.88                   | 0.39                        | 0.11                                  | 3.54                         | 0.86                                 |
| 2005                         | 0.15                        | 2.51                   | 0.28                        | 0.09                                  | 3.03                         | 0.88                                 |
| 2004                         | 0.12                        | 2.28                   | 0.24                        | 0.08                                  | 2.73                         | 0.84                                 |
| 2003                         | 0.20                        | 2.40                   | 0.16                        | 0.10                                  | 2.87                         | 0.75                                 |
| 2002                         | 0.27                        | 2.78                   | 0.15                        | 0.12                                  | 3.32                         | 0.55                                 |
| 2001                         | 0.19                        | 2.61                   | 0.09                        | 0.09                                  | 2.98                         | 0.53                                 |
| 2000                         | 0.19                        | 2.56                   | 0.03                        | 0.08                                  | 2.87                         | 0.52                                 |
| 1999                         | 0.16                        | 2.24                   | 0.08                        | 0.07                                  | 2.55                         | 0.46                                 |
| 1998                         | 0.23                        | 2.57                   | 0.05                        | 0.05                                  | 2.90                         | 0.36                                 |
| Average                      | 0.14                        | 2.52                   | 0.81                        | 0.14                                  | 3.62                         | 0.62                                 |
| Change per year <sup>1</sup> | -0.01                       | 0.01                   | 0.12                        | 0.01                                  | 0.13                         | 0.01                                 |
| Trend <sup>2</sup>           | -0.01                       | -0.01                  | 0.13                        | 0.01                                  | 0.12                         | 0.00                                 |

1. Change per year is the absolute change in average allocation from 1998 to 2017 divided by the number of years. It represents the average change occurring in each year.

2. Trend is the change per year inferred from regression analysis. It differs from the trend because it adjusts for noise caused by un-even sampling of funds over the sample period.

Table 12. Correlations between annual average real estate net returns by implementation style (1998-2017). Unlisted asset class returns (i.e., internal, external direct, external LP, and fund of fund) have been standardized to remove lag in net returns [see Ref. 2 for details]. Also shown are correlations between real estate net returns by implementation style and the most common building blocks of U.S. DB pension fund portfolios, large cap. U.S. stocks and broad U.S. fixed income.

|                              | Internal (core) | External direct (core) | External LP (opportunistic) | Fund of fund (opportunistic) | Listed equity REITs | Large cap. U.S. stocks | Broad U.S. fixed income |
|------------------------------|-----------------|------------------------|-----------------------------|------------------------------|---------------------|------------------------|-------------------------|
| Internal (core)              | n/a             | 0.98                   | 0.97                        | 0.97                         | 0.90                | 0.45                   | 0.35                    |
| External direct (core)       | 0.98            | n/a                    | 0.97                        | 0.98                         | 0.91                | 0.48                   | 0.38                    |
| External LP (opportunistic)  | 0.97            | 0.97                   | n/a                         | 0.95                         | 0.88                | 0.54                   | 0.31                    |
| Fund of fund (opportunistic) | 0.97            | 0.98                   | 0.95                        | n/a                          | 0.90                | 0.53                   | 0.40                    |
| Listed equity REITs          | 0.90            | 0.91                   | 0.88                        | 0.90                         | n/a                 | 0.54                   | 0.47                    |
| Average                      | 0.96            | 0.96                   | 0.94                        | 0.95                         | 0.90                | 0.51                   | 0.38                    |