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Using Equity Duration In Pension Fund Asset Allocation

Introducing a new data series: The 30-year history of duration for the S&P 500

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- The divergent fortunes of equities and bonds over the last few years, combined with the long-term trend of ageing work forces and increasing benefit costs, have led to serious rethinking of pension plan issues. Among the ideas being floated has been the radical suggestion that pension plans should shift completely away from equities toward bonds.
- We disagree with this suggestion. We believe that a diversified portfolio of equities and bonds can be immunized and lowers the risk of deficits.
- We describe a simple model of asset allocation for pension plans that incorporates the concept of equity duration.
- Akin to the well-known concept of bond duration, equity duration measures the sensitivity of equities to interest rates. Although research on this subject is more recent and the concept is rarely used in asset allocation, we believe equity duration is of significant importance in immunization, risk management, and asset allocation.
- We develop a simple model of equity duration that uses the dividend discount model and incorporates the sensitivity of growth to rates. Based on our empirical model, duration (or interest-rate sensitivity) is higher for high-growth stocks, stocks whose dividend growth is not sensitive to interest rates, and in low–discount rate environments.
- We estimate the current duration of the S&P 500 index to be 15 years. The metric reached its 15-year highs near the peak of the recent bull market and has subsequently declined moderately.
- We also give a 30-year history of duration for the S&P 500. Duration has shown a declining trend over the last 20 years, suggesting that the equity market has become less sensitive to interest rates.
- Standard & Poor's will henceforth publish, on an annual basis, a current report and a 30-year history of duration for the S&P 500. We will also publish duration for other Standard & Poor's indices. We acknowledge that equity duration estimation is an evolving science. We also believe that a regularly available and updated source of equity duration data will make this important metric more accessible for further research and practitioner use.

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Running Away From Equities Is Not an Answer to the Pension Crisis

The divergent fortunes of equities and bonds over the last few years, combined with the long-term trend of ageing work forces and increasing employee benefit costs, has led to serious rethinking of pension plan issues. Increasing scrutiny of pension accounting, pension plans' impact on earnings statements, and the ability of pension funds to meet their obligations is a welcome trend. Among the slew of ideas and opinions being floated has been the radical suggestion that pension plans should shift completely away from equities toward bonds or, alternatively, that they should restrict equities to a minimal portion of their portfolio. In 2001, Boots Pensions Ltd., one of the top 50 pension funds in the United Kingdom, announced that it had moved 100% of its portfolio into high-quality bonds in order to have a "more conservative investment strategy that aims to secure members' pensions and reduce investment risks to a minimum."[1] A recent *Harvard Business Review* article avers, "equities have little place in corporate pension funds."[2]

The reasons advocated for moving away from equities are:

- **The Immunization Argument:** With a 100% bond portfolio, you can match (or immunize) pension assets with liabilities, ensuring that pension assets move closely in line with obligations.
- **The Cost Argument:** Costs of bond fund management, especially passive bond fund management, are substantially less than those for equity funds.
- **The Risk Argument:** Holding equities, which are riskier assets, creates the risk of deficits that have to be matched by increased contributions.

However, we believe that each of these arguments points toward holding a diversified portfolio of bonds and equities, not moving away from equities completely.

- **The Immunization Argument:** Both equities and bonds have price risk and reinvestment risk. As we will demonstrate in subsequent sections, the concept of equity duration can be combined with bond duration to immunize a diversified portfolio of bonds and stocks.
- **The Cost Argument:** Costs of passive equity fund management are much less than active equity management costs, and are in line with or lower than those of passive bond fund management. Furthermore, although active equity management costs much more, a large body of literature suggests that a majority of active managers fail to add value over benchmarks over extended periods of time.[3]
- **The Risk Argument:** Not having equities in a portfolio *increases* the risk of deficits that would require increased contributions. As Exhibit 1 shows, equities earn greater return than bonds, on average. Over the last 40 years, the average annual return from equities has been 11.3%, compared with 7.5% from government bonds. As the last line in the exhibit shows, the compounding effect of this return differential is substantial. Given an average inflation rate of around 4.5% annually, projected double-digit increases in medical benefit costs, and an ageing work force, it is incumbent upon fiduciaries to keep an asset mix that can earn higher returns than a portfolio of just bonds can provide. Furthermore, a portfolio diversified across assets offers lower risk per unit of return.

[1] See "Boots Pension Scheme Trustee Review 2001"
[2] See "Pension Roulette: Have You Bet Too Much on Equities?" *Harvard Business Review*, June 2003.
[3] For example, see the quarterly Standard & Poor's Index Versus Active (SPIVA) scorecards at www.standardandpoors.com/spiva

Exhibit 1: Annual Returns For Different Assets

	Long-Term Government Bonds	Baa-Rated Corporate Bonds	3-Month T-Bills	S&P 500	Inflation
1962	6.55%	7.24%	2.77%	-8.73%	1.33%
1963	0.43%	5.72%	3.16%	22.65%	1.64%
1964	4.15%	5.32%	3.55%	16.31%	0.97%
1965	0.41%	2.32%	3.95%	12.36%	1.92%
1966	1.78%	-7.35%	4.86%	-10.05%	3.46%
1967	-3.99%	-2.06%	4.31%	23.88%	3.04%
1968	1.62%	3.60%	5.34%	10.98%	4.72%
1969	-7.39%	-6.60%	6.67%	-8.43%	6.20%
1970	17.54%	4.28%	6.39%	3.97%	5.57%
1971	10.27%	16.65%	4.33%	14.31%	3.27%
1972	5.50%	13.13%	4.07%	18.99%	3.41%
1973	-2.40%	2.46%	7.03%	-14.69%	8.71%
1974	1.80%	-10.36%	7.83%	-26.46%	12.34%
1975	2.36%	11.29%	5.77%	37.22%	6.94%
1976	16.75%	25.23%	4.97%	23.93%	4.86%
1977	-2.74%	10.33%	5.27%	-7.16%	6.70%
1978	-4.50%	0.19%	7.18%	6.57%	9.02%
1979	-4.25%	-7.79%	10.06%	18.61%	13.29%
1980	-10.60%	-9.74%	11.40%	32.50%	12.52%
1981	3.76%	5.70%	14.01%	-4.92%	8.92%
1982	40.94%	36.84%	10.59%	21.55%	3.83%
1983	0.00%	16.86%	8.61%	22.55%	3.79%
1984	14.36%	17.23%	9.52%	6.27%	3.95%
1985	29.24%	30.28%	7.48%	31.73%	3.80%
1986	32.18%	27.04%	5.98%	18.67%	1.10%
1987	-6.79%	-1.53%	5.77%	5.25%	4.43%
1988	8.87%	17.13%	6.66%	16.61%	4.42%
1989	21.98%	18.70%	8.11%	31.69%	4.65%
1990	5.42%	4.44%	7.49%	-3.10%	6.11%
1991	17.04%	22.23%	5.37%	30.47%	3.06%
1992	10.91%	13.77%	3.43%	7.62%	2.90%
1993	19.77%	20.66%	3.00%	10.07%	2.75%
1994	-11.29%	-5.50%	4.24%	1.32%	2.67%
1995	31.95%	26.96%	5.49%	37.58%	2.54%
1996	0.51%	3.72%	5.01%	22.96%	3.32%
1997	14.01%	14.37%	5.06%	33.36%	1.70%
1998	15.96%	8.23%	4.78%	28.58%	2.04%
1999	-9.43%	-1.27%	4.64%	21.04%	2.67%
2000	16.94%	10.07%	6.21%	-9.10%	3.37%
2001	3.74%	11.30%	3.46%	-11.89%	1.60%
2002	13.91%	13.92%	1.63%	-22.10%	2.31%
Average	7.49%	9.15%	5.99%	11.29%	4.53%
Standard Deviation	12.2%	11.3%	2.5%	16.7%	3.1%
Value of $1 invested at the beginning of 1962	$14.99	$29.04	$10.73	$49.13	$6.05

Source: Standard & Poor's Financial Communications.

A Rather Simple Model of Pension Fund Asset Allocation

In the spirit of Leibowitz (1986), we describe a rather simple model of asset allocation in pension funds. For our demonstration, we will assume that there are only three kinds of assets: equities, bonds, and cash. While these constitute the major asset classes in a pension fund portfolio, the model can be easily extended to multiple classes of assets.

Let us define the following variables:

WE	=	Weight of the equity portion in the asset mix
WB	=	Weight of the bond portion in the asset mix
WC	=	Weight of cash portion in asset mix
RR	=	Long-term rate of return required to satisfy plan obligations
RE	=	Projected long-term return of equities
RB	=	Projected long-term return of bonds
RC	=	Projected long-term return of cash
DL	=	Duration of plan liabilities
DE	=	Duration of equity portfolio
DB	=	Duration of bond portfolio

To satisfy the return requirements,

$$RR = WE.RE + WB.RB + WC.RC \quad (1)$$

To immunize the portfolio against changes in the discount rate,

$$DL = WE.DE + WB.DB \quad (2)$$

Also,

$$WE + WB + WC = 1 \quad (3)$$

Among the above variables, duration of bonds and plan liabilities (DB and DL) can be fairly accurately predicted. (Duration of cash is zero.) Projected long-term returns on equities, bonds, and cash (RE, RB, and RC) are standard inputs used in asset allocation, and there are numerous sources and estimation approaches for these variables. The required rate of return to satisfy plan obligations (RR) is another standard input used in asset allocation and is determined by the projected growth in plan liabilities. If WB and WE are variables to be determined, that leaves us with duration of equities (DE), a fairly ignored concept that we shall discuss in subsequent sections. Once all the above variables have been input, WB, WC, and WE can be calculated by solving (1), (2), and (3). Depending upon the plan's asset rebalancing frequency, fresh inputs will be used to evaluate the new weights of equities and bonds.

Equity Duration

Duration, first defined by Macaulay (1938) as the weighted average term to maturity of cash flows of a bond, is a standard and ubiquitous measure of the price sensitivity of a bond to interest rate changes in fixed income analytics. Equity duration measures the sensitivity of equity prices to rate changes.[4] The extension of the duration concept to equities is more recent, with the earliest literature on the subject dating back just 20 years

[4] It is important to note that, unlike in bonds, interest rates do not have significant explanatory power for equity returns; rather, the rate effect is transmitted to equity prices through other variables that have significant explanatory power (see Cornell, 2000). Equity duration is merely a measure of rate sensitivity.

(Casabona, Fabozzi, and Francis; 1984), and its use in investment management is far from widespread. The reasons for this are not hard to find:

- Unlike plain bonds, the terminal value of equities is not fixed.
- Interest payments of plain bonds are predetermined and known in advance. Dividend payments of equities are not as certain.

The difficulties in estimating equity duration do not detract from its importance in immunization, tactical asset allocation, and risk management.

Immunization: Immunization refers to investment of assets in such a manner so as to enable matching of assets and liabilities regardless of changes in interest rates. It refers not only to matching the present value of assets with the present value of liabilities, but also to matching the interest rate sensitivities of assets with those of liabilities. Since the duration of any instrument varies with time and changes in rates, complete immunization is costly or impractical. Immunization in practice is often a tradeoff between cost and efficiency. As we mentioned in the previous section, a common example is a pension plan that not only has to match its present value of assets with its projected obligations, but also has to ensure that the duration of assets matches those of its obligations. Since equities account for nearly half of assets in most pension plans, an estimate of equity duration is important.

Risk Management: Equities constitute a significant proportion of investor portfolios, and empirical evidence suggests that equities do react to changes in rates. Therefore, any risk management plan needs to factor in the sensitivity of the equity portfolio to rate changes.

Tactical Asset Allocation: Tactical asset allocation makes opportunistic bets on changes in the external economic environment by shifting allocations among different asset classes. Since interest rate changes are one signal of the external economic environment, knowledge of equities' rate sensitivity would be very important for plan managers considering shifts in asset allocations to take advantage of projected changes in interest rates.

In this paper, we will present the long-term evolution of the duration of the U.S. equity market. We will review different approaches to the calculation of equity duration and explain our calculation methodology. Standard & Poor's will henceforth report the duration of the U.S. equity market, along with a history of more than 30 years, on an annual basis.

Different Approaches to Evaluating Equity Duration

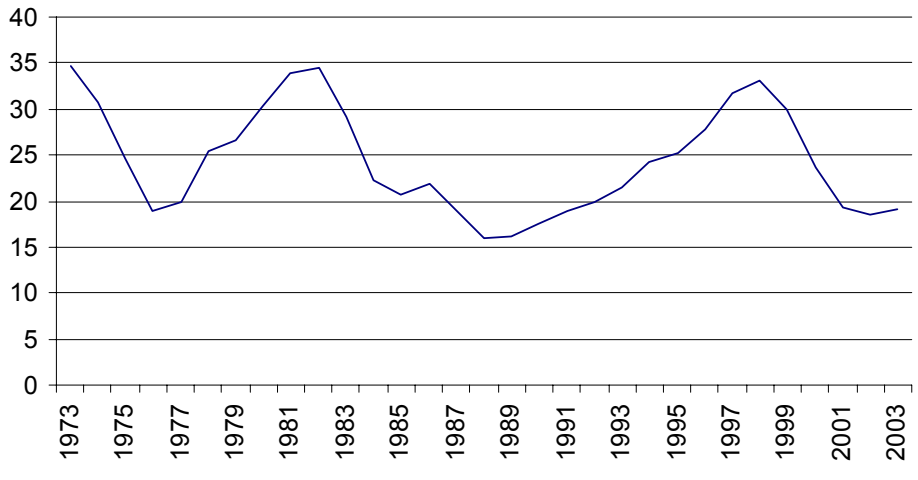
The Dividend Discount Model Approach

The earliest literature on the subject flows from Gordon's dividend discount model, which values a stock based on its estimated dividend, the equity discount rate (k), and the dividend growth rate (g). Casabona, Fabozzi, and Francis (1984) derive equity duration from first principles as simply $1/(k\text{-}g)$. The solution is intuitive — this is the average age of a perpetuity whose payout grows at a rate of g per year, and is discounted at a rate of k.

The 30-year history of duration for the U.S. equity market calculated by the dividend discount model is shown in Exhibit 2. [5]

The simplicity of this approach is appealing. However, it gives high estimates of equity duration. More importantly, it does not take into account the "flow-through" effects of interest rates; that is, it does not consider the fact that *g* might be sensitive to *k*.

Exhibit 2: Duration Estimated by Dividend Discount Model



Source: Standard & Poor's. Estimates are for the middle of each year.

The Empirical Approach

Leibowitz (1986) suggested a radically different way of estimating equity duration empirically. His method was derived from historical changes in equity prices and interest rates, and yielded much shorter duration estimates.

Leibowitz specifies returns on equities and bonds as follows:

$$RE - Rf = \alpha 1 + \beta.(RB-Rf) + \varepsilon 1 \quad (4)$$
$$RB - Rf = \alpha 2 - DB.\Delta + \varepsilon 2 \quad (5)$$

Where RE and RB are equity and bond market returns, [AQ: need to define Rf?] β is the regression coefficient reflecting sensitivity of equity prices to bond returns, Δ is change in benchmark long-term yield, and DB is the bond market duration (*i.e.*, the sensitivity of bond market returns to changes in the benchmark yield). $\alpha 1$ and $\alpha 2$ are regression intercepts, while $\varepsilon 1$ and $\varepsilon 2$ are residual terms.

Substituting RB from (5) in (4),

$$RE - Rf = \alpha 3 - DE.\Delta + \varepsilon 3 \quad (6)$$

DE is Leibowitz's equity duration, which he estimated to be 2.8 years for the U.S. market. $\alpha 3$ and $\varepsilon 3$ are the regression intercept and the residual term, respectively.

[5] Data used and calculation methodology is similar to those described the section titled "Duration of the S&P 500 – A 30-Year History."

Using this approach, we calculate the duration of the U.S. equity market to be 2.32 as of mid-2003. In our calculation, we have taken the S&P 500's quarterly returns from 1973 to 2003 for the equity side of the equation, and 10-year treasury bill rates for the bond side of the equation. We do not expect R^2 to be significant, since interest rates have been empirically proven to be not as significant as the market effect or other stock-specific factors in explaining equity returns. However, the F-value of 5.16 is significant, suggesting that the rate variable has some explanatory power. More to our purpose, the t-statistic of the rate coefficient is 2.27, which is significant at the 5% level.

However, from the two equations, Johnson (1989) pointed out that

$$\alpha 3 = \alpha 1 + \beta.(\alpha 2) \quad (7)$$

From (7), it is clear that presence of β in both the constant term in (6) and the slope coefficient in (4) results in multicollinearity. This will bias the estimate of DE downward, since part of the explanatory power of the slope coefficient is present in the constant term. This explains the low estimates obtained by this empirical approach.

Flow-Through Models

Leibowitz and Kogelman (1993) propose to calculate equity duration by calculating the duration of assets in place (AIP), which they refer to as tangible value, separately from those of growth opportunities (GO), which they refer to as franchise value. The duration of equity is the weighted average sum of duration of each of these two components. Inflation affects AIP and GO differently. The ability to pass through unexpected increases in costs, referred to as inflation flow through, is higher for GO than for AIP. Leibowitz, et al (1989) adopt the dividend discount model as their starting point, then incorporate sensitivity of the equity risk premium to inflation and real rates; Hamelink, et al (2002) adapt this in a more practical and usable format.

Our Approach to Equity Duration

Let us start off with equity valuation embodied in Gordon's dividend discount model.

$$P = D/(k\text{-}g) \quad (8)$$

Where P is the price of the stock, D is the next period dividend payment (a known constant), k is the equity discount rate, and g is the dividend growth rate (as defined previously).

Taking log on both sides,

$$\ln (P) = \ln (D) - \ln (k - g) \quad (9)$$

Taking the derivative with respect to the discount rate k,

$$1/P\ (\delta P/\delta k) = -1/(k\text{-}g)\ (1\text{-}\delta g/\delta k) \quad (10)$$

Since the left-hand term of equation 10 is the definition of duration[6], the right-hand term is duration.

[6] We use duration to mean modified duration, not Macaulay's duration. Macaulay's duration is modified duration multiplied by (1+k).

This is a simple flow-through model, where d*g*/d*k* measures the sensitivity of dividend growth to changes in the equity discount rate. From equation (8), we recognize that this estimate simply multiplies the dividend discount model duration estimate by 1 minus the sensitivity factor.

Several properties of duration can be drawn from this approach. Ceteris paribus,

1. Higher growth implies higher duration. That is, higher-growth portfolios will have a higher duration and, therefore, greater sensitivity to interest rates.

2. If the dividend growth rate is steady, a higher equity discount rate implies a lower duration and, therefore, a lower sensitivity to changes in interest rates.

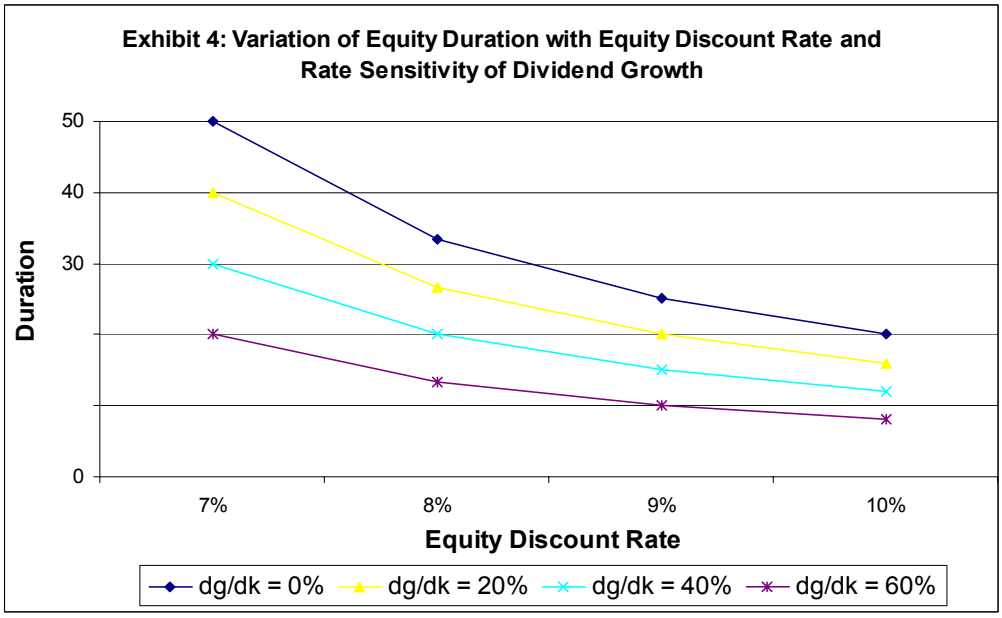
3. Low sensitivity of growth opportunities to the discount rate increases the duration of a portfolio and therefore increases the sensitivity of a portfolio's value to changes in interest rates.

The value of equity duration for different scenarios is shown in Exhibit 3 and plotted in Exhibit 4. The properties outlined above can be observed in the exhibits. Specifically, Exhibit 4 plots duration for different values of the discount rate and sensitivity factor, assuming 5% dividend growth, which is the long-term average for the S&P 500.

Exhibit 3: Values of Equity Duration for Different Parameters

dg/dk	g	k			
		7%	8%	9%	10%
0.0	3%	25.00	20.00	16.67	14.29
	4%	33.33	25.00	20.00	16.67
	5%	50.00	33.33	25.00	20.00
	6%	100.00	50.00	33.33	25.00
0.2	3%	20.00	16.00	13.33	11.43
	4%	26.67	20.00	16.00	13.33
	5%	40.00	26.67	20.00	16.00
	6%	80.00	40.00	26.67	20.00
0.4	3%	15.00	12.00	10.00	8.57
	4%	20.00	15.00	12.00	10.00
	5%	30.00	20.00	15.00	12.00
	6%	60.00	30.00	20.00	15.00
0.6	3%	10.00	8.00	6.67	5.71
	4%	13.33	10.00	8.00	6.67
	5%	20.00	13.33	10.00	8.00
	6%	40.00	20.00	13.33	10.00

Source: Standard & Poor's



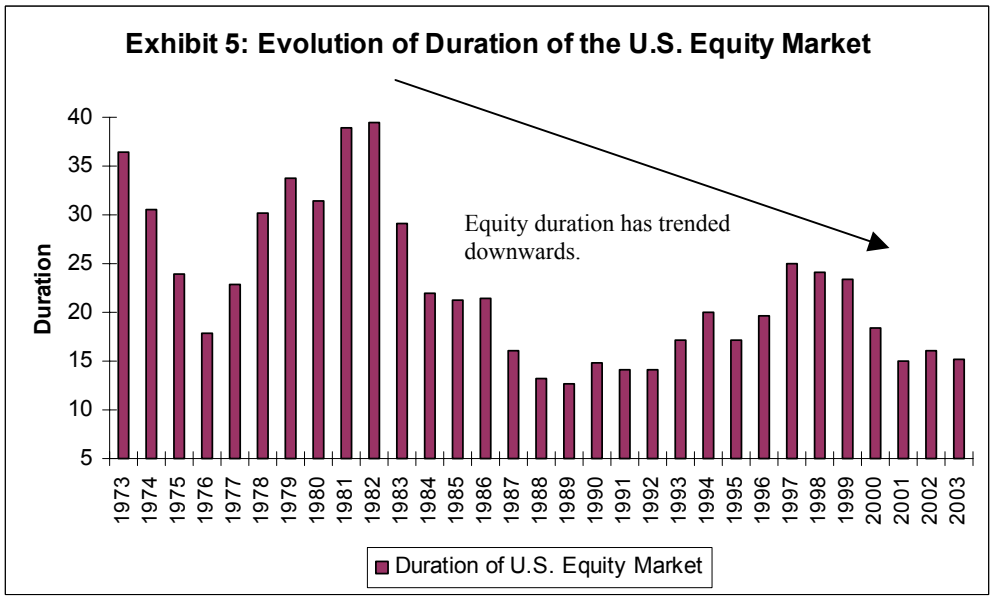
Source: Standard & Poor's

Duration of the S&P 500 — A 30-Year History

We adopt the approach suggested by equation 10 to evaluate duration of the U.S. equity market. We take quarterly dividend growth of the S&P 500 for *g*. For *k*, we choose to use the Moody's Baa yield series. The choice of a corporate bond yield series departs from literature, but we believe is more practical. Traditionally, the equity discount yield in this context has been taken as a long-term (10- or 20-year) treasury bond, with a constant equity risk premium added to it. However, because the equity risk premium varies from one time period to another, an average might not be appropriate — leaving aside the intricacies involved in computing the risk premium if one is not adding an average number. The corporate bond series gives a market-determined, risk-adjusted measure of the discount rate.

The sensitivity of *g* to *k* is difficult to estimate. This factor can be positive or negative, depending on whether specific components of change in rates are passed on to the customer. Following Hamelink, et al (2002), we take this factor as the correlation of change in *g* to change in *k*. Recognizing that the denominators are long-term factors and duration is not a high-frequency estimation parameter, we take the previous 10-year (40-quarter) averages for the *g* and *k* terms and for the correlation estimation.

Appendix 1 shows the duration of the S&P 500 since 1973. Standard & Poor's will update this table on an annual basis. This evolution of duration for the U.S. equity market over the last 31 years is shown in Exhibit 5. The most striking feature is the downward trend in equity duration; that is, equities have become less sensitive to interest rates. Of course, this is related to the striking market and interest rate cycles of the previous three decades. In addition, however, there is perhaps a structural factor is this reduction in duration, with non-rate features becoming more important.



Source: Standard & Poor's. Estimates are for the middle of each year.

Exhibit 6 takes a more microscopic view, looking at the last market cycle. It is interesting to note that duration of the equity market had reached 15-year highs toward the end of the bull market. This is related to the first property of duration discussed earlier: higher growth implies higher duration. Therefore, as a monetary tightening policy took effect, the sensitivity of the equity market to rates was at 15-year highs. The downward pressure on equities was swift and sharp. At the time, pension plans and ordinary investors had a higher-than-average exposure to equities and suffered sharp losses in portfolio value.

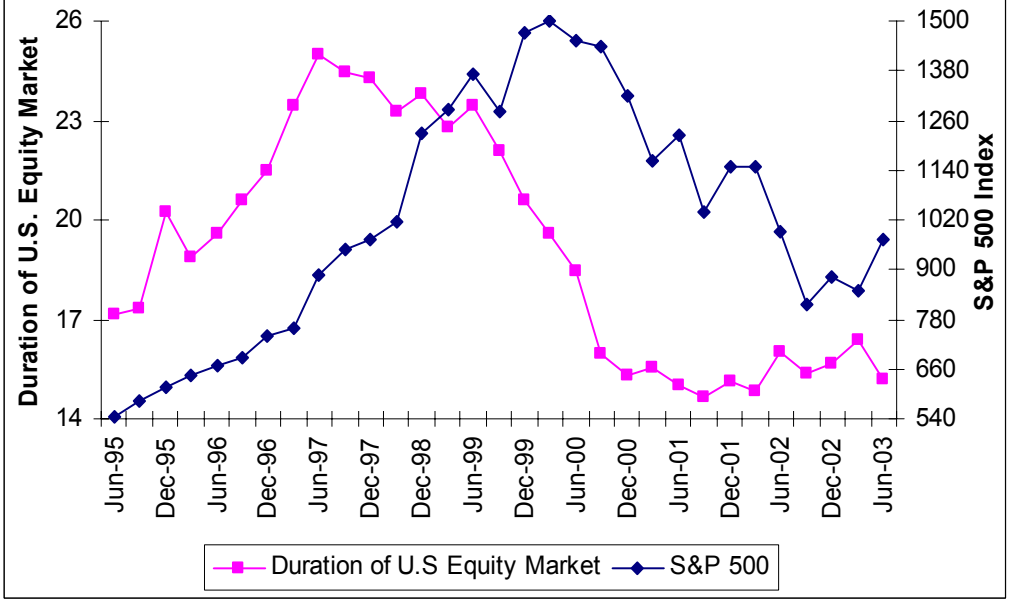
Use of the equity duration metric in asset allocation might have alerted fiduciaries to the heightened interest rate risk. Following our simple allocation model, to satisfy equation (2) a pension fund would have either lowered its equity exposure or lowered duration of its equity portfolio (by moving to a low *g* equity portfolio).

A subsequent series of interest rate cuts did little to bolster equity prices. This is not surprising, because rate sensitivity, or equity duration, had fallen to a 10-year low. The equity duration concept has interesting implications on the policy front regarding the degree of interest rate shock needed to "correct" equity prices.

Note that our simple model would have increased equity allocations or shifted the equity portfolio toward high-duration stocks in the middle of the bear market if one is following a frequent rebalancing strategy. This suggests that the metric is not appropriate for short-term market timing, but can work for long-term asset allocation involving rebalancing every two to three years or more. This is consistent with asset allocation review cycles of most pension plans. Further, the trend should be considered as important as the point estimate. Therefore, in Appendix 1, we have added a three-year moving average column.

Exhibit 6: Duration of the Equity Market and the Recent Market Cycle

Equity duration is at 15-year high. Tightening of rates causes sharp correction in equity prices.



Source: Standard & Poor's. Estimates are for the middle of each year.

Don't Run Away From Equities, Just Understand Them Better

Pension funds of going concerns need to continue with a diversified portfolio of equities and bonds, rather than making radical shifts that eliminate or drastically reduce equity exposure. The equity duration metric can be used within the pension fund asset allocation context to immunize the pension fund portfolio. Standard & Poor's will publish, on an annual basis, a current report and a 30-year history of equity duration of the S&P 500. We will also publish duration metrics for other Standard & Poor's indices. We acknowledge that equity duration estimation is an evolving science, and there is no single, universally acknowledged approach. However, we believe that a regularly available and updated source of equity duration will support further research and use of this important metric.

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Appendix 1: Annual Duration of S&P 500

	Duration of U.S. Equity Market	12 Quarter Moving Average of Duration
1973	36.4	
1974	30.6	
1975	23.9	
1976	17.8	26.0
1977	22.9	22.2
1978	30.2	22.7
1979	33.8	27.1
1980	31.5	30.8
1981	39.0	33.8
1982	39.5	36.2
1983	29.1	36.4
1984	21.9	32.4
1985	21.2	26.2
1986	21.4	22.5
1987	16.0	20.4
1988	13.3	17.9
1989	12.8	15.1
1990	14.9	13.7
1991	14.2	13.8
1992	14.2	14.2
1993	17.2	14.9
1994	19.9	16.3
1995	17.1	17.3
1996	19.6	18.2
1997	25.0	19.7
1998	24.2	21.9
1999	23.4	23.3
2000	18.5	22.5
2001	15.0	19.7
2002	16.0	16.9
2003	15.2	15.4

Source: Standard & Poor's. Estimates are as of the middle of each year.

The duration estimate is obtained from the formula given in equation (10), with equity duration being equal to $-1/(k-g)\,(1-\delta g/\delta k)$. We take quarterly dividend growth of the S&P 500 for g. For k, we choose to use the Moody's Baa yield series. We use averages for the past 40 quarters (10 years). For the $\delta g/\delta k$ term, we use the correlation of change in g to change in k for the previous 40 quarters.

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