The impact of equities in pension investing: It's not just return

Vanguard research | October 2012

Executive summary. Many factors, including volatile global financial markets and a more stringent U.S. regulatory and accounting environment, are encouraging pension plan sponsors to use investment strategies that manage funding-status volatility. The objective of these liability-driven strategies is to hedge or immunize much of the risk inherent in pension funding levels. The primary vehicle for interest rate hedging in pension plans is bonds. However, most pension plans maintain some allocation to equities because of stocks' higher expected returns. It's important, then, for plan sponsors to consider not only the relationship between bonds and interest rates but also that between equities and interest rates.

Over shorter time horizons, the equity to interest rate relationship varies and is not easily quantified. But over long periods, the statistical link between interest rates and stocks can be empirically examined to project the future potential impact on a portfolio's assets. For time horizons greater than five years, valuing what we refer to as *equity duration*,[1] based

Author
Kimberly A. Stockton

1 The term *equity duration* has been variously defined, but is generally described as a measure of the sensitivity of stock prices to interest rates.

on long-term averages, may provide a better estimate of actual experience. This estimate captures the relationship between equities and interest rates, which although volatile in the short run, persists over longer periods.

This paper discusses the equity to interest rate relationship in terms of issues with estimating equity duration, approaches to measuring duration, and incorporating duration into a pension plan investment strategy.

Most pension plans implementing a liability-driven investment (LDI) strategy consider portfolio duration based only on fixed income duration. However, the vast majority of pension plans maintain a large allocation to equities because of stocks' higher return expectations. As a result, it's important to consider the impact of the relationship between stocks and interest rates on portfolio duration in an LDI portfolio. This paper reviews issues with estimating duration, approaches to measuring duration, and how to incorporate duration into a pension plan investment strategy.

The equity/interest rate link

Intuitively, the relationship between equity and interest rates is straightforward, because interest rates determine borrowing costs. Considered from a corporate finance perspective, rates affect the cost of capital. The three primary equity valuation models—dividend discount, free cash flow, and residual income—include interest rates as the opportunity cost of capital. Other impact from rates is more indirect, such as their effect on operating or financial leverage, which ultimately affects the share price. The impact of rates on a company's value, as well as on the durations of portfolios with equity allocations, can be significant.

Despite the obvious link between interest rates and equities, the relationship is volatile and indirect. To illustrate, this paper's analysis regressed the change in 10-year U.S. Treasury yields against equity returns represented by the Standard & Poor's 500 Index over a 50-year period, 1962–2011; our results were statistically significant. As shown in **Figure 1**, the R-squared was quite low, because interest rates alone do not consistently explain the level of equity returns. Yet the intercept and slope (beta)[2] were statistically significant, underscoring that *some* relationship, albeit a weak one, exists over long periods.[3]

Figure 1. Regressing the change in 10-year U.S. Treasury yields versus equity returns: 1962–2011

Regression statistics	
R-squared	3.02%
Observations	600

	Coefficients	Standard error	*T*-statistic
Intercept	0.01	0.00	4.70
Treasury change	–2.58	0.60	–4.32

Notes: "Observations" refers to the number of observations in the analysis. A total of 600 months of the change in 10-year U.S. Treasury yields were regressed on 600 months of equity returns (as represented by Standard & Poor's 500 Index). "Intercept" in a simple linear regression model is the value of the dependent variable when the independent variable is equal to zero. "*T*-statistic" refers to the ratio of the estimated parameter to its estimated standard error; this used to determine how probable it is that the true value of the parameter is zero.

Source: Vanguard calculations.

2 *Beta* refers to a measure of the volatility of a security or portfolio relative to a benchmark.

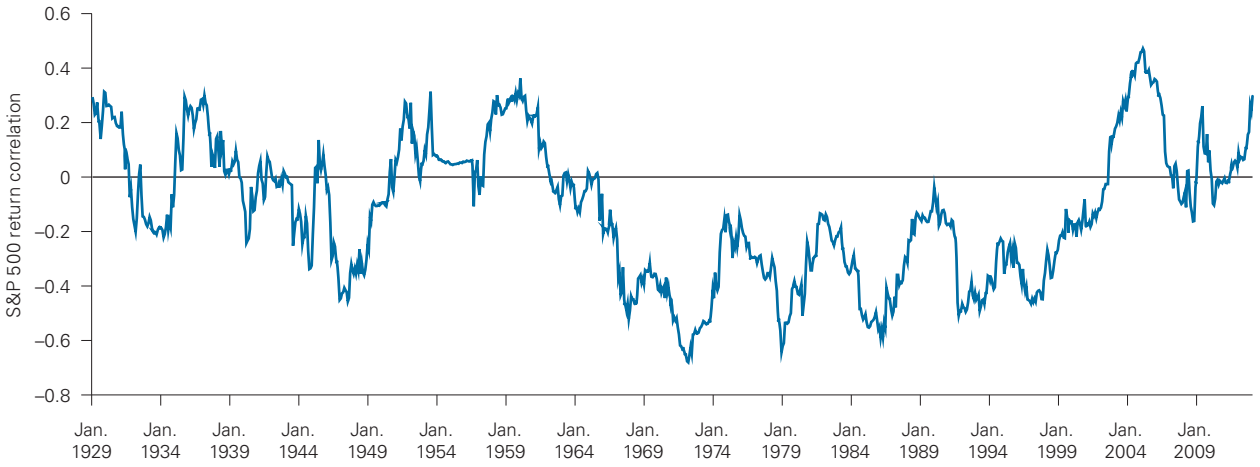
3 Regressing rate changes on equity returns using the same indexes over different periods—1926–2011 and 1982–2011—produced similar results: low R-squared and statistically significant intercepts and coefficients.

We next reviewed historical correlations over the 86 years from 1926 through 2011 between rates and equities. **Figure 2**, on page 4, shows 3-year rolling correlations between the S&P 500 Index and the monthly change in 10-year Treasury yields from 1926 through 2011. Even with rolling correlations, the volatility of the relationship was evident, with correlations ranging from nearly 0.50 to –0.70 over the period. Yet, the figure also shows that the relationship was negative 66% of the time over this period. These relationship patterns can be used to make general assumptions about forward-looking estimates of equity duration and its long-term impact on an LDI portfolio.

Equities not a hedge for pension liabilities

To say that that there is a relationship between interest rates and equities is not to say that equities are in any way a hedge for pension liabilities. Long-duration fixed income is the traditional asset hedge for pension liabilities. The character of liabilities and long fixed income are similar: Both comprise a relatively predictable, long-duration stream of periodic future payments; and their value is primarily explained by interest rates. Because of this, long fixed income assets tend to move in tandem with liabilities and, therefore, can provide an effective portfolio hedge for rate declines. In contrast, equities are not a good liability hedge. Dividend payment streams for equities are very uncertain, and interest rates are not a primary driver of equity returns.

Figure 2. S&P 500 Index return correlations with monthly change in 10-year U.S. Treasury yields: Rolling three-year periods, 1926–2011



Source: Vanguard.

Equity-duration models

Although the concept of duration does not translate easily to equities, several models have been developed that attempt to capture the equity to interest rate relationship. These approaches are of two major types: dividend discount models (DDM) and empirical models.

Dividend discount model

Early methods for measuring equity duration employed Gordon's constant-growth dividend discount model (DDM).[4] The constant-growth model can be revised to accommodate equity duration.[5] Such a framework has often assumed that changes in the discount rate come from changes in the Treasury yield curve and that the equity risk premium is constant. This approach is appealing because of its simplicity. However, it has produced overly large estimate values, and the appropriateness of the model's assumptions has been questioned. Some criticism stems from the model's assumption of constant dividend growth, which implies that dividend growth is unrelated to changes in the discount rate.

4 Myron J. Gordon published the DDM model in 1959, based on theory proposed decades earlier by John Burr Williams.

5 DDM equity duration is equivalent to the average age of an annuity, $1/(k–g)$, with k equal to the discount rate and g equal to the constant growth rate in dividends.

S&P modified (flow-through) DDM

Standard & Poor's applies a flow-through model[6] to estimate equity duration. Flow-through models modify the traditional DDM to address some of the issues just mentioned. For example, the correlation between discount rates and dividend growth rates is a formula variable, which captures the sensitivity of dividend growth rates to interest rates.[7] In addition, the discount rate is the yield on corporate bonds, addressing the flawed assumption of a constant equity risk premium. There are several intuitively appealing properties of this approach, including:

- Higher dividend growth results in higher duration.
- Given a steady dividend growth rate, a higher equity discount rate implies a lower duration.
- Low sensitivity of growth opportunities to the discount rate increases the duration.

Standard & Poor's historical duration estimates of its S&P 500 Index can be interpreted in years, similar to a modified Macaulay bond-duration measure.[8] Estimates using this approach are generally high relative to the empirical approaches discussed later in this paper (for example, in 2008, equity-duration estimates were near 43 years). (Note: All duration amounts in the remainder of this paper are thus measured in years.)

Empirical approach (Leibowitz)

Leibowitz (1986) proposed a method of measuring equity duration empirically. Such an approach is intuitive to many because it relies on conventional asset allocation metrics and procedures. The Leibowitz formula includes the correlation between stocks and bonds, the variance of each, and a bond market duration measure.[9] Higher stock to bond correlations and higher bond durations result in higher equity duration.

Estimates of duration using the Leibowitz method are considerably lower than those using a DDM approach. They have large variance, but are positive on average.

DDM versus empirical method

Although the DDM and empirical approaches just discussed are imperfect and produce extremely different equity-duration values, each approach provides useful insights into the equity to interest rate relationship. For example, in 2008 the Leibowitz method estimated equity-duration value at 5.8, versus 42.6 for the S&P method. Yet the direction of change over time, although varying somewhat annually, has generally been the same, as shown in **Figure 3**, on page 6 (see also the notes to Figure 3, for calculations used for each method). The figure shows three-year rolling estimates for equity duration using both the Leibowitz and S&P methods, from 1990 through 2010. This again illustrates the relationship between equities and interest rates, regardless of how one attempts to measure it.

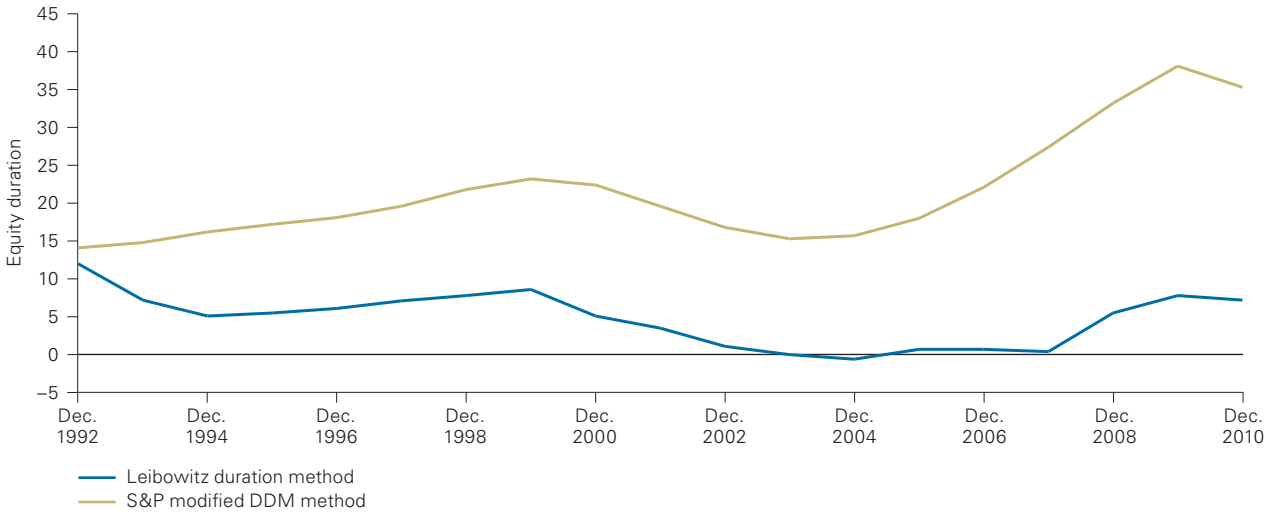
6 Flow-through models account for the ability of a company to pass on unexpected cost increases in the form of higher prices, referred to as inflation flow-through.

7 Equity duration = $-1/(k-g)\,(1-\delta g/\delta k)$, where k = Moody's Baa yield, g = quarterly growth of the S&P 500 Index, and $\delta g/\delta k$ = correlation of change in g to change in k. For a detailed discussion, see Blitzer and Dash (2004).

8 In 1938, Frederick Macaulay created the formula traditionally used to calculate a bond's basic duration—the Macaulay duration. It is a measure of the length of time that a bond is outstanding. Modified Macaulay duration is: Macaulay duration/$(1+y)$, where y = one-half the yield to maturity or required yield.

9 Equity duration = $(\sigma E/\sigma B) \times \rho(E, B) \times$ bond duration, where $\sigma E/\sigma B$ = standard deviation of equity/standard deviation of long corporate bond returns, and $\rho(E, B)$ = correlation of equity with long corporate bond returns.

Figure 3. Three-year rolling average estimates for equity duration: Leibowitz versus S&P methods: 1990–2010



Notes: Leibowitz method: Equity duration = ($\sigma E/\sigma B$) x $\rho(E, B)$ x bond duration, where $\sigma E/\sigma B$ = standard deviation of S&P 500 Index/ standard deviation of Barclays U.S. Long Credit Index; and $\rho(E, B)$ is correlation of S&P 500 with Barclays U.S. Long Credit Index. Rolling three-year average of annual estimate from monthly returns, volatility, and corporate bond duration. S&P method: Twelve-quarter moving average of annual estimate, calculated as follows. Equity duration = $-1/(k-g)$ $(1-\delta g/\delta k)$, where k = Moody's Baa yield, g = quarterly growth of the S&P 500, and $\delta g/\delta k$ = correlation of change in g to change in k. Data for 2010 calculated as of second-quarter 2010.

Sources: Vanguard calculations for Leibowitz method; Standard & Poor's calculations for S&P method.

Equity duration over the long-term

In practice, equity durations are typically assigned a value of zero. Over periods shorter than five years, the relationship between interest rates and equities is so volatile that an average value is not reliable enough. Thus, assigning a value of zero to equity duration, when making short-term liability hedge estimates, is a reasonable approach. However, if short-term volatility is not a big concern, the statistics and measures reviewed here provide evidence from which we can glean a long-term equity duration estimate. First, the results for each equity duration method we reviewed were primarily positive, and the direction of change was the same. Second, as we have also shown, there has been a primarily inverse relationship between interest rates and equities historically. And, finally, although the Leibowitz estimates varied substantially, the average estimate was a low positive number, which seems reasonable when compared with bond durations.

To test these intuitions, we simulated asset and liability tracking error[10] for a hypothetical pension plan five years going forward. We simulated tracking error based on two portfolios, both of which used the same starting duration and liability hedge ratios. One portfolio, however, was formed with the duration calculation based on an equity duration of 0, and the other with equity duration assigned a relatively low positive value, based on long-term averages. We then simulated returns and tracking error. **Figure 4a** shows results for portfolios based on an equity duration valued at 0, compared with those from an equity duration valued at 2.0. **Figure 4b** compares portfolios with equity duration valued at 0 with those formed with equity duration valued at 4.0. We assumed that the plan for either set of portfolios was 84% funded and had a liability duration of 12.6. Further details on the simulation's assumptions are shown in Appendix II.

10 Tracking error reflects the portfolio's volatility relative to its liability.

Figure 4. Simulated asset and liability tracking error for hypothetical pension plan five years going forward

a. Tracking error impact: Equity duration at 2.0 years versus 0

	Portfolio					Liability tracking error	
	U.S. equity	International equity	Total bond	Long credit bonds	Extended duration	Median	95th percentile
Hedge ratio, 80%; duration, 12.0 years							
Portfolio A_0	30%	10%	0%	20%	40%	8.1%	15.3%
Portfolio A_2	30	10	0	25	35	**7.8**	**14.4**
Hedge ratio, 71%; duration, 10.7 years							
Portfolio B_0	35%	15%	0%	11%	39%	9.5%	17.6%
Portfolio B_2	35	15	0	17	33	**9.2**	**16.7**

b. Tracking error impact: Equity duration at 4.0 years versus 0

	Portfolio					Liability tracking error	
	U.S. equity	International equity	Total bond	Long credit bonds	Extended duration	Median	95th percentile
Hedge ratio, 80%; duration, 12.0 years							
Portfolio A_0	30%	10%	0%	20%	40%	8.1%	15.3%
Portfolio A_4	30	10	0	30	30	**7.5**	**13.8**
Hedge ratio, 71%; duration, 10.8 years							
Portfolio B_0	35%	15%	0%	10%	40%	9.6%	17.8%
Portfolio B_4	35	15	0	22	28	**9.0**	**16.1**

Sources: Vanguard, from VCMM forecasts.

Notes: Portfolios A_0 and B_0 were formed with equity duration valued at 0 for the initial duration and hedge estimates. Portfolios A_2 and B_2 were formed with equity duration valued at 2.0 years. Portfolios A_4 and B_4 were formed with equity duration valued at 4.0 years. We calculated tracking error here as the standard deviation of the change in return less the change in plan liability. Results were based on five-year forecasts from the VCMM. Tracking-error distribution results are drawn from 10,000 VCMM simulations based on market data and other information available as of December 31, 2011. (See page 3 and Appendix I, for further description of the VCMM; see Appendix II, for this figure's assumptions.)

We conducted this exercise for several different liability cash flows and duration estimates. The results were consistent with those in Figure 4a and 4b. Median tracking error was lower for portfolios built with equity durations valued at 4.0 or 2.0 than for those formed with an equity duration of 0. Even the 95th percentile (downside) results were better (there was lower tracking error) for those portfolios. For example, in Figure 4b, median (expected) liability tracking error over the five-year period for portfolio A_4—formed with equity duration valued at 4.0—was about 7.5%,

lower than that for portfolio A_0, which was formed with an equity duration valued at 0. The 95th percentile results were even stronger for these portfolios, with expected tracking error for portfolio A_4 of 13.8, compared with 15.3 for portfolio A_0.

In accounting for equity duration here, we are essentially increasing the beginning portfolio duration valuation to capture the long-term relationship between rates and equities. Doing this necessitates a shorter-duration bond portfolio to hit the desired starting hedge ratio. What the results show then is that portfolios that do not account for the longer portfolio duration from equities may end up with higher than expected risk and liability tracking error. For instance, if a portfolio is matched to the liability with bonds, but still has an equity position, that portfolio's duration may be too long, if no duration has been assigned to equities. Given a good chance of rates rising from their current level (as of mid-August 2012), this "overduration" could cause this portfolio to underperform the liability.[11]

Conclusion

Because of the short-term measurement difficulties with equity duration, a reasonable approach for pension plans implementing shorter-term, risk-control strategies such as LDI is to value equity duration at zero. Near-term and precise estimates are problematic because of the volatility and instability in equity and interest rate correlations. At the same time, most pension plans maintain a large allocation to equity because of stocks' higher return expectations. The equity allocation, moreover, affects liability tracking error. Our results show that portfolios formed using long-term average equity duration estimates for initial liability hedge estimations produced lower expected tracking error over a five-year period than those formed with equity duration assigned a value of zero. It follows that for long time horizons, using a longer-term estimate of equity duration is likely to produce a better estimate of actual portfolio experience. Given today's low interest rates, equity sensitivity to rising rates should be a recognized risk.

11 We conducted this exercise for several different portfolios, including a more liability-sensitive portfolio with 80% bonds/20% equity and a 98% hedge ratio. The results held; that is, the portfolios formed with equity duration assigned a value greater than zero had lower expected tracking error over the planning horizon. Of course, the smaller the equity allocation, the smaller the reduction in tracking error.

References

Blitzer, David M., and Srikant Dash, 2004. *Using Equity Duration in Pension Fund Asset Allocation. Introducing a New Data Series: The 30-Year History of Duration for the S&P 500*. New York: Standard & Poor's, January.

Blitzer, David M., Srikant Dash, and Philip Murphy, 2009. *Equity Duration—Updated Duration of the S&P 500*. New York: Standard & Poor's, July.

Blitzer, David M., Srikant Dash, and Aye M. Soe, 2010. *Equity Duration—Updated Duration of the S&P 500*. New York: Standard & Poor's, September.

Craft, Timothy M., 2006. Home Bias Makes Sense for U.S. Pension Plans. *Journal of Portfolio Management* 32(3, Spring): 26–32.

Gordon, Myron J., 1959. Dividends, Earnings, and Stock Prices. *Review of Economics and Statistics* (MIT Press) 41(2): 99–105.

Johnson, L.D., 1989. Equity Duration: Another Look. *Financial Analysts Journal* 45(2): 73–75.

Leibowitz, Martin L., 1986. Total Portfolio Duration: A New Perspective on Asset Allocation. *Financial Analysts Journal* 42(5):18–29.

Leibowitz, Martin L., Eric H. Sorensen, Robert D. Arnott, and H. Nicholas Hanson, 1989. A Total Differential Approach to Equity Duration. *Financial Analysts Journal* 45(5): 30–37.

Lewin, Richard A., and Stephen E. Satchell, 2001. *The Derivation of a New Model of Equity Duration*. Judge Institute of Management Studies and Faculty of Economics and Politics. Cambridge, England: University of Cambridge, April 30.

Stockton, Kimberly A., Scott J. Donaldson, and Anatoly Shtekhman, 2008. *Liability-Driven Investing: A Tool for Managing Pension Plan Funding Volatility*. Valley Forge, Pa.: The Vanguard Group.

Appendix I. About the Vanguard Capital Markets Model

The Vanguard Capital Markets Model (VCMM) is a proprietary financial simulation tool developed and maintained by Vanguard's Investment Strategy Group and the Investment Counseling & Research group. The VCMM uses a statistical analysis of historical data for interest rates, inflation, and other risk factors for global equities, fixed income, and commodity markets to generate forward-looking distributions of expected long-term returns. The asset-return distributions shown in this paper are drawn from 10,000 VCMM simulations based on market data and other information available as of December 30, 2011.

The VCMM is grounded in the empirical view that the returns of various asset classes reflect the compensation investors receive for bearing different types of systematic risk (or beta). Using a long span of historical monthly data, the VCMM estimates a dynamic statistical relationship among global risk factors and asset returns. Based on these calculations, the model uses regression-based Monte Carlo simulation methods to project relationships in the future. By explicitly accounting for important initial market conditions when generating its return distributions, the VCMM framework departs fundamentally from more basic Monte Carlo simulation techniques found in certain financial software.

The primary value of the VCMM is in its application to analyzing potential client portfolios. VCMM asset-class forecasts—comprising distributions of expected returns, volatilities, and correlations—are key to the evaluation of potential downside risks, various risk-and-return trade-offs, and diversification benefits of various asset classes. Although central tendencies are generated in any return distribution, Vanguard stresses that focusing on the full range of potential outcomes for the assets considered, such as the data presented in this paper, is the most effective way to use VCMM output.

The projections or other information generated by the VCMM regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. VCMM results will vary with each use and over time. Future returns may behave differently from the historical patterns captured in the VCMM. More important, the VCMM may be underestimating extreme negative scenarios unobserved in the historical period on which the model estimation is based.

Appendix II. Assumptions for Figure 4a, b: VCMM-based forecasts

Time horizon: 5 years

Plan information:

- Plan status: closed.
- Initial assets: $4,169M.
- Liability: $4,938M.
- Liability duration: 12.6 years.
- Discount rate: 5.1.
- Asset liability ratio (funding): 84%.

Asset classes used in analysis:

- U.S. equity.
- International equity.
- Total bonds.
- Long credit bonds.
- Extended-duration bonds.

P.O. Box 2600
Valley Forge, PA 19482-2600

Connect with Vanguard® > vanguard.com

Vanguard research >
Vanguard Center for Retirement Research
Vanguard Investment Counseling & Research
Vanguard Investment Strategy Group

E-mail > research@vanguard.com

For more information about Vanguard funds, visit vanguard.com or call 800-662-2739 to obtain a prospectus. Investment objectives, risks, charges, expenses, and other important information about a fund are contained in the prospectus; read and consider it carefully before investing.

CFA® is a trademark owned by CFA Institute.

ICRNJR 102012