

Implied Equity Duration: A New Measure of Equity Risk*

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Abstract

We derive an expression for implied equity duration by adapting the traditional expression for bond duration and develop an algorithm for its empirical estimation. We find that the standard empirical predictions and results for bond duration hold for our measure of implied equity duration. Stock return volatilities and betas are increasing in implied equity duration. Moreover, estimates of common shocks to expected equity returns extracted using our measure of implied equity duration capture a strong common factor in stock returns. We also show that book-to-market ratio represents a special case of our expression for implied equity duration that imposes restrictive assumptions on the evolution of future cash flows. Consequently, our implied equity duration framework provides an explanation for the empirical properties of the book-to-market related factor documented Fama and French (1993). Empirical tests confirm that the common factor related to our more general measure of implied equity duration dominates and subsumes the common factor related to book-to-market.

Introduction

Techniques for analyzing the risk characteristics of fixed income securities have evolved within a theoretically rigorous framework based on the discounted expectations of the future cash flows of the securities. Constructs such as duration and convexity are well established for fixed income securities and are embraced by academics and practitioners alike. The analysis of equity securities, in contrast, has evolved in a relatively ad hoc manner. Following disappointment with the performance of equilibrium pricing models such as the CAPM, academics and practitioners have adopted empirically motivated procedures for the analysis of equity risk. For example, following Fama and French (1993), a popular academic approach to modeling the risk characteristics of stock returns is through a three-factor model incorporating a market-related factor, a size-related factor and a book-to-market-related factor. Similarly, practitioners have embraced the notion of classifying stocks on the basis of market capitalization and the extent to which they exhibit the ‘style’ characteristics of ‘value’ and ‘growth’. We bridge this gap in the analysis techniques for fixed income and equity securities by developing an implied equity duration measure that provides both a theoretically justifiable and empirically powerful technique for the analysis of equity security risk.¹

We begin by developing a measure of implied equity duration based on Macaulay’s traditional measure of bond duration. The primary obstacle in implementing the bond duration formula for equities is in the estimation of the expected future cash distributions for equities. We develop a two-stage procedure to facilitate this task. First, using simple forecasting models based on historical financial data, we estimate the expected future cash flows for a finite forecast horizon. Second, we assume that the remaining value implicit in the observed stock price will be distributed as a level perpetuity beyond our finite forecast horizon. We then apply the standard

duration formula to compute our measure of implied equity duration. We recognize that our estimation procedure for implied equity duration represents a simple approximation based on relatively crude forecasting assumptions. Nevertheless, the resulting duration estimates perform well in empirical tests, and our basic framework is easily adapted to incorporate more sophisticated forecasting models.

Empirical tests demonstrate the effectiveness of our measure of implied equity duration in explaining the risk characteristics of equity security returns. Implied equity duration is strongly positively related with stock return volatilities and betas and has incremental explanatory power over past volatilities/betas in forecasting future volatilities/betas. Moreover, estimates of common shocks to expected equity returns extracted using our measure of implied equity duration capture a strong common factor in stock returns. We also show that book-to-market ratio represents a special case of our expression for implied equity duration that imposes restrictive assumptions on the evolution of future cash flows. Consequently, our implied equity duration framework provides a rigorous explanation for the empirical properties of the book-to-market-related factor documented in Fama and French (1993). Empirical tests confirm that the common factor related to our measure of implied equity duration dominates and subsumes the common factor related to book-to-market.

The remainder of the paper is organized as follows. The next section discusses our measure of implied equity duration and our empirical predictions. Section 2 describes our data, Section 3 presents our results and section 4 concludes.

1. Implied Equity Duration: Definition, Measurement and Predictions

1.1. Definitions

The traditional measure of duration (D) for a bond is the Macaulay duration formula:

$$D = \frac{\sum_{t=1}^T t \times \frac{CF_t}{(1+r)^t}}{P} \quad (1)$$

where CF denotes the cash flow at time t , r denotes the yield to maturity and P denotes the bond price. This measure of duration is a weighted average of the times to each of the respective cash flows on the bond, where the weights represent the relative contributions of the cash flows to the bond's value. Intuitively, duration represents the average maturity of the bond's promised cash flows.

The primary role of duration in the analysis of fixed income securities is as a measure of bond price sensitivity to changes in the yield to maturity. Differentiating the expression for the value of a bond with respect to the yield to maturity gives:

$$\frac{\partial P}{\partial r} = -P \times \frac{D}{1+r} \quad (2)$$

Intuitively, this result indicates that the relation between bond prices changes and changes in bond yields is a simple function of duration:²

$$\frac{\Delta P}{P} \approx -\frac{D}{1+r} \Delta r \quad (3)$$

The expression $\frac{D}{1+r}$ is often referred to as the 'modified duration', and it provides a simple measure of the sensitivity of bond prices changes to yield changes.

Extending the duration concept to equities introduces two key problems:

1. A bond typically makes a finite number of cash payments, while the sequence of payments on equity is potentially infinite.

2. The amount and timing of the cash payments on a bond are usually specified in advance and subject to little uncertainty, while the payments on equity are not specified in advance and can be subject to great uncertainty.

To address the first problem, we partition the duration formula in equation (1) into two parts, a finite forecasting horizon of length T and an infinite terminal expression:

$$D = \frac{\sum_{t=1}^T t \times \frac{CF_t}{(1+r)^t}}{\sum_{t=1}^T \frac{CF_t}{(1+r)^t}} \times \frac{\sum_{t=1}^T \frac{CF_t}{(1+r)^t}}{P} + \frac{\sum_{t=T+1}^{\infty} t \times \frac{CF_t}{(1+r)^t}}{\sum_{t=T+1}^{\infty} \frac{CF_t}{(1+r)^t}} \times \frac{\sum_{t=T+1}^{\infty} \frac{CF_t}{(1+r)^t}}{P} \quad (4)$$

Since we are now dealing with equity, P denotes the market capitalization of equity (stock price multiplied by shares outstanding), CF denotes the net cash distributions to equity holders and r denotes the expected return on equity. Equation (4) expresses equity duration as the value-weighted sum of the duration of the finite forecasting horizon cash flows and the duration of the infinite terminal cash flows. Next, we assume that the terminal cash flow stream consists of a level perpetuity with a value equal to the difference between the observed market capitalization implicit in the stock price and the present value of the cash flows over the finite forecast period, so that:

$$\sum_{t=T+1}^{\infty} \frac{CF_t}{(1+r)^t} = (P - \sum_{t=1}^T \frac{CF_t}{(1+r)^t}) \quad (5)$$

Recognizing that the duration of a level perpetuity beginning in T periods is $T + (1+r)/r$, and substituting (5) into (4) simplifies our expression for equity duration to:

$$D = \frac{\sum_{t=1}^T t \times \frac{CF_t}{(1+r)^t}}{P} + (T + \frac{(1+r)}{r}) \times \frac{(P - \sum_{t=1}^T \frac{CF_t}{(1+r)^t})}{P} \quad (6)$$

The assumption that the cash flow stream for an equity security can be partitioned into a finite forecasting period and an infinite terminal expression is standard in the equity valuation literature. The assumption that the terminal cash flows are realized as a level perpetuity is less standard. More commonly, the terminal cash flows are assumed to grow at a constant terminal rate, such as the expected macroeconomic growth rate. We make the level perpetuity assumption for tractability and without loss of generality. As long as the forecasting horizon is long enough to exhaust plausible opportunities for firm-specific or industry-specific super-normal growth, the terminal growth rate will be a cross-sectional constant, and so will not be an important source of cross-sectional variation in implied equity duration. Because the terminal cash flow perpetuity is inferred from the observed stock, we refer to the resulting measure of equity duration as ‘*implied*’ equity duration. In other words, our measure of equity duration is based on investors’ consensus expectations, as reflected in stock prices, rather than on necessarily rational forecasts of future cash flows.

The discussion above deals with the infinite cash flow problem. The second problem in implementing equation (6) is the forecasting of the finite period cash distributions, CF_t , $0 \leq t \leq T$. Our forecasting model is based on recent research indicating that accounting-based performance measures provide effective information variables for forecasting future cash flows (Nissim and Penman 2001). We begin with the accounting identity that expresses net cash distributions to equity in terms of earnings and book value of equity:³

$$CF_t = E_t - (BV_t - BV_{t-1}) \quad (7)$$

where E_t represents accounting earnings at the end of period t and BV_t represents the book value of equity at the end of period t . Re-arranging the right-hand side of equation (7) gives:

$$CF_t = BV_{t-1} \times \left[\frac{E_t}{BV_{t-1}} - \frac{(BV_t - BV_{t-1})}{BV_{t-1}} \right] \quad (8)$$

Equation (8) indicates that to forecast net cash distributions to equity, one needs to first forecast:

- (i) Return on equity (ROE) denoted by E_t/BV_{t-1} ; and
- (ii) Growth in equity, denoted by $(BV_t - BV_{t-1})/BV_{t-1}$.

It is well established that ROE follows a slowly mean reverting process [Stigler 1968, Penman 1991]. Moreover, both economic intuition and empirical evidence suggest that the mean to which ROE reverts approximates the cost of equity [Nissim and Penman 2001]. We therefore model ROE as a first-order autoregressive process with an autocorrelation coefficient based on the long-run average rate of mean reversion in ROE and a long-run mean equal to the cost of equity.

To forecast growth in equity, we rely on the results in Nissim and Penman (2001) indicating that past sales growth is a better indicator of future equity growth than past equity growth. Sales growth follows a mean reverting process similar to ROE, but mean reversion in sales growth tends to be more rapid [see Nissim and Penman (2001)]. Economic intuition suggests that the mean to which sales growth reverts should approximate the long-run macroeconomic growth rate.⁴ We therefore model growth in equity as a first-order autoregressive process, with an autocorrelation coefficient equal to the long-run average rate of mean reversion in sales growth and a mean equal to the long-run GDP growth rate.

Implementation of our estimation procedure for implied equity duration requires four financial variables and four forecasting parameters as inputs. We summarize these inputs in Table 1. The four financial variables are book value (both current and lagged one year), sales

(both current and lagged one year), earnings (current) and market capitalization (current). The four forecasting parameters are the autocorrelation coefficient for ROE, the autocorrelation coefficient for sales growth, the cost of equity and the long-run GDP growth rate. We conduct our analysis using annual data and obtain the required financial variables from the annual COMPUSTAT files. Using pooled data over our sample period, we obtain average estimates of the autocorrelation coefficients for ROE and sales growth of 0.57 and 0.24 respectively. The long-run averages for cost of equity and GDP growth rate are based on the long-run averages reported by Ibbotson (1999) of (approximately) 12% and 6% respectively. Note that we use a naïve forecast of the cost of equity that assumes it to be a cross-sectional constant. Such a naïve assumption is necessary however, to avoid the possibility that we could induce our empirical results through systematic variation in the cost of equity capital. By assuming that the cost of equity is a cross-sectional constant, we ensure that our measure of implied equity duration is driven solely by differences in the timing of the expected future cash flows.⁵

Finally, we use a finite forecast horizon of ten years, because most of the mean reversion in sales growth and ROE is complete after 10 years. We emphasize that these forecasting procedures are relatively crude. For example, certain forecasting parameters have been shown to vary systematically as a function of industry membership and other firm characteristics. However, our immediate goal is to introduce the concept of implied equity duration and demonstrate the ability of a relatively parsimonious empirical estimation procedure to produce an effective measure of implied equity duration.

[Table 1 here]

We illustrate our implied equity duration estimation procedure using two representative firm-years from our sample in table 2. The first example in panel A is for Alaska Air in 1999 and is designed to be illustrative of low duration equity. The second example in panel B is for Amazon.com in 1999 and is designed to be illustrative of high duration equity. Values for the required forecasting variables are listed at the top left of each panel and the forecasting parameters, which are assumed to be the same across firms, are listed at the top right of each panel. Forecasts of cash flows and their present values are derived for the ten-year forecast horizon. The growth rate is derived by reverting past sales growth to the long-run mean of 6% using the autocorrelation coefficient of 0.24. Similarly, ROE is derived by reverting past ROE to its long run mean of 12% using the autocorrelation coefficient of 0.57. Applying the forecast growth rates to lagged book value generates the forecasts of future book values. Applying the forecast ROEs to the lagged book value forecasts generates the earnings forecasts. Cash flow forecasts are then backed out from earnings and book value forecasts using equation (7).

The duration of the finite forecast cash flows is equal to the ratio of the time weighted present value to the present value of the forecast cash flows. The weight assigned to the finite period duration is equal to the ratio of the present value of the forecast cash flows to the market capitalization. The duration of the terminal cash flows is always equal to 19.33 [i.e., $T + (1+r)/r = 10 + 1.12/0.12=19.33$]. The weight assigned to the terminal duration is simply one minus the weight assigned to the finite period duration. Implied equity duration is computed by taking the weighted sum of the finite and terminal period durations.

The computation for Alaska Air indicates that 64% of the value implicit in the current price is expected to be realized during the finite forecast period. Alaska Air's forecast ROE

exceeds its forecast growth rate in every year of the finite forecast period, which results in positive cash distributions in each of these periods. This results in a relatively low implied equity duration figure of just 10.0 years for Alaska Air. The computation for Amazon.com indicates that the cash flows realized during the forecast period amount to -21% of the value implicit in the current price. In Amazon's case, the negative current ROE and high growth rate combine to generate cash flows over the finite forecast period that are mostly negative and have a negative net present value. Implicit in this negative cash flow is the necessity for Amazon.com to raise additional capital over the finite forecasting horizon. Not until the eighth year of the finite period does the ROE exceed the growth rate in book value, which is what is required for positive cash distributions. As a consequence of the negative weighting on the finite forecast period duration, Amazon's implied equity duration of 23.0 years exceeds the terminal period duration of 19.33 years. Thus, duration tends to be low for firms with high ROE, low growth and low market valuations and high for firms with low ROE, high growth and high market valuations.

[Table 2 here]

1.2. *Equity duration and the earnings-to-price ratio and book-to-market ratios*

Finance practitioners and academics frequently use earnings-to-price and book-to-market ratios as equity style and risk characteristics. Our measure of implied equity duration is closely related to these valuation ratios. We demonstrate the links by considering some special cases of the implied equity duration formula in equation (6). These special cases all involve the assumption that the net cash distributions over the finite forecasting period take the form of a level annuity, denoted A. The duration of a level annuity of length T is given by:

$$D_A = \frac{(1+r)}{r} - \frac{T}{(1+r)^T - 1} \quad (9)$$

and the present value of a level annuity of amount A and length T is given by:

$$PV_A = A \times \frac{1 - \frac{1}{(1+r)^T}}{r} \quad (10)$$

Substituting these two equations into equation (6) and simplifying yields:

$$D = T + \frac{(1+r)}{r} - \frac{A/r}{P} \times T \quad (11)$$

This expression highlights the fact that implied equity duration is decreasing in the magnitude of the net cash distributions paid over the finite forecast horizon. Differentiating (11) with respect to A gives:

$$\frac{\partial D}{\partial A} = \frac{-T}{r \times P} \quad (12)$$

Duration is decreasing in the magnitude of the annuity, with the rate of decrease being larger for longer forecast horizons, lower discount rates and lower stock valuations.

Equation (11) is the key to understanding the relation between implied equity duration, the earnings-to-price ratio and the book-to-market ratio. Recall from equation (8) that the net cash distributions received over the finite forecast horizon can be expressed as:

$$CF_t = BV_{t-1} \times \left[\frac{E_t}{BV_{t-1}} - \frac{(BV_t - BV_{t-1})}{BV_{t-1}} \right]$$

If we assume that growth in equity is zero for all finite forecast periods (i.e., $BV_t = BV_{t-1}$ for $0 \leq t \leq T$) and perfect persistence of current ROE over the forecast period (i.e., $\frac{E_t}{BV_{t-1}} = \frac{E_0}{BV_{-1}}$ for $0 \leq t \leq T$), then $CF_t = E_0$ for $0 \leq t \leq T$. The amount of the annuity for the finite forecast horizon is now equal to earnings at the beginning of the forecast horizon, and equation (11) becomes:

$$D = T + \frac{(1+r)}{r} - \frac{E_0}{P} \times \frac{T}{r} \quad (13)$$

Here we see that there is a negative relation between implied equity duration and the earnings-to-price ratio. So the earnings-to-price ratio will be a good proxy for equity duration in firms where growth in equity is low and ROE is highly persistent. Table 2 provides estimates of implied equity duration for Alaska Air and Amazon.com based on (13) labeled ‘earnings-to-price approximation.’ The equation (13) approximation understates duration for Alaska Air. This occurs because Alaska Air has a high current ROE and maintaining the ROE over the finite horizon results in the higher cash distributions. On the other hand, equation (13) overstates duration for Amazon, this occurs because Amazon has a very negative ROE and maintaining the ROE over the finite forecast horizon results in more required capital infusions.

To see the relation between implied equity duration and the book to market ratio, assume that growth in equity is again zero over the forecast period but that ROE immediately mean reverts to the cost of capital in the first year of the forecast period (i.e., $\frac{E_t}{BV_{t-1}} = r$ for $0 \leq t \leq T$).

Equation (8) now simplifies to $CF_t = r \times BV_0$. The amount of the annuity for the finite forecast horizon is equal to book value at the beginning of the forecast horizon multiplied by the cost of capital, and implied equity duration becomes:

$$D = T + \frac{(1+r)}{r} - \frac{BV_0}{P} \times T \quad (14)$$

In this special case, there is a simple negative relation between implied equity duration and the book-to-market ratio. The book-to-market ratio will be a good proxy for duration for firms where growth in equity is low and ROE is rapidly mean reverting. Table 2 provides estimates of implied equity duration for Alaska Air and Amazon.com based on (14) labeled ‘book-to-market approximation.’ The approximation based on equation (14) understates duration for both Alaska Air and Amazon.com. For Alaska Air, the understatement arises because the implicit assumption of no growth in equation (14) results in higher cash distributions in the forecast period. For Amazon, the understatement arises because the implicit assumptions of no growth and the immediate mean reversion to a positive ROE result in higher cash distributions in the finite forecast period.

The close links between our measure of implied equity duration and these popular valuation ratios suggest that they may serve as useful proxies for equity duration. We explore this possibility more fully in our empirical tests.

1.3 Empirical Predictions

The primary empirical implication of duration stems from the relation between ex post holding period returns and changes in expected return. Denoting holding period returns as h and changes in expected return as Δr , equation (3) indicates that the influence of a changes in expected return on the ex post holding period is:

$$h = \frac{\Delta P}{P} \approx -\frac{D}{1+r} \Delta r \quad (15)$$

Empirical verification of the relation in (15) is difficult, because changes in expected equity returns are not directly observable. Nevertheless, we can use (15) to generate predictions concerning the role played by duration in transmitting expected return volatility to holding period return volatility. First, defining volatility in terms of the standard deviation (σ), we can use (15) to determine the impact of volatility in expected returns on the volatility of holding period returns:

$$\sigma(h) \approx \frac{D}{1+r} \sigma(\Delta r) \quad (16)$$

Note that equation (16) only models the role of expected return shocks on volatility. It ignores other potential sources of volatility, such as volatility attributable to cash flow shocks. Equation (16) indicates that the impact of expected return volatility on holding period return volatility is greater for long duration stocks. This leads to our first empirical prediction:

P1: The volatility of equity holding period returns is increasing in equity duration.

Our first prediction relates to the total volatility of equity returns. However, asset-pricing theory suggests that non-diversifiable volatility constitutes a more relevant measure of risk. In

particular, the capital asset pricing model indicates that only systematic risk (β) that is related to movements in the market portfolio should be priced. Defining h_m as the ex post holding-period return on the market portfolio, D_m as the duration of the market portfolio and r_m as the expected return on the market portfolio, we can use (15) to determine the impact of common shocks to expected returns, (Δr_m) on systematic risk ($\beta(h, h_m)$):

$$\beta(h, h_m) = \frac{\sigma(h, h_m)}{\sigma^2(h_m)} \approx \frac{D}{D_m} \times \frac{(1+r_m)}{(1+r)} \times \beta(\Delta r, \Delta r_m) \quad (17)$$

The final term in (17) represents the sensitivity of changes in the expected return on the equity security to changes in the expected return on the market portfolio. There is a large body of empirical evidence documenting strong common shocks to expected equity returns [e.g., Campbell and Shiller (1988), Campbell and Mei (1993)]. Thus, we expect the final term to be positive and close to one for the typical equity security. Equation (17) indicates that the impact of common expected return volatility on holding period return volatility is increasing in the duration of the equity security relative to the duration of the market portfolio. Equation (17) forms the basis for our second prediction:

P2: Equity betas computed from holding-period returns are increasing in the duration of the equity relative to the duration of the market portfolio.

Tests of our second prediction build on evidence in Campbell and Mei (1993) and Cornell (1999). Campbell and Mei use a log-linear approximation of returns to estimate the proportion of the variation in beta attributable to common variation in cash flows versus common variation in expected returns. They find that the betas are largely attributed to common innovations in expected returns. Thus, their evidence implies that equation (17) should capture

an important determinant of beta. Cornell anticipates our second prediction by recognizing that Campbell and Mei's results imply that equity duration should be an important determinant of betas. He presents preliminary tests in this respect by correlating betas with earnings-to-price ratios, dividend-to-price ratios and growth forecasts. Cornell provides mixed and indirect evidence in support of *P2*. We build on Cornell's results by constructing more direct tests of *P2*.

Our second prediction rests on the assumption that some shocks to expected returns are common across securities. However, it does not necessarily rule out the case of idiosyncratic shocks to expected returns. For example, liquidity has been proposed as an important determinant of expected returns [e.g., Amihud and Mendelson (1983)]. Therefore, events having an impact on a firm's liquidity, such as changes in exchange listing, addition/removal from an index and the listing of derivative securities, may result in idiosyncratic shocks to expected returns. Denoting h_f and r_f as the firm-specific components of realized and expected returns respectively and substituting into (16) yields:

$$\sigma(h_f) \approx \frac{D}{1+r} \sigma(\Delta r_f) \quad (18)$$

from which we generate our third prediction:

P3: The standard deviation of the idiosyncratic component of realized holding-period returns is increasing in equity duration.

Our first three predictions concern associations between equity duration and common measures of volatility. Our remaining predictions concern the ability of equity duration to capture a unique common factor in stock returns. We estimate a factor related to duration using two alternative procedures. Our first procedure uses a straightforward regression approach that

attempts to directly estimate the common shocks to expected returns through cross-sectional regressions of holding period returns on duration:

$$h_{it} = \alpha_t + \gamma_t \frac{-D_{it}}{(1+r)} + \varepsilon_{it} \quad (19)$$

The model in (19) is estimated separately for each calendar month in our sample. Comparing equation (19) to equation (15), we see that if duration is estimated without error and shocks to expected returns are common across equities, then $\alpha_t=0$ and $\gamma_t=\Delta r_t$. The intuition behind this regression is that we can infer the common shock to expected returns by observing the differential holding period returns on stocks of differing durations. We make two predictions with respect to the γ estimates:

P4: The γ estimates from equation (19) are negatively correlated with the holding period returns on the market portfolio.

P5: The γ estimates from equation (19) are negatively correlated with the holding period returns on long duration bonds.

P4 follows directly from the observation that γ measures the change in the common expected return on equities. Increases in the expected return on equities should lead to reductions in equity prices and lower holding period returns on equities. Thus, we should observe a negative correlation between γ and the returns on the market portfolio. *P5* is more tenuous, since it requires commonality in the expected return shocks across stocks and bonds. If shocks to the risk free rate of return are a significant source of shocks to the expected returns on both stocks and bonds, then there should be a negative correlation between γ and long duration bond returns.

However, if shocks to expected returns on equities are largely attributable to shocks to the equity premium, then we will still find support for $P4$, but not necessarily $P5$.

Existing academic research has focused on three significant common factors in stock returns: a market factor, a factor related to firm size and a factor related to the book-to-market ratio [Fama and French 1993]. Our procedure for constructing a duration-related factor uses the Fama and French approach of constructing a mimicking portfolio for duration. That is, we take the difference between the monthly returns on stocks with high versus low durations. This relatively crude factor estimation procedure results in a loss of efficiency relative to the regression procedure. However, using this procedure allows us to directly compare our duration factor to the book-to-market factor created by Fama and French 1993. Recall from the previous section that the book-to-market ratio can be interpreted as a crude duration proxy. Our objective is to assess the relative ability of our measure of implied equity duration to capture a common factor in expected returns. Accordingly, we test the following two predictions:

P6: A mimicking portfolio for duration captures strong common variation in stock returns.

P7: A mimicking portfolio for duration subsumes a mimicking portfolio for book-to-market in capturing common variation in stock returns.

2. Data

Our sample includes all firms with available data from the NYSE, Amex and NASDAQ from 1963 through 1998. Financial statement data are obtained from the COMPUSTAT annual tapes. Earnings are measured using income before extraordinary items (annual data item #18). Market value of equity is calculated by multiplying price as of the fiscal year end (annual data item #199) with the number of shares outstanding as of the fiscal year end (data item #25). Book

value of common equity (BV) represents the par value of common stock, treasury stock, additional paid in capital and retained earnings as of the fiscal year end (annual data item #60). Observations with negative book value of equity are deleted from the sample. Sales growth is calculated as the one-year discrete growth rate in annual net sales (annual data item #12). Stock returns are drawn from the Center for Research on Securities Prices (CRSP) daily tape. We use the CRSP value-weighted index with dividends as our measure of the market return. The excess monthly market return is equal to the monthly market return less the one-month treasury bill rate.

We compute three measures of stock return volatility all using weekly holding period returns over a two-year period. First we compute the standard deviation of total monthly stock returns (σ), second we estimate a market model regression for each firm and use the beta (β), and third we use the market model regression residual standard deviation (σ_f). For each firm-year, we compute volatility using both historical and forward data. The historical estimates employ data from the two-year period ending at the end of the fiscal year from which we obtain our financial data. The forward estimates use data from the two-year period beginning at the end of the fiscal year from which we obtain our financial data.

To be included in our final sample, a firm must have non-missing values for all the required variables from COMPUSTAT and must have at least some of the required return data available on CRSP. This sample consists of 126,870 firm-year observations. Of these observations, data is available to compute at least one of the volatility metrics for 102,684 observations. We also winsorize the one-percent tails of each of the financial ratios computed using the COMPUSTAT data to reduce the influence of extreme outliers.

Finally, we obtain data on monthly percent long-term government bond returns from Ibbotson Associates. We construct our excess long-bond return series by subtracting the one-month Treasury bill rate, measured at the beginning of the month.

3. Results

3.1. Descriptive Statistics

Panel A of Table 3 reports univariate statistics on our implied equity duration variable. Implied equity duration has a mean of 15.1 years and a standard deviation of 4.1 years. The lower quartile value is 13.3 and the upper quartile value is 17.4. Thus, for most firms duration is somewhat below 19.3 years, the value of duration in the special case where no cash distributions are made in the finite forecast horizon. Most firms therefore distribute just a small proportion of the value represented by their stock price during the 10-year finite forecast period. However, the minimum value of duration is -16.8 years, indicating that there are exceptions. A negative value for duration requires that the present value of the cash flows over the finite forecast horizon exceed the market value of equity. One explanation for such a situation is that the stock is underpriced. An alternative explanation is that our forecasting model has incorrectly forecast that past profitability will continue into the future. At the other extreme, the maximum value of duration is 32.0 years. For duration to be so much greater than 19.3 years, the negative present value of the finite forecast period cash flows must be large relative to the market capitalization.

Panel B of Table 3 reports the correlations between implied equity duration and related financial variables. The correlations are generally strong and are consistently of the expected signs. Implied equity duration is strongly negatively correlated with book-to-market (Pearson= -0.67 ; Spearman= -0.73) and earnings-to-price (Pearson= -0.79 ; Spearman= -0.76). We also find

that implied equity duration is positively correlated with sales growth (Pearson=0.20; Spearman=0.19). Ceteris paribus, higher sales growth implies more near-term investment and longer duration. It is also noteworthy that the correlations between book-to-market and earnings-to-price (Pearson=0.57; Spearman=0.58) are lower than the respective correlations of each of these variables with duration. In other words, duration synthesizes common variation in book-to-market and earnings-to-price. Book-to-market, earnings-to-price and sales growth have all been proposed as empirical proxies for unidentified common risk factors in stock returns. The correlations in Table 3 are consistent with implied equity duration representing the underlying common factor represented by each of these variables.

[Table 3 here]

3.2. *Volatility Results*

The first three predictions outlined in Section 1.3 concern the relation between implied equity duration and stock return volatility. This section presents the results of tests of these predictions. We begin in Table 4 by providing evidence on the association between implied equity duration and historical stock return volatility. Table 5 then provides evidence on the ability of duration to forecast future stock return volatility.

Panel A of Table 4 presents correlations between our estimates of implied equity duration and estimates of the standard deviation of weekly stock returns. We also report correlations for related financial variables. Consistent with our first prediction, *PI*, implied equity duration has a strong positive correlation with stock return volatility (Pearson=0.19, Spearman=0.23). Book-to-market, earnings-to-price, sales growth and market capitalization also have significant correlations with stock return volatility. However, in the case of book-to-market, earnings-to-

price and sales growth, the correlations are much weaker than they are for implied duration. Moreover, the sign of the correlations for these variables are the same as the sign of their correlations with implied equity duration. The results for these variables are therefore consistent with them serving as noisy proxies for duration. For market capitalization, however, the correlations with stock return volatility are negative and the Spearman correlation, is stronger than the corresponding return for implied duration. The strong negative correlations for market capitalization cannot be explained by a duration proxy story, and are probably attributable to the greater cash flow volatility of smaller, less diversified firms.

Panels B and C of Table 4 look at the correlations between implied equity duration and the systematic and firm-specific components of volatility respectively. Consistent with *P2*, there is a strong positive correlation between relative duration and beta (Pearson=0.12; Spearman=0.19). The correlations for book-to-market, earnings-to-price and sales growth are somewhat weaker, and are of the same sign as their respective correlations with duration. The results for these variables are again consistent with them serving as noisy proxies for duration. In contrast, the sign of the correlations on market capitalization switches from negative to positive from panel A to panel B. Small firms have higher total volatility, while large firms have higher systematic volatility. This result is consistent with the higher return volatility of small firms arising from higher firm-specific volatility in their underlying cash flows.

Finally, Panel C reports the correlations for the firm-specific component of stock return volatility (σ_f). Consistent with *P3*, there is a strong positive correlation between implied duration and σ_f (Pearson=0.18; Spearman=0.22). Again, the correlations for book-to-market, earnings-to-price and sales growth are somewhat weaker. Finally, the correlations for market

capitalization are large and negative, confirming the conjecture that the higher return volatility of small firms arises from higher firm-specific cash flow volatility.

[Table 4 here]

Table 5 investigates the ability of implied equity duration to forecast future stock return volatility. We use the same measures of stock return volatility as Table 4, but the measures are now estimated using weekly stock returns in the two years following the computation of implied equity duration. Instead of reporting correlations, we report regressions of our volatility metrics on implied equity duration. This approach allows us to include lagged values of the volatility metrics as competing explanatory variables. For our estimates of implied equity duration to be useful from a forecasting perspective, they must have incremental explanatory power over lagged values of the volatility metrics. Panel A of Table 5 provides evidence of the hypothesized positive relation between implied equity duration and future stock return volatility. Panels B and C confirm that the positive relation extends to both the systematic and firm-specific components of return volatility. Finally, we find that the implied equity duration still loads with a significant positive coefficient when we include lagged values of the respective volatility metrics in the regressions. Thus, implied equity duration is incrementally useful in forecasting future stock return volatility and its components.

[Table 5 here]

In summary, we provide three key findings concerning the relation between implied equity duration and stock return volatility. First, we find strong evidence of the hypothesized positive relation between implied equity duration and stock return volatility. Second, we show that associations of book-to-market and earnings-to-price with stock return volatility is consistent

with these variables serving as noisy proxies for duration. Finally, we show that implied equity duration is incrementally useful over past stock return volatility in forecasting future stock return volatility.

3.3. *Common Factor Results*

In our next set of tests, we examine whether duration represents a significant common factor in stock returns. In section 1.3, we derived the following cross-sectional relation between monthly holding period returns and duration (see equation 19):

$$h_{it} = \alpha_t + \gamma_t \frac{-D_{it}}{(1+r)} + \varepsilon_{it}$$

The coefficient γ_t from these monthly cross-sectional regressions provides an estimate of the change in expected return (Δr) for month t . We predict that γ_t , our estimate of (Δr), will be negatively correlated with the excess monthly market return. Empirical estimation of this regression is subject to several specification issues. First, the relation is only approximate and not valid for large values of Δr (the convexity property described in footnote 2). This should not create a serious problem, since our estimation uses monthly data, and monthly changes in expected return are unlikely to be large enough to create serious violations of the linearity assumption. Second stock returns are also determined by cash flow shocks. This omitted variable has the potential to bias our γ_t estimates if cash flow shocks are correlated with expected return shocks. Third, there is an errors-in-variables problem arising from our use of empirical estimates for duration (D) and expected returns (r). This problem will cause the intercept in the regression to be positive and the slope to be biased toward zero, thus understating the magnitude

of the estimated changes in expected returns. We have no a priori reasons to expect that any of these specification issues will bias our empirical tests in favor of our predictions.

Panel A of Table 6 and Figure 1A report the distributional properties of our estimates of change in expected return on equities (Δr). The Δr estimates range from a low of -0.82% to a high of 1.51% . The low of -0.82% occurred in October of 1969, a month in which the market rose by over 5% . The high of 1.51% occurred in June of 1970, a month when the market fell by over 11% . During the best month for the market in our sample period (October 1974), the market rose by over 16% and Δr was less than -0.5% . Conversely, during the worst month for the market in our sample period (October 1987), the market fell by over 22% and Δr exceeded 0.5% . Thus, our analysis suggests that our lower bound estimates of Δr exhibit substantial temporal variation. Moreover, significant shocks to expected returns are associated with significant shocks to holding period returns of the opposite sign, consistent with the predictions of basic valuation theory. Figure 1A indicates that the distribution of Δr is right-skewed (skewness= 0.54) and highly leptokurtic (kurtosis= 5.04). It is well known that monthly market returns are left skewed and leptokurtic. Our results suggest that these properties in returns can be attributed, at least in part, to related properties in the distribution of shocks to expected returns.

[Table 6 and Figure 1 here]

$P4$ and $P5$ predict a negative correlation between Δr and both the market return and the excess long bond return. Panel B of Table 6 reports these correlations. For the market return, both the Pearson and Spearman correlations are strongly negative (-0.45 and -0.45 respectively) and support $P4$. Visual confirmation of the negative correlation between our estimates of Δr and the market return are provided in Figures 1B (monthly realizations) and 1C (12-month moving

averages). For the long bond return, however, the correlations are negative but are not statistically significant. This latter result is somewhat puzzling. One explanation for the result is that shocks to the risk-free component of expected equity returns are extremely small relative to shocks to the equity premium. However, the relatively strong correlation between the market return and the long-bond return is difficult to reconcile with this explanation. Alternatively, shocks to the risk-free rate may be correlated with shocks to short-term cash flows that are greater for short duration equities and hence confound the reported correlations.

We next test predictions *P6* and *P7*. For these tests we form a duration mimicking portfolio (HDMLD) by taking the difference between the returns on stocks with high duration and the returns on stocks with low duration each month in exactly the same manner as Fama and French (1993) use to calculate their book-to-market mimicking portfolio (HML). We also create a size factor (SMB) and a book-to-market factor (HML) using the exact procedures described in Fama and French (1993).⁶

Panel B of Table 6 compares the correlation of HDMLD with the market return and the excess bond return. Consistent with *P6*, HDMLD has a strong positive correlation with the market return. This correlation is stronger than either HML or SMB. However, Δr has the strongest correlation with the market return. This is consistent with Δr representing our most efficient estimate of the common factor in returns related to duration. As would be expected, Δr is highly negatively correlated with our mimicking portfolio for duration (Pearson=-0.73 and Spearman=-0.72) and positively correlated with the mimicking portfolio for book-to-market (Pearson=0.57, Spearman=0.57).

Panel C of table 6 provides tests of $P7$. Model 1 indicates that 14 percent of the variation in excess monthly market returns is explained by the SMB and HML mimicking factors. In models 2 and 3 we add duration-related factors (Δr and HDMLD). The results indicate that our duration factors subsume the explanatory power of HML. Both Δr and HDMLD load with a significant coefficient and the coefficient on HML falls close to zero and is no longer statistically significant. This is consistent with $P7$. The R^2 is highest (24 percent) when Δr is used as the duration factor (Model 2). This result is comforting, because the Δr estimates are derived from the underlying theoretical relation between duration and returns rather than an ad hoc mimicking factor. Overall, these results are consistent with book-to-market and its associated HML factor serving as noisy proxies for equity duration-related effects in stock returns. Our refined proxies for duration lead to significant improvements in explanatory power.

4. Conclusions

In this paper, we develop an expression for implied equity duration and provide a simple algorithm for its empirical estimation. We show that the standard empirical predictions and results for bond duration hold for our measure of equity duration and that equity duration represents an important common factor in stock returns. We document that stock return volatility and stock betas are both increasing in implied equity duration. We also show how empirical estimates of equity duration can be used to impute the common shocks to the expected equity returns.

Our results suggest that the book-to-market ratio provides a crude proxy for equity duration, and that the Fama and French (1993) book-to-market factor can be interpreted as a noisy duration factor. Fama and French 1995 present loose arguments to the effect that their

book-to-market factor captures a financial distress factor. We present a tighter set of arguments and empirical results indicating that a duration-related factor represents a more natural explanation. We also acknowledge that our cash flow forecasting model is crude. Improvements in the forecasting model should lead to improved measures of equity duration and more refined estimates of expected return shocks.

Finally, our measure of implied equity duration provides a natural and defensible ranking of stocks' style characteristics on the value/growth dimension that is popular among practitioners. Currently, index providers such as Standard and Poor's, Dow Jones and Russell compete to provide the 'best' indices of value and growth stocks.⁷ Yet their growth and value classifications are based on ad hoc reasoning and data-motivated statistical procedures. By combining information about expected growth, expected profitability and current stock price into a single and rigorously developed measure, implied equity duration provides an attractive alternative to the ad hoc measures of value and growth proposed by practitioners.

REFERENCES

- Amihud, Y. and H. Mendelson, 1986. Asset Pricing and the Bid-Ask Spread, *Journal of Financial Economics*. Vol 17, 223-260.
- Campbell, J. and J. Mei, 1993. Where Do Beta Come From? Asset Price Dynamics and the Sources of Systematic Risk, *The Review of Financial Studies*. Vol 6, 567-592.
- Campbell, J. and R. Shiller, 1988. Stock Prices, Earnings and Expected Dividends, *Journal of Finance*, Vol. 43, 661-677.
- Cornell, B., 1999. Risk, Duration, and Capital Budgeting: New Evidence on Some Old Questions, *Journal of Business*. Vol 72, 183-200.
- Fama, E.F. and K.R. French, 1992. The Cross-Section of Expected Stock Returns, *Journal of Finance* 47, 427-465.
- Fama, E.F. and K.R. French, 1993. Common Risk Factors in the Returns on Stocks and Bonds, *Journal of Finance* 33, 3-55.
- Fama, E.F. and K.R. French, 1995. Size and Book-to-Market Factors in Earnings and Returns, *Journal of Finance* 50. 131-155.
- Gould, J. B., and E. H. Sorensen, 1986. A Factor in Equity Pricing, *Journal of Portfolio Management*; New York; Fall 1986.
- Ibbotson Associates.Stocks, 1999. Bonds, Bills and Inflation Yearbook.
- Nissim, D. and S. H. Penman, 2001. Ratio Analysis and Equity Valuation: From Research to Practice, *Review of Accounting Studies* 6, 109-154.
- Penman, S. H., 1991. An Evaluation of Accounting Rate-of-Return, *Journal of Accounting, Auditing and Finance*, Vol 6. Spring 233-256.
- Stigler, G.J.. 1963. *Capital and Rates of Return in Manufacturing Industries*, Princeton University Press, Princeton, NJ.

TABLE 1
Summary of Financial Variables and Forecasting Parameters Used in the Estimation of Implied Equity Duration

Panel A: Financial Variables

Financial Variable	Compustat Definition
Book Value of Equity (BV)	Data Item 60
Earnings (E)	Data Item 18 = Income before extraordinary items
Sales (S)	Data Item 12
Market Capitalization	Data Item 199 x Data Item 25

Panel B. Forecasting Parameters

Forecasting Parameter	Value
Autocorrelation Coefficient for Return on Equity	0.57
Cost of Equity Capital	0.12
Autocorrelation Coefficient for Growth in Sales/Book Value	0.24
Long-Run Growth Rate in Sales/Book Value	0.06

The autocorrelation coefficients are based on pooled autoregressions for Return on Equity and Sales Growth using a sample of 139,404, observations over Compustat years 1950 to 1999. The Cost of Equity Capital and Long-Run Growth Rates are based on their long-run historical averages.

TABLE 2
Panel A: The Computation of Implied Equity Duration for Alaska Air Group and Amazon.com for 1999

Calculation of Implied Equity Duration for Alaska Air in 1999

Input data (\$millions, except percentages)	Forecasting Parameters											
Price (P_0)	685.90										Autocorr. Coeff. for ROE	57%
Lagged Book Value (B_{-1})	789.50										Cost of equity capital (r)	12%
Book Value (B_0)	930.70										Autocorr. Coeff. for Growth	24%
Growth rate ($(S_0 - S_{-1})/S_{-1}$)	9.70%										Long-Run Growth Rate	6%
Earnings (E_0)	134.20											

Forecast Model											
Time Period (t)	0	1	2	3	4	5	6	7	8	9	10
Growth Rate	9.70%	6.89%	6.21%	6.05%	6.01%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
ROE _t (E_t/B_{t-1})	17.00%	14.85%	13.62%	12.93%	12.53%	12.30%	12.17%	12.10%	12.06%	12.03%	12.02%
BV _t	930.70	994.81	1,056.62	1,120.55	1,187.92	1,259.23	1,334.80	1,414.89	1,499.78	1,589.77	1,685.15
$E_t = B_{t-1} * ROE_t$	134.20	138.20	135.53	136.57	140.38	146.12	153.27	161.48	170.57	180.45	191.06
$CF_t = B_{t-1} + E_t - BV_t$		74.09	73.72	72.64	73.01	74.81	77.70	81.39	85.68	90.46	95.67
PV(CF_t)		66.15	58.77	51.70	46.40	42.45	39.37	36.82	34.60	32.62	30.80
$t * PV(CF_t)$		66.15	117.54	155.10	185.59	212.25	236.20	257.72	276.84	293.60	308.04
$\Sigma(PV(CF_t))$		439.69	Terminal PV				246.21				
$\Sigma(t * PV(CF_t))$		2,109.04									
10 Year Duration		4.80	Terminal Duration				19.33				
10 Year Weight		0.64	Terminal Weight				0.36				
Implied Equity Duration		10.01 years									
Earnings-to-Price Approximation		3.03	Years								
Book-to-Market Approximation		5.76	Years								

TABLE 2 - continued
Panel B: The Computation of Implied Equity Duration for Alaska Air Group and Amazon.com for 1999

Calculation of Implied Equity Duration for Amazon.com in 1999

Input data (\$millions, except percentages)	Forecasting Parameters											
Price (P_0)	8,905.00										Autocorr. Coeff. for ROE	57%
Lagged Book Value (B_{-1})	138.75										Cost of equity capital (r)	12%
Book Value (B_0)	266.28										Autocorr. Coeff. for Growth	24%
Growth rate ($(S_0 - S_{-1})/S_{-1}$)	168.90%										Long-Run Growth Rate	6%
Earnings (E_0)	-719.97											

Forecast Model												
Time Period (t)	0	1	2	3	4	5	6	7	8	9	10	
Growth Rate	168.90%	45.10%	15.38%	8.25%	6.54%	6.13%	6.03%	6.01%	6.00%	6.00%	6.00%	
$ROE_t (E_t/B_{t-1})$	-518.90%	-290.61%	-160.49%	-86.32%	-44.04%	-19.94%	-6.21%	1.62%	6.08%	8.63%	10.08%	
BV_t	266.28	386.36	445.80	482.58	514.15	545.66	578.57	613.33	650.14	689.15	730.50	
$E_t = B_{t-1} * ROE_t$	(719.97)	(773.84)	(620.07)	(384.80)	(212.54)	(102.54)	(33.87)	9.38	37.32	56.09	69.45	
$CF_t = B_{t-1} + E_t - BV_t$		(893.92)	(679.50)	(421.59)	(244.10)	(134.06)	(66.78)	(25.38)	0.51	17.08	28.10	
$PV(CF_t)$		(798.14)	(541.69)	(300.08)	(155.13)	(76.07)	(33.83)	(11.48)	0.20	6.16	9.05	
$t * PV(CF_t)$		(798.14)	1,083.39)	(900.24)	(620.52)	(380.33)	(203.01)	(80.35)	1.63	55.44	90.48	
$\Sigma(PV(CF_t))$		-1,901.00		<i>Terminal PV</i>			10,806					
$\Sigma(t * PV(CF_t))$		-3,918.42										
10 Year Duration		2.06					<i>Terminal Duration</i>	19.33				
10 Year Weight		(0.21)					<i>Terminal Weight</i>	1.21				
Implied Equity Duration		23.02 years										
Earnings-to-Price Approximation		26.07 years										
Book-to-Market Approximation		19.03 years										

TABLE 3
Descriptive Statistics for Estimates of Implied Equity Duration (Duration) and Other Related Equity Security Characteristics

Panel A: Univariate Statistics

	Obs	Mean	Std. Dev.	Min.	Lower Quartile	Median	Upper Quartile	Max.
Duration	126870	15.13	4.09	-16.75	13.30	15.63	17.36	31.97
Book-to-Market	126870	0.86	0.73	0.02	0.38	0.67	1.11	7.58
Earnings-to-Price	102083	0.09	0.07	0.00	0.05	0.08	0.12	0.66
Sales Growth	126870	0.17	0.30	-0.69	0.01	0.12	0.26	1.00
Market Cap.	126870	749.35	3192.00	0.65	16.52	65.41	308.89	64261.30

Panel B: Correlations (Pearson above the diagonal, Spearman below the diagonal)

	Duration	Book-to-Market	Earnings-to-Price	Sales Growth	Market Cap.
Duration	-	-0.67	-0.79	0.20	0.08
Book-to-Market	-0.73	-	0.57	-0.22	-0.13
Earnings-to-Price	-0.76	0.58	-	-0.07	-0.11
Sales Growth	0.19	-0.27	-0.07	-	-0.01
Market Cap.	0.16	-0.37	-0.21	0.10	-

See Table 2 for the calculation of duration for fiscal year t . Book-to-Market is calculated as book value of equity divided by the market value of equity measured at the end of fiscal-year t . Earnings-to-Price is earnings divided by the market value of equity measured at the end of fiscal-year t . Sales Growth is calculated as $(Sales_t - Sales_{t-1}) / Sales_{t-1}$, where t is the current fiscal year. Market Capitalization (Market Cap.) is the market value of equity measured at the end of fiscal-year t .

TABLE 4
Correlation Between Equity Volatility and Implied Equity Duration, Book-to-Market, Earnings-to-Price, Sales Growth and Size.

Panel A: Volatility is the Standard Deviation of Weekly Stock Returns [σ]

	Duration	Book-to-market	Earnings-to-Price	Sales Growth	Market Cap.
Pearson Corr of σ with	0.19	-0.03	-0.04	0.08	-0.16
Spearman Corr of σ with	0.23	-0.09	-0.12	0.04	-0.49
Observations	102,684	102,684	83,155	102,684	102,684

Panel B: Volatility is the Stock Return Beta [β]

	Relative Duration	Book-to-market	Earnings-to-Price	Sales Growth	Market Cap.
Pearson Corr of β with	0.12	-0.10	-0.06	0.07	0.06
Spearman Corr of β with	0.19	-0.15	-0.09	0.08	0.18
Observations	102,684	102,684	83,155	102,684	102,684

Panel C: Volatility is the Standard Deviation of Firm-Specific Weekly Stock Returns [σ_f]

	Duration	Book-to-market	Earnings-to-Price	Sales Growth	Market Cap.
Pearson Corr of σ_f with	0.18	-0.02	-0.03	0.07	-0.16
Spearman Corr of σ_f with	0.22	-0.07	-0.12	0.03	-0.54
Observations	102,684	102,684	83,155	102,684	102,684

Relative Duration for firm i in year t is calculated as $\text{Duration}_{it}/(\text{Market Duration}_t)$. Market Duration is the value-weighted average of all firms with a measure of duration in fiscal year t . See Table 2 for the calculation of duration for firm i in fiscal year t . Book-to-Market is calculated as book value of equity divided by the market value of equity measured at the end of fiscal-year t . Earnings-to-Price is earnings divided by the market value of equity measured at the end of fiscal-year t . Sales Growth is calculated as $(\text{Sales}_t - \text{Sales}_{t-1}) / \text{Sales}_{t-1}$, where t is the current fiscal year. Market Capitalization (Market Cap.) is the market value of equity measured at the end of fiscal-year t .

β for firm i for fiscal year t is estimated via a market model regression. The regression is run using weekly returns for a period of two years ending at the end of the fiscal year from which we obtain the data to compute each of the financial ratios. The standard deviation of stock returns [σ] is the standard deviation of the weekly returns calculated over the same two-year period. The standard deviation of firm-specific stock returns [σ_f] is the standard deviation of the residuals from the market model regression.

All correlations are significant at the 0.0001 level.

TABLE 5
Forecasting Ability of Implied Equity Duration with Respect to Equity Security
Volatility

Model 1: Volatility(t+1) = α + δ Duration(t)

Model 2: Volatility(t+1) = α + δ Duration(t) + χ Volatility(t)

Panel A: Volatility is Standard Deviation of Stock Returns [σ]				
	Intercept	Duration	Volatility(t)	Adj. R ²
Model 1				
Coefficient	0.039	0.002		0.04
Standard Error	0.000	0.000		
t-statistic	95.39	60.15		
 Model 2				
Coefficient	0.009	0.001	0.662	0.46
Standard Error	0.000	0.000	0.003	
t-statistic	26.91	34.08	236.85	

Panel B: Volatility is Stock Return Beta [β]				
	Intercept	Relative Duration	Volatility(t)	Adj. R ²
Model 1				
Coefficient	0.580	0.3177		0.02
Standard Error	0.008	0.008		
t-statistic	71.76	40.35		
 Model 2				
Coefficient	0.329	0.197	0.39	0.19
Standard Error	0.008	0.008	0.00	
t-statistic	41.21	25.85	120.80	

Panel C: Volatility is Standard Deviation of Firm-Specific Stock Returns [σ_f]				
	Intercept	Duration	Volatility(t)	Adj. R ²
Model 1				
Coefficient	0.036	0.002		0.04
Standard Error	0.000	0.000		
t-statistic	80.18	54.91		
 Model 2				
Coefficient	0.009	0.001	0.649	0.41
Standard Error	0.000	0.000	0.003	
t-statistic	23.12	30.82	215.28	

The number of observations in the Model 1 regressions is 83,785 and in Model 2 regression is 71,491. Relative Duration for firm i in year t is calculated as $\text{Duration}_{it}/(\text{Market Duration}_t)$. Market Duration is the value-weighted average of all firms with a measure of duration in fiscal year t . See Table 2 for the calculation of duration for firm i in fiscal year t .

β for firm i for fiscal year t is estimated via a market model regression. The regression is run using weekly returns for a period of two years starting following the year from which we obtain the data to compute each of the financial ratios. The standard deviation of stock returns $[\sigma]$ is the standard deviation of the weekly returns calculated over the same two-year period. The standard deviation of firm-specific stock returns $[\sigma_f]$ is the standard deviation of the residuals from the market model regression.

All correlations are significant at the 0.0001 level.

TABLE 6
Relation between estimated changes in expected returns (Δr), market returns and other common factors in stock returns.

Panel A: Univariate Statistics								
	Obs.	Mean	Std. Dev.	Min	Low	Median	Upper	Max
Excess Market Return (RM-RF)	420	.53	4.30	-22.82	-1.95	.72	3.28	16.00
Excess Long Bond Return (TERM)	420	.11	3.02	-8.69	-1.63	-.02	1.82	12.02
Change in Expected Return (Δr)	420	.05	.23	-.82	-.06	.05	.18	1.51
Duration Factor (HDMLD)	420	-.50	2.61	-8.69	-2.01	-.56	1.01	9.96
Size Factor (SMB)	420	.27	2.81	-10.01	-1.42	.09	1.98	9.06
Book-to-market Factor (HML)	420	.41	3.17	-14.22	-2.39	-.58	1.34	16.50
Panel B: Correlations (Pearson above the diagonal, Spearman below the diagonal)								
	RM-RF	TERM	Δr	HDMLD	SMB	HML		
RM-RF	-	0.33 (0.0001)	-0.45 (0.0001)	0.35 (0.0001)	0.31 (0.0001)	-0.24 (0.0001)		
TERM	0.36 (0.0001)	-	-0.08 (0.1155)	0.01 (0.7888)	-0.12 (0.0119)	-0.02 (0.6531)		
Δr	-0.45 (0.0001)	-0.06 (0.2000)	-	-0.73 (0.0001)	-0.28 (0.0001)	0.57 (0.0001)		
HDMLD	0.33 (0.0001)	0.01 (0.9428)	-0.72 (0.0001)	-	0.17 (0.0001)	-0.77 (0.0004)		
SMB	0.25 (0.0001)	-0.10 (0.0177)	-0.25 (0.0001)	0.18 (0.0001)	-	-0.05 (0.0001)		
HML	-0.26 (0.0001)	-0.06 (0.2019)	0.57 (0.0001)	-0.76 (0.0001)	-0.12 (0.0137)	-		

Panel C: Regressions of the excess market return (RM-RF) on common factors

	Intercept	Δr	HDMLD	SMB	HML	Adj. R ²
Model 1						
Coefficient	0.003			0.456	-0.306	0.142
Standard Error	0.002			0.069	0.061	
T-statistic	1.46			6.57	-4.98	
Model 2						
Coefficient	0.009	-7.409		0.299	-0.008	0.237
Standard Error	0.002	1.019		0.068	0.071	
T-statistic	4.53	-7.27		4.34	-0.11	
Model 3						
Coefficient	0.007		0.545	0.387	0.038	0.182
Standard Error	0.002		0.118	0.069	0.096	
T-statistic	3.42		4.63	5.58	0.40	

The common factors are the market return, long-term bond return, change in expected return, duration, size, and book-to-market. In Panel B Pearson Correlation Coefficients are reported in the upper right diagonals and Spearman Correlation Coefficients in the lower left diagonal (p-values in parentheses). The time period is from July 1964 to December 1999 and consists of 420 months. The excess long-bond return (TERM) is computed as the difference between the long-run government bond return and the one-month Treasury bill return. The excess market return (RM-RF) is computed as the difference between the CRSP value-weighted index monthly return and the one-month Treasury bill return. The change in the expected return (Δr) is the estimate of γ from cross

sectional regressions of the form:
$$h_{it} = \alpha_i + \gamma_i \frac{-D_{it}}{(1+r)} + \varepsilon_{it}.$$

SMB (small minus big), the return on the mimicking portfolio for the common size factor in stock returns, is the difference each month between the simple average of the percent returns on the three small-stock portfolios (*S/L*, *S/M*, and *S/H*) and the simple average of the returns on the three big-stock portfolios (*B/L*, *B/M*, and *B/H*). *HML* (high minus low), the return on the mimicking portfolio for the common book-to-market equity factor in returns, is the difference each month between the simple average of the returns on the two high-*BE/ME* portfolios (*S/H* and *B/H*) and the average of the returns on the two low-*BE/ME* portfolios (*S/L* and *B/L*). *HDMLD* (high minus low), the return on the mimicking portfolio for the duration factor in returns, is the difference each month between the simple average of the returns on the two high-*duration* portfolios (*S/HD* and *B/HD*) and the average of the returns on the two low-*duration* portfolios (*S/LD* and *B/LD*).

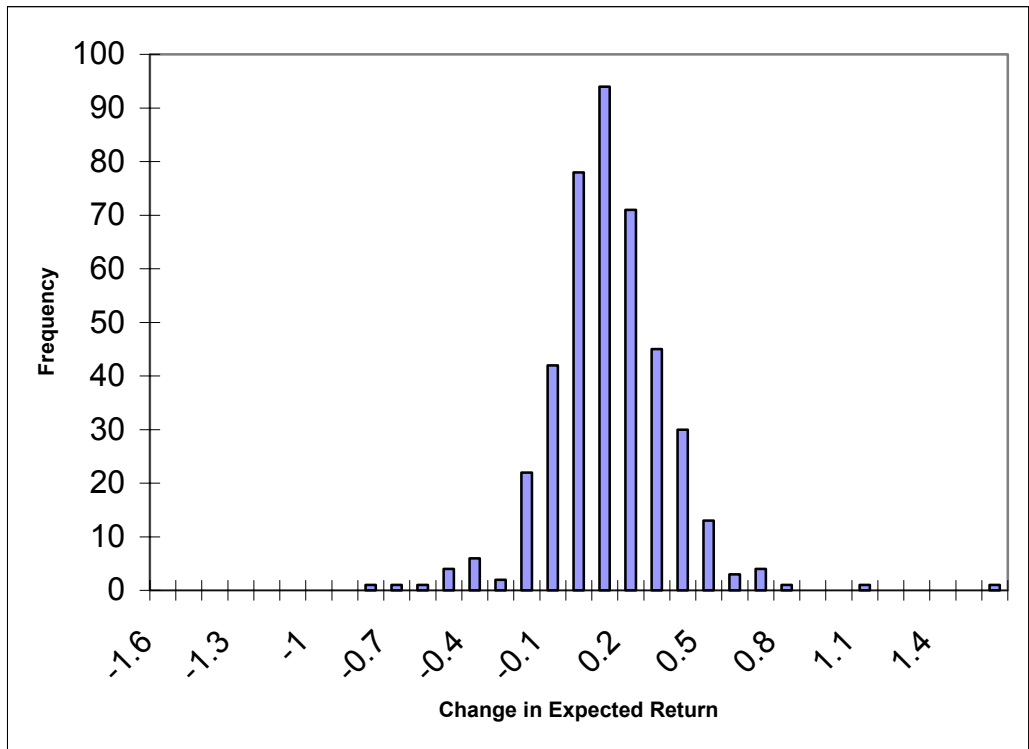


Figure 1A - Histogram of Monthly Estimates of Change in Expected Return. The Figure is a graphical Illustration of Monthly Estimates of the Change in Expected Return (Δr) where the change in expected return is the γ coefficient from the regression: $h_{it} = \alpha_t + \gamma_t \frac{-D_{it}}{(1+r)} + \varepsilon_{it}$.

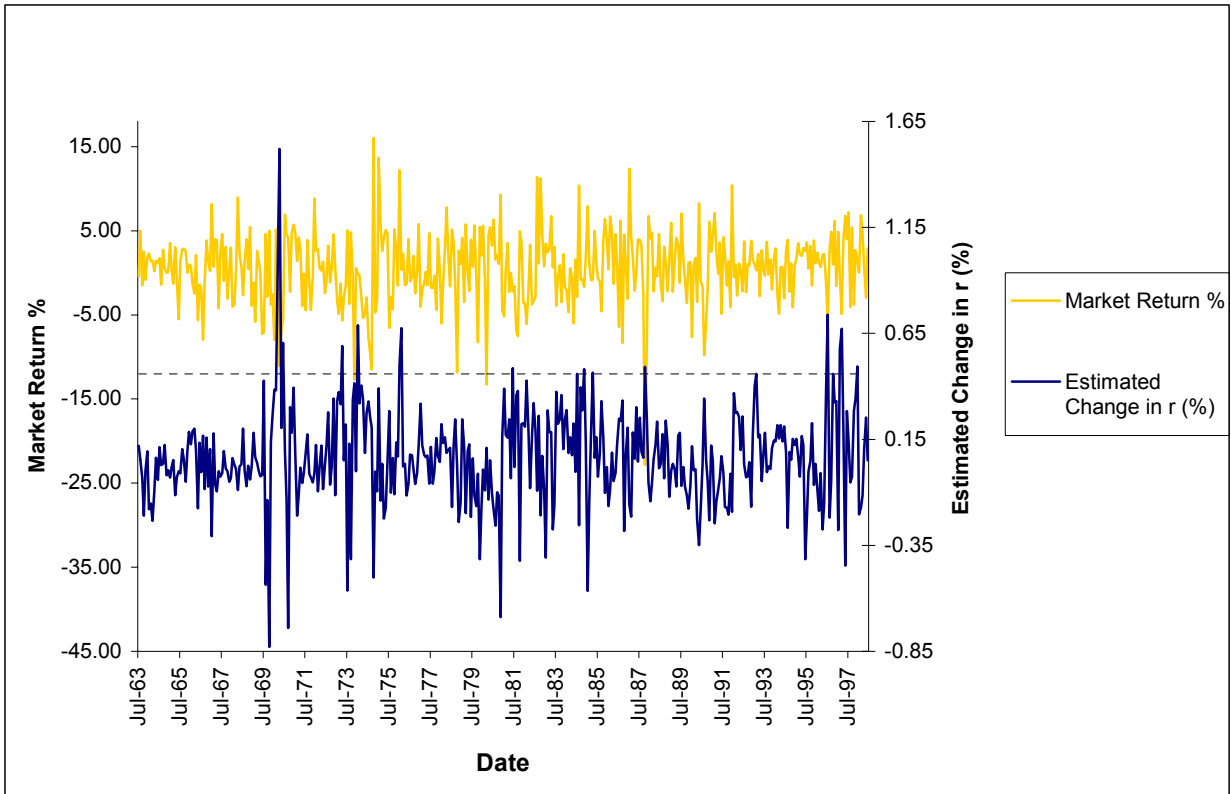


Figure 1B - Monthly Data for the Market Return and the Estimated Change in Expected Return.

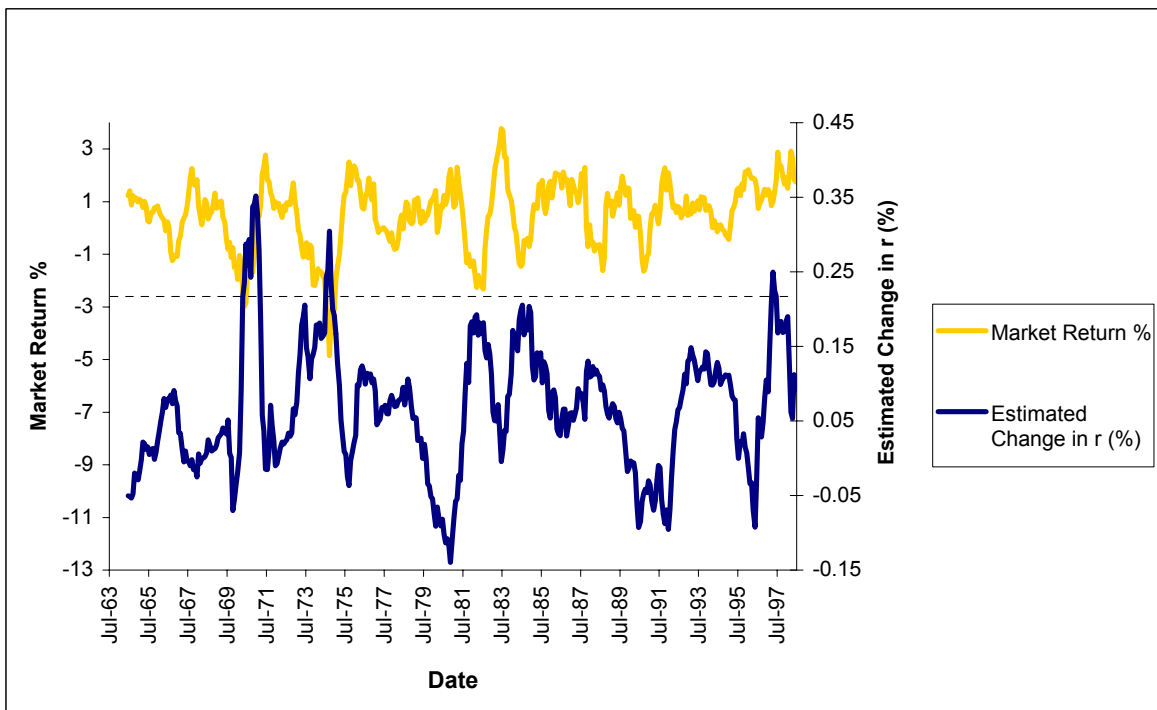


Figure 1C - Twelve Month Moving Average Monthly Data for the Market Return and the Estimated Change in Expected Return

Endnotes:

¹ Cornell (1999) recognizes the role of duration as a measure of equity risk and provides some preliminary evidence of its importance by documenting a negative relation between dividend yields and betas. Gould and Sorensen (1986) also argue that duration is an important source of risk in high earnings growth firms.

² This linear relation is an approximation based on a one-term Taylor series expansion of a bond's price as a function of its yield, divided by its price. The Taylor series can be used to approximate the bond price to any level of accuracy. The two-term series expansion incorporates convexity (the second derivative, $\partial^2 P / \partial r^2$).

³ This identity requires the "clean surplus" assumption: the book value of equity only increases with earnings and equity issuances and decreases through payment of dividends or repurchases of stock. In practice, there are some minor violations of this relation such as foreign currency translation adjustments and unrealized gains and losses on marketable securities. These violations are not expected to introduce any systematic biases.

⁴ Sales growth rates for US equities have averaged around 10% over the past 40 years [see Nissim and Penman 2001]. This period, however, has been one of unprecedented growth for US equity markets, and the long-run macroeconomic growth rate provides a more plausible ex ante estimate of long-run sales growth.

⁵ We also replicated our results using a cost of equity capital ranging from 8% to 18%. A lower (higher) cost of capital increases (decreases) the average duration of the entire sample, but has little impact on the relative rankings of duration across securities. As a result, all of our key results are robust with respect to changing the cost of equity.

⁶ Our timing conventions for computing portfolio returns follow those in Fama and French (1993). If we are computing returns for portfolios formed on financial data from year t-1, then we compute monthly holding period returns from July of year t through June of year t + 1. We compute excess returns for each of our stock portfolios by subtracting the one-month Treasury bill rate, measured at the beginning of the month. Six portfolios are formed from sorts on size and book-to-market. Two size groupings (S and B) are formed around the NYSE median and three book-to-market groupings (L, M and H) are formed around the NYSE 30th and 70th percentiles. Six value-weighted portfolios are constructed from the intersection of these groupings (S/L, S/M, S/H, B/L, B/M, B/H). The mimicking factor for size (SMB) is constructed by taking the difference, each month, between the simple average of the returns on the three small-stock portfolios and the three big-stock portfolios. Similarly, the mimicking factor for book-to-market (HML) is the difference, each month, between the simple average of the returns on the two high-book-to-market portfolios and the two low-book-to-market portfolios. For HDMLD we form three duration groupings (LD, MD and HD) are formed around the NYSE 30th and 70th percentiles. Six value-weighted portfolios are constructed from the intersection of two size groups and the three duration groups (S/LD, S/MD, S/HD, B/LD, B/MD, B/HD). The mimicking factor for duration (HDMLD) is the difference, each month, between the simple average of the returns on the two high duration portfolios and the two low duration portfolios.

⁷ Standard and Poor's uses the BARRA classification of value versus growth, which is based on book-to-market. Dow Jones and Russell use more complex measures that combine more than one indicator of value and growth. A comparison of the alternative approaches is provided at http://208.198.167.32/dj_style/index.html.