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DOES RISK OR MISPRICING EXPLAIN THE CROSS-SECTION OF STOCK PRICES?

Randolph B. Cohen
Harvard Business School
Boston, MA 02163, USA

Christopher Polk
Kellogg School of Management, Northwestern University
Evanston, IL 60208, USA

Tuomo Vuolteenaho*
Harvard University and the NBER
Cambridge, MA 02138, USA

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* Corresponding author: Tuomo Vuolteenaho; mailing address: Harvard University Department of Economics, Littauer Center 312, 1875 Cambridge Street, MA 02138-3001, USA; phone: +1 617 496 6284; fax: +1 617 495 8570; email: t_vuolteenaho@harvard.edu. We would like to thank Ken French for providing us with some of the data used in this study. We are grateful to John Campbell, Josh Coval, Kent Daniel, Gene Fama, Ken French, Matti Keloharju, Owen Lamont, and Jeremy Stein for their comments and suggestions. We would also like to thank seminar participants at the Harvard University Economics Department junior faculty lunch and the Tuck School.

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Abstract

Most previous research evaluates market efficiency and asset pricing models using average abnormal trading profits on dynamic trading strategies. We measure the ability of the capital asset pricing model (CAPM) and the efficient-market hypothesis to explain the level of stock prices. First, we find that cash-flow betas (measured by regressing firms' ROEs on the market's ROE) explain the prices of value and growth stocks well, with a plausible premium. Second, we use a present-value model to decompose the cross-sectional variance of firms' price-to-book ratios into two components due to risk-adjusted fundamental value and mispricing. When we allow the discount rates to vary as predicted by the CAPM, the variance share of mispricing is negligible.

Keywords: stock prices, present value, book-to-market, variance decomposition, capital asset pricing model, beta, expected returns, return on equity

JEL classification codes: G120, G140

Most previous research uses average abnormal trading profits on dynamic trading strategies to test market efficiency and asset pricing models. The joint hypothesis of the capital asset pricing model (CAPM) and market efficiencies is typically rejected by these tests. The economic significance of these rejections is usually evaluated based on Sharpe ratios (average return over return standard deviation) of zero-investment strategies that do not expose the investor to systematic risks. The discovery of economically high Sharpe ratios has lead many to reject the CAPM and efficient-market hypothesis (EMH) as a good approximate description of the stock market.[1]

We argue that asset pricing models and market efficiency should be evaluated by their ability to explain stock price levels, not by their ability to explain the average returns on frequently-rebalanced dynamic trading strategies. The price-level criterion is superior to the Sharpe-ratio criterion for the following reasons. First, although available Sharpe ratios are clearly the main object of interest to a professional money manager, the level of price is more relevant to most other economic decision makers. For example, a corporate manager making a large long-term investment decision cannot engage in a dynamic trading strategy of investing or divesting a small fraction every month, depending on stock market conditions. Thus, if the price is approximately "right," the impact of the stock market to his/her investment decisions is also likely to be consistent with market efficiency, and the high available Sharpe ratios only an interesting side show.

Second, tests of market efficiency that are based on trading profits typically use high-frequency return covariances or betas to adjust for risk. Although such a practice is consistent with jointly testing a sharp null hypothesis of an asset pricing model and market efficiency, it is less appropriate for measuring the impact of mispricing on average returns or prices. If markets are even slightly inefficient, mispricing may contaminate not only the average returns but also the measures of risk. The price-level tests we advocate connect stock prices to covariances or betas of cash flows. Regressing prices on cash-flow betas is a cleaner way to measure a model's explanatory power than regressing average returns on return betas, because the cash-flow betas are less affected by mispricing.

We test empirically the ability of the CAPM and EMH to explain the stock-price levels of low-price-to-book "value" stocks and high-price-to-book "growth" stocks. Our empirical tests concentrate on price-to-book-sorted portfolios for the following reasons. First, the average returns generated by value-minus-growth strategies (that buy value and short growth stocks) cannot be explained by CAPM betas measured from high-frequency returns (Rosenberg, Reid, and Lanstein (1985), Fama and French (1992), and others). Furthermore, the pricing errors are highly economically significant when the Sharpe-ratio criterion is used as the metric of economic significance (MacKinlay (1995)). Second, Fama and French (1995) and Cohen, Polk, and Vuolteenaho (2002) show that a firm's price-to-book ratio is a persistent variable that forecasts the returns on the firm's stock far in the future and that the return predictability related to price-to-book ratios has a large price-level effect. Thus, price-to-book-sorted portfolios have the potential of being significantly mispriced by the price-level criterion as well.

Our empirical results suggest that mispricing relative to the CAPM is not an important factor in determining the prices of value and growth stocks. Cash-flow betas (measured by regressing firms' log ROEs on the market's log ROE) essentially explain the prices of and long-horizon returns on price-to-book-sorted portfolios, with a premium that is high but not implausible. In addition to traditional regressions of prices and long-horizon average returns on betas, we specify a stochastic-discount-factor present-value model that links firms' current price-to-book ratios to expected future cash flows and to covariances of future cash flows with the stochastic discount factor. If we restrict discount rates to be constant across firms, our present-value model allocates more than 25 percent of the cross-sectional price-to-book variance to mispricing. However, if we allow the discount rates to vary as predicted by the CAPM and measure risk as cash-flow covariances, the variance share of mispricing is reduced to near zero. The share of mispricing is reduced, because our present-value model detects more systematic risk in value firms' future cash flows than in growth firms'.

Previous results by Fama and French (1992, 1993, 1996), Lakonishok, Shleifer, and Vishny (1994), and others suggest that value stocks have lower, not higher, CAPM betas than growth stocks. We thus expect the above seemingly contradictory results obtained with our ROE regressions and stochastic-discount-factor methodology to be treated with healthy skepticism. To reconcile our results with those in the previous literature, we examine the long-run and short-run behavior of the average returns on and stock-return betas of price-to-book-sorted portfolios.

We form ten equal-weight portfolios by combining the same-rank value-weight deciles from N different sorts on t-1 to t-N price-to-book ratios. Much as in event studies that use the calendar-time methodology, these portfolios approximate the N-year investor experience of investing in value and growth stocks, and can be used as test assets in standard Black-Jensen-Scholes (1972) or Gibbons-Ross-Shanken (1989) time-series asset-pricing tests.

Consistent with the results of Fama and French (1992, 1993, 1996) and Lakonishok, Shleifer, and Vishny (1994), we find that growth stocks have higher CAPM betas than value stocks during the first year after portfolio formation. Because the betas of these portfolios are negatively related to their expected returns, the CAPM fails to explain the returns of value and growth stocks during the first year subsequent to portfolio formation.

Our novel finding is that value stocks' betas sharply increase and growth stocks' betas sharply decrease after portfolio formation. Within five years from portfolio formation, value stocks' (three lowest price-to-book deciles) betas have increased to approximately 1.0 and growth stocks' (three highest price-to-book deciles) betas have declined to approximately 0.9. Our tests detect continuation of this trend for fifteen years after the sort. Thus, the lower long-run risk of growth stocks that is detected from cash flows by our ROE regressions and present-value model can also be detected from long-horizon stock returns.

Are these changes in betas sufficient to explain the substantial long-run return spread, as our present-value model suggests? An answer from a return-based asset-pricing test is yes. Consistent with our present-value model's results, the CAPM (with betas measured from stock returns over a long horizon) explains an awe-inspiring 70 percent of the substantial variation in average returns at the fifteen-year investment horizon. Furthermore, this R^2 is obtained with a reasonable beta premium estimate of 9.4 percent per year.

Our finding that the CAPM in conjunction with market efficiency provides a good approximate description of the level of stock prices has important implications. For example, our results justify corporations' current use of the CAPM in capital budgeting, as most long-term investment decisions depend upon the level of net present value instead of near-term expected returns.[2] Similarly, the higher long-run risk of value stocks also explains why low-priced value stocks are not immediately acquired by healthier companies, or bought out by a sophisticated buy-and-hold investor, such as Berkshire Hathaway or an LBO fund.

These findings also rationalize an apparent contradiction in MBA curriculums: Investment courses teach that beta is dead, and then corporate finance classes proceed to use the CAPM in firm or project valuation. Our price-level results justify this distinction – the CAPM fails to explain the one-period expected returns on some dynamic trading strategies but gets stock prices and expected long-term returns approximately right. Researchers should likewise resentence beta from death row to probation in those analyses where firms' stock prices (rather than returns on trading strategies) are the objects of interest.

The remainder of the paper is organized as follows. Section I describes the data. Section II links cash-flow betas to price-to-book ratios. Section III uses a present-value formula to test the CAPM's ability to explain the cross-section of price-to-book ratios. Section IV presents portfolio-return evidence. Section V concludes.

I. Data

The basic U.S. data come from the merger of three databases. The first one of these, the Center for Research in Securities Prices (CRSP) monthly stock file, contains monthly prices, shares outstanding, dividends, and returns for NYSE, AMEX, and NASDAQ stocks. The second database, the COMPUSTAT annual research file, contains the relevant accounting information for most publicly traded U.S. stocks. The COMPUSTAT accounting information is supplemented by the third database, Moody's book equity information collected by Davis, Fama, and French (2000).[3] The basic merged data cover the period 1928-2000. In the merged data set, the panel contains 208,804 firm-years. Table I shows descriptive statistics of the data.

Detailed data definitions are the following. Book equity is defined as stockholders' equity, plus balance sheet deferred taxes (COMPUSTAT data item 74) and investment tax credit (data item 208) (if available), plus post-retirement benefit liabilities (data item 330) (if available) minus the book value of preferred stock. Depending on availability, we use redemption (data item 56), liquidation (data item 10), or par value (data item 130) (in that order) for the book value of preferred stock. We calculate stockholders' equity used in the above formula as follows. We prefer the stockholders' equity number reported by Moody's, or COMPUSTAT (data item 216). If neither one is available, we measure stockholders' equity as the book value of common equity (data item 60) plus the par value of preferred stock. (Note that the preferred stock is added at this stage because it is later subtracted in the book equity formula.) If common equity is not available, we compute stockholders' equity as the book value of assets (data item 6) minus total liabilities (data item 181), all from COMPUSTAT.

The price-to-book ratio used to form portfolios in May of year *t* is book common equity for the fiscal year ending in calendar year *t*-1, divided by market equity at the end of May of year *t*. We require the firm to have a valid past price-to-book ratio. Moreover, in order to eliminate likely data errors, we discard those firms with price-to-book ratio less than 0.01 and greater than 100. When using COMPUSTAT as our source of accounting information, we require that the firm must be on COMPUSTAT for two years. This requirement avoids potential survivor bias due to COMPUSTAT backfilling data. After imposing these data requirements, the cumulative number of firms sorted into portfolios is 165,945. The annual panel spans the period 1928-1999; note that in our timing convention, the 1928 data is computed by using book values from end of 1927 and returns through May 1929.

After portfolio formation, we follow the portfolios for fifteen years while holding the portfolio definitions constant. Because we perform a new sort every year, our final annual data set is three dimensional: the number of portfolios formed in each sort times the number of years we follow the portfolios times the time dimension of our panel.

Missing data are treated as follows. If a stock was included in a portfolio but its book equity is temporarily unavailable at the end of some future year *t*, we assume that the firm's book-to-market ratio has not changed from *t*-1 and compute the book-equity proxy from the last period's book-to-market and this period's market equity. We treat negative or zero book-equity values as missing. We then use this book-equity figure in computing clean-surplus earnings. We follow standard practice and substitute zeros for CRSP missing returns, as long as the firm is not delisted. For market equity, we use the latest available figure.

We deal with delisting firms as follows. First, we compute the stock return, profitability, and the exit price-to-book ratio for the firm at the end of its delisting year. We use delisting data, when available on the CRSP tapes, in computing the stock returns and the exit market value. In some cases, CRSP records delisting prices several months after the security ceases trading and thus after a period of missing returns. In these cases, we calculate the total return from the last available price to the delisting price and pro-rate this return over the intervening months. If a firm is delisted but the delisting return is missing, we investigate the reason for disappearance. If the delisting is performance-related, we assume a -30 percent delisting return.[4] Otherwise, we assume a zero delisting return.

Second, we take the delisting market value of the firm and invest it in another firm that was originally sorted into the same portfolio as the disappearing firm. Among the firms in the same portfolio, we pick the one that has a current price-to-book ratio closest to the exit price-to-book ratio of the disappearing firm.

II. Do cash-flow betas explain stock-price levels?

Previous research finds that CAPM betas have essentially no explanatory power with respect to average returns on annually rebalanced value-minus-growth strategies, if betas are measured from high-frequency stock returns. In this section, we measure CAPM betas from firms' cash flows and find that these cash-flow betas largely explain the prices of and long-run average returns on value and growth stocks.

We define the cash-flow beta as the regression coefficient of a firm's discounted log ROE on the market portfolio's discounted log ROE:

$$\sum_{j=0}^{N-1} \rho^j \log(1 + ROE_{k,t+j}) = \beta_{k,0}^{CF} + \beta_{k,1}^{CF} \sum_{j=0}^{N-1} \rho^j \log(1 + ROE_{M,t+j}) + \varepsilon_{k,t+N-1} \tag{1}$$

Above, ROE denotes the ratio of clean-surplus earnings ($X_t = BE_t - BE_{t-1} + D_t^{gross}$) to beginning-of-the-period book equity (BE_{t-1}), with subscript k corresponding to the firm or portfolio under scrutiny and subscript M to the market portfolio. D_t^{gross} is gross dividends computed from the difference between CRSP returns and returns excluding dividends. ρ is a constant related to one minus the average dividend yield. We follow Cohen, Polk, and Vuolteenaho (2002) and set ρ to 0.96 in our regressions.

This measure of cash-flow risk can be motivated with the price-to-book decomposition used by Vuolteenaho (2001) and Cohen, Polk, and Vuolteenaho (2002). This decomposition shows that, to a very close approximation,

$$\log\left(\frac{ME_{t-1}}{BE_{t-1}}\right) = \sum_{j=0}^{\infty} \rho^j \log(1 + ROE_{t+j}) - \sum_{j=0}^{\infty} \rho^j \log R_{t+j} \,. \tag{2}$$

Above, ME/BE denotes the price-to-book ratio and R the (gross) return on a firm's stock.

Over an infinite horizon, the unexpected realizations of the first (ROE) term are equal to the unexpected realizations of the second (stock-return) term for every sample path. Thus measuring the risk from either infinite-horizon discounted log returns or profitabilities will necessarily yield the same result. However, if the sums in (2) are evaluated over a finite horizon, the covariances of the first and second term with a risk factor may be different. Furthermore, if the stock market is potentially inefficient, mispricing may contaminate not only the average returns but also short-horizon return covariances. Thus, measuring risks from the cash-flow term of (2) instead of the return term may result in a cleaner risk measure.

When measuring the cash-flow betas of price-to-book-sorted portfolios, it is important to specify the regressions in logs. This is because the book-equity data are contaminated with measurement error that affects the ROE levels, and the sort disproportionately selects negative-measurement-error firms to the high-price-to-book portfolio and positive-measurement-error firms to the low-price-to-book portfolio. Consider the case where book-equity data are contaminated with constant measurement errors. If the regression (1) is run in levels, the covariances are deflated by one plus the percentage measurement error (e / BE_{t-1}^{true}):

$$\begin{aligned} \operatorname{cov}_{t-1}(1 + X_t / BE_{t-1}^{measured}, F_t) &= \operatorname{cov}_{t-1}[1 + X_t /(BE_{t-1}^{true} + e), F_t] \\ &= (1 + e / BE_{t-1}^{true})^{-1} \operatorname{cov}_{t-1}[X_t / BE_{t-1}^{true}, F_t] \end{aligned} \tag{3}$$

This problem is mitigated if the regression (1) is run in logs, because

$$\operatorname{cov}_{t-1}\left[\log\left(1 + \frac{X_t}{BE_{t-1}^{measured}}\right), F_t\right] \approx \operatorname{cov}_{t-1}\left[\log\left(1 + \frac{X_t}{BE_{t-1}^{true}}\right), F_t\right]. \tag{4}$$

The approximation in equation (4) is accurate, if the product $(e / BE_{t-1}^{true})(X_t / BE_{t-1}^{true})$ is small.

Table II measures the cash-flow betas for ten price-to-book-sorted portfolios. The columns one to eleven correspond to price-to-book-sorted portfolios and rows to selected horizons *N*. The regressions are estimated from overlapping observations using OLS. We use Newey-West (1987) standard-error formulas that correct for the cross-sectional and time dependence of the residuals.

The first row of Table II shows the one-year cash-flow betas of value and growth stocks immediately after the sort. Apart from the highest price-to-book decile, the cash-flow betas of the stocks in our sample line up nicely with their price-to-book ratios: The second-highest price-to-book decile has a cash-flow beta of 0.85 and the lowest price-to-book decile a cash-flow beta of 1.35. The highest price-to-book decile has a cash-flow beta of 1.00, which is slightly higher than expected.

Moving down the rows of Table II and increasing the horizon to five years further strengthens the results. The highest price-to-book portfolio now has the lowest cash-flow beta and the lowest price-to-book portfolio the highest cash-flow beta for all horizons from two to fifteen years. The differences are economically significant: Five-year cash-flow beta of the extreme decile of growth stocks is 0.69 and that of the extreme decile of value stocks is 1.67. The mean reversion in covariances attenuates this difference in betas at the ten and fifteen-year horizons, but the spread remains economically significant (0.89 vs. 1.47 and 0.95 vs. 1.24, respectively).

Table II also measures how well the cash-flow betas explain the prices of value and growth stocks. The dependent variable in the pricing regressions is the average *N*-period discounted stock return and the independent variable the estimated cash-flow beta:

$$\frac{1}{\sum_{j=0}^{N-1}\rho^j}\hat{E}\left[\sum_{j=0}^{N-1}\rho^j(R_{k,t+j,j+1}-1)\right]=\lambda_0+\lambda_1\hat{\beta}_{1,k}^{CF}+u_k\,, \tag{5}$$

where $\hat{E}$ denotes the sample mean and $\hat{\beta}_{1,k}^{CF}$ the estimated cash-flow beta. The dependent variable of (5) can be motivated as a price-level measure. Reorganizing (2) and taking conditional expectation yields:

$$-\log ME_{t-1}+\left[\log BE_{t-1}+\sum_{j=0}^{\infty}\rho^j E_{t-1}\log(1+ROE_{t+j})\right]=\sum_{j=0}^{\infty}\rho^j E_{t-1}\log R_{t+j}\,. \tag{6}$$

The expected discounted long-horizon return equals the negative of log price (the first term) plus log book value adjusted for the expected cash-flow growth (second term). The dependent variable of the regression (5) differs from this price-level metric due to the finite horizon and choice between log and simple returns. In addition, the dependent variable of (5) is normalized by $\sum_{j=0}^{N-1}\rho^j$ to annual-return units.

Columns twelve to fourteen of Table II report the estimates of regression (5) for different horizons. In the full sample, the cross-sectional regression R^2 of average discounted long-horizon returns on cash-flow betas stays over 60 percent for all considered horizons. At the three-year and five-year horizons, roughly corresponding to the frequency of the business cycle, the regression R^2 is near 90 percent.

Are these impressive R^2 obtained with implausible premia? In Table II Panel A, the estimated intercepts of the regression range from -6.3 to 5.3 percent and slopes from 10.5 to 20.2 percent. One way to judge whether the premium on cash-flow beta is reasonable is to recognize that λ_0 should equal the risk-free rate and λ_1 the average discounted net return on the market portfolio less the risk-free rate. The predicted λ_0 and λ_1 are thus approximately 4 percent and 9-10 percent, which are close to the unrestricted estimates of the premia. If we restrict the premia to the values predicted by the CAPM ($\lambda_0=0.04$ and $\lambda_1=0.10$), the R^2 of the cross-sectional regressions remain high (from 30 to 70 percent).

III. Evidence from a present-value model

In this section, we use a formal present-value model to measure the relative importance of risk and mispricing to the cross-section of price-to-book ratios from a 1928-1999 panel of U.S. firms. Our tests demonstrate that CAPM risk explains a substantial majority of the component of the dispersion in price-to-book ratios related to predictable variation in returns, while the share of mispricing is small and statistically insignificant. The market risk factor is especially successful when we measure good and bad states of the world based on the market portfolio's cash flows. Our results suggest that mispricing relative to the CAPM is not an important factor in determining a firm's valuation multiple and consequently the level of a firm's stock price.

Our test is based on a variant of the present-value formula. We specify a stochastic-discount-factor present-value model that links firms' current price-to-book ratios to expected future cash flows and to covariances of future cash flows with the stochastic discount factor. If we restrict discount rates to be constant across firms, our decomposition allocates more than 25 percent of the cross-sectional price-to-book variance to mispricing. However, if we allow the discount rates to vary as predicted by the CAPM, the variance share of mispricing is reduced to 20 percent in tests thathe t use market portfolio's stock return as the risk factor and to –0.1 percent in tests that use the market portfolio's cash flows as the factor. The present-value model is a success in pricing value and growth stocks, because it detects more market risk in value firms' future cash flows than in growth firms'.

A. Stochastic-discount-factor present-value framework

Our approach is based on the stochastic-discount-factor framework that enables us to easily study the pricing of risk and the impact of risk on the level of the stock prices. Ultimately, this framework leads to a cross-sectional variance decomposition of price-to-book ratios. We allocate the price-to-book variance to predictable variation in three components: (1) a risk-adjusted present value of *N*-period cash flows; (2) a risk-adjusted present value of the *N*-period-ahead terminal value (capturing the effects beyond the *N*-period horizon); and (3) a pricing-error component (as assigned by a particular economic model).

A stochastic-discount-factor present-value model equates the stock price to the stochastically discounted value of the asset's payoffs. Consider buying a stock and selling it ex dividend a year from now. The stochastic-discount-factor formula equates the purchase price with the expectation of the product of the sale price plus dividend and the one-period discount factor:

$$P_{k,t-1} = E_{t-1}\left[(P_{k,t} + D_{k,t}) \frac{Q_t}{Q_{t-1}} \right] , \tag{7}$$

where P is the stock price, D dividends, and Q the cumulative stochastic discount factor. Subscripts k and t are indices to assets and time, respectively. We denote the one-period stochastic discount factor by Q_t / Q_{t-1} and normalize the initial value Q_0 to one. Our notation differs slightly from that in the previous literature: Cochrane (2001, p. 8) denotes the same one-period stochastic discount factor by m_t and Duffie (1996, p.29) by π_t / π_{t-1} .

In general, if the law of one price holds, we can find at least one random variable Q_t / Q_{t-1} such that (7) holds in population (or in sample) if we make Q_t / Q_{t-1} a function of population (or sample) moments and random asset payoffs. However, it is important to note that if we specify Q_t / Q_{t-1} based on an economic model, (7) need not hold even in population, if the chosen economic model is not true. To capture the fact that an economic model and its implied stochastic discount factor are just models, we add a pricing-error term to (7):

$$P_{k,t-1} = E_{t-1}\left[(P_{k,t} + D_{k,t} + \varepsilon_{k,t})\frac{Q_t}{Q_{t-1}}\right] = E_{t-1}\left[(P_{k,t} + D_{k,t})\frac{Q_t}{Q_{t-1}}\right] + E_{t-1}\left(\varepsilon_{k,t}\frac{Q_t}{Q_{t-1}}\right) \quad (8)$$

In (8), $\varepsilon_t \, Q_t / Q_{t-1}$ denotes the realized pricing error, and $E_{t-1}(\varepsilon_t \, Q_t / Q_{t-1})$ the (conditional) average pricing error. Economic models of equilibrium prices, since they imply a stochastic discount factor Q_t / Q_{t-1}, are "false" if any $E_{t-1}(\varepsilon_t \, Q_t / Q_{t-1})$ is nonzero.

To measure the price-level impact of pricing errors, we iterate (8) forward N periods and use the law of iterated expectations to link the stock price to long-horizon sequences of stochastic discount factors and dividends:

$$ME_{k,t-1} = P_{k,t-1} = \frac{1}{Q_{t-1}}\sum_{j=0}^{N-1} E_{t-1}\left(Q_{t+j} D_{k,t+j}\right) + \frac{1}{Q_{t-1}} E_{t-1}\left(Q_{t+N-1} P_{k,t+N-1}\right) + \frac{1}{Q_{t-1}}\sum_{j=0}^{N-1} E_{t-1}\left(Q_{t+j}\varepsilon_{k,t+j}\right). \quad (9)$$

To relate the quantities in (9) to a firm, we equate P to the market value of equity (ME) and D to dividends net of equity issues. The implicit assumption here is that the investor follows a strategy of holding the entire equity-capital stock of the firm and participating in all equity issues and share repurchases.

Suppose that the model (7) is true, and the conditional expected pricing error in (8) is always zero. Clearly, equation (9) is derived from (8), and therefore cannot provide any new restrictions that are not implied by (8). However, the real advance in moving from (8) to (9) comes from better diagnosing the model's failure if the model is not true, i.e., pricing errors are nonzero. This is because equation (9) relates prices to long-horizon sequences of stochastic discount factors and dividends, instead of to the one-period-ahead stochastic discount factor and future price. Equation (9) provides a price-level mispricing metric, $(1/Q_{t-1})\sum_{j=0}^{N-1} E_{t-1}(Q_{t+j}\varepsilon_{k,t+j})$, a diagnostic that is perhaps more interpretable than the one-period pricing error of (2).

Since we are interested in the cross-section of firms, working with a dividend-based model is inconvenient. Therefore, we make an innocuous substitution: We use the clean-surplus relation $BE_t = BE_{t-1} + X_t - D_t$, where BE is book equity and X clean-surplus earnings, to transform the dividend-discount model to an empirically more convenient abnormal-earnings valuation model:

$$\begin{aligned} ME_{k,t-1} = BE_{k,t-1} &+ \frac{1}{Q_{t-1}} \sum_{j=0}^{N-1} E_{t-1}\left\{ Q_{t+j}\left[X_{k,t+j} - \left(\frac{Q_{t+j-1}}{Q_{t+j}} - 1 \right) BE_{k,t+j-1} \right] \right\} \\ &+ \frac{1}{Q_{t-1}} E_{t-1}\left[Q_{t+N-1}(ME_{k,t+N-1} - BE_{k,t+N-1}) \right] \\ &+ \frac{1}{Q_{t-1}} \sum_{j=0}^{N-1} E_{t-1}\left(Q_{t+j}\varepsilon_{k,t+j} \right) \end{aligned} \qquad (10)$$

(Feltham and Ohlson (1999) and Ang and Liu (2001) derive similar risk-adjusted abnormal-earnings models and investigate the models' properties in more detail.) Since we do not iterate (10) to infinity and since we define earnings such that it satisfies the clean-surplus relation by construction, the substitution of earnings and book values is truly innocuous and does not transform our paper from a finance paper to an accounting paper as a byproduct.

We define the quantity in brackets in first line of equation (10) as "abnormal earnings," A:

$$A_{k,t} \equiv X_{k,t} - \left(\frac{Q_{t-1}}{Q_t} - 1 \right) BE_{k,t-1} \qquad (11)$$

Equation (11) defines abnormal earnings as (clean-surplus) accounting earnings less a state-dependent charge for the amount of book equity employed in producing those earnings. Intuitively, the addition of risk to the basic abnormal-earnings formula of Edwards and Bell (1961) and Ohlson (1995) recognizes the fact that the cost of capital varies across states of the economy.

Our empirical tests require stationary variables; however, stock prices are clearly nonstationary. To achieve stationarity, price needs to be normalized by some variable that is cointegrated with price. Dividing both sides of (11) by book equity (BE_{t-1}) yields a model for the simple (not log) price-to-book ratio:

$$\begin{aligned} \frac{ME_{k,t-1}}{BE_{k,t-1}} = 1 &+ \frac{1}{Q_{t-1}} \sum_{j=0}^{N-1} E_{t-1}\left(Q_{t+j} A_{k,t+j} / BE_{k,t-1} \right) \\ &+ \frac{1}{Q_{t-1}} E_{t-1}\left[Q_{t+N-1}\,(ME_{k,t+N-1} - BE_{k,t+N-1}) / BE_{k,t-1} \right] \\ &+ \frac{1}{Q_{t-1}} \sum_{j=0}^{N-1} E_{t-1}\left(Q_{t+j}\varepsilon_{k,t+j} / BE_{k,t-1} \right) \end{aligned} \qquad (12)$$

For finite N, the terms of (12) can plausibly be assumed to be stationary. In addition to the above-mentioned desirable statistical property, the terms of the normalized equation (12) also have economically intuitive interpretations. The first term of (12) is a unit constant, defining the base case of market equity trading at the value of book equity. The second term discounts the firms' future abnormal earnings over the explicit forecasting period of N years, adjusting for risk: A firm's stock deserves to trade above its book value, if the firm's profitability exceeds the risk-adjusted cost of capital.[5] The third term is a terminal-value term, which takes the value zero if the market value and book value are expected to fully converge within the explicit forecasting period. If full convergence is not achieved, the terminal value captures the effect of all future abnormal earnings and pricing errors. Finally, the fourth term captures the contribution of N-period cumulative pricing error to a firm's price-to-book ratio.

Equation (12) serves as the basis of our cross-sectional variance decomposition. Following Cochrane (1991,1992), we multiply both sides of (6) by $ME_{k,t-1}/BE_{k,t-1} - E(ME/BE)$, where $E(ME/BE)$ denotes the average price-to-book ratio (over time and stocks), so that $ME_{k,t-1}/BE_{k,t-1} - E(ME/BE)$ is simply the demeaned price-to-book ratio. Taking unconditional expectations of the result yields a variance decomposition:

$$\begin{aligned}\operatorname{var}\left(\frac{ME_{k,t-1}}{BE_{k,t-1}}\right) &= \operatorname{cov}\left[\sum_{j=0}^{N-1}\left(\frac{Q_{t+j}}{Q_{t-1}}\times\frac{A_{k,t+j}}{BE_{k,t-1}}\right),\frac{ME_{k,t-1}}{BE_{k,t-1}}\right] \\ &+ \operatorname{cov}\left[\left(\frac{Q_{t+N-1}}{Q_{t-1}}\times\frac{ME_{k,t+N-1}-BE_{k,t+N-1}}{BE_{k,t-1}}\right),\frac{ME_{k,t-1}}{BE_{k,t-1}}\right] \\ &+ \operatorname{cov}\left[\sum_{j=0}^{N-1}\left(\frac{Q_{t+j}}{Q_{t-1}}\times\frac{\varepsilon_{k,t+j}}{BE_{k,t-1}}\right),\frac{ME_{k,t-1}}{BE_{k,t-1}}\right]\end{aligned} \tag{13}$$

Price-to-book ratios can vary more if price-to-book covaries strongly with future risk-adjusted abnormal earnings and/or pricing errors, or if the convergence of price and book value is slow.

Dividing both sides by the variance of price-to-book ratios gives the relative variance decomposition in terms of three predictive regression coefficients:

$$
\begin{aligned}
1 &= \beta' + \beta'' + \beta''' \\
&= \text{regression coefficient of } \overbrace{\sum_{j=0}^{N-1}\left(\frac{Q_{t+j}}{Q_{t-1}} \times \frac{A_{k,t+j}}{BE_{k,t-1}}\right)}^{\substack{\text{present value of cumulative} \\ \text{N-period abnormal earnigns}}} \text{ on } \frac{ME_{k,t-1}}{BE_{k,t-1}} \\
&+ \text{regression coefficient of } \overbrace{\frac{Q_{t+N-1}}{Q_{t-1}} \times \frac{ME_{k,t+N-1} - BE_{k,t+N-1}}{BE_{k,t-1}}}^{\text{terminal value after N periods}} \text{ on } \frac{ME_{k,t-1}}{BE_{k,t-1}} \\
&+ \text{regression coefficient of } \overbrace{\sum_{j=0}^{N-1}\left(\frac{Q_{t+j}}{Q_{t-1}} \times \frac{\varepsilon_{k,t+j}}{BE_{k,t-1}}\right)}^{\substack{\text{present value of cumulative} \\ \text{N-period pricing error}}} \text{ on } \frac{ME_{k,t-1}}{BE_{k,t-1}}
\end{aligned}
\tag{14}
$$

The three regression coefficients in equation (14) can be interpreted as a percentage variance decomposition of firms' price-to-book ratios. The price-to-book ratio must predict at least some of the following three components: Risk-adjusted present value of cumulative *N*-period abnormal earnings and/or the risk-adjusted terminal value and/or the risk-adjusted present-value of cumulative *N*-period pricing errors. We account for 100 percent of the variance: Since the three components sum up to the *t*-1 price-to-book ratio, the regression coefficients also sum up to one.

To make the variance decomposition (14) operational, we also need a model of priced risk, a stochastic discount factor. We estimate the variance decomposition with three simple candidate discount factors. The first discount factor is simply a constant δ , which we use as the benchmark case. Because we specify the stochastic discount factors and their parameters in real terms, but our asset data are nominal, we also multiply our real discount factors by the ratio of price levels, π_{t-1}/π_t . The nominal "constant" discount factor is thus a random variable $\delta\pi_{t-1} / \pi_t$.

The second discount factor is a linear function of the excess return on a value-weight portfolio of all stocks (*RMRF*):

$$Q_t / Q_{t-1} = (\gamma_0 + \gamma_1 RMRF_t) \times \pi_{t-1}/\pi_t \tag{15}$$

We dub this discount-factor model the "stock-return CAPM." The logic behind the second discount factor is the hope that priced risk is captured by a single factor prescribed by the Sharpe-Lintner-Black CAPM, in which the stochastic discount factor is a linear function of the return on the portfolio of aggregate wealth (the market portfolio). Although the CAPM is a very simple model and thus probably a naïve description of reality, it has two important advantages over its competitors: First, it has only two parameters, increasing the statistical power that is at a premium in our long-horizon regressions (14). Second, because the CAPM was proposed before the relation between price-to-book ratios and average returns was discovered in the academic literature, the CAPM is largely immune to the problem termed "model-mining" bias by Fama (1991).

Our third discount factor model is also motivated by the CAPM, but gets closer to the spirit of robust measurement of risks if stock-return covariances are potential contaminated with mispricing. Our third risk factor is a linear function of the market portfolio's ROE:

$$Q_t / Q_{t-1} = [g_0 + g_1 \log(1 + ROE_{M,t}^{real})] \times \pi_{t-1} / \pi_t \,, \tag{16}$$

where $ROE_{M,t}^{real}$ is the aggregate real clean-surplus earnings of all stocks divided by the aggregate beginning-of-the-period real book equity. If g_1 is negative as most asset-pricing theories would predict, the discount factor penalizes stocks whose profitability covaries with market-wide profitability. We dub this discount factor the "cash-flow CAPM."

B. Estimation strategy and empirical results

Our estimation procedure has two integrated steps. The regressions (14) assume that the stochastic-discount-factor realizations are known and can be used to construct the dependent variables of the regressions. Thus, the first necessary step is to pick the parameter values for the stochastic discount factor to be used in computation of the stochastic-discount-factor realizations. The second step estimates the relative variance decomposition (14) by running the three regressions. We implement both stages simultaneously using Hansen's (1982) generalized method of moments (GMM) so that the standard errors of the second-step regressions take into account the estimation uncertainty due to the first stage.

The stochastic-discount-factor parameters contained in vector b (δ in the case of the constant discount rate model and γ_0, γ_1, g_0, and g_1 in the case of the CAPM) are estimated by matching the following set of moments:

$$\begin{aligned}
&0 = E\left(R_{rf,t} \frac{Q(b)_t}{Q(b)_{t-1}} - 1 \right) \\
&0 = E\left(RMRF_t \frac{Q(b)_t}{Q(b)_{t-1}} \right) \\
&0 = E\left[\frac{ME_{k,t-1}}{BE_{k,t-1}} - 1 - \sum_{j=0}^{N-1} \left(\frac{Q(b)_{t+j}}{Q(b)_{t-1}} \frac{A(b)_{k,t+j}}{BE_{k,t-1}} \right) - \frac{Q(b)_{t+N-1}}{Q(b)_{t-1}} \times \frac{ME_{k,t+N-1} - BE_{k,t+N-1}}{BE_{k,t-1}} \right], \quad \forall k
\end{aligned} \tag{17}$$

We omit the first moment condition when estimating the constant-discount-factor model, because it would be unrealistic to ask the same constant discount factor to fit the average returns on stocks and Treasury bills. The first and second moment conditions help in picking the stochastic-discount-factor parameters by asking the model to price the one-period (nominally) risk-free return and one-period excess return on the market portfolio, respectively. The remaining moment conditions in (17) are restrictions on average price-to-book ratios relative to the present value of subsequent abnormal earnings and terminal values of the test assets, derived from (12) by assuming that the stochastic-discount-factor model is true and the average pricing errors are zero.

We use two stages in our GMM procedure. In the first stage, we use an identity matrix as the weighting matrix. This weighting matrix is likely to produce sensible but imprecise first-stage parameter estimates. We then collect the moment errors u_t and compute a Newey-West (1987) estimate of the long-run moment-error covariance matrix, $\hat{S}_{NW}$. We set the number of lags and leads in the Newey-West formula to the length of the explicit forecast horizon, N. In the second stage, we use

$$W_2 \equiv \begin{bmatrix} \hat{S}_{NW\,1,1} & 0 & \cdots & 0 \\ 0 & \hat{S}_{NW\,1,1} & & 0 \\ \vdots & & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{S}_{NW\,\max,\max} \end{bmatrix}^{-1} \tag{18}$$

as the GMM weighting matrix, where $\max$ is the number of moment conditions in the system. Our weighting matrix W_2 recognizes the heteroskedasticity of the moment errors and places more weight on low-variance moments, but does not adjust the weighting to accommodate the (often spurious) correlation structure of the moment errors.

Although using $\hat{S}_{NW}^{-1}$ as the second-stage weighting matrix leads to an asymptotically efficient estimator (given the chosen moments), the finite-sample performance of this weighting matrix is often poor. Since our moment-error matrix has a low time dimension, a high cross-sectional dimension, and significant autocorrelation, using the asymptotically optimal weighting matrix $\hat{S}_{NW}^{-1}$ would be a recipe for disaster, especially for long forecast horizons. The peril in using $\hat{S}_{NW}^{-1}$ in small samples stems from the matrix inverse being a highly nonlinear function of the estimated correlations. Small estimation errors in the off-diagonal elements of $\hat{S}_{NW}$ may unexpectedly result in enormous errors in $\hat{S}_{NW}^{-1}$. For a detailed discussion on the selection of a robust weighting matrix in asset-pricing applications, see Cochrane (2001, p.210-219).

Because we use W_2 instead of $\hat{S}_{NW}^{-1}$ as the weighting matrix, we compute the sampling covariance matrix of the estimated parameters using the formulas modified by Cochrane (2001, p. 212) for the case of a prespecified weighting matrix.

Each year we create ten value-weight portfolios of stocks by sorting on price-to-book and track the subsequent dividends, book values, and market values of these portfolios for fifteen years subsequent to the portfolio formation (or until the end of the sample, whichever comes first.) All data for these portfolios are annual and in nominal terms. We use this 10-by-15-by-60 data panel as our sample. Our factor data, *RMRF*, are the same as used by Davis, Fama, and French (2000).

We compute the clean-surplus earnings on the stocks in these portfolios using a formula $X_t = BE_t - BE_{t-1} + D_t^{net}$, where D^{net} is net dividends, i.e., gross dividends D^{gross} (from CRSP) less equity offerings plus share repurchase. We use an implied figure for year t equity offerings less share repurchases:

$$ME_t = (1 + R_t)ME_{t-1} + D_t^{gross} \tag{19}$$

The adjustment is not essential, however: Using gross instead of net dividends in the clean-surplus formula will yield very similar results.

Table III shows the parameter estimates for the constant-discount-rate model and the two versions of the CAPM. As listed in column one, each row in Table III corresponds to a specific horizon N of equation (17); for example, row three picks the parameters to match the average price-to-book ratio with the value of three-year cumulative abnormal earnings plus the terminal value after the three-year horizon.

The second column of Table III shows the parameter estimates of the constant-discount-rate model. The estimated real constant discount rate, $\hat{\delta}$, lies between 0.91 and 0.93, depending on the estimation horizon. The third and fourth columns of Table III report the parameter estimates of the stock-return CAPM stochastic discount factor. The intercept, $\hat{\gamma}_0$, ranges from 1.02 to 1.08 and the slope, $\hat{\gamma}_1$, from -0.90 to -1.42, depending on the horizon. The negative coefficient on *RMRF* is consistent with the theory: An asset is risky if it covaries negatively with the stochastic discount factor.

The fifth and sixth columns show the implications of the estimated stock-return CAPM parameters for the risk-free rate and the market premium, which may be more interesting than the parameter estimates per se. To evaluate whether particular parameter values of the CAPM-based stochastic discount factor are reasonable, we solve for the implied average risk-free rate and market premium. The average one-period risk-free (in real terms) bond price is simply the expectation of the real stochastic discount factor, $\gamma_0 + \gamma_1 E(RMRF)$. The real risk-free rate that corresponds to this average price, $1/[\gamma_0 + \gamma_1 E(RMRF)] - 1$, can be compared to historical bond-market data to judge its plausibility. Given the second moment of the excess market return, our parameters also imply the average market premium:

$$\begin{aligned} 0 &= E\left[RMRF \times (\gamma_0 + \gamma_1 RMRF)\right] \Rightarrow \\ E(RMRF) &= -\gamma_1 \frac{E(RMRF^2)}{\gamma_0} \end{aligned} \tag{20}$$

We add two moment conditions to the system that measure the average excess return and average squared excess return on the market portfolio:

$$\begin{aligned} 0 &= E(RMRF - \mu_1) \\ 0 &= E(RMRF^2 - \mu_2) \end{aligned} \tag{21}$$

Adding these moment conditions allows us to compute the point estimates and standard errors of the average risk-free rate and market premium implied by the CAPM stochastic discount factor.

The estimated average real risk-free one-period bond prices range from 0.94 to 0.95; these bond prices correspond to (net) real risk-free rates from 6 to 5 percent. Although these estimates are higher than the realized real returns on one-year T-bills over our sample period, Siegel (1999) argues that values within this range may be reasonable estimates of the ex-ante expected real risk-free rate. The market-premium estimates are also reasonable, ranging from 7 to 10 percent. Although these estimates are high compared to the predictions of most economic models, they are close to the historical average as well as to the dividend-yield-based estimates of Fama and French (2002) over our sample period.

The cash-flow CAPM's estimated parameters are shown in columns seven and eight of Table III. Consistent with the theory, the slopes on the market's ROE are negative and statistically significant.

Our tests assume that the market premium does not covary systematically with betas, ruling out the conditional CAPM. Instead of testing a conditional CAPM specification, we measure the price-level impact of the static CAPM's pricing errors. The approach of this paper is thus distinct from those of Jagannathan and Wang (1996), Lettau and Ludvigson (2001), and Santos and Veronesi (2001) who argue that conditional versions of the CAPM help explain the cross-section of one-period expected returns (instead of prices or price-to-book ratios). Our results, of course, do not contradict those of the above authors.

The cross-sectional variance decomposition (14) is simultaneously estimated from another set of independent moment conditions. Since these additional regression moment conditions are exactly identified as a separate group, adding them to the system does not alter the point estimates of stochastic-discount-factor parameters identified from the other moment conditions.

We mold (14) to our exact regression specification as follows. First, we include time dummies in the pooled regressions, effectively running the regressions with cross-sectionally demeaned data. This allows us to focus on the cross-sectional variation in firms' price-to-book ratios. Second, we deflate both the dependent and explanatory variables with the particular portfolio's average price-to-book ratio. This weighting practice can be seen as a simplified version of generalized least squares (GLS). As the subsequent plots will show, the regression residuals of (14) are much more variable for high-price-to-book portfolios than for low-price-to-book portfolios in our data, which is a natural consequence of high-price-to-book portfolios' data being divided by very low book-equity numbers. By placing less emphasis on data points with more variable errors, our weighting scheme acts much like GLS.

We set up the weighted least squares (WLS) regressions as:

$$\begin{aligned}
\frac{1}{w_k}\sum_{j=0}^{N-1}\left(\frac{\hat{Q}_{t+j}}{\hat{Q}_{t-1}}\times\frac{\hat{A}_{k,t+j}}{BE_{k,t-1}}\right) &= \beta'_{WLS}\times\frac{1}{w_k}\frac{ME_{k,t-1}}{BE_{k,t-1}}+\Delta'_{WLS}\times\frac{1}{w_k}DT_t+e'_t \\
\frac{1}{w_k}\times\frac{\hat{Q}_{t+N-1}}{\hat{Q}_{t-1}}\times\frac{ME_{k,t+N-1}-BE_{k,t+N-1}}{BE_{k,t-1}} &= \beta''_{WLS}\times\frac{1}{w_k}\frac{ME_{k,t-1}}{BE_{k,t-1}}+\Delta''_{WLS}\times\frac{1}{w_k}DT_t+e''_t \qquad (22)\\
\frac{1}{w_k}\sum_{j=0}^{N-1}\left(\frac{\hat{Q}_{t+j}}{\hat{Q}_{t-1}}\times\frac{\hat{\varepsilon}_{k,t+j}}{BE_{k,t-1}}\right) &= \beta'''_{WLS}\times\frac{1}{w_k}\frac{ME_{k,t-1}}{BE_{k,t-1}}+\Delta'''_{WLS}\times\frac{1}{w_k}DT_t+e'''_t
\end{aligned}$$

where β'_{WLS} is the variance share of risk-adjusted abnormal earnings, β''_{WLS} is the variance share of the terminal value, β'''_{WLS} is the variance share of pricing error, and $\beta'_{WLS}+\beta''_{WLS}+\beta'''_{WLS}=1$. As noted before, the weights,

$$w_k \equiv \frac{1}{T}\sum_{j=1}^{T}\frac{ME_{k,j}}{BE_{k,j}}, \qquad (23)$$

are the time-series averages of each portfolios price-to-book ratios. DT is a matrix of time dummies (subsuming the regression constant), and $\Delta'_{WLS}, \Delta''_{WLS}$, and Δ'''_{WLS} are dummy coefficients which we subsequently ignore. The stochastic-discount-factor realizations in the above formulas are computed using the parameter estimates of Table III.

Table IV shows the results from the WLS regressions with time dummies (equation (22)). As in Table III, each row of Table IV corresponds to the horizon indicated in the first column. Columns 2-4 of the table show the price-to-book variance decomposition for the constant-discount-factor model. Moving down column two of the tables, the variance share of cash flows increases from 6.6 percent at the one-year horizon to 37.7 percent at the fifteen-year horizon. The mispricing component of the constant-discount-factor model also grows as the regressions' horizon lengthens. Moving down column four of Table IV, the variance share of mispricing increases from 3.2 at the one-year horizon to 26.9 percent at the fifteen-year horizon. Summarizing the results, the constant-discount-rate model allocates about 40 percent of the cross-sectional price-to-book variance to variation in present value of future fifteen-year cash flows, about 35 percent to variation in fifteen-year terminal values, and about 25 percent to mispricing.

Columns 5-7 of Table IV show the price-to-book variance decomposition for the stock-return CAPM. Column 5 shows that the variance share of cash flows increases from 6.7 percent at the one-year horizon to 42.3 at the fifteen-year horizon. The variance shares for the cash-flow CAPM are in columns 8-10. The variance share of cash flows in column eight increases from 5.0 percent at the one-year horizon to 52.0 percent at the fifteen-year horizon.

Remarkably, the variance share of the risk-adjusted present value of cash flows is much higher for both the stock-return and cash-flow CAPM specifications than for the constant-discount-rate model. In words, the CAPM values the long-run cash flows of growth stocks at a higher multiple than value stocks', because growth stocks' long-run ability to generate cash flows covaries more strongly with the stock return and ROE on the market portfolio than value stocks'.

The mispricing share of stock-return CAPM is shown in column 7 of Table IV. Consistent with the previous research by Fama and French (1992, 1993, and 1996) and Davis, Fama, and French (2000), at the one-year horizon the stock-return CAPM cannot price portfolios sorted on price-to-book ratios. At the fifteen-year horizon, however, the stock-return CAPM allocates 20.1 percent of the variance to mispricing, which is less than for the constant discount rate model.

The punch line (or column) of our paper is in column ten of Table IV. The cash-flow CAPM is our most successful specification. At fifteen-year horizon, the cash-flow CAPM allocates only -0.1 percent of the price-to-book variance to mispricing. We interpret this variance shares as economically and statistically insignificantly different from zero. Remarkably, introducing the market portfolio's cash flow as a risk factor will move the component considered mispricing by the constant-discount-rate model to the risk-adjusted present value of cash flows, not to terminal value. We find it comforting that our results identify systematic risk in the cash flows of value stocks rather than in the fifteen-year terminal value as the former are unambiguously interpretable as covariance due to cash flows, not mispricing.[6]

Figure 1 graphs the variance shares from Table IV's stock-return CAPM specification as a function of the horizon. The lightly colored area in the bottom represents the variance share of risk-adjusted cash flows, the white area in the middle the share of terminal value, and the dark area in the top the share of pricing error; all relative to the stock-return CAPM. For comparison purposes, the variance shares from the constant-discount-rate model are plotted with bold dashed lines. After the first year, the variance share of stock-return CAPM mispricing is always less than that of the constant-discount-rate model. Consistent with the above-cited results in the previous literature, there is a visible pricing-error component at the one-year horizon. This is what one would expect knowing that immediately after the sort value stocks' returns actually have lower CAPM betas than growth stocks' returns. However, increasing the horizon beyond one year does not increase the variance share of mispricing as much as for the constant-discount-rate model.

Figure 2 plots a similar variance-share graph for the cash-flow CAPM. For most horizons, the pricing error is negatively related to the price-to-book ratios, that is, value stocks appear slightly overpriced relative to growth stocks. At the fifteen-year horizon, the mispricing share ends at almost exactly zero. Approximately fifteen percentage points of the improvement over the constant-discount-rate model at the fifteen-year horizon comes from the cash-flow component. Although value stocks continue to earn higher returns than growth stocks for the entire fifteen-year horizon, the cash-flow CAPM justifies these expected returns first by the riskiness of the terminal value in the shorter-horizon regressions and later by the riskiness of cash flows in the long-horizon regressions.

Our variance-decomposition results suggest that the CAPM provides a high-R^2 explanation of the levels of stock prices for value and growth stocks. Although the abnormal returns on a strategy of sorting stocks into price-to-book deciles, buying value stocks and shorting growth stocks, and turning the portfolio over every year cannot be explained by the stock-return CAPM, the cash-flow version of the model gets the levels of stock prices almost exactly "right."

IV. Evidence from portfolio returns

In this section, we present more traditional evidence from portfolio returns and confirm our results using simple portfolio trading rules, monthly returns, and bootstrapped confidence levels. The portfolio-return evidence complements the above cash-flow-based results for the following reasons. First, the cash flows are measured annually, while our portfolio-return tests use monthly stock returns. Second, statistical inference in the previous tests relies on asymptotic Newey-West (1987) standard errors, while our return tests use more reliable bootstrap methods. Third, the portfolio-return tests allow us to establish a direct link to the previous literature on the performance of value-minus-growth strategies.

We first sort stocks into price-to-book deciles. Every year, we run fifteen different sorts: Deciles sorted on year-t-1 price-to-book ratios, deciles sorted on year-t-2 price-to-book ratios,…, and deciles sorted on year-t-15 price-to-book ratios. As a result, we have 715 months of returns on 150 portfolios for the period 6/1941-12/2000 (the maximum period for which our data made it possible to compute returns for the portfolios formed by sorting on the year-t-15 price-to-book ratios).

We compute our measure of risk by regressing the monthly returns on the resulting 150 portfolios (fifteen different horizons by ten price-to-book categories) on the contemporaneous and lagged market returns. We then sum up the regression coefficients into what we call "total beta," in contrast to "contemporaneous beta," i.e., beta estimated without the lagged market returns in the regression. The logic underlying the inclusion of lagged returns is the following. We argue that the betas measured based on only contemporaneous monthly returns may be misleading for a number of reasons. If some price-to-book deciles systematically contain illiquid securities, the measured monthly returns may be asynchronous, and some portfolios' returns disproportionately so. In addition, relatively short-horizon effects such as tax-loss harvesting by individual investors, window dressing by institutional investors, and/or delayed reaction to information for stocks that are not extensively covered by analysts may garble the relevant long-run relations in contemporaneous monthly returns. The impact of asynchronous price reaction on beta estimates has been studied by Scholes and Williams (1977) and Dimson (1979) who propose simple techniques to measure market betas by utilizing summed betas from regressions of returns on both contemporaneous and lagged market returns. We follow their suggestion when measuring betas, and include up to eleven lags in our regressions.[7]

Figure 3 shows the evolution of the CAPM beta of a value-minus-growth portfolio as a function of years from the sort. The dependent variables in the regressions are an equal-weight portfolio of the three value-weight lowest-price-to-book deciles (marked with a solid line and triangles) and an equal-weight portfolio of the three value-weight highest-price-to-book deciles (marked with just a solid line). The upper-left plot is produced with no lagged market returns in the regressions, the upper-right with one lag, the lower-left with five lags, and the lower-right with eleven lags.

Figure 3 clearly illustrates how the long-horizon risks of value and growth stocks are very different from the risks at short horizons. Focusing on the contemporaneous betas in the upper-left plot, growth stocks have much higher contemporaneous betas than value stocks immediately after the sort. However, as time passes from the sort, the risk of value stocks increases while the risk of growth stocks decreases. Between the years five and ten, contemporaneous betas cross and value stocks reach their permanently high and growth stocks their permanently low contemporaneous betas. The time pattern in total betas is very similar, but the total betas of growth stocks are much lower than their contemporaneous betas at all horizons, and the crossing takes place much earlier. Thus, we conclude that the long run permanent level of CAPM beta is significantly higher for value stocks than for growth stocks, a difference as large as 0.17 for these portfolios in some of the specifications (and larger for the extreme deciles one and ten).

To verify that the surprising crossing pattern in Figure 3 is not an artifact of the time trend in value and growth stocks' betas, in Table V we estimate a parametric specification for the betas:

$$\begin{aligned} R_{i,t} - R_{rf,t} = \alpha_i &+ \sum_{l=0}^{L} \beta_{0,l} \times RMRF_{t-l} + \sum_{l=0}^{L} \beta_{1,l} \times TREND_t \times RMRF_{t-l} \\ &+ \sum_{l=0}^{L} \beta_{2,l} \times YEARS_i \times RMRF_{t-l} + \sum_{l=0}^{L} \beta_{3,l} \times YEARS_i \times TREND_t \times RMRF_{t-l} + \varepsilon_{i,t} \end{aligned} \tag{24}$$

Above, *TREND* is a linear time trend in centuries (month index divided by 1200), normalized to zero in the middle of the sample. *YEARS* is the number of years from the sort divided by one hundred; or more informatively the number of lags we used in firms' price-to-book ratios when sorting the portfolios into deciles, divided by one hundred. Table V reports the sums of coefficients for the value, growth and difference portfolios as a function of L. The results suggest that even after controlling for the time trend, growth stocks' betas decline and value stocks' betas increase after the sort. These patterns appear to be especially strong in the later years of the sample.

The above results show that value stocks do have higher long-run betas than growth stocks. The task remains to show that the magnitude of this difference in long-run betas is large enough to justify the magnitude of the long run returns, which we take up below.

We examine *N*-year holding-period strategies based on return series computed from the 150 portfolios used in the beta tests. We define the *N*-year decile *M* as a portfolio strategy that invests equally in *N* portfolios: Decile *M* sorted on year-*t*-1 price-to-book ratios, decile *M* sorted on year-*t*-2 price-to-book ratios,…, and decile *M* sorted on year-*t*-*N* price-to-book ratios. For example, a two-year holding-period strategy for the highest price-to-book portfolio (two-year decile ten) invests half in stocks that are the highest price-to-book stocks in the beginning of the return period and half in stocks that were the highest price-to-book stocks a year ago. We extend these "holding periods" out to fifteen years. As a consequence, the fifteen-year decile portfolios approximate a buy-and-hold investor's experience and allow us to examine long-horizon effects at a higher frequency and with more reliable statistical tools than in the price-level variance-decomposition tests.

For all of the statistics we report in Table VI, we also report standard errors (reported inside parentheses) as well as p-values (estimated using a bootstrap technique and reported inside braces). The bootstrap procedure proceeds as follows. First, we repeat the regression of the 150 portfolios on the market return and eleven lags setting the coefficient on the constant to zero. We preserve the 12-by-1 beta vector and the 715-by-150 error matrix. We demean the error matrix using the time-series mean of each column of errors, since under the null the mean error from the regression is zero. Then we begin 10,000 bootstrap iterations. At each iteration we produce a random design matrix by sampling 715 rows from the original 715-by-12 design matrix of market returns. We separately randomly sample 715 rows from the demeaned error matrix. All sampling is done with replacement. We produce a new dependent-variable matrix using the newly selected design and error matrices in conjunction with the beta estimate ($Y = X \times beta + errors$). Finally, we regress the new dependent-variable matrix on the new design matrix to get a draw of the intercept vector and corresponding GRS statistic (Gibbons, Ross, and Shanken (1989)) under the null. Then, we compute the percentiles of our point estimates in our sample of 10,000 bootstrap iterations.

The second column of Table VI reports the GRS statistic of CAPM tests of the ten portfolios at different horizons, along with the asymptotic and bootstrap probability values. For the sake of brevity, we only report results for one, two, three, five, ten, and 15-year deciles. The first row reports the well-known result that the CAPM cannot price returns over the next year on portfolios formed by sorting on the most recent price-to-book ratio. The GRS statistic is 1.9182, which rejects the null hypothesis that the one-year deciles' intercepts are jointly zero at about five-percent level of significance. This pattern holds true and strengthens over holding periods up to five years. However, for ten-year and fifteen-year holding period returns (ten-year and fifteen-year deciles), we are unable to reject the hypothesis that the CAPM can price the returns on the price-to-book deciles. Moreover, the CAPM alphas are no longer positively correlated with the price-to-book ratios.

The significance of the holding period for alphas is further illustrated in Figure 4. The top panel of Figure 4 shows the evolution of mean excess returns. The price-to-book pattern in mean returns is strong even at the fifteen-year holding period. In the alphas displayed in the bottom panel, however, the pattern has disappeared almost completely.

A simple back-of-the-envelope calculation demonstrates the economic importance of CAPM risk adjustment. Concentrating on deciles one and ten at the fifteen year horizon (not reported in Table VI) , the price level impact of the difference in expected returns is approximately 44 percent (ignoring compounding and using the formula 12×15×(0.99%-0.75%).) Not adjusting for risk (or assuming that the risk is equal) would lead to a conclusion that the highest-price-to-book decile is overpriced by almost 50 percent relative to the lowest-price-to-book decile. However, adjusting returns with their total CAPM betas leads to a very different conclusion: The price level impact of the difference in alphas is a statistically insignificant 14 percent (12×15×(0.0820%-0.0018%)).) The economic significance of the difference between 14 and 44 percent mispricing is enormous.

The next two columns analyze similar value-minus-growth long-short portfolios in more detail. We report the mean return and alpha of a strategy that goes long the top three portfolios (low price-to-book) and shorts the bottom three portfolios (high price-to-book). Thus at the one-year horizon, the strategy is quite similar to Fama and French's (1993) HML, except that there is no size stratification. As Fama and French show, in the year following portfolio formation, all of the average return can be attributed to mispricing vis-à-vis the CAPM. This fact is true even for the strategy that buys value and sells growth equally in each of the last three years. For the three-year holding portfolio, the mean and CAPM alpha are both 0.0037, measured in fractions per month. In a statistical test not reported in the table, we cannot reject the null that the ratio of alpha to mean is 1.0 at the five-percent level of significance.

However, as the holding period grows beyond three years, the CAPM explains more and more of the average return differential. At the ten-year horizon, the long-short portfolio generates an average return of 0.0025. Approximately half of this return is justified by the CAPM, as the alpha is only 17 basis points per month. For the fifteen-year holding period strategy, the alpha is only eight basis points, though the mean return is still an economically important 18 basis points and marginally statistically significantly different from zero. We argue that the risk of the fifteen-year holding period strategy approximates the risk relevant for price levels. In a statistical test not reported, we are unable to reject the hypothesis that the ratio of alpha to mean is zero at the five-percent level of significance. This result confirms the findings of the previous sections.

Recall that, for a given horizon, we have ten price-to-book-sorted portfolio returns each month. The remaining columns in Table VI report results from a regression of the average return on the ten portfolios on the total beta of these portfolios. Column five reports the intercept (λ_0) from this regression; column six reports the coefficient on total beta (λ_1), and column seven has the (unadjusted) R^2.

As in Fama and MacBeth (1973), under the null that the CAPM is true, the intercept from a regression of mean excess return on beta is an estimate of the excess return on the riskless (zero-beta) portfolio. The regression slope is an estimate of the market premium (premium for an additional unit of beta). Column five shows that the results for short holding periods are inconsistent with the Sharpe-Lintner CAPM. The zero-beta rate estimated is negative; for the two- and three-year holding-period portfolios we can reject the hypothesis that the CAPM is true and the zero-beta rate is zero. For the fifteen-year holding period, in contrast, the point estimate is about zero, consistent with the Sharpe-Lintner CAPM.

Column six shows estimates of the market premium. For short holding periods, the slope has a wrong sign and/or small magnitude. For intermediate holding periods (3-10 years) the estimated λ_1 is far higher than the historical market premium, often over 20 percent per annum. The hypothesis that the estimate equals the market premium is strongly rejected for holding periods from three to ten years. This is because the value portfolios substantially outperform the growth portfolios, but there is only small difference in the portfolio betas, so a large beta premium is necessary to explain differences in average returns. The fifteen-year horizon portfolios, on the other hand, imply a market premium estimate of 79 basis points, quite similar to the historical market premium. We are unable to reject the null that the alphas are zero and therefore the hypothesis that the beta premium is equal to the historical average excess return on the market.

Column seven of Table VI shows the R^2 from the regression of means on betas. For short holding periods, betas explain virtually none of the difference in mean excess returns. For the longest-horizon portfolio, however, the R^2 is 70.31 percent; we manifestly fail to reject the null that the R^2 is equal to 100 percent, with a bootstrap p-value of 0.4474.

V. Conclusions

The goal of this paper is to evaluate the relative importance of risk and mispricing to the cross-sectional variation in firms' stock prices. Our approach differs from the previous cross-sectional research in two important ways.

First, unlike most previous cross-sectional studies, we follow Summers (1986) and concentrate on the level of the price instead of trading profits. We argue that focusing on the level of the price has important advantages. A common definition of market efficiency states that stock prices reflect information to the point that the marginal benefits of acquiring information and trading on it do not exceed the marginal costs (Jensen (1978)). One problem in testing market efficiency is that what constitutes a reasonable level of information and transaction costs is ambiguous. The interpretation of before-cost trading profits on high-turnover investment strategies can crucially depend on the assumed level of costs. On the contrary, the price-level criterion advocated by us is largely immune to this concern. Evaluating market efficiency at the price level is analogous to evaluating trading profits on a simple strategy of buying or short-selling a stock once and holding the position forever. Thus, the price-level criterion is clearly less sensitive to assumptions about reasonable trading and information costs.

Similarly, the price-level criterion is interesting to an investor who, for some reason, is constrained to a long holding period. For example, the level of price is the appropriate measure for a host of economically important decisions including firms' real investment decisions as well as merger and acquisition activity – endeavors essentially requiring buy-and-hold behavior.

Second, we measure risk by covariances of cash-flow fundamentals instead of covariances of stock returns. If the objective is to test the joint hypothesis of market efficiency and an asset pricing model being literally true, a valid test of this joint hypothesis examines the relation between first and second moments of high-frequency stock returns. However, if the objective is to measure how well the joint hypothesis approximates the stock market, tests relying solely on the properties of stock returns are handicapped by the following disadvantage. Market inefficiencies can affect not only average returns but also return covariances, and this problem is likely to be more severe the higher the frequency of the returns. The price-level tests we advocate connect stock prices to covariances or betas of cash flows. Regressing prices on cash-flow betas is a cleaner way to measure a model's explanatory power than regressing average returns on return betas, because the cash-flow betas are less affected by mispricing.

We test empirically the ability of the CAPM to explain value and growth stocks' prices. Our empirical results suggest that mispricing relative to the CAPM is not an important factor in determining the prices of value and growth stocks. Cash-flow betas (measured by regressing firms' log ROEs on the market's log ROE) essentially explain the prices of and long-horizon returns on price-to-book-sorted portfolios, with a premium consistent with the theory.

In addition to traditional regressions of prices and long-horizon average returns on betas, we specify a stochastic-discount-factor present-value model that links firms' current price-to-book ratios to expected future cash flows and to covariances of future cash flows with the stochastic discount factor. Ultimately, this present-value framework leads us to a cross-sectional variance decomposition of price-to-book ratios. We allocate the price-to-book variance to predictable variation in three components: The risk-adjusted present value of cash flows, the terminal value (capturing the effects beyond our fifteen-year horizon), and a pricing-error component (as assigned by a particular economic model).

We examine pricing errors relative to three discount-factor models, a constant discount factor and two implementations of the CAPM discount factor. If we restrict discount rates to be constant across firms, our decomposition allocates about 27 percent of the cross-sectional price-to-book variance to mispricing. However, if we allow discount rates to vary as predicted by the CAPM, the variance share of mispricing is reduced to –0.1 percent. The CAPM is a success at the price level because the present-value model detects more market risk in value firms' long-term cash flows than in growth firms'.

We confirm and extend these findings with tests on stock returns. When we sort stocks on price-to-book ratios, immediately after the sort the low-price-to-book (value) portfolios have lower CAPM betas than the high-price-to-book (growth) portfolios. However, this lower risk of value stocks is entirely temporary: As time since the sort increases, the beta of the value-stock portfolio increases while the beta of the growth-stock portfolio decreases. Within ten to fifteen years, the betas of these portfolios have reached their long-run permanent levels, and the long-run CAPM betas of value stocks are much higher that those of growth stocks. If an investor has a fifteen-year investment horizon, value and growth portfolios' average returns line up closely with their CAPM betas.

Of course, the CAPM cannot explain the abnormal performance of an annually rebalanced value-minus-growth strategy. That strategy will have a high return and low stock-return beta, irrespective of what happens to those stocks after they are sold (or bought back on the short side). However, the long-run betas are crucial when diagnosing the economic significance of the value-minus-growth anomaly. We argue that, for many purposes, the joint hypothesis of the CAPM and market efficiency approximates the pricing of value and growth stocks well.

Our results may validate what beforehand might have been seen as a common but inappropriate use of CAPM-based hurdle rates by firms, given the empirical evidence on the CAPM's inability to explain one-period expected returns. For example, Graham and Harvey (2001) state: "*It is very interesting that CFOs pay very little attention to risk factors based on momentum and book-to-market value.*" Our empirical results, like the theoretical results by Stein (1996), support the use of the CAPM in capital budgeting, as long as the betas are measured from cash flows or long-term stock returns. Unlike Stein's, however, our results also suggest that once a project is undertaken, the stock market values it approximately "right."

Shleifer and Vishny (2001) model merger and acquisition decisions and suggest that these transactions are motivated by acquirers/targets being overpriced/underpriced. Their model makes the implicit assumption that deviations from fundamental values are economically significant. Our findings suggest that high-book-to-market "fallen angels" within industries are not necessarily obvious takeover targets based on their valuations alone, because the average take-over premium and other transaction costs are an order of magnitude higher than the mispricing we detect (Bradley (1980)). At minimum, our results suggest that empirical tests of this valuation motive should carefully estimate the risk-adjusted price-level impact of any return predictability assumed to be due to market inefficiencies.

Our evidence is directly relevant to the interpretation of Baker and Wurgler's (2002) empirical evidence on equity issues. Based on their finding that the historical sequence of past book-to-market ratios forecasts the capital structure far into the future, Baker and Wurgler argue that a firm's long-run capital structure is determined by the sequence of opportunistic equity-issuance and share-repurchase decisions. Our finding that firms' book-to-market ratios are associated with only modest levels of relative mispricing suggests that the benefits from this timing activity are small. If the benefits are small, the costs of deviating from the "optimal" capital structure must also be small, and the optimal capital structure must be well approximated by the Modigiliani-Miller (1958) irrelevancy principle.

Appendix: Additional robustness checks

A. Post-1938 period

We also examine a shorter 1938-1999 sample in tests that interpret price-to-book ratios on a ratio scale (e.g., regressions on the price-to-book ratios), consisting of 159,537 firm-years. The logic behind this choice of periods is based on the pre-1938 level of disclosure regulation. Before the Securities Exchange Act of 1934, there was essentially no regulation to ensure the flow of accurate and systematic accounting information. Among other things, the act prescribes specific annual and periodic reporting and record-keeping requirements for publically-traded companies. The companies required to file reports with the SEC must also "*make and keep books, records, and accounts, which, in reasonable detail, accurately and fairly reflect the transactions and disposition of the assets of the issuer.*" In addition, the legislation introduces the concept of "*an independent public or certified accountant*" to certify financial statements and imposes statutory liabilities on accountants. Clearly, interpreting the book-equity predating the act on the same ratio scale as more recent data would be unrealistic.

Merino and Mayper (1999) provide statistics on the enforcement of the 1934 Securities Exchange Act. The SEC began 279 proceedings in the first ten years of the enforcement of the 1934 act, and 272 of those proceedings were begun in the 1933-37 period and only seven in the subsequent five-year period. This decline in proceedings may signal increasing compliance by registrants or declining interest by the SEC in regulatory enforcement. We believe the former cause was the driving force behind the reduced number of new proceedings. In our opinion, it is reasonable to characterize the 1934-1937 period as an initial enforcement period, after which reporting conventions have converged to their steady states.

Table A.I shows the results for the 1938-1999 subperiod. Panel A shows descriptive statistics, Panel B cash-flow-beta regressions, and Panel C and D the variance-decomposition results. The cash-flow-beta regressions estimated from the 1938-1999 subsample (Panel B) are similar to those obtained from the full sample. The main difference is that in the shorter subsample, the spread in cash-flow betas is stronger immediately after the sort but weaker at fifteen-year horizon than in the full sample. The main difference between the 1928-1999 and 1938-1999 variance-decomposition results is that the stock-return CAPM does slightly better at the fifteen-year horizon in the shorter subsample.

B. OLS variance decomposition

We also estimated the regression equation (14) with OLS. Although common sense dictates some weighting scheme similar to ours, due to their simplicity we also present the estimated OLS regressions, specified exactly as in equation (14). The OLS results are generally consistent with the WLS results, and we focus on WLS regressions in discussing the implications of our results. Our main conclusions are also robust to omitting the time dummies from the WLS specification and thereby allowing the time-series variation to affect the parameter estimates, as well as to reasonable alterations of the WLS weighting scheme.

Table A.II shows the results from the simple OLS regressions (equation (14)). As in Table III, each row corresponds to the horizon indicated in the first column. Columns 2-4 of Table A.II show the price-to-book variance decomposition for the constant-discount-factor model. Moving down column two of the tables, the variance share of cash flows increases from 2.1 percent at the one-year horizon to 12.4 percent at the fifteen-year horizon. The mispricing component of the constant-discount-factor model also grows as the regressions' horizon lengthens. Moving down column four, the variance share of mispricing increases from 4.4 percent at the one-year horizon to 48.7 percent at the fifteen-year horizon.

The difference between the constant-discount-rate results in Tables IV (WLS) and A.II (OLS) at the fifteen-year horizon is due to the time dummies. From the empirical results by Vuolteenaho (2001) we know that the time-series variation in the aggregate book-to-market ratio is almost exclusively due to expected-return effects. Time dummies in Table IV suck up this aggregate time-series variation and the remaining cross-sectional variation is mostly due to cash-flow effects, as documented by Cohen, Polk, and Vuolteenaho (2002).

Columns 5-7 of Table A.II shows the price-to-book variance decomposition for the stock-return CAPM. Column 5 of both tables shows that the variance share of cash flows increases from 0.9 percent at the one-year horizon to 25.9 percent at the fifteen-year horizon. The variance shares for the cash-flow CAPM are in columns 8-10. The variance share of cash flows in column eight increases from 3.7 percent to 31.0 percent for OLS as the horizon increases.

The mispricing share of stock-return CAPM is shown in column 7 of Table A.II. At the fifteen-year horizon, the stock-return CAPM allocates 28.8 percent to mispricing, which is less than for the constant discount rate model. The cash-flow CAPM is our most successful specification in OLS regressions as well. At fifteen-year horizon, the cash-flow CAPM allocates 7.7 percent in OLS regressions to mispricing.

Concentrating on the long-horizon mispricing component, Figures A.1-3 plot the estimated realized fifteen-year pricing errors versus price-to-book ratios for the constant-discount-rate model, the stock-return CAPM, and the cash-flow CAPM. The data points are color coded from black for price-to-book decile ten to light gray for price-to-book decile one. Consistent with our variance-decomposition regressions, pricing errors are strongly positively related to price-to-book ratios for the constant-discount-rate model in Figure A.1. Also, the evident heteroskedasticity related to the price-to-book ratio in Figure A.1 justifies the scaling used in our WLS regression, and suggest that one should place more weight to the results in Table IV than to those in Table A.II.

Figure A.3 plots realized pricing errors produced by the cash-flow CAPM against price-to-book-ratios. The positive relation that was clearly present with constant-discount-rate model's pricing errors in Figure A.1 is completely absent in the cash-flow CAPM's pricing errors. At the fifteen-year horizon, price-to-book ratios are essentially unrelated to the subsequent pricing-error realizations. A more detailed analysis reveals that most of the improvement comes from the cash-flow CAPM's ability to explain the deviations of the ten portfolios' price-to-book ratios from their time-series means. The portfolios' time-series mean price-to-book ratios are still slightly positively related to the pricing errors, but less so for the cash-flow CAPM than for the constant-discount-rate model.

C. Finer sorts

Our results are not sensitive to sorting stocks into twenty, thirty, or forty portfolios instead of ten portfolios. In fact, some of our results get stronger as we increase the number of portfolios. Focusing on the forty-portfolio sort, the estimates of the premium of cash-flow beta are 5.26% (1.1) at the one-year horizon, 8.40% (1.5) at the two-year horizon, 10.73% (2.5) at the three-year horizon, 9.24% (2.3) at the five-year horizon, 10.14% (2.6) at the ten-year horizon, and 8.72% (3.4) at the fifteen-year horizon (t-statistics in parentheses). The cross-sectional R^2 range from 21% to 73%.

The variance decomposition results for finer sorts are also consistent with our main results. If we use forty portfolios in our test, the constant-discount-rate model's shares are 37 percent due to cash flows, 37 percent due to the terminal value, and 26 percent due to pricing error. The stock-return CAPM's variance shares are 0.41, 0.37, and 0.22; and the cash-flow CAPM's 0.58, 0.49, and -0.07.

[1] Fama (1970, 1991) surveys the empirical literature on testing market efficiency. Daniel, Hirshleifer, and Subrahmanyam (1998) survey the recent evidence on trading strategies that would have produced abnormal profits and high Sharpe ratios. Hansen and Jagannathan (1991) show that in a frictionless rational-expectations model, the available Sharpe ratios are related to the variability of the marginal utility. MacKinlay (1995) argues that the Sharpe ratios of some trading strategies, if taken at face value, are too large to be explained by a rational multifactor model. Shleifer (2000, p. 8) characterizes the impact of this evidence on the views of finance academicians: "*We have learned a lot, and what we think now is quite a bit different from what we thought we knew in 1978. Among the many changes of views, the increased skepticism about market efficiency stands out.*"

[2] Graham and Harvey (2001) survey CFO's concerning firm business investment decisions and find that 73.5% of companies use the CAPM in capital budgeting.

[3] We thank Kenneth French for providing us with the data.

[4] The delisting-return assumptions follow Shumway's (1997) results. Shumway tracks a sample of firms whose delisting returns are missing from CRSP and finds that performance-related delistings are associated with a significant negative return, on average approximately -30 percent. This assumption is unimportant to our final results, however.

[5] Because $E(xy) = E(x)E(y) + \text{cov}(x,y)$, abnormal earnings are more valuable if they covary positively with the stochastic discount factor (holding the expected levels constant).

[6] Our cross-sectional result that the CAPM works well for the level of prices may be related to Daniel and Marshall's (1997). They document that the consumption-based habit model of Constantinides (1990) is able to match the mean and the variance of the observed equity premium, capture time variation in the equity premium, and can better match the observed risk-free rate when using long-horizon return and consumption data.

[7] Kothari, Shanken, and Sloan (1995) as well as Handa, Kothari, and Wasley (1993) show that the CAPM performs better when betas are measured using annual instead of monthly returns. Their focus is in explaining short-horizon expected returns, differentiating our tests from theirs.

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Table I: Descriptive statistics

This table reports descriptive statistics of the data. ME is market value of equity, BE book value of equity, and D dividends. Data are annual, except monthly stock returns.

Variable	Mean	Standard deviation	5th percentile	25th percentile	Median	75th percentile	95th percentile
Monthly stock return	0.0122	0.1748	-0.2109	-0.0628	0.0000	0.0696	0.2581
Annual stock return	0.1554	0.7091	-0.6133	-0.1983	0.0627	0.3595	1.1471
ME_{t-1} / BE_{t-1}	2.8839	5.9173	0.3927	0.8358	1.4170	2.6642	9.1470
D_{t-1} / ME_{t-1}	0.0221	0.0688	0.0000	0.0000	0.0067	0.0359	0.0770
$(ME_t - ME_{t-1}) / ME_{t-1}$	0.2002	1.1358	-0.6057	-0.2007	0.0536	0.3691	1.3200
$(BE_t - BE_{t-1}) / BE_{t-1}$	0.2037	1.7492	-0.4414	0.0000	0.0810	0.1846	0.8525

Table II: Cash-flow betas

This table reports the estimated cash-flow betas for value and growth stocks. In addition, the table reports the regression coefficients and the R^2 of the regression of the expected-return component of price on cash-flow betas. The sample period is 1928-1999.

Column one shows the horizon *N*. Columns 2-11 report the estimated cash-flow betas of price-to-book sorted decile portfolios. The cash-flow betas are the slopes of the following regressions:

$$\sum_{j=0}^{N-1} \rho^j \log(1+ROE_{k,t+j}) = \beta_{k,0} + \beta_{k,1} \sum_{j=0}^{N-1} \rho^j \log(1+ROE_{M,t+j}) + \varepsilon_{k,t+N-1},$$

where *k* denotes the decile portfolio, *M* the market portfolio, and *ROE* a portfolio's aggregate clean-surplus earnings divided by the beginning-of-the-year aggregate book equity. ρ is a constant equal to 0.95. Columns 12-13 report the intercept and the slope of a cross-sectional regression of the expected-return component of price on cash-flow betas:

$$\frac{1}{\sum_{j=0}^{N-1} \rho^j} \hat{E}\left[\sum_{j=0}^{N-1} \rho^j (R_{k,t+j,j+1} - 1)\right] = \lambda_0 + \lambda_1 \hat{\beta}_{1,k} + u_k,$$

where $R_{k,t,j}$ -1 is the year *t* simple (net) return on decile portfolio *k* during the *j*th year from the sort and $\hat{\beta}_{1,k}$ the estimated cash-flow beta. $\hat{E}$ denotes the sample mean. Column fourteen reports the R^2 of this cross-sectional regression

All regressions are estimated with OLS. GMM standard errors computed using the Newey-West formula with *N* leads and lags, which account for both the estimation uncertainty of the cash-flow betas and for the cross-sectional and time-series correlation of the error terms, are reported in parentheses.

N	High ME/BE	2	3	4	5	6	7	8	9	Low ME/BE	λ_0	λ_1	R^2
1	1.00	0.85	0.72	1.13	1.03	1.07	1.08	1.02	1.28	1.35	0.008	0.145	60.47%
	(0.58)	(0.37)	(0.25)	(0.83)	(0.36)	(0.31)	(0.43)	(0.42)	(0.52)	(0.41)	(0.229)	(0.258)	
2	0.79	0.93	0.80	1.05	1.00	1.08	1.14	1.20	1.29	1.42	-0.009	0.159	88.99%
	(0.59)	(0.36)	(0.13)	(0.50)	(0.16)	(0.12)	(0.31)	(0.33)	(0.39)	(0.42)	(0.201)	(0.192)	
3	0.73	0.90	0.90	0.89	1.11	1.05	1.04	1.28	1.42	1.50	0.024	0.129	91.90%
	(0.54)	(0.32)	(0.10)	(0.17)	(0.24)	(0.10)	(0.22)	(0.36)	(0.38)	(0.45)	(0.138)	(0.131)	
5	0.67	0.86	0.95	1.04	1.00	0.99	1.03	1.20	1.39	1.68	0.053	0.105	87.98%
	(0.41)	(0.28)	(0.11)	(0.19)	(0.13)	(0.12)	(0.15)	(0.26)	(0.35)	(0.34)	(0.088)	(0.083)	
10	0.90	0.90	0.99	1.04	1.05	1.09	1.03	1.18	1.24	1.47	0.018	0.128	84.22%
	(0.26)	(0.17)	(0.09)	(0.10)	(0.17)	(0.10)	(0.12)	(0.17)	(0.20)	(0.35)	(0.096)	(0.096)	
15	0.94	0.96	1.02	1.05	1.10	1.14	1.06	1.10	1.17	1.21	-0.063	0.202	77.83%
	(0.15)	(0.16)	(0.14)	(0.09)	(0.12)	(0.07)	(0.17)	(0.17)	(0.11)	(0.18)	(0.150)	(0.143)	

Table III: Estimated parameters of stochastic discount factors

This table reports the estimated parameters of three stochastic-discount-factor models. The first model, $Q_t / Q_{t-1} = \delta \pi_{t-1} / \pi_t$, is a constant real discount factor, δ, times the ratio of price levels, π_{t-1} / π_t. The parameter estimates with standard errors for the constant-discount-rate model are reported in second column of the table.

The second model is the stock-return CAPM: $Q_t / Q_{t-1} = (\gamma_0 + \gamma_1 RMRF_t) \pi_{t-1} / \pi_t$. This stochastic discount factor is a linear function of the excess stock return on the value-weight market portfolio $(\gamma_0 + \gamma_1 RMRF_t)$ times the ratio of price levels. The third and fourth columns report the parameter estimates with standard errors.

The fifth and sixth columns show some implications of the stock-return CAPM parameter estimates. The fifth column shows the implied average price of a real risk-free one-period discount bond, and the sixth column the implied average *RMRF*. These implied statistics are computed by adding two additional moment conditions (one for mean *RMRF* and another for mean squared *RMRF*) to the system and using the formulas $\gamma_0 + \gamma_1 E(RMRF)$ and $-\gamma_1 \operatorname{var}(RMRF) / [\gamma_0 + \gamma_1 E(RMRF)]$.

The seventh and eight columns show the parameter estimates of the third model, the cash-flow CAPM: $Q_t / Q_{t-1} = [g_0 + g_1 \log(1 + ROE_{M,t}^{real})] \pi_{t-1} / \pi_t$, where $ROE_{M,t}^{real}$ is the market portfolio's aggregate real clean-surplus earnings for year *t* divided by the beginning of the year *t* aggregate real book equity.

The parameters are estimated using GMM based on the following moment conditions:

$$(1) \quad 0 = \frac{1}{T} \sum_{t=1}^{T} \left(R_{rf,t} \frac{Q(b)_t}{Q(b)_{t-1}} - 1 \right)$$

$$(2) \quad 0 = \frac{1}{T} \sum_{t=1}^{T} \left(RMRF_t \frac{Q(b)_t}{Q(b)_{t-1}} \right)$$

$$(3) \quad 0 = \frac{1}{T} \sum_{t=1}^{T} \left[\frac{ME_{k,t-1}}{BE_{k,t-1}} - 1 - \sum_{j=0}^{N-1} \left(\frac{Q(b)_{t+j}}{Q(b)_{t-1}} \frac{A(b)_{k,t+j}}{BE_{k,t-1}} \right) - \frac{Q(b)_{t+N-1}}{Q(b)_{t-1}} \times \frac{ME_{k,t+N-1} - BE_{k,t+N-1}}{BE_{k,t-1}} \right]$$

The moment condition (1) is omitted from the system used to estimate the constant-discount-rate model. Above, R_{rf} is the gross nominally risk-free interest rate, ME is market value of equity, A abnormal earnings, BE book equity, and Q the cumulative stochastic discount factor. Subscripts *k* and *t* are indices to portfolios and time, respectively. b denotes the generic stochastic-discount-factor parameter vector. The first column of the table reports N, the horizon used the price-to-book restrictions.

The portfolios used as test assets in the price-to-book moment conditions are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after portfolio formation. The sample period is 1928-1999 and all data and parameters are in annual terms.

GMM standard errors computed using the Newey-West formula with *N* leads and lags, which account for both the estimation uncertainty of the cash-flow betas and for the cross-sectional and time-series correlation of the error terms, are reported in parentheses.

Horizon: N	Constant discount rate: $\hat{\delta}$	Stock-return CAPM stochastic discount factor: $\hat{\gamma}_0$	$\hat{\gamma}_1$	Implications of stock-return CAPM's parameters: $E(R_{rf,real}^{-1})$	$E(RMRF)$	Cash-flow CAPM stochastic discount factor: $\hat{g}_0$	$\hat{g}_1$
1	0.9193 (0.0189)	1.0703 (0.0765)	-1.3327 (0.5917)	0.9436 (0.0241)	0.0898 (0.0289)	2.0984 (0.4428)	-17.0091 (5.7880)
2	0.9177 (0.0167)	1.0766 (0.0805)	-1.4156 (0.6623)	0.9448 (0.0191)	0.0952 (0.0295)	1.5819 (0.2551)	-9.5922 (3.6484)
3	0.9178 (0.0159)	1.0714 (0.0782)	-1.3485 (0.6577)	0.9472 (0.0153)	0.0919 (0.0296)	1.8591 (0.3991)	-13.7438 (5.6569)
5	0.9171 (0.0135)	1.0500 (0.0612)	-1.1680 (0.5270)	0.9455 (0.0126)	0.0825 (0.0278)	1.5401 (0.2871)	-9.0116 (4.2850)
10	0.9237 (0.0141)	1.0309 (0.0564)	-1.0251 (0.5668)	0.9360 (0.0149)	0.0794 (0.0296)	1.9781 (0.3181)	-15.1786 (4.1686)
15	0.9272 (0.0131)	1.0167 (0.0493)	-0.9020 (0.5091)	0.9355 (0.0163)	0.0746 (0.0336)	1.2956 (0.1954)	-5.1805 (2.8265)

Table IV: Cross-sectional WLS variance decomposition of price-to-book ratios

This table reports three sets of variance-decomposition regressions. The variance-decomposition regressions are estimated by separately regressing the three components of the price-to-book ratios on the price-to-book ratios and time dummies:

$$\frac{1}{w_k}\sum_{j=0}^{N-1}\left(\frac{\hat{Q}_{t+j}}{\hat{Q}_{t-1}}\times\frac{\hat{A}_{k,t+j}}{BE_{k,t-1}}\right)=\beta'_{WLS}\times\frac{1}{w_k}\frac{ME_{k,t-1}}{BE_{k,t-1}}+\Delta'_{WLS}\times\frac{1}{w_k}DT_t+e'_{k,t+N-1}$$

$$\frac{1}{w_k}\times\frac{\hat{Q}_{t+N-1}}{\hat{Q}_{t-1}}\times\frac{ME_{k,t+N-1}-BE_{k,t+N-1}}{BE_{k,t-1}}=\beta''_{WLS}\times\frac{1}{w_k}\frac{ME_{k,t-1}}{BE_{k,t-1}}+\Delta''_{WLS}\times\frac{1}{w_k}DT_t+e''_{k,t+N-1}$$

$$\frac{1}{w_k}\sum_{j=0}^{N-1}\left(\frac{\hat{Q}_{t+j}}{\hat{Q}_{t-1}}\times\frac{\hat{\varepsilon}_{k,t+j}}{BE_{k,t-1}}\right)=\beta'''_{WLS}\times\frac{1}{w_k}\frac{ME_{k,t-1}}{BE_{k,t-1}}+\Delta'''_{WLS}\times\frac{1}{w_k}DT_t+e'''_{k,t+N-1}$$

Above, ME is the market value of equity, $\hat{A}$ estimated abnormal earnings, BE book equity, DT matrix of time dummies, $\hat{Q}$ cumulative stochastic discount factor, and $\hat{\varepsilon}$ estimated realized pricing error. $w_k=(1/T)\sum_{t=1}^{t}(ME_{k,t-1}/BE_{k,t-1})$. $\hat{Q}$ and $\hat{\varepsilon}$ are computed using the parameter estimates from Table III. Subscripts k and t are indices to portfolios and time, respectively.

The first column of the table shows N, the horizon used in computing the dependent variables of the regressions. The columns 2-4 show the WLS regression coefficients for the dependent variables constructed using the constant discount factor. The columns 5-7 show the results for the stock-return CAPM, $\hat{Q}_t/\hat{Q}_{t-1}=(\hat{\gamma}_0+\hat{\gamma}_1 RMRF_t)\pi_{t-1}/\pi_t$, where $RMRF$ is the excess return on the value-weight market portfolio. Columns 8-10 show the results for the cash-flow CAPM, $Q_t/Q_{t-1}=[g_0+g_1\log(1+ROE^{real}_{M,t})]\pi_{t-1}/\pi_t$, where $ROE^{real}_{M,t}$ is the market portfolio's real ROE.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on the price-to-book ratios and cover the period 1928-1999. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after the portfolio formation. Standard errors (in parentheses) account for both the estimation uncertainty of the stochastic-discount-factor parameters and for the cross-sectional and time-series correlation of the errors.

	Constant real discount factor			Stock-return CAPM:			Cash-flow CAPM:		
N	β' Cash flows	β'' Terminal value	β''' Mispricing	β' Cash flows	β'' Terminal value	β''' Mispricing	β' Cash flows	β'' Terminal value	β''' Mispricing
1	0.066	0.902	0.032	0.067	0.880	0.053	0.050	1.061	-0.111
	(0.009)	(0.023)	(0.019)	(0.010)	(0.020)	(0.018)	(0.027)	(0.097)	(0.080)
2	0.119	0.824	0.057	0.125	0.844	0.031	0.112	0.937	-0.049
	(0.016)	(0.044)	(0.035)	(0.018)	(0.037)	(0.031)	(0.027)	(0.056)	(0.047)
3	0.159	0.780	0.061	0.173	0.808	0.019	0.146	0.994	-0.141
	(0.023)	(0.067)	(0.051)	(0.027)	(0.056)	(0.046)	(0.038)	(0.119)	(0.103)
5	0.224	0.659	0.117	0.231	0.712	0.057	0.231	0.857	-0.088
	(0.025)	(0.074)	(0.062)	(0.028)	(0.074)	(0.067)	(0.039)	(0.102)	(0.092)
10	0.313	0.493	0.194	0.335	0.569	0.096	0.446	0.693	-0.139
	(0.035)	(0.116)	(0.099)	(0.036)	(0.141)	(0.121)	(0.086)	(0.192)	(0.247)
15	0.377	0.354	0.269	0.423	0.376	0.201	0.520	0.480	-0.001
	(0.049)	(0.091)	(0.059)	(0.056)	(0.075)	(0.062)	(0.131)	(0.103)	(0.121)

Table V: Parametric model of beta evolution

This table shows an estimated parametric specification for betas:

$$R_{i,t} - R_{rf,t} = \alpha_i + \sum_{l=0}^{L} \beta_{0,l} \times RMRF_{t-l} + \sum_{l=0}^{L} \beta_{1,l} \times TREND_t \times RMRF_{t-l}$$
$$+ \sum_{l=0}^{L} \beta_{2,l} \times YEARS_i \times RMRF_{t-l} + \sum_{l=0}^{L} \beta_{3,l} \times YEARS_i \times TREND_t \times RMRF_{t-l} + \varepsilon_{i,t}$$

TREND is a linear time trend in centuries (month index divided by 1200), normalized to zero in the middle of the sample. *YEARS* is the number of years from the sort divided by one hundred, or more accurately the number of lags we used in firms' price-to-book ratios when sorting the portfolios into deciles divided by one hundred. *RMRF* is the excess return on the market portfolio. *L* is the number of *RMRF* lags included in the regressions. The table reports the sums of coefficients for value, growth and value-minus-0growth portfolios:

$$\text{b(intercept)} = \sum_{l=0}^{L} \beta_{0,l},\ \text{b(trend)} = \sum_{l=0}^{L} \beta_{1,l},\ \text{b(years from sort)} = \sum_{l=0}^{L} \beta_{2,l},\ \text{b(years from sort} \times \text{trend)} = \sum_{l=0}^{L} \beta_{3,l}$$

The dependent variables are constructed as follows. We first sort stocks into price-to-book deciles. Every year, we run fifteen different sorts: Deciles sorted on year-*t*-1 price-to-book ratios, deciles sorted on year-*t*-2 price-to-book ratios,…, and deciles sorted on year-*t*-15 price-to-book ratios. As a result, we have 715 months of returns on 150 portfolios for the period 6/1941-12/2000 (the maximum period for which our data made it possible to compute the fifteen-years-from-the-sort portfolio). The dependent variables in the regressions are an equal-weight portfolio of the three value-weight lowest-price-to-book deciles (Panel A), an equal-weight portfolio of the three value-weight highest-price-to-book deciles (Panel B), and the difference of the two (Panel C).

Panel A:

Value					
Lags of RMRF (L):	0	1	2	5	11
b(intercept)	**0.98**	**0.96**	**0.97**	**0.98**	**0.94**
standard error	0.01	0.02	0.02	0.03	0.05
t-statistic	69.84	50.44	42.05	30.98	20.63
b(trend)	**-0.68**	**-0.70**	**-0.84**	**-0.62**	**-0.64**
standard error	0.08	0.11	0.13	0.17	0.22
t-statistic	-8.49	-6.48	-6.60	-3.61	-2.93
b(time from sort)	**0.43**	**0.53**	**0.52**	**0.66**	**0.54**
standard error	0.10	0.14	0.16	0.23	0.32
t-statistic	4.29	3.93	3.14	2.91	1.65
b(time from sort * trend)	**0.10**	**0.80**	**1.50**	**1.78**	**2.16**
standard error	0.57	0.77	0.91	1.22	1.57
t-statistic	0.17	1.04	1.66	1.46	1.38

Panel B:

Growth					
Lags of RMRF (L):	0	1	2	5	11
b(intercept)	**1.05**	**1.05**	**1.04**	**1.01**	**1.00**
standard error	0.01	0.01	0.01	0.02	0.03
t-statistic	116.09	85.39	70.18	49.56	34.04
b(trend)	**0.27**	**0.35**	**0.46**	**0.54**	**0.68**
standard error	0.05	0.07	0.08	0.11	0.14
t-statistic	5.22	5.04	5.59	4.86	4.82
b(time from sort)	**-0.63**	**-0.78**	**-0.80**	**-0.68**	**-0.54**
standard error	0.07	0.09	0.11	0.15	0.22
t-statistic	-9.24	-8.46	-7.11	-4.37	-2.46
b(time from sort * trend)	**-1.55**	**-1.84**	**-2.16**	**-2.01**	**-0.98**
standard error	0.39	0.52	0.62	0.83	1.06
t-statistic	-3.96	-3.54	-3.51	-2.42	-0.92

Panel C:

Difference					
Lags of RMRF (L):	0	1	2	5	11
b(intercept)	**-0.07**	**-0.08**	**-0.07**	**-0.03**	**-0.06**
standard error	0.02	0.03	0.03	0.05	0.07
t-statistic	-3.35	-3.09	-2.09	-0.65	-0.87
b(trend)	**-0.95**	**-1.05**	**-1.29**	**-1.15**	**-1.32**
standard error	0.12	0.15	0.18	0.24	0.31
t-statistic	-8.30	-6.81	-7.14	-4.71	-4.21
b(time from sort)	**1.06**	**1.32**	**1.31**	**1.34**	**1.08**
standard error	0.13	0.18	0.22	0.30	0.43
t-statistic	7.92	7.25	5.98	4.42	2.49
b(time from sort * trend)	**1.65**	**2.64**	**3.66**	**3.80**	**3.14**
standard error	0.77	1.02	1.21	1.63	2.09
t-statistic	2.15	2.58	3.03	2.33	1.51

Table VI: Calendar-time portfolio returns

This table reports stock-return-based tests for different investment horizons. We first sort stocks into price-to-book deciles and then calculate the value-weight monthly returns on each decile over the next fifteen years (without re-sorting the stocks). We define the *N*-year decile *M* as a portfolio strategy that invests equally in *N* portfolios: Decile *M* sorted on year-*t*-1 price-to-book ratios, decile *M* sorted on year-*t*-2 price-to-book ratios,…, and decile *M* sorted on year-*t*-*N* price-to-book ratios. We extend the "holding periods" (i.e., *N*) out to fifteen years.

Column two reports the GRS statistic testing the intercepts in regressions of the monthly returns on these ten *N*-year deciles on the excess market stock return and eleven lags. Column three reports the mean of a strategy that goes long the top three decile portfolios (low price-to-book) and shorts the bottom three decile portfolios (high price-to-book). Column four reports the alpha in regressions of this portfolio on the excess market return and eleven lags. Columns five and six report the intercept and coefficient of a cross-sectional regression of the average returns on the ten *N*-year decile portfolios on the total betas of those portfolios. We construct total betas by summing the individual partial betas on the excess market return and eleven lags of the excess market return. Column seven reports the (unadjusted) R^2 from that cross-sectional regression.

Standard errors are in parentheses except in column two where we report the probability value associated with the GRS statistic in brackets. We provide bootstrapped probability values in braces under the null hypothesis that the CAPM is true except in column three where the null hypothesis is a mean return on the value-minus-growth portfolio of zero.

N	GRS [asympt. pval.] {bootstrap pval.}	μ (asympt std. err.) {bootstrap pval.}	α (asympt std. err.) {bootstrap pval.}	λ_0 (asympt std. err.) {bootstrap pval.}	λ_1 (asympt std. err.) {bootstrap pval.}	R^2 (asympt std. err.) {bootstrap pval.}
	1.9182	0.0037	0.0042	0.0091	-0.0007	0.0008
1	[0.0399]	[0.0011]	[0.0013]	[0.0087]	[0.0088]	[0.0219]
	{0.0524}	{0.0015}	{0.0014}	{0.0397}	{0.0525}	{0.0117}
	2.3707	0.0040	0.0042	0.0052	0.0034	0.0144
2	[0.0092]	[0.0010]	[0.0012]	[0.0099]	[0.0099]	[0.1003]
	{0.0122}	{0.0009}	{0.0004}	{0.2007}	{0.3112}	{0.0302}
	2.2770	0.0037	0.0037	-0.0017	0.0103	0.1552
3	[0.0126]	[0.0010]	[0.0011]	[0.0086]	[0.0085]	[0.2813]
	{0.0127}	{0.0015}	{0.0014}	{0.5235}	{0.3153}	{0.0839}
	2.4368	0.0034	0.0031	-0.0066	0.0151	0.4407
5	[0.0074]	[0.0010]	[0.0011]	[0.0061]	[0.0060]	[0.3247]
	{0.0095}	{0.0025}	{0.0036}	{0.0609}	{0.0241}	{0.1568}
	1.2411	0.0025	0.0017	-0.0031	0.0113	0.6736
10	[0.2609]	[0.0009]	[0.0010]	[0.0028]	[0.0028]	[0.1966]
	{0.2727}	{0.0316}	{0.0972}	{0.2866}	{0.1869}	{0.3307}
	1.1113	0.0018	0.0008	0.0003	0.0079	0.7031
15	[0.3507]	[0.0009]	[0.0010]	[0.0018]	[0.0018]	[0.1653]
	{0.3699}	{0.1436}	{0.3808}	{0.8005}	{0.6476}	{0.4474}

Table A.I: Results for the 1938-1999 subperiod

This table shows the paper's main tests and results for the 1938-1999 subperiod.

Panel A reports descriptive statistics of the data. ME is market value of equity, BE book value of equity, and D dividends. Data are annual, except monthly stock returns.

Panel B replicates the cash-flow-beta regressions. Notes in Table II apply.

Panel C shows the parameter estimates of the stochastic discount factors. Notes in Table III apply.

Panel D shows the variance decomposition of price-to-book ratios. Notes in Table IV apply.

Panel A: Descriptive statistics for the sample period 1938-1999; 200,871 firm-years

Variable	Mean	Standard deviation	5th percentile	25th percentile	Median	75th percentile	95th percentile
Monthly stock return	0.0139	0.1599	-0.1916	-0.0588	0	0.0702	0.2448
Annual stock return	0.1735	0.6837	-0.5559	-0.1705	0.0808	0.3684	1.1481
ME_{t-1} / BE_{t-1}	2.6240	5.3242	0.3946	0.8089	1.3477	2.4768	7.9820
D_{t-1} / ME_{t-1}	0.0261	0.0419	0	0	0.0156	0.0442	0.0831
$(ME_t - ME_{t-1}) / ME_{t-1}$	0.2043	0.9218	-0.5479	-0.1765	0.0655	0.3707	1.2952
$(BE_t - BE_{t-1}) / BE_{t-1}$	0.2047	1.1314	-0.3147	0.0110	0.0841	0.1814	0.8044

Panel B: Table II's cash-flow-beta regressions estimated form the 1938-1999 sample

N	High ME/BE	2	3	4	5	6	7	8	9	Low ME/BE	λ_0	λ_1	R^2
1	0.65	0.57	0.86	0.80	0.88	0.73	0.76	0.65	1.30	1.38	0.097	0.070	60.40%
	(1.31)	(0.55)	(0.50)	(0.36)	(0.66)	(0.29)	(0.35)	(0.34)	(0.67)	(1.07)	(0.115)	(0.116)	
2	0.16	0.69	0.83	0.76	0.87	1.03	0.79	0.81	1.08	1.27	0.104	0.066	52.42%
	(1.13)	(0.64)	(0.41)	(0.48)	(0.24)	(0.33)	(0.33)	(0.26)	(0.66)	(1.02)	(0.124)	(0.134)	
3	0.12	0.67	0.87	0.74	0.83	0.98	0.76	0.79	1.02	1.45	0.111	0.061	60.08%
	(1.01)	(0.69)	(0.38)	(0.40)	(0.28)	(0.27)	(0.24)	(0.21)	(0.41)	(1.00)	(0.098)	(0.111)	
5	0.14	0.52	0.87	0.82	0.80	0.89	0.84	0.76	0.85	1.30	0.116	0.059	44.79%
	(1.18)	(0.80)	(0.45)	(0.40)	(0.22)	(0.22)	(0.23)	(0.31)	(0.33)	(0.80)	(0.106)	(0.124)	
10	0.99	0.94	0.92	1.12	0.86	1.01	0.94	0.97	0.95	1.07	0.102	0.053	3.76%
	(0.47)	(0.43)	(0.24)	(0.22)	(0.33)	(0.18)	(0.19)	(0.18)	(0.26)	(0.27)	(0.082)	(0.082)	
15	1.11	1.09	1.05	1.17	1.07	1.11	0.98	0.93	1.02	1.04	0.290	-0.133	33.71%
	(0.16)	(0.29)	(0.23)	(0.11)	(0.32)	(0.15)	(0.22)	(0.19)	(0.08)	(0.17)	(0.201)	(0.200)	

Panel C: Parameters of the stochastic discount factors estimated from the 1938-1999 sample

Horizon: N	Constant discount rate: $\hat{\delta}$	Stock-return CAPM stochastic discount factor: $\hat{\gamma}_0$	$\hat{\gamma}_1$	Implications of stock-return CAPM's parameters: $E(R_{rf,real}^{-1})$	$E(RMRF)$	Cash-flow CAPM stochastic discount factor: $\hat{g}_0$	$\hat{g}_1$
1	0.9110 (0.0167)	1.1599 (0.1053)	-2.4670 (0.7415)	0.9422 (0.0206)	0.0908 (0.0202)	0.0454 (0.7627)	12.9512 (9.9670)
2	0.9082 (0.0149)	1.1939 (0.1033)	-2.5785 (0.7600)	0.9726 (0.0181)	0.0918 (0.0210)	1.3559 (0.2105)	-6.2949 (3.6484)
3	0.9079 (0.0143)	1.1771 (0.0983)	-2.4700 (0.7314)	0.9684 (0.0170)	0.0897 (0.0215)	1.4171 (0.2126)	-7.2554 (3.1968)
5	0.9103 (0.0142)	1.1538 (0.0930)	-2.3016 (0.7308)	0.9671 (0.0207)	0.0858 (0.0243)	1.7144 (0.3121)	-11.8475 (4.9069)
10	0.9195 (0.0153)	1.1063 (0.0853)	-1.9315 (0.7445)	0.9438 (0.0287)	0.0817 (0.0335)	1.2944 (0.1702)	-5.2280 (2.3483)
15	0.9246 (0.0152)	1.1403 (0.1547)	-2.3235 (1.4225)	0.9543 (0.0330)	0.0986 (0.0614)	1.1518 (0.1071)	-3.0628 (1.4724)

Panel D: Variance-decomposition results for the 1938-1999 sample

	Constant real discount factor			Stock-return CAPM:			Cash-flow CAPM:		
N	β' Cash flows	β'' Terminal value	β''' Mispricing	β' Cash flows	β'' Terminal value	β''' Mispricing	β' Cash flows	β'' Terminal value	β''' Mispricing
1	0.060 (0.010)	0.906 (0.024)	0.034 (0.020)	0.062 (0.010)	0.864 (0.022)	0.074 (0.023)	0.074 (0.010)	0.790 (0.053)	0.136 (0.051)
2	0.107 (0.016)	0.837 (0.045)	0.056 (0.036)	0.114 (0.017)	0.870 (0.044)	0.016 (0.046)	0.105 (0.023)	0.936 (0.041)	-0.040 (0.033)
3	0.142 (0.021)	0.800 (0.067)	0.058 (0.052)	0.154 (0.023)	0.819 (0.063)	0.028 (0.063)	0.142 (0.031)	0.956 (0.077)	-0.099 (0.065)
5	0.200 (0.022)	0.682 (0.074)	0.118 (0.065)	0.227 (0.030)	0.738 (0.082)	0.035 (0.092)	0.210 (0.042)	0.935 (0.122)	-0.144 (0.113)
10	0.280 (0.024)	0.519 (0.121)	0.201 (0.109)	0.374 (0.061)	0.609 (0.144)	0.017 (0.152)	0.400 (0.070)	0.557 (0.128)	0.043 (0.106)
15	0.339 (0.041)	0.383 (0.097)	0.278 (0.070)	0.530 (0.185)	0.355 (0.060)	0.115 (0.212)	0.437 (0.103)	0.518 (0.102)	0.045 (0.071)

Table A.II: OLS variance decomposition of price-to-book ratios

This table reports three sets of variance-decomposition regressions estimated with OLS by separately regressing the three components of the price-to-book ratios on the price-to-book ratios:

$$\sum_{j=0}^{N-1}(\hat{Q}_{t+j}/\hat{Q}_{t-1})\times(\hat{A}_{k,t+j}/BE_{k,t-1})=\alpha'+\beta'(ME_{k,t-1}/BE_{k,t-1})+e'_{k,t+N-1}$$

$$(\hat{Q}_{t+N-1}/\hat{Q}_{t-1})\times[(ME_{k,t+N-1}-BE_{k,t+N-1})/BE_{k,t-1}]=\alpha''+\beta''(ME_{k,t-1}/BE_{k,t-1})+e''_{k,t+N-1}$$

$$\sum_{j=0}^{N-1}(\hat{Q}_{t+j}/\hat{Q}_{t-1})\times(\hat{\varepsilon}_{k,t+j}/BE_{k,t-1})=\alpha'''+\beta'''(ME_{k,t-1}/BE_{k,t-1})+e'''_{k,t+N-1}$$

Above, ME is market equity, $\hat{A}$ estimated abnormal earnings, BE book equity, $\hat{Q}$ cumulative stochastic discount factor, and $\hat{\varepsilon}$ estimated realized pricing error. $\hat{Q}$ and $\hat{\varepsilon}$ are computed using the parameter estimates from Table III. Subscripts k and t are indices to portfolios and time, respectively.

The first column of the table shows N, the horizon used in computing the dependent variables of the regressions. Columns 2-4 show the regression coefficients for the dependent variables constructed using the constant discount factor. The discount factor of this model is the estimated constant real discount factor $\hat{\delta}$ times the ratio of price levels π_{t-1}/π_t. Columns 5-7 show the regression coefficients for the dependent variables constructed using the stock-return CAPM. The stock-return CAPM stochastic discount factor is $\hat{Q}_t/\hat{Q}_{t-1}=(\hat{\gamma}_0+\hat{\gamma}_1 RMRF_t)\pi_{t-1}/\pi_t$, where $RMRF$ is the excess stock return on the value-weight market portfolio. Columns 8-10 show the regression coefficients for the dependent variables constructed using the cash-flow CAPM. The cash-flow CAPM stochastic discount factor is $Q_t/Q_{t-1}=[g_0+g_1\log(1+ROE^{real}_{M,t})]\pi_{t-1}/\pi_t$, where $ROE^{real}_{M,t}$ is the market portfolio's real ROE.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after portfolio formation.

Standard errors, which account for both the estimation uncertainty of the stochastic-discount-factor parameters and for the cross-sectional and time-series correlation of the error terms, are reported in parentheses.

	Constant real discount factor			Stock-return CAPM:			Cash-flow CAPM:		
N	β' Cash flows	β'' Terminal value	β''' Mispricing	β' Cash flows	β'' Terminal value	β''' Mispricing	β' Cash flows	β'' Terminal value	β''' Mispricing
1	0.021	0.935	0.044	0.009	0.916	0.075	0.037	1.133	-0.170
	(0.006)	(0.038)	(0.036)	(0.010)	(0.036)	(0.038)	(0.020)	(0.135)	(0.151)
2	0.042	0.893	0.065	0.062	0.931	0.008	0.061	1.027	-0.088
	(0.012)	(0.065)	(0.058)	(0.022)	(0.050)	(0.059)	(0.022)	(0.084)	(0.097)
3	0.061	0.892	0.047	0.106	0.922	-0.028	0.107	1.147	-0.254
	(0.017)	(0.099)	(0.090)	(0.034)	(0.072)	(0.087)	(0.045)	(0.159)	(0.191)
5	0.105	0.809	0.087	0.157	0.901	-0.058	0.158	1.094	-0.252
	(0.020)	(0.117)	(0.122)	(0.037)	(0.120)	(0.144)	(0.042)	(0.155)	(0.185)
10	0.121	0.616	0.263	0.226	0.751	0.023	0.503	0.877	-0.381
	(0.029)	(0.160)	(0.157)	(0.075)	(0.217)	(0.236)	(0.279)	(0.299)	(0.549)
15	0.124	0.390	0.487	0.259	0.453	0.288	0.310	0.613	0.077
	(0.060)	(0.114)	(0.077)	(0.133)	(0.107)	(0.160)	(0.213)	(0.164)	(0.252)

Figure 1: Variance shares for the stock-return CAPM

This figure graphs the variance shares from Table IV columns 5-7 as a function of the horizon *N*. The lightly colored area in the bottom represents the variance share of risk-adjusted cash flows, the white area in the middle the share of the terminal value, and the dark area in the top the share of pricing errors; all relative to the stock-return CAPM. For comparison purposes, the variance shares from the constant-discount-rate model (Table IV columns 2-4) are plotted with bold dashed lines.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after the portfolio formation. The sample period is 1928-1999 and all data are annual.

Figure 2: Variance shares for the cash-flow CAPM

This figure graphs the variance shares from Table IV columns 8-10 as a function of the horizon *N*. The lightly colored area in the bottom represents the variance share of risk-adjusted cash flows, the white area in the middle the share of the terminal value, and the dark area in the top the share of pricing errors; all relative to the cash-flow CAPM. For comparison purposes, the variance shares from the constant-discount-rate model (Table IV columns 2-4) are plotted with bold dashed lines.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after the portfolio formation. The sample period is 1928-1999 and all data are annual.

Figure 3: Evolution of the CAPM beta after portfolio formation

This figure shows the evolution of the total CAPM beta for value and growth stocks after portfolio formation. We first sort stocks into price-to-book deciles. Every year, we run fifteen different sorts: Deciles sorted on year-*t*-1 price-to-book ratios, deciles sorted on year-*t*-2 price-to-book ratios,…, and deciles sorted on year-*t*-15 price-to-book ratios. As a result, we have 715 months of returns on 150 portfolios for the period 6/1941-12/2000 (the maximum period for which our data made it possible to compute the fifteen-years-from-the-sort portfolio).

We compute our measure of risk by regressing the monthly returns on the portfolios on the contemporaneous and lagged market returns. We then sum the regression coefficients for each dependent variable to obtain what we call "total beta." The upper-left plot is produced with no lagged market returns in the regressions, the upper-right with one lag, the lower-left with five lags, and the lower-right with eleven lags. The dependent variables in the regressions are an equal-weight portfolio of the three value-weight lowest-price-to-book deciles and an equal-weight portfolio of the three value-weight highest-price-to-book deciles. The total beta of value stocks is plotted with a solid line and triangles and the total beta of growth stocks with just a solid line. The dashed lines show one-standard-error bounds.

Figure 4: Mean excess returns and alphas for different holding periods

This figure shows annualized average excess returns (top graph) and alphas (bottom graph) on deciles for up to *N*-year holding period. We first sort stocks into price-to-book deciles. Every year, we run fifteen different sorts: Deciles sorted on year-*t*-1 price-to-book ratios, deciles sorted on year-*t*-2 price-to-book ratios,…, and deciles sorted on year-*t*-15 price-to-book ratios. As a result, we have 715 months of returns on 150 portfolios for the period 6/1941-12/2000. We define the *N*-year decile *M* as a portfolio strategy that invests equally in *N* portfolios: Decile *M* sorted on year-*t*-1 price-to-book ratios, decile *M* sorted on year-t-2 price-to-book ratios,…, and decile M sorted on year-t-N price-to-book ratios. The height of the column corresponds to 1200 times the mean excess return in the top graph and to 1200 times the intercept of a regression of the monthly excess returns on the contemporaneous excess market return and eleven lags of the excess market return in the bottom graph.

Figure A.1: Realizations of the constant-discount-rate pricing-error component

This figure plots the estimated realized fifteen-year pricing errors versus price-to-book ratios for the constant-discount rate model. The realized pricing-error component is computed as

$$\frac{ME_{k,t-1}}{BE_{k,t-1}} - 1 - \frac{1}{\hat{Q}_{t-1}} \sum_{j=0}^{14} \frac{\hat{Q}_{t+j}\hat{A}_{k,t+j}}{BE_{k,t-1}} - \frac{\hat{Q}_{t+14}}{\hat{Q}_{t-1}} \times \frac{ME_{k,t+14} - BE_{k,t+14}}{BE_{k,t-1}}.$$

Above, ME is the market value of equity, $\hat{A}$ estimated abnormal earnings, BE book equity, and $\hat{Q}$ estimated cumulative stochastic discount factor. The (nominal) discount factor of the constant-discount-factor model, $\hat{Q}_t / \hat{Q}_{t-1} = \hat{\delta}\pi_{t-1} / \pi_t$, is $\hat{\delta}$ estimate from Table III times the ratio of price levels π_{t-1} / π_t.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after portfolio formation. The data points are color coded from black for price-to-book decile ten to light gray for price-to-book decile one. The sample period is 1928-1999 and data are annual.

Figure A.2: Realizations of the stock-return CAPM pricing-error component

This figure plots the estimated realized fifteen-year pricing errors versus price-to-book ratios for the stock-return CAPM. The realized pricing-error component is computed as in Figure 3 but using the stochastic-discount-factor model $\hat{Q}_t / \hat{Q}_{t-1} = (\hat{\gamma}_0 + \hat{\gamma}_1 RMRF_t)\pi_{t-1} / \pi_t$, where $RMRF$ is the excess return on the value-weight market portfolio. The stock-return CAPM parameters are from Table III.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after portfolio formation. The data points are color coded from black for price-to-book decile ten to light gray for price-to-book decile one. The sample period is 1928-1999 and data are annual.

Figure A.3: Realizations of the cash-flow CAPM pricing-error component

This figure plots the estimated realized fifteen-year pricing errors versus price-to-book ratios for the cash-flow CAPM. The realized pricing-error component is computed as in Figure 3 but using the stochastic-discount-factor model $\hat{Q}_t / \hat{Q}_{t-1} = [\hat{g}_0 + \hat{g}_1 \log(1 + ROE_{M,t}^{real})]\pi_{t-1} / \pi_t$, where $ROE_{M,t}^{real}$ is the market portfolio's aggregate real clean-surplus earnings for year t divided by the beginning of the year t aggregate real book equity. The cash-flow CAPM parameters are from Table III.

The portfolios used as test assets are formed by sorting stocks into ten value-weight portfolios based on their price-to-book ratios. After sorting, we follow the market and book values as well as abnormal earnings for the portfolios up to fifteen years after portfolio formation. The data points are color coded from black for price-to-book decile ten to light gray for price-to-book decile one. The sample period is 1928-1999 and data are annual.

Figure 1: Variance shares for the stock-return CAPM

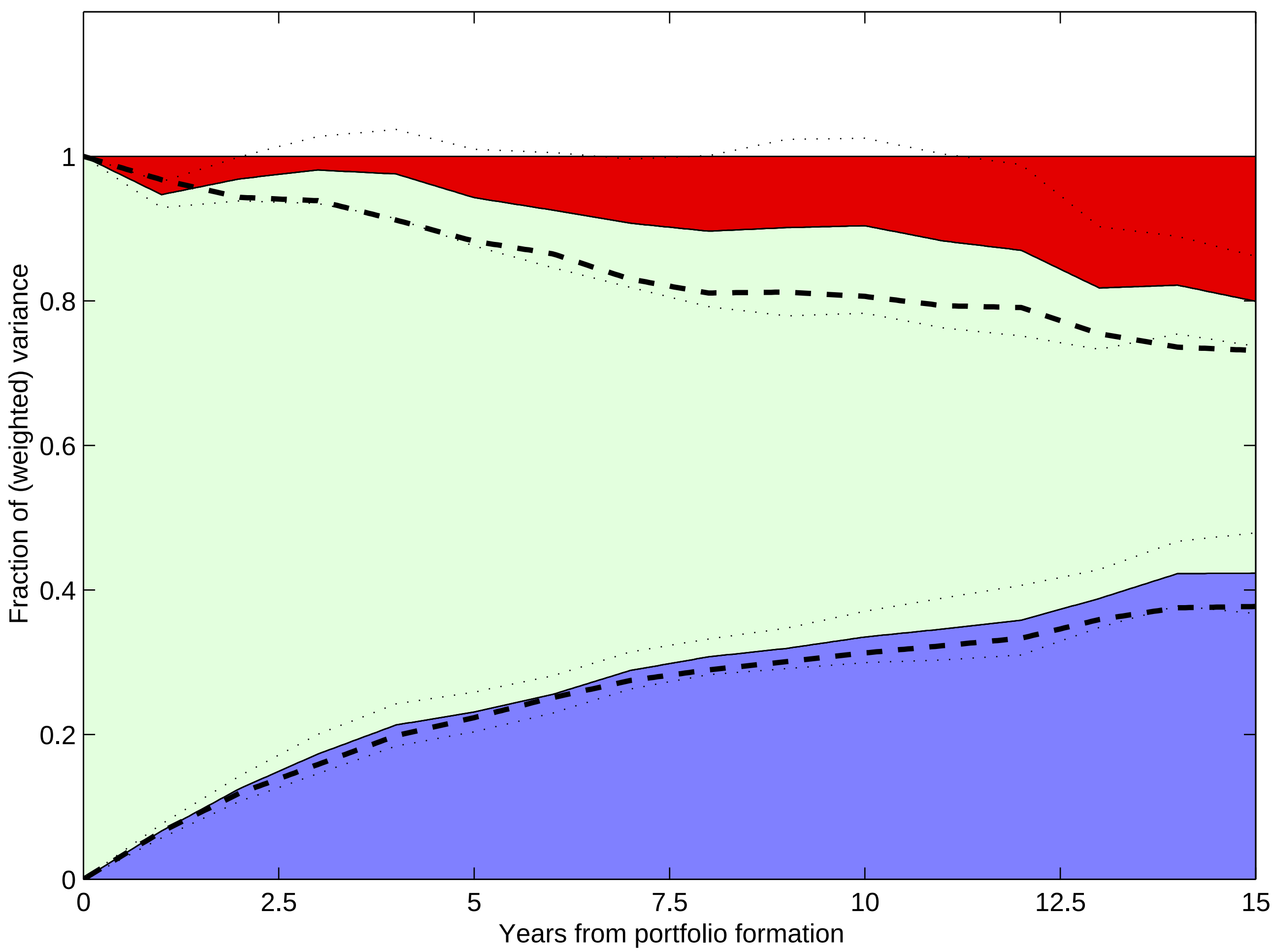


Figure 2: Variance shares for the cash-flow CAPM

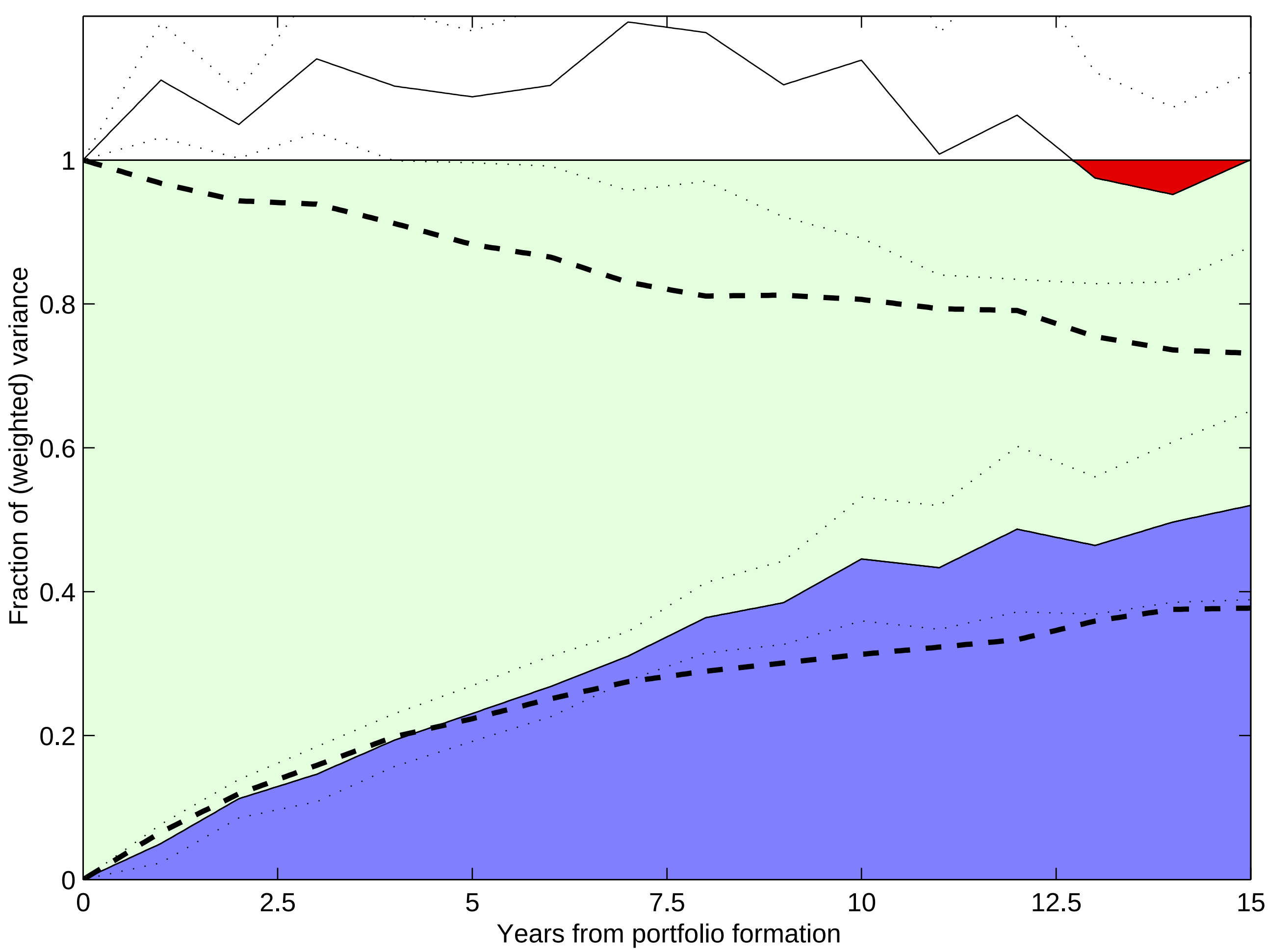


Figure 3: Evolution of the CAPM beta after portfolio formation

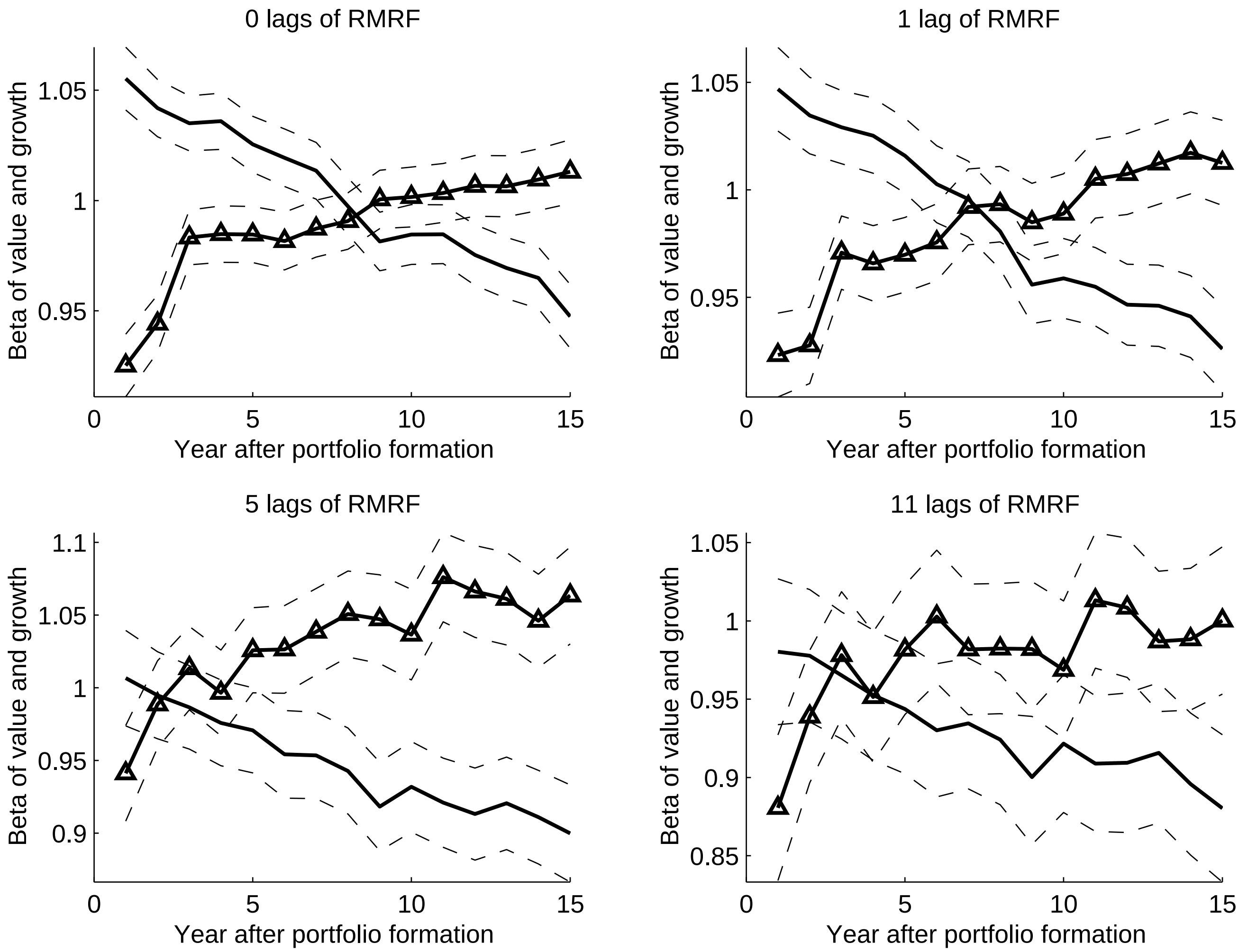
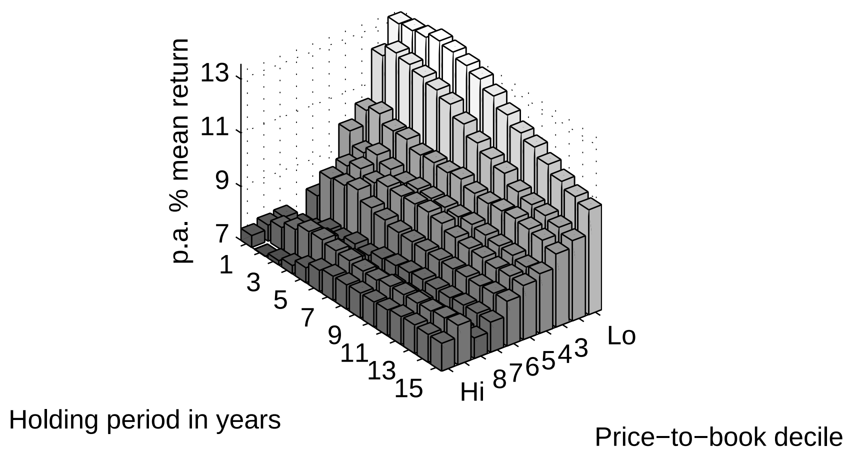


Figure 4: Mean excess returns and alphas for different holding periods



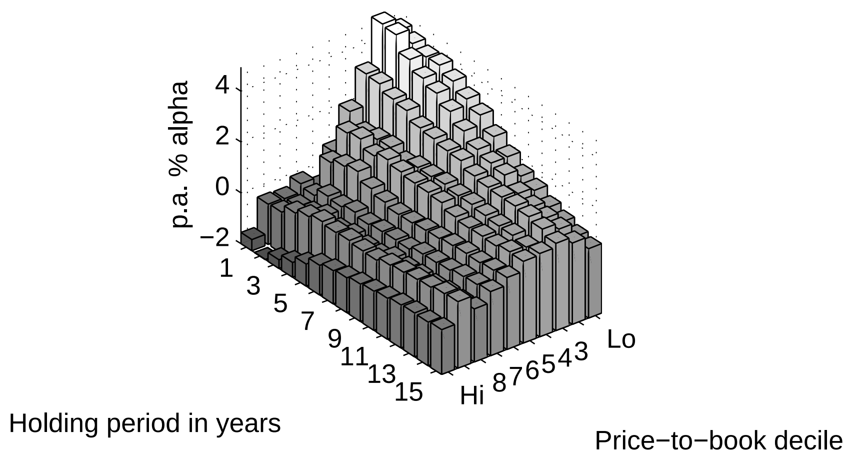


Figure A.1: Realizations of the constant-discount-rate pricing-error component

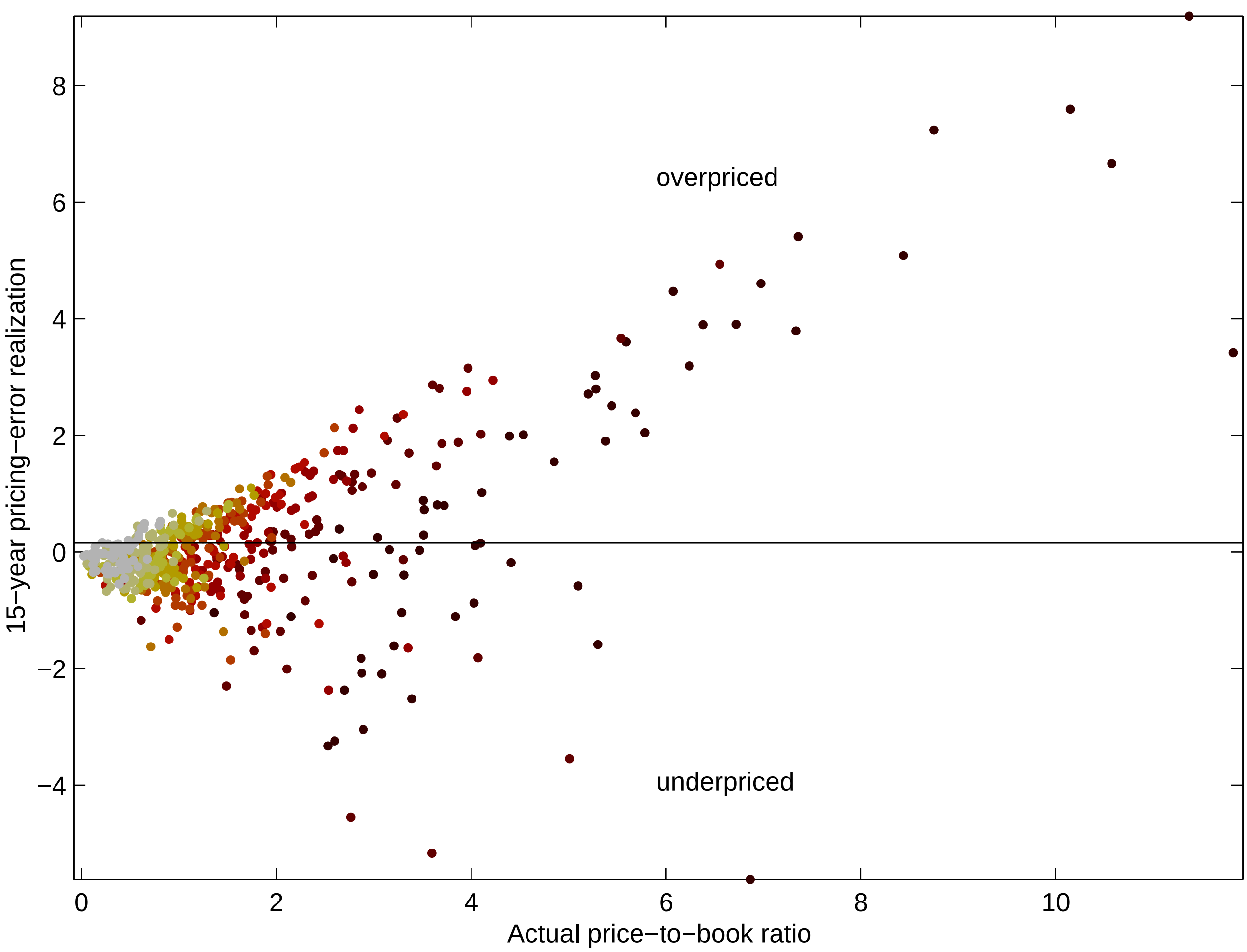


Figure A.2: Realizations of the stock-return CAPM pricing-error component

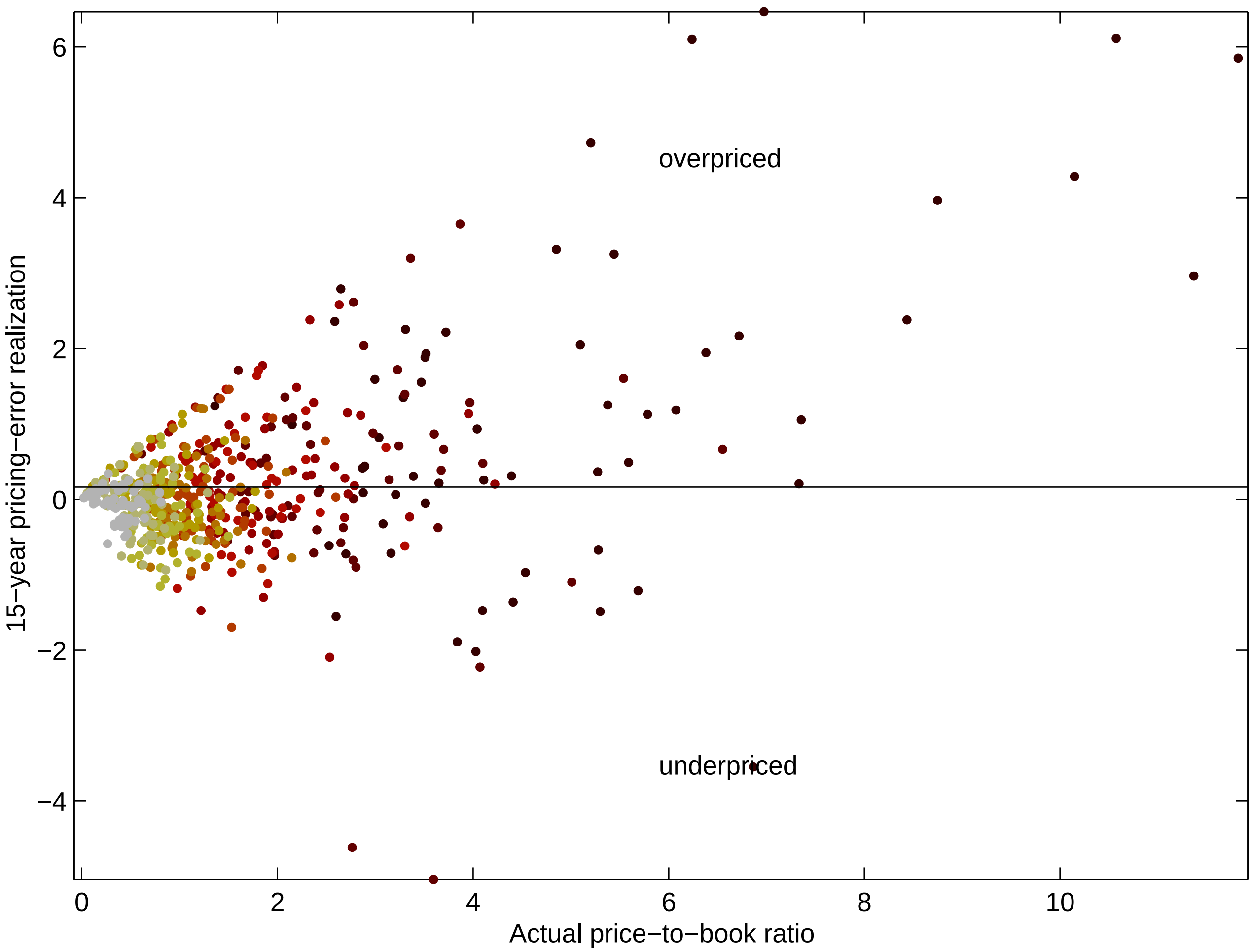


Figure A.3: Realizations of the cash-flow CAPM pricing-error component