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# Subjective Cash Flow and Discount Rate Expectations

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**ABSTRACT**

Why do stock prices vary? Using survey forecasts, we find that cash flow growth expectations explain most movements in the S&P 500 price-dividend and price-earnings ratios, accounting for at least 93% and 63% of their variation. These expectations comove strongly with price ratios, even when price ratios do not predict future cash flow growth. In comparison, return expectations have low volatility and small comovement with price ratios. Short-term, rather than long-term, expectations account for most price ratio variation. We propose an asset pricing model with beliefs about earnings growth reversal that accurately replicates these cash flow growth expectations and dynamics.

A CENTRAL QUESTION IN FINANCE IS WHAT drives stock price movements. Specifically, researchers want to know what explains the large movements in the aggregate price-dividend ratio, a measure of how cheap or expensive stocks are at a given time. Based on the present value approach, for any investor that prices the stock, the stock's price should equal her expected discounted value of future dividends. This is true whether her expectations match an objective probability distribution or they come from a subjective distribution. Price changes should therefore be due to changes in her dividend expectations or her return expectations, and changes in the price-dividend ratio should be due to changes in her dividend growth expectations or return expectations.

The challenge is determining the expectations of market participants. If investors have rational expectations, then we can infer the importance of

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dividend growth and return expectations from the realized data. Regressions using historical price and dividend data for the S&P 500 index show that a high price-dividend ratio is typically followed by low future returns, not high future dividend growth (e.g., Campbell and Shiller (1988a), Cochrane (2008, 2011)). This result has motivated many models in which price movements are driven by agents' time-varying expected returns, such as habit formation, stochastic volatility, and time-variation in disaster probabilities. Many of these models assign little or no importance to fluctuations in expected dividend growth for explaining price movements.

Rather than assuming rational expectations, in this paper we use survey forecasts to measure investors' subjective expectations of dividend growth and returns for the S&P 500 index. Using these subjective expectations and the Campbell and Shiller (1988b) variance decomposition, we estimate how much of the variation in the price-dividend ratio comes from changes in dividend growth expectations versus return expectations. We then perform the same exercise for the price-earnings ratio using earnings growth expectations from the survey data. We estimate that dividend growth expectations explain at least 93% of the variation in the price-dividend ratio and earnings growth expectations explain at least 63% of the variation in the price-earnings ratio. In other words, a model with these subjective cash flow growth expectations can match most aggregate price ratio movements, even with constant discount rates. Based on these results, we construct a model of expectations formation that accurately replicates these subjective expectations and generates price ratios that are explained predominantly by movements in cash flow growth expectations, rather than movements in return expectations.

We use data from several surveys to measure subjective cash flow growth and return expectations. For both dividends and earnings, cash flow growth expectations vary substantially over time and comove positively with price ratios. To evaluate the rationality of these expectations, we examine whether their forecast errors are predictable using current price ratios. We find that these expectations are irrational over long samples, with cash flow growth expectations being overly optimistic when price ratios are high and overly pessimistic when price ratios are low. In comparison, return expectations across multiple surveys have relatively low volatility over time and limited comovement with either the price-dividend or price-earnings ratio. We construct quarterly one- and two-year subjective expectations of S&P 500 dividends and earnings from the Thomson Reuters Institutional Brokers Estimate System (I/B/E/S) by aggregating analyst forecasts for individual firms in the S&P 500. The one- and two-year dividend forecasts are available from 2003 onward, and the one- and two-year earnings forecasts are available from 1976 and 1985 onward, respectively. We measure one- and 10-year return expectations for the S&P 500 from the quarterly Graham-Harvey Global Business Outlook Survey, which surveys chief financial officers (CFOs) of major U.S. corporations. We also collect additional surveys of return expectations that go back as far as 1952.

The variance decompositions for both price ratios show three key results: a large contribution from cash flow growth expectations, a negligible contribution from return expectations, and a dominance of short-term expectations. Our methodology allows us to measure how well cash flow growth expectations explain the observed price ratios holding expected returns constant or using survey expectations of returns. These three key results hold in both cases. Cash flow growth expectations vary significantly over time and are high when the price ratios are high, so most price ratio movements can be explained by investors expecting higher or lower future cash flows. Return expectations have much lower volatility, which means price ratio movements are not explained by changes in discount rates. If anything, return expectations rise slightly when price ratios are high, which means that discount rates dampen the movements in the price ratios. Finally, we find that movements in both price ratios can be explained in large part by changes in short-term cash flow growth expectations, with one-year dividend growth expectations accounting for 39% of the variation in the price-dividend ratio from 2003 to 2015 and one-year earnings growth expectations accounting for 42% of the variation in the price-earnings ratio for 1976 to 2015. Including two-year expectations increases these values to 65% and 64%, respectively.

To quantify the entire contribution of cash flow growth and return expectations, we estimate a simple decay functional form for expectations. This allows us to estimate expectations for horizons that are not reported in the survey data. Longer-horizon subjective expectations show that investors do not believe that changes in short-term cash flow growth or returns will be persistent. Changes in short-term subjective expectations are only associated with small changes in longer-horizon subjective expectations, and the comovement between subjective expectations and price ratios is concentrated primarily in short-term expectations.

To provide a theoretical benchmark for the three key results of these decompositions, we calculate the variance decompositions in four leading models from different branches of the asset pricing literature. Specifically, we focus on the external habit formation model of Campbell and Cochrane (1999), the long-run risk model of Bansal, Kiku, and Yaron (2012), the parameter learning model of Collin-Dufresne, Johannes, and Lochstoer (2016), and the return extrapolation model of Barberis et al. (2015). Both the external habit formation model and the learning model generate a zero or very small contribution of cash flow growth expectations to explaining price-dividend ratio variation.

In the return extrapolation model, cash flow growth expectations vary over time, but not enough to create a volatile price-dividend ratio, as their effect is almost completely negated by movements in return expectations. In the long-run risk model, cash flow growth expectations do explain some of the price-dividend ratio variation, but return expectations continue to explain the majority of the variation.

These results illustrate the challenges of reconciling the large variation in subjective cash flow growth expectations with standard asset pricing models. We propose a simple asset pricing model that is able to replicate the subjective cash flow growth expectations from the survey data and match relevant moments from the joint dynamics of asset prices and subjective expectations. In the model, agents believe that shocks to earnings will be partially transitory, which means that changes in earnings growth will be partially reversed by future earnings growth, and believe that changes in earnings will be gradually incorporated into dividends. Agents' discount rates are based on consumption growth, which is only weakly related to dividend growth, resulting in low volatility for agents' return expectations and allowing for a closed-form solution for price ratios. We refer to this as the Earnings Growth Reversal model.

The three model parameters are estimated from the survey expectations data. We do not use any information about the observed price ratios. The model succeeds along several dimensions. First, the model matches the variance decompositions documented in the paper. Second, the model is able to closely reproduce both the subjective earnings growth and the dividend growth expectations time series. Third, in addition to the covariance between expectations and price ratios measured in the decompositions, the model also matches the comovement between short-horizon and longer-horizon subjective expectations and the volatilities for price ratios, price ratio changes, and realized returns. Fourth, model-implied cash flow growth expectations rise with price ratios, even when price ratios do not predict realized future cash flow growth, meaning that forecast errors may be predictable by price ratios. The predictability of these forecast errors varies over time in the data and the model accurately replicates this finding. Finally, the model reconciles our findings with two important findings from the return extrapolation literature.[1]

Our paper contributes to a growing literature that uses surveys of expectations, rather than rational expectations based on regressions, to understand aggregate asset price movements. This literature typically focuses on expectations of aggregate returns for the stock market and other asset classes (Bacchetta, Mertens, and Van Wincoop (2009), Greenwood and Shleifer (2014), Piazzesi, Salomao, and Schneider (2015)) and how these expectations relate to current market conditions and future realized returns. We similarly use expectations of aggregate stock market returns, but importantly, we also construct measures of aggregate cash flow growth expectations. Through the three key results from the decompositions and the success of the proposed model, we show that these cash flow growth expectations have significant potential for explaining stock market volatility. Our paper is therefore also connected to the literature challenging the irrelevance of expected cash flow growth and the dominance of expected returns in driving price ratios. Several papers (Larrain and Yogo (2008), Koijen and Van Nieuwerburgh (2011), Ang (2012)) argue that sample selection and changing the definition of cash flows (e.g., reinvesting dividends in a particular way, including payments to bondholders) could lead to results whereby realized future cash flow growth has nontrivial

[1] In the model, return expectations are more correlated with current returns than with future returns, as Greenwood and Shleifer (2014) document, and the ability of the price-dividend ratio to predict future returns is stronger when return expectations are more related to recent returns than earlier returns, as Cassella and Gulen (2018) find.

significance.[2] Our paper sticks to the standard definitions of dividend growth and earnings growth and shows that expectations of standard cash flow growth, and in particular short-term cash flow growth, are the main driver of price ratio movements when expectations are measured from the survey data.[3]

Recent theoretical models (e.g., Barberis et al. (2015), Adam, Marcet, and Beutel (2017)) have been proposed to reconcile survey data on expectations with price volatility. With some exceptions (e.g., Bordalo et al. (2019)), these papers focus primarily on explaining the behavior of subjective return expectations. The main force driving price ratio movements in these models is typically expectations of future price growth. Consistent with these models, high price ratios in our data are not explained by lower discount rates because agents report slightly higher expected returns when price ratios are high. Our paper adds to this literature by creating measures of subjective cash flow growth expectations and showing that expectations of future cash flow growth, rather than expectations of future price growth, account for the vast majority of price ratio movements.[4] This can still be consistent with a model of return extrapolation, as shown by Jin and Sui (2019). In their model, agents form their cash flow growth expectations based on their expectations of future price-dividend ratios and their expectations of future returns, which allows return expectations to play an important role in asset price movements via their effect on cash flow growth expectations. We also contribute to the theoretical literature by proposing a model of subjective expectation formation focused on earnings growth reversal that is able to replicate this stylized fact and our other main findings on cash flow growth expectations and generates return expectations consistent with the findings of the return extrapolation literature.

The paper is organized as follows. Section I introduces the Campbell-Shiller decomposition and discusses our approach relative to the current literature. Sections II and III describe the data construction and explore the key characteristics of the short-term subjective expectations. Section IV calculates the role of cash flow growth and return expectations in explaining movements in the price ratios. Section V tests four leading asset pricing models, presents the Earnings Growth Reversal model, and discusses its results. Section VI concludes.

[2] Chen, Da, and Zhao (2013) also cast doubt on the importance of return expectations in moving prices using firm-level earnings expectations data. Their objects of study are different from the traditional cash flow growth and return decomposition in existing literature, as they decompose prices into the implied cost of equity capital, which they treat as a measure of discount rates, and a residual measure of cash flows. They show that the implied cost of equity capital cannot explain the majority of price movements.

[3] This importance of short-term expectations is consistent with Van Binsbergen, Brandt, and Koijen (2012), who construct dividend strip prices and conclude that excess volatility in the aggregate stock market can be explained largely by excess volatility in short-term dividend strip prices.

[4] See Barsky and DeLong (1993) and Barberis, Shleifer, and Vishny (1998) for examples of models that focus on cash flow expectations.

## I. Decomposing Price Movements

Movements in the S&P 500 index must reflect changes in expected future dividends or changes in discount rates. A stock's price is the discounted value of future dividends, which means the value of the S&P 500 is the discounted value of future dividends paid by the constituent firms. In this section, we first focus directly on the expected future dividends and discount rates. The majority of S&P 500 firms pay dividends. By market value, the dividend-paying firms represent 80% to 90% of the entire index, and dividends are the main method through which S&P 500 firms make cash distributions to their shareholders.[5] We then use the payout ratio, which is the ratio of dividends to earnings, to express changes in prices as changes in expected future earnings, discount rates, or expected future payout ratios.

### *A. Theory*

This section describes the variance decompositions used for the price-dividend and price-earnings ratios of the S&P 500 index. Throughout the paper, we use the notation $O^*$ to denote when an operator such as expected value, covariance, or variance uses the subjective probability distribution, and will use $O$ when the operator uses the objective distribution. For example, $\mathrm{E}^*[\cdot]$ represents the subjective expectation of a variable, while $\mathrm{cov}(\cdot,\cdot)$ represents the objective covariance of the variables.

We start with the one-year return identity

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} = \frac{\left(\frac{P_{t+1}}{D_{t+1}} + 1\right)\frac{D_{t+1}}{D_t}}{\frac{P_t}{D_t}},$$

where $P_t$ and $D_t$ represent the current price and dividends of the index. Because we are using the aggregate S&P 500, dividends are always positive even if some individual firms are not paying dividends. Log-linearizing around a long-term average of $P/D$, we can state the price-dividend ratio $pd_t$ in terms of future dividend growth, $\Delta d_{t+1}$, future returns, $r_{t+1}$, and the future price-dividend ratio, $pd_{t+1}$, all in logs,

$$pd_t = \kappa + \Delta d_{t+1} - r_{t+1} + \rho pd_{t+1}, \tag{1}$$

where $\kappa$ is a constant, $\rho = e^{\bar{pd}}/(1 + e^{\bar{pd}}) < 1$, and $\bar{pd}$ is the mean value of the log price-dividend ratio. By further imposing a no-bubble condition, $\lim_{T\to\infty} \rho^T \mathrm{E}_t^*[pd_{t+T}] = 0$, we can iterate this equation and apply subjective expectations to write the price-dividend ratio as the sum of a constant plus

[5] Dividends represent 80% of total payouts made by S&P 500 firms over 2003 to 2015, where total payouts are measured as dividends plus share repurchases minus share issuance. In earlier samples, dividends represent an even higher portion of total payouts.

two main factors,

$$pd_t = \frac{1}{1-\rho}\kappa + \sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[\Delta d_{t+j}] - \sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[r_{t+j}]. \tag{2}$$

Note that these subjective expectations do not need to be rational. Given any set of dividend growth and return expectations, equation (2) will hold as long as $\lim_{T\to\infty} \rho^T \mathrm{E}_t^*[pd_{t+T}] = 0$ is satisfied (i.e., investors' return and dividend growth expectations do not imply that the price-dividend ratio is expected to explode to positive or negative infinity). In the Internet Appendix,[6] we relax this no-bubble condition and explicitly allow for a nonzero limit term.

This equation directly shows that an increase in the price-dividend ratio must be due to higher subjective dividend growth expectations or lower subjective return expectations. While equation (2) holds without expectations, applying expectations makes all components known at time $t$. This allows us to see what drives the change in the price-dividend ratio (i.e., did prices rise because investors are optimistic about future dividends or because they expect lower returns?).

To evaluate the relative importance of subjective dividend growth expectations and subjective return expectations in explaining price movements, we separate the variance of the price-dividend ratio into its covariance with subjective expected dividend growth and its covariance with subjective expected returns to get the following decomposition:

$$1 = \frac{\mathrm{cov}\left(\sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[\Delta d_{t+j}], pd_t\right)}{\mathrm{var}(pd_t)} + \frac{\mathrm{cov}\left(-\sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[r_{t+j}], pd_t\right)}{\mathrm{var}(pd_t)}. \tag{3}$$

The two terms represent the fraction of the variance of the price-dividend ratio that is explained by changes in subjective expected dividend growth and the fraction explained by changes in subjective expected returns. This is the standard Campbell-Shiller decomposition. These two terms tell us whether price changes are explained primarily by changes in cash flow growth expectations (dividend growth expectations) or changes in discount rates (return expectations). We refer to these terms as cash flow news and discount rate news, respectively.[7]

Our subjective dividend expectations data start in 2003Q1, but the subjective earnings expectations go as far back as 1976Q1. We therefore also use a separate decomposition for the price-earnings ratio that does not require

[6] The Internet Appendix may be found in the online version of this article.

[7] Another useful decomposition from Campbell (1991) measures the importance of cash flow growth expectations and return expectations for explaining unexpected returns, rather than price-dividend ratio movements. We estimate this decomposition in the Internet Appendix and find that the results are remarkably similar to our results for the price-dividend ratio decomposition.

the use of subjective dividend expectations or assumptions about subjective expectations of future price-dividend ratios. Using the log payout ratio $de_t$, we can substitute the identity $pe_t = pd_t + de_t$ into (1) to obtain

$$pe_t = \kappa + \Delta e_{t+1} - r_{t+1} + (1-\rho)de_{t+1} + \rho pe_{t+1}. \tag{4}$$

Just as with dividends, we do not need to worry about very small or negative values for earnings because we are using the earnings for the entire S&P 500 index. Since $1-\rho$ is close to zero, movements in the future payout ratio do not play a large role in explaining movements in the price-earnings ratio. We ignore these movements in the majority of the paper and use the following approximation for $pe_t$:

$$pe_t \approx \tilde{\kappa} + \Delta e_{t+1} - r_{t+1} + \rho pe_{t+1}, \tag{5}$$

$$\approx \frac{1}{1-\rho}\tilde{\kappa} + \sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta e_{t+j}] - \sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}], \tag{6}$$

where $\tilde{\kappa} = \kappa + (1-\rho)\bar{de}$ and $\bar{de}$ is the mean log payout ratio. Equation (6) requires the no-bubble condition $\lim_{T\to\infty}\rho^T\mathrm{E}_t^*[pe_{t+T}] = 0$, which we relax in the Internet Appendix. We now have a decomposition of $pe_t$ analogous to (3) that does not require dividend expectations,

$$1 \approx \frac{\mathrm{cov}\left(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta e_{t+j}], pe_t\right)}{\mathrm{var}(pe_t)} + \frac{\mathrm{cov}\left(-\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}], pe_t\right)}{\mathrm{var}(pe_t)}. \tag{7}$$

Movements in the price-earnings ratio must come primarily from changes in subjective cash flow growth expectations (subjective earnings growth expectations) or changes in discount rates (subjective return expectations). In the Internet Appendix, we estimate the exact decomposition for $pe_t$ by including subjective expectations of future payout ratios and show that our results are virtually unchanged.

### *B. Estimation*

It is important to note that when these decompositions are estimated in the data, they do not measure causal relationships. Nonetheless, these decompositions are useful for diagnosing possible sources of variation in the price ratio. For example, a large estimate for cash flow news means that whatever shock is responsible for variation in the price ratio must have a larger impact on subjective cash flow growth expectations than subjective return expectations. While direct shocks to investors' subjective cash flow growth expectations would be the simplest type of shock that meets this criterion, other shocks could also generate large cash flow news so long as they primarily impact subjective cash flow growth expectations. For instance, a return extrapolation model can match our main findings if changes in return expectations lead to even larger changes in cash flow growth expectations.[8]

There are two possible approaches to empirically estimate these decompositions. A common approach in the literature is to assume that agents have rational expectations. An econometrician can then statistically infer agents' expectations from historical dividend, earnings, and price data. For every horizon $T$, these *rational expectations*, $\mathrm{E}[\cdot]$, have the property $\mathrm{cov}(\sum_{j=1}^{T} \mathrm{E}_t[\Delta d_{t+j}], pd_t) = \mathrm{cov}(\sum_{j=1}^{T} \Delta d_{t+j}, pd_t)$ as long as the price-dividend ratio is used in the inference. Consequently, the component of expected dividend growth can be approximated by $\frac{\mathrm{cov}(\sum_{j=1}^{T} \rho^{j-1} \Delta d_{t+j}, pd_t)}{\mathrm{var}(pd_t)}$, which under stationarity is just the OLS coefficient of a simple regression of future dividend growth on $pd_t$. Similarly, we can obtain the contribution of expected returns by regressing future returns on $pd_t$ and repeating this procedure for the price-earnings ratio using future earnings growth and returns.

Findings by Campbell and Shiller (1988b), Fama and French (1988), Cochrane (2008), and others suggest that the contribution of future dividend growth is virtually zero and all price-dividend ratio movements must be explained by future returns. Since the price-dividend ratio does not covary with observed future dividend growth, many economic models assume that dividend growth expectations are constant or unimportant for stock market volatility and that time-varying risk premia are the primary factor driving prices in the economy.[9] Campbell and Shiller (2005), Lewellen (2004), and Maio and Xu (2020) find that a similar result holds for the price-earnings ratio, where changes in the price-earnings ratio are explained mainly by changes in future returns, rather than changes in future earnings growth.

There is a second approach to measure the importance of cash flow growth expectations versus return expectations. Rather than assuming rational expectations, we directly measure the expectations held by investors at each point in time. We use forecast surveys to construct robust measures of dividend growth, earnings growth, and return expectations at different horizons. With these direct measures of subjective expectations, $\mathrm{E}^*[\cdot]$, we revisit the relative importance of cash flow growth expectations and return expectations in explaining price ratio movements. This analysis allows us to reevaluate whether the current models of time-varying risk premia and constant cash flow growth expectations align with actual investor expectations or whether more focus should be placed on modeling agents with large time-varying cash flow growth expectations.

[8] See Jin and Sui (2019) for an example.

[9] Even models that incorporate time-varying cash flow growth, such as Bansal and Yaron (2004), typically focus on how cash flow risk affects the risk premia demanded by investors by making cash flows correlated with investors' consumption.

## II. Data and Variable Construction

In this section, we explain the data sources for our main calculations and the construction process to build expectations of aggregate dividend growth, earnings growth, and returns.

### *A. S&P 500 Index*

From Compustat, we create a list of all companies in the S&P 500 at the end of each quarter and record their price, dividends, and earnings per share together with their number of outstanding shares. We calculate a quarterly dividend measure for the index by aggregating the total ordinary dividends paid by each company and adjusting them by the S&P 500 index divisor. Similarly, we calculate an aggregate earnings measure by summing over the total earnings reported by each firm and adjusting by the same S&P 500 divisor. We build the S&P 500 index divisor by taking the total market capitalization of the S&P 500 companies and dividing by the S&P 500 index at the end of each quarter.

### *B. Subjective Cash Flow Expectations*

We construct cash flow expectations for the S&P 500 using the Summary Statistics of the Thomson Reuters I/B/E/S Estimates Database. I/B/E/S is a comprehensive forecast database containing analyst estimates for more than 20 forecast measures—including DPS (dividends per share) since 2003 and EPS (earnings per share) since 1976. The Summary Statistics contain the median forecasts on different horizons for U.S. publicly traded companies.[10] We build measures of aggregate dividend and earnings expectations using the constituents of the S&P 500 at each point in time. This procedure is analogous to the process used to calculate the S&P 500 index and is explicitly derived in Appendix.

It is important to note that Thomson Reuters gathers their forecasts from hundreds of brokerage and independent analysts who track companies as part of their investment research work. Each individual estimate is identified by the name of the analyst or brokerage firm. Because the forecasts are not anonymous, analysts have a strong incentive to accurately report their expectations.[11] Previous literature finds evidence that accuracy in earnings forecasts is important for tenure and compensation (Mikhail, Walther, and Willis (1999), Cooper, Day, and Lewis (2001)). Furthermore, research on the I/B/E/S Estimates Database suggests that financial firms' trades are consistent with

[10] Using the mean forecasts does not change the results in any noticeable way.

[11] In Section III.A, we confirm that short-term cash flow growth expectations are strongly correlated with future short-term cash flow growth, and in the Internet Appendix we discuss the possibility that the analysts' responses reflect risk-neutral expectations.

**Table I**
**Correlations of S&P 500 Dividend Measures**

This table shows the correlations for four quarterly time series of realized dividends spanning 2003Q1 to 2015Q3. All Companies contains the sum of all realized quarterly dividends paid out by all S&P 500 companies. I/B/E/S contains the sum of all realized quarterly dividends paid out by those S&P 500 companies for which a one-year subjective dividend expectation exists in I/B/E/S. Shiller contains the quarterly S&P 500 dividends obtained from Shiller (2015). SPY contains the quarterly dividends paid out by the SPDR S&P 500 ETF. Under the Levels columns, we calculate the correlation of the four series. Under the Growth columns, we calculate the log annual change of each of the four series and take the correlations.

| | Levels | | | Growth | | |
|---|---|---|---|---|---|---|
| | I/B/E/S (1) | Shiller (2) | SPY (3) | I/B/E/S (4) | Shiller (5) | SPY (6) |
| All companies | 0.996 | 0.995 | 0.994 | 0.974 | 0.937 | 0.928 |
| I/B/E/S | | 0.995 | 0.993 | | 0.901 | 0.892 |
| Shiller | | | 0.997 | | | 0.963 |

their own analysts' forecasts and recommendations, which adds to the evidence that reported forecasts genuinely reflect firms' beliefs.[12]

Two aspects of the data must be addressed in order to calculate aggregate expectations. To calculate dividend growth expectations, we first note that the I/B/E/S database contains DPS forecasts for up to five Annual Fiscal Periods (FY1 to FY5), four Quarter Fiscal Periods (Q1 to Q4), and a Long-Term Growth measure. Because not all companies have the same fiscal year-end, we interpolate across the different horizons to obtain a precise expectation over the next 12 months following the response of the analyst. For example, if the fiscal year of Firm A ends nine months after the survey date, we may only have a nine-month dividend expectation and a 21-month dividend expectation for that firm. We interpolate these two measures to ensure that every expectation is exactly 12 months ahead. We use an analogous procedure to construct two-year expectations. The second feature of the data is that I/B/E/S estimates are not available for all S&P 500 companies. We calculate the aggregate dividend expectation of those companies in the S&P 500 with available forecasts and multiply it by the ratio of total S&P 500 market value to the market value of the forecasted companies. The assumption behind this normalization is that the forecasted companies are a representative sample of the S&P 500. We follow the same procedure to calculate aggregate earnings expectations. We test the representativeness assumption for both dividends and earnings in Table I and in the Appendix and find that it holds quite well. The Appendix provides more details on our methodology. I/B/E/S collects dividend forecasts since 2003 and earnings forecasts since 1976. We are therefore able to construct one- and two-year dividend expectations for the range 2003Q1 to 2015Q3.

[12] Bradshaw (2004) shows that individual earnings forecasts are correlated with Buy/Sell recommendations, while Chan, Chang, and Wang (2009) show that financial firms' own stock holding changes are significantly positively related to recommendation changes.

Since earnings forecasts for longer horizons are only available after 1985, we construct one-year earnings expectations for 1976Q1 to 2015Q3 and two-year earnings expectations for 1985Q1 to 2015Q3.

Since we cannot know the expected cash flows for those companies that do not report forecasts, we test our methodology using realized cash flows. Table I shows tests of our methodology applied to realized dividends. We construct aggregate realized dividends using the same method applied to subjective expected dividends. The first three columns of Table I give the correlation of our aggregate dividend measure with Robert Shiller's S&P 500 dividend and the dividend for SPY, a popular S&P 500 replicating exchange traded fund. The first dividend measure is our aggregate dividend using all companies in the S&P 500. The high correlation of this measure with Shiller and SPY dividends shows that our aggregation technique is accurate. The second measure is identical to the first, except it only uses companies for which we have a one-year subjective dividend expectation from the I/B/E/S data and is scaled by the ratio of total S&P 500 market value to total forecasted companies' market value. The high correlation between the first two measures shows that the forecasted companies are representative of the entire set of constituents.

The second set of columns in Table I show the correlation of dividend growth for each of the four measures. As before, the high correlation between All Companies dividend growth and I/B/E/S dividend growth shows that the companies in the I/B/E/S data set are a representative subset. The high correlation of these two measures with Shiller and SPY dividend growth shows that our dividend aggregation procedure is accurate. The Appendix shows the equivalent tests performed on the construction of earnings expectations, which gives similar results.

Table II shows the key features of the subjective expectations. From the subjective expectations of future dividends and earnings, we calculate the subjective expectations of dividend growth and earnings growth. In Panels A and B, we see that subjective expectations for annual dividend growth and earnings growth have high standard deviations, meaning that there is significant time-variation in investors' cash flow growth expectations. Importantly, subjective dividend growth expectations and subjective earnings growth expectations also have large comovements with the price-dividend ratio and price-earnings ratio. In fact, just the movement in the one-year subjective dividend growth expectations accounts for 39% of the variation in the price-dividend ratio, and the movement in one-year subjective earnings growth expectations accounts for 42% of the variation in the price-earnings ratio. The two-year annual dividend growth and earnings growth expectations also have large comovements with price ratios, implying that subjective expectations of total dividend growth and earnings growth over the next two years can explain the majority of price-dividend ratio and price-earnings ratio variation.

**Table II**

**Comovement of Subjective Expectations and Price Ratios**

This table features survey data on annualized expectations of dividend growth, earnings growth, and returns for the S&P 500 and their comovement with the price-dividend and price-earnings ratio of the S&P 500. Panels A and B show dividend growth and earnings growth survey expectations for the S&P 500 obtained from Thomson Reuters I/B/E/S estimates. Panel C shows return expectations for the S&P 500 obtained from the Graham-Harvey survey of Duke University (G-H), the Federal Reserve Bank of Philadelphia's Livingston Survey (Livingston), the University of Michigan Survey of U.S. consumers (Michigan), and the Survey of Professional Forecasters (SPF). The survey responses indicate the expected average annual dividend growth, earnings growth, and return expectations over the horizon specified in column (2). Small-sample adjusted Newey-West standard errors are given in parentheses.

| Survey | Horizon (years) (1) | Sample (2) | Std. Dev. (3) | $\frac{\text{cov}(\cdot, pd_t)}{\text{var}(pd_t)}$ (4) | $\frac{\text{cov}(\cdot, pe_t)}{\text{var}(pe_t)}$ (5) |
|---|---|---|---|---|---|
| **Panel A: Dividend Growth Expectations** | | | | | |
| I/B/E/S | 1 | 2003 to 2015 | 8.1% | 0.39 | |
| | | | | (0.03) | |
| I/B/E/S | 2 | 2003 to 2015 | 7.3% | 0.33 | |
| | | | | (0.06) | |
| **Panel B: Earnings Growth Expectations** | | | | | |
| I/B/E/S | 1 | 1976 to 2015 | 27.5% | | 0.42 |
| | | | | | (0.10) |
| I/B/E/S | 2 | 1985 to 2015 | 15.4% | | 0.32 |
| | | | | | (0.07) |
| **Panel C: Return Expectations** | | | | | |
| G-H | 1 | 2003 to 2015 | 1.3% | 0.05 | 0.00 |
| | | | | (0.01) | (0.01) |
| Livingston | 1 | 1952 to 2016 | 5.2% | 0.03 | 0.03 |
| | | | | (0.02) | (0.02) |
| Michigan | 2-3 | 2000 to 2005 | 1.2% | 0.07 | −0.01 |
| | | | | (0.02) | (0.01) |
| G-H | 10 | 2003 to 2015 | 0.8% | 0.01 | 0.01 |
| | | | | (0.01) | (0.01) |
| SPF | 10 | 1992 to 2016 | 1.1% | 0.00 | 0.01 |
| | | | | (0.01) | (0.01) |

### *C. Subjective Return Expectations*

Our main measure of subjective return expectations is taken from a survey conducted by John Graham and Campbell Harvey of Duke University's Fuqua School of Business. The survey is completed quarterly by 200 to 500 CFOs of major U.S. corporations. Among other things, the survey solicits CFO views about the U.S. economy. In particular, they report their expectations of returns on the S&P 500 index over the next 12 months and their expectations of average annual returns over the next 10 years. The sample includes CFOs from both public and private companies representing a broad range of industries, geographic areas, and sizes. The data are available from the third quarter of 2000 onward. We choose the Graham-Harvey survey as our main source for return expectations because it provides both short-term and long-term return forecasts and aligns with our dividend forecast sample.

Table II, Panel C, shows the results for the Graham-Harvey survey as well as three additional surveys of return expectations for the S&P 500. The additional surveys have different sampling periods, methodologies, and population targets, and provide external validation for our main results. A detailed description of the additional surveys is available in the Internet Appendix. All five measures of subjective return expectations have low standard deviations compared to the dividend growth and earnings growth expectations. Furthermore, none of the subjective return expectations have large comovements with the price-dividend ratio or the price-earnings ratio. Even the relatively higher standard deviation of the Livingston survey does not translate into high comovement with the price ratios. This implies that these subjective return expectations do not account for much of the variation in the price-dividend or price-earnings ratios.

In Section IV, we formally estimate the portions of price-dividend ratio variation and price-earnings ratio variation that are explained by subjective dividend growth, earnings growth, and return expectations. This will include accounting for the powers of $\rho$ coefficients in the decompositions and estimating long-horizon expectations. However, Table II already indicates that discount rate news is unlikely to account for much of the variation in the price ratios, given that none of the subjective return expectations comove substantially with the price-dividend ratio or the price-earnings ratio. Instead, the cash flow news is a much more promising candidate for explaining price ratio variation. Cash flow growth expectations have high variation over time and large comovements with the price ratios. Furthermore, these key features of subjective cash flow growth expectations and subjective return expectations are consistent across different samples and forecast horizons.

## III. Short-Term Subjective Expectations

In this section, we take a first look at the time series and the main properties of the short-term subjective expectations. For both dividends and earnings, one-year subjective cash flow growth expectations are volatile and significantly correlated with future realized cash flow growth. In comparison, one-year subjective return expectations have relatively low volatility and a weak negative correlation with future realized returns. Despite the significant correlation between subjective cash flow growth expectations and future realized cash flow growth, subjective cash flow growth expectations are not fully rational. Investors make predictable forecast errors, overestimating future cash flow growth when current price ratios are high and underestimating cash flow growth the price ratios are low. This occurs because their subjective cash flow growth expectations comove positively with price ratios while price ratios generally do not predict future cash flow growth.


**Figure 1. Expected and realized one-year dividend growth**. The figure compares the one-year subjective dividend growth expectation and the realized future one-year dividend growth of the S&P 500. The solid line plots the one-year subjective dividend growth expectation based on survey data. The dotted line plots the realized future one-year dividend growth. (Color figure can be viewed at wileyonlinelibrary.com)

### *A. Characteristics of Subjective Expectations*

We know from Section I that the large variation in the observed price ratios means that there must be large time-variation in either the cash flow growth expectations or the return expectations. Figure 1 shows that one-year dividend growth expectations, denoted by $\mathrm{E}_t^*[\Delta d_{t+1}]$, have similar volatility as that of realized future one-year dividend growth and track it quite well. Dividend growth expectations have a standard deviation of 8.1% and are strongly correlated with realized future dividend growth (a correlation of 0.74).[13] The accuracy of the dividend growth expectations is one more piece of evidence that investors are making an effort in reporting their true expectations through these dividend forecasts.

Figure 2 shows the one-year earnings growth expectations and realized future one-year earnings growth. Earnings growth expectations are also highly volatile with a standard deviation of 28%. Although the large recovery after the recent financial crisis is the main episode of volatility, earnings growth expectations are still volatile outside the recession. Earnings growth expectations typically fail to predict the change in earnings during busts, but they do tend to predict recoveries and track future earnings growth reasonably well during

[13] At first sight, one may think that the high correlation between $\mathrm{E}_t^*[\Delta d_{t+1}]$ and $\Delta d_{t+1}$ may be due to high persistence in the dividend growth process. However, the correlation between $\mathrm{E}_t^*[\Delta d_{t+1}]$ and $\Delta d_t$, although positive, is noticeably lower (0.29) than $\mathrm{corr}(\mathrm{E}_t^*[\Delta d_{t+1}], \Delta d_{t+1})$, suggesting an important component of the prediction is unexplained by current dividend growth.

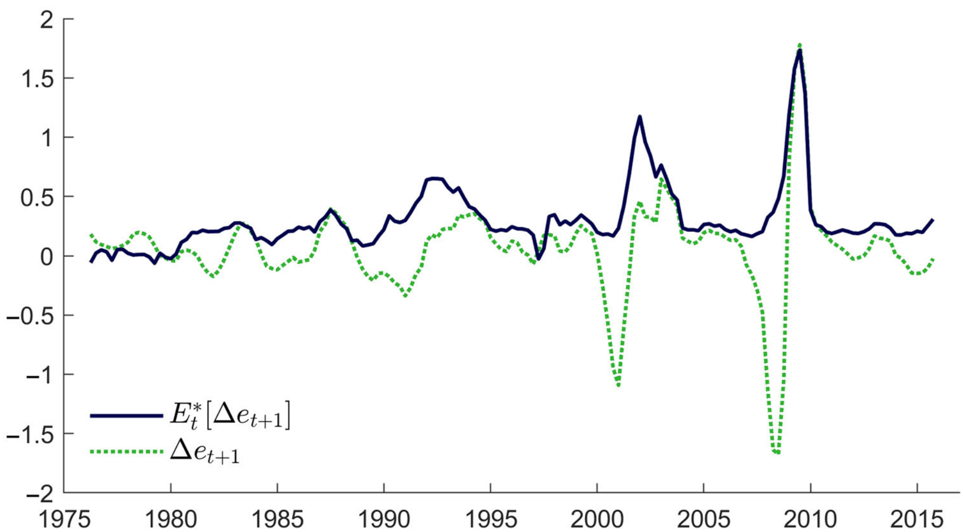


**Figure 2. Expected and realized one-year earnings growth**. The figure compares the one-year subjective earnings growth expectation and the realized future one-year earnings growth of the S&P 500. The solid line plots the one-year subjective earnings growth expectation based on survey data. The dotted line plots the realized future one-year earnings growth. (Color figure can be viewed at wileyonlinelibrary.com)

normal times. During the recent financial crisis, earnings fell several quarters before dividends, which may explain why investors did not foresee the drop in earnings growth but did predict the subsequent drop in dividend growth. Despite their inability to predict busts, the correlation between earnings growth expectations and realized future earnings growth is significant and relatively high at 0.33 for 1976 to 2002, 0.59 for 2003 to 2015, and 0.48 for the full-sample period from 1976 to 2015.

The behavior of subjective one-year return expectations is shown in Figure 3. In Panel A, we show the one-year subjective return expectations together with the one-year subjective dividend growth expectations. Compared to subjective cash flow growth expectations, subjective return expectations $\mathrm{E}^*_t[r_{t+1}]$ look noticeably less volatile with a standard deviation of just 1.3%. Moreover, subjective return expectations have no clear relationship with future realized returns, with an insignificant correlation of −0.03. Greenwood and Shleifer (2014) show that the correlation of return expectations with realized future returns is, if anything, negative and that these expectations are more correlated with past returns.

We can conclude thus far that short-term cash flow growth expectations are significantly more volatile than short-term return expectations. The volatility of dividend growth expectations (8.1%) is six times larger than the volatility of return expectations (1.3%), and the volatility of earning growth expectations is approximately 17 times larger. In Section IV, we see that changes in return

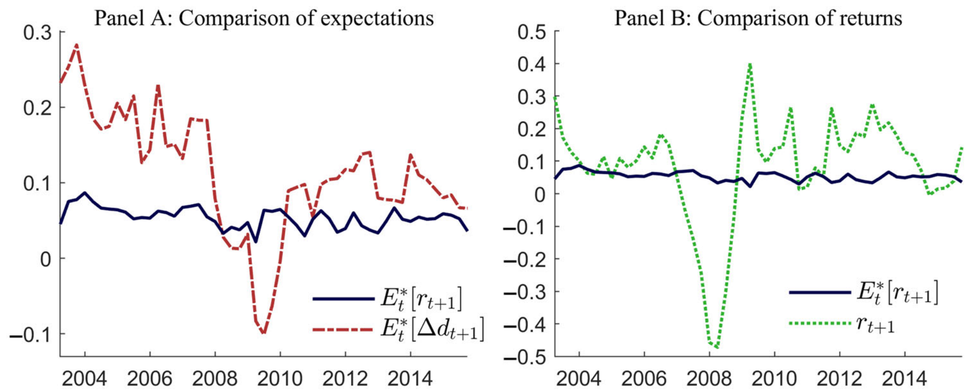


**Figure 3. Expected and realized one-year returns**. Panel A compares the one-year subjective return and dividend growth expectations based on the survey data. The solid line plots the one-year subjective return expectation. The dashed line plots the one-year subjective dividend growth expectation. Panel B compares the one-year subjective return expectation and the realized future one-year return on the S&P 500. The solid line plots the one-year subjective return expectation. The dotted line plots realized future one-year return. (Color figure can be viewed at wileyonlinelibrary.com)

expectation are not large enough to account for significant movements in the aggregate price ratios in the variance decomposition. The standard deviations of the price-dividend ratio (18%) and price-earnings ratio (35%) are simply too large.

### *B. Predictability of Forecast Errors*

In Section I, we see that high price ratios must be followed by either low returns or high cash flow growth. The conventional wisdom from the literature is that high price ratios predict lower future returns and do not predict future cash flow growth. If investors have full-information rational expectations, their forecast errors for cash flow growth and return expectations should be uncorrelated with prices at time $t$, meaning that their return expectations should fall with price ratios and cash flow growth expectations should be uncorrelated with price ratios. We measure the one-year forecast errors as the realized future values minus the expected values.

Table III, Panel A, shows that dividend growth expectations are strongly positively correlated with the price-dividend ratio (0.86). When the price-dividend ratio is high, dividend growth expectations are high. However, we can see in column (3) that prices are also positively correlated with future realized dividend growth (0.70). This goes against the conventional wisdom based on previous samples, in which the price-dividend ratio did not predict dividend growth. The 2003 to 2015 period was unusual in the sense that prices did predict dividend growth. For this sample, dividend growth forecast errors turn out to be uncorrelated with the price-dividend ratio. There are

**Table III**

**Correlation of Cash Flow Growth and Price Ratios**

This table shows the correlation of price ratios with expected and realized one-year cash flow growth. Panel A shows the correlation of the price-dividend ratio with subjective expected one-year dividend growth $E_t^*[\Delta d_{t+1}]$, realized future one-year dividend growth $\Delta d_{t+1}$, and the forecast errors $fe_{t+1}^d = \Delta d_{t+1} - E_t^*[\Delta d_{t+1}]$. Panel B shows the correlation of the price-earnings ratio with expected one-year earnings growth $E_t^*[\Delta e_{t+1}]$, realized future one-year earnings growth $\Delta e_{t+1}$, and the forecast errors $fe_{t+1}^e = \Delta e_{t+1} - E_t^*[\Delta e_{t+1}]$ for different samples. Both panels use quarterly data. Small-sample adjusted Newey-West standard errors are given in parentheses.

| | Sample (1) | Expected (2) | Realized (3) | Forecast Error (4) |
|---|---|---|---|---|
| Panel A: Dividend Growth | | | | |
| $Corr(pd_t, \cdot)$ | 2003 to 2015 | 0.86 | 0.70 | −0.03 |
| | | (0.08) | (0.23) | (0.34) |
| Panel B: Earnings Growth | | | | |
| $Corr(pe_t, \cdot)$ | 2003 to 2015 | 0.93 | 0.61 | 0.07 |
| | | (0.09) | (0.11) | (0.07) |
| $Corr(pe_t, \cdot)$ | 1976 to 2002 | 0.78 | 0.14 | −0.52 |
| | | (0.15) | (0.11) | (0.14) |
| $Corr(pe_t, \cdot)$ | 1976 to 2015 | 0.77 | 0.27 | −0.30 |
| | | (0.19) | (0.18) | (0.10) |

two possible explanations for the apparent lack of predictability of dividend growth forecast errors. One possibility is that dividend forecast errors are generally not predictable. Investors understand the relationship between dividend growth and prices. They quickly learned the atypical nature of the 2003 to 2015 period and reported their expectations accordingly. The second possibility is that dividend forecast errors are unpredictable only for this unusual sample. Investors' dividend growth expectations are generally correlated with prices, despite the lack of a relationship between the two variables in earlier samples. The 2003 to 2015 period just happened to be a sample in which the relationship happened to hold and errors appeared unpredictable.

In theory, the two explanations could be tested by looking at dividend growth expectations at earlier dates, where prices are not correlated with realized dividend growth. Under the first explanation, we should see that dividend growth expectations are not correlated with prices due to the rationality of investors. Under the second explanation, we should see that even for earlier dates, expectations are still positively correlated with prices. Unfortunately, there are no data on dividend growth expectations at earlier dates. However, the evidence from earnings growth expectations strongly supports the second story. Over 2003 to 2015, both expected and realized earnings growth are highly correlated with the price-earnings ratio, matching what we find for dividend growth. When we look at the 1976 to 2002 sample, the correlation of realized earnings growth with the price-earnings ratio drops substantially, while the correlation between expected earnings growth and the price-earnings ratio remains high. Over this earlier sample, 1976 to 2002, we see that investors' forecast errors are significantly correlated with current prices. When prices are high, investors overpredict future earnings growth. It is natural to think that for this earlier period of time, dividend growth expectations are also significantly correlated with prices. The third row of Table III, Panel B, shows that the significance of their forecasts errors remains even when we extend the sample to the period 1976 to 2015. Looking at column (2) of Table III, the correlation of subjective cash flow growth expectations with price ratios is strikingly similar across the different samples and the two measures of cash flows, indicating that this high correlation is a consistent feature of subjective expectations.

Return expectations are positively correlated with the price-dividend ratio (0.65) even though the price-dividend ratio is weakly negatively correlated with future realized returns (−0.20). This means that when prices are high, return survey respondents consistently overestimate one-year future returns and their forecast errors are negatively correlated with the current price-dividend ratio (−0.25). This positive correlation of subjective return expectations with the price-dividend ratio is also documented in Greenwood and Shleifer (2014). In the next section, we show that the comovement not only has the wrong sign for explaining variation in the price ratios, but also is very small, especially when compared to the comovement of cash flow growth expectations with prices ratios. Even if the relationship between subjective return expectations and price ratios were reversed so that expectations fell when price ratios were high, it would still account for only a negligible amount of the variation in the price ratios.

The evidence of this section already suggests that high prices can be accounted for largely by high expectations for future cash flows. Cash flow growth expectations are volatile and significantly correlated with prices. In comparison, return expectations are much less volatile and positively correlate with prices, meaning that high prices cannot come from low discount rates. In the next section, we confirm this finding by quantifying the contribution of each type of expectation in explaining price ratio movements.

## IV. Decomposition of Price Ratio Volatility

In this section, we decompose the variance of the price-dividend and price-earnings ratios into movements in subjective cash flow growth and return expectations. First, we use one-year subjective expectations to estimate the importance of short-term subjective cash flow growth and return expectations relative to the long-term component. We then extend the decomposition using two-year cash flow growth expectations and 10-year return expectations. Finally, we estimate the importance of subjective cash flow growth expectations relative to subjective return expectations when all horizons are included. The portion of price ratio movements that is explained by changes in subjective cash flow growth expectations is defined as cash flow news, and the portion that is explained by changes in subjective return expectations is defined as discount rate news.

### A. Finite-Horizon Decomposition

Applying expectations to equation (1), we see that changes in the price-dividend ratio must be explained by changes in one-year dividend growth expectations, one-year return expectations, or expectations of the future price-dividend ratio. This gives the following one-year decomposition:

$$1 = \underbrace{\frac{\text{cov}\left(\mathrm{E}_t^*\left[\Delta d_{t+1}\right], pd_t\right)}{\text{var}\left(pd_t\right)}}_{CF_1} + \underbrace{\frac{-\text{cov}\left(\mathrm{E}_t^*[r_{t+1}], pd_t\right)}{\text{var}\left(pd_t\right)}}_{DR_1} + \underbrace{\rho\frac{\text{cov}\left(\mathrm{E}_t^*\left[pd_{t+1}\right], pd_t\right)}{\text{var}\left(pd_t\right)}}_{LT}. \quad (8)$$

Our measures $CF_1$ and $DR_1$ capture the influence of one-year subjective dividend growth expectations (cash flow news) and one-year subjective return expectations (discount rate news). The influence of subjective dividend growth and return expectations looking more than one year ahead is captured in our measure of long-term influence $LT$. We can directly measure one-year subjective dividend growth and return expectations, while the one-year subjective price-dividend ratio expectation $(\mathrm{E}_t^*[pd_{t+1}])$ is inferred from the current price-dividend ratio and one-year subjective dividend growth and return expectations.

A useful feature of this decomposition is that one-year cash flow news and one-year discount rate news are estimated completely separately. There is no concern that subjective return expectations are affecting the estimate of cash flow news or that subjective dividend growth expectations are affecting the estimate of discount rate news. In particular, our estimate of cash flow news is unchanged if one holds discount rates constant or if one uses survey expectations of returns to measure discount rates. This separation of the two types of subjective expectations also means that these estimates will still be accurate even if the investors answering the return surveys and the investors answering the dividend surveys disagree on their beliefs. If the two groups of investors have different subjective expectations, then $LT$ can simply be interpreted as the portion of the price-dividend ratio variation that is not explained by movements in the first group's subjective return expectations or the second group's subjective dividend growth expectations.

In Table IV, we see that one-year cash flow news is large and positive, with one-year subjective dividend growth expectations explaining 39% of the variation in the price-dividend ratio. As discussed in Section III, investors tend to report higher subjective dividend growth expectations during market booms. Because these expectations vary significantly over time, they account for a large portion of the volatility of the price-dividend ratio. One-year dividend growth can have a large effect on prices because it affects the levels of both short-term and long-term dividends. Holding dividend growth fixed for all

**Table IV**

**Variance Decomposition of Price Ratios Using One-Year Estimates**

This table shows the importance of one-year cash flow news ($CF_1$) and one-year discount rate news ($DR_1$) in the price-dividend ratio and price-earnings ratio variance decompositions. For the price-dividend ratio, $CF_1$, $DR_1$, and $LT$ are the coefficients obtained by individual regressions of the one-year dividend growth expectations, the one-year returns expectations, and $\rho$ multiplied by the one-year price-dividend ratio expectations on the current price-dividend ratio. For the price-earnings ratio, $CF_1$, $DR_1$, and $LT$ are the coefficients obtained by individual regressions of the one-year earnings growth expectations, the one-year returns expectations, and $\rho$ multiplied by the one-year price-earnings ratio expectations on the current price-earnings ratio. All rows use quarterly data. Only the earnings growth expectations are available for the longer 1976Q1 to 2015Q3 sample, so only $CF_1$ is estimated in the third row. Small-sample adjusted Newey-West standard errors are reported in parentheses.

| | Sample (1) | $CF_1$ (2) | $DR_1$ (3) | $LT$ (4) |
|---|---|---|---|---|
| Price-dividend ratio | 2003 to 2015 | 0.390 | −0.049 | 0.659 |
| | | (0.034) | (0.013) | (0.037) |
| Price-earnings ratio | 2003 to 2015 | 0.937 | −0.004 | 0.064 |
| | | (0.095) | (0.008) | (0.105) |
| | 1976 to 2015 | 0.417 | | |
| | | (0.105) | | |

following years, a 10-percentage point drop in one-year dividend growth means that all future dividends fall by 10%, which causes the price to fall by 10%.

Using equation (5), we can create a similar decomposition for the price-earnings ratio. Changes in the price-earnings ratio must be explained by changes in one-year expected earnings growth, one-year expected returns, or the expected future price-earnings ratio. Similar to the decomposition for the price-dividend ratio, one-year cash flow news will represent the portion of the price-earnings ratio variance that is explained by one-year subjective earnings growth expectations, and one-year discount rate news will represent the portion explained by one-year subjective return expectations. All price-earnings ratio movements that are explained by longer-horizon earnings growth or return expectations will be captured by the long-term component. The decomposition is given by

$$1 \approx \underbrace{\frac{\operatorname{cov}\left(\mathrm{E}_t^*[\Delta e_{t+1}], pe_t\right)}{\operatorname{var}(pe_t)}}_{CF_1} + \underbrace{\frac{-\operatorname{cov}\left(\mathrm{E}_t^*[r_{t+1}], pe_t\right)}{\operatorname{var}(pe_t)}}_{DR_1} + \underbrace{\rho\frac{\operatorname{cov}\left(\mathrm{E}_t^*[pe_{t+1}], pe_t\right)}{\operatorname{var}(pe_t)}}_{LT}. \tag{9}$$

For the 2003 to 2015 sample, we have subjective earnings growth, dividend growth, and return expectations, which allows us to compute all three components. We estimate the cash flow news using the subjective earnings growth expectations and we estimate the discount rate news from the subjective return expectations. As with the price-dividend ratio decomposition, this means that cash flow news and discount rate news are estimated completely separately and remain valid even if the investors answering the two surveys have different beliefs. We infer the expected future price-dividend ratio from the current price-dividend ratio, the one-year dividend growth expectations, and the one-year return expectations. Using the expected future price-dividend ratio, the current price-earnings ratio, and the one-year earnings and dividend growth expectations, we then infer the expected future price-earnings ratio and calculate $LT$.

Table IV reports the results of this decomposition. The fact that $CF_1$, $DR_1$, and $LT$ sum almost exactly to one (0.997) shows that our approximation is quite accurate; in the Internet Appendix we estimate the exact decomposition including expectations of future payout ratios. We continue to find large, positive cash flow news and small, negative discount rate news. Over the longer 1976 to 2015 sample, one-year subjective earnings growth expectations account for 42% of price-earnings ratio movements, which is similar to the one-year cash flow news for the price-dividend ratio. Just like subjective dividend growth expectations and the price-dividend ratio, subjective earnings growth expectations are high when the price-earnings ratio is high. From Section III, we know that this positive correlation exists even when realized future earnings growth is not correlated with the price-earnings ratio. This high correlation, combined with the high volatility of subjective earnings growth expectations, implies that subjective earnings growth expectations can explain a large portion of price-earnings ratio movements.

In the 2003 to 2015 sample, one-year subjective earnings growth expectations account for virtually all (94%) of the price-earnings ratio movements. From Table III, we know that the correlation of earnings growth expectations with the price-earnings ratio is quite stable across different samples, so this high value for $CF_1$ is due primarily to higher volatility of earnings growth expectations in this period. Interestingly, the cash flow news for the 2003 to 2015 sample implies that investors believed that changes in the price-earnings ratio would be extremely short-lived over this period, as we can see from the low value of $LT$.

Over the 2003 to 2015 sample, discount rate news explains only −0.4% of the variation in the price-earnings ratio. While we do not have a return survey that perfectly aligns with the 1976 to 2015 quarterly earnings growth expectations, we can look back to Table II and the Livingston survey, which covers 1952 to 2015 and is reported twice a year. For this measure of subjective one-year return expectations, the covariance of the price-earnings ratio with subjective return expectations is 3% of the total variance of the price-earnings ratio. From equation (9), this means that one-year discount rate news would be −0.03. If we use the Livingston survey only for 1976 to 2015, the one-year discount rate news is −0.02. Thus, even over long samples, one-year discount rate news remains small and negative.

Table V shows that these results for the price-dividend ratio and price-earnings ratio also hold for two-year cash flow news and 10-year discount rate news. Specifically, two-year cash flow news can explain the majority of price-dividend and price-earnings ratio movements, while discount rate news,

**Table V**

**Extended Variance Decomposition of Price Ratios**

This table shows the importance of two-year cash flow news ($CF_2$) and 10-year discount rate news ($DR_{10}$) in price ratio variance decompositions. For the price-dividend ratio, $CF_2$ and $DR_{10}$ are the coefficients obtained by individual regressions of $\sum_{j=1}^{2}\rho^{j-1}\mathrm{E}_t^*[\Delta d_{t+j}]$ and $\sum_{j=1}^{10}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}]$ on the price-dividend ratio. For the price-earnings ratio, $CF_2$ and $DR_{10}$ are the coefficients obtained by individual regressions of $\sum_{j=1}^{2}\rho^{j-1}\mathrm{E}_t^*[\Delta e_{t+j}]$ and $\sum_{j=1}^{10}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}]$ on the price-earnings ratio. The sum of one- and two-year dividend growth and earnings growth expectations are calculated from the I/B/E/S forecasts. The sum of one- to 10-year return expectations is calculated from the one- and 10-year return forecasts from Graham-Harvey. The first two rows use quarterly data from 2003Q1 to 2015Q3. The third row uses quarterly data from 1985Q1 to 2015Q3. Only earnings growth expectations are available for this longer sample, which is why only the cash flow news is estimated. Small-sample adjusted Newey-West standard errors are reported in parentheses.

| | Sample (1) | $CF_2$ (2) | $DR_{10}$ (3) |
|---|---|---|---|
| Price-dividend ratio | 2003 to 2015 | 0.65 | −0.07 |
| | | (0.12) | (0.11) |
| Price-earnings ratio | 2003 to 2015 | 0.98 | −0.08 |
| | | (0.10) | (0.04) |
| | 1985 to 2015 | 0.64 | |
| | | (0.15) | |

even out to the 10-year horizon, is small and negative. Using the two-year expected dividend growth obtained from I/B/E/S and the average 10-year expected return obtained in the Graham-Harvey CFO survey, we can estimate the two-year cash flow news and 10-year discount rate news:

$$CF_2 = \frac{\mathrm{cov}\left(\sum_{j=1}^{2}\rho^{j-1}\mathrm{E}_t^*\left[\Delta d_{t+j}\right], pd_t\right)}{\mathrm{var}\left(pd_t\right)}, \tag{10}$$

$$DR_{10} = \frac{\mathrm{cov}\left(-\sum_{j=1}^{10}\rho^{j-1}\mathrm{E}_t^*\left[r_{t+j}\right], pd_t\right)}{\mathrm{var}\left(pd_t\right)}. \tag{11}$$

Two-year subjective dividend growth expectations account for 65% of the volatility of the price-dividend ratio. Ten-year subjective return expectations rise slightly with the price-dividend ratio, producing small, negative 10-year discount rate news of −0.07. For the price-earnings ratio, two-year cash flow news and 10-year discount rate news are identical to equations (10) and (11) but use earnings growth expectations and the price-earnings ratio rather than dividend growth expectations and the price-dividend ratio. One- and two-year earning growth expectations account for 64% of price-earnings ratio movements in the 1985 to 2015 period, and 98% in the 2003 to 2015 period. Ten-year discount rate news is still small and negative at −0.08.

*B. Full-Horizon Decomposition*

In this section, we calculate the full-horizon cash flow news and discount rate news for the price-dividend and price-earnings ratios. To start, we focus on the price-dividend ratio. From equation (3), we know that the full-horizon cash flow news is $CF = \frac{\text{cov}(\sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[\Delta d_{t+j}], pd_t)}{\text{var}(pd_t)}$ and the full-horizon discount rate news is $DR = \frac{\text{cov}(-\sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[r_{t+j}], pd_t)}{\text{var}(pd_t)}$. Since survey data on expectations are not available for an infinite horizon, we need to estimate investors' long-horizon subjective dividend growth and return expectations. We use a simple decay model of investor expectations,

$$\mathrm{E}_t^*[\Delta d_{t+1+j}] - \mu_d = \phi_d^j \big(\mathrm{E}_t^*\big[\Delta d_{t+1}\big] - \mu_d\big) + \varepsilon_{t,j}^d, \tag{12}$$

$$\mathrm{E}_t^*\big[r_{t+1+j}\big] - \mu_r = \phi_r^j \big(\mathrm{E}_t^*[r_{t+1}] - \mu_r\big) + \varepsilon_{t,j}^r. \tag{13}$$

Given the investor's one-year expectations, her expectations for longer-horizon dividend growth and returns gradually decay back to their mean values of $\mu_d$ and $\mu_r$ with persistences $\phi_d$ and $\phi_r$, respectively. We choose this form because of its simplicity and the fact that it holds for most standard asset pricing models, due to the fact that stock fundamentals are typically written as AR(1) processes. We estimate the persistence of dividend growth using the two-year subjective dividend growth expectations obtained from I/B/E/S. For returns, we use the subjective expected returns for the next 10 years, $\mathrm{E}_t^*[r_{t+1,t+10}]$, and the one-year subjective return expectations to calculate subjective return expectations for years 2 through 10, $\mathrm{E}_t^*[r_{t+2,t+10}]$. We then use this value to estimate the persistence of returns.

With this simple specification, we have a straightforward definition for full horizon cash flow news and discount rate news, $CF = \frac{1}{1-\rho\phi_d} CF_1$ and $DR = \frac{1}{1-\rho\phi_r} DR_1$. Even if subjective expectations do not follow a simple decay process, this definition of cash flow news and discount rate news will still be correct as long as $\sum_{j=1}^{\infty} \rho^{j-1} \varepsilon_{t,j}^d$ and $\sum_{j=1}^{\infty} \rho^{j-1} \varepsilon_{t,j}^r$ are not correlated with the current price-dividend ratio. Using the two-year subjective dividend growth expectations and 10-year subjective return expectations, we do not find any evidence that the error terms are correlated with $pd_t$. Combining our definitions for $CF$ and $DR$ with equation (3) gives three equations that determine $\phi_d$ and $\phi_r$:

$$\mathrm{E}_t^*\big[\Delta d_{t+2}\big] - \mu_d = \phi_d \big(\mathrm{E}_t^*\big[\Delta d_{t+1}\big] - \mu_d\big) + \nu_t^d, \tag{14}$$

$$\mathrm{E}_t^*\big[r_{t+2,t+10}\big] - 9\mu_r = \phi_r \frac{1-\phi_r^9}{1-\phi_r} \big(\mathrm{E}_t^*[r_{t+1}] - \mu_r\big) + \nu_t^r, \tag{15}$$

$$1 = \frac{1}{1-\rho\phi_d} CF_1 + \frac{1}{1-\rho\phi_r} DR_1. \tag{16}$$

The benefit of having both subjective dividend growth expectations and subjective return expectations is that we have independent methods for

**Table VI**

**Variance Decomposition of Price-Dividend Ratio into Full-Horizon *CF* and *DR***

This table calculates the full-horizon variance decomposition using different subsets of data sources. In the first row, we use exclusively the one- and two-year subjective dividend growth expectations from I/B/E/S and estimate the persistence $\phi_d$. We then estimate $CF$ as $CF_1/(1-\rho\phi_d)$ and infer $DR$ as $1-CF$. In the second row, we use exclusively the one- and 10-year subjective return expectations from Graham-Harvey and estimate the persistence $\phi_r$. We then estimate $DR$ as $DR_1/(1-\rho\phi_r)$ and infer $CF$ as $1-DR$. The third row uses both sources of data to perform a maximum likelihood estimation constrained by the identity $1 = CF + DR$ and jointly estimate the persistences $\phi_d$ and $\phi_r$, which determine $CF$ and $DR$. We estimate $CF_1$ and $DR_1$ by regressing one-year dividend growth expectations and one-year return expectations on the price-dividend ratio. All rows use quarterly data from 2003Q1 to 2015Q3. Standard errors are reported in parentheses. For the first and second rows, standard errors for $\phi_d$ and $\phi_r$ are small-sample adjusted Newey-West. For all rows, standard errors for $CF$ and $DR$ are calculated from the standard errors for $CF_1, DR_1, \phi_d$, and $\phi_r$ assuming independence of the errors.

| Subjective Expectations Data | $\phi_d$ (1) | $\phi_r$ (2) | $CF$ (3) | $DR$ (4) |
|---|---|---|---|---|
| Dividend growth | 0.59 | | 0.93 | 0.07 |
| | (0.22) | | (0.48) | (0.48) |
| Returns | | 0.48 | 1.09 | −0.09 |
| | | (0.39) | (0.07) | (0.07) |
| Dividend growth and returns | 0.66 | 0.47 | 1.09 | −0.09 |
| | (0.03) | (0.21) | (0.04) | (0.04) |

measuring the size of cash flow news and discount rate news. There are three possible ways to estimate the decomposition. First, we can estimate $\phi_d$ from the subjective dividend growth expectations, calculate $CF$ and then infer $DR = 1 - CF$. Second, we can estimate $\phi_r$ from the subjective return expectations, calculate $DR$, and infer $CF = 1 - DR$. Third, we can jointly estimate $\phi_d$ and $\phi_r$ such that $CF + DR = 1$ using maximum likelihood. Table VI shows the results of these three estimations.

Both the dividend growth and return surveys provide strong evidence that price movements are predominantly explained by investors' subjective dividend growth expectations. Since the surveys are taken from different groups of investors, it is remarkable that the directly observed $CF$ and the inferred $CF$ are so similar. In the first row of Table VI, where the effect of subjective dividend growth expectations is estimated directly, we see that subjective dividend growth expectations explain 93% of price-dividend ratio movements. While this coefficient has only moderate statistical significance, it fits well with the one-year cash flow news of 0.39 estimated in Table IV and two-year cash flow news of 0.65 estimated in Table V, both of which have high statistical significance. This estimation relies only on subjective dividend growth expectations data and is completely separate from the subjective return expectations data.

The second row shows the results when the contribution of subjective dividend growth expectations is estimated indirectly using subjective return expectations. The contribution of subjective return expectations is $-9\%$. The negative contribution means that subjective dividend growth expectations must explain over 100% of the price-dividend ratio volatility, as it must drive the price-dividend ratio movements and make up for the positive comovement of subjective return expectations and $pd_t$. In addition to being negative, the *DR* measured from the return surveys is small in magnitude. Even if the sign of *DR* was reversed to positive 9%, meaning that subjective return expectations were low when the price-dividend ratio is high, we would still infer that dividend growth expectations must be driving the vast majority of price-dividend ratio movements. There is simply not enough volatility in the return expectations to explain the large observed movements in the price-dividend ratio.

When the persistences of dividend growth and returns are estimated jointly, the result is similar to the case in which discount rate news is estimated directly. Because subjective return expectations have low volatility and $DR_1 < 0$, it is difficult to noticeably change *DR* from a small, negative value. Therefore, in the joint estimation it is far more likely that the direct estimation of *CF* slightly understates the role of subjective dividend growth expectations than the indirect estimation of *CF* from the subjective returns data overstates the role of subjective dividend growth expectations.

In all three cases, we estimate low persistence $\phi_d$ and $\phi_r$ for dividend growth and return expectations, respectively. For the first two rows, we directly estimate that movements in one-year expectations are associated with only modest changes in longer-horizon expectations. In the third row, we find that the observed movements in one-year expectations are large enough to account for all price-dividend ratio variation with only small movements in longer-horizon expectations. Given that return expectations do not account for much of the price-dividend ratio variation, this means that short-term dividend growth expectations can explain the majority of price-dividend ratio movements.

One potential limitation of this simple decay functional form is that movements in long-horizon dividend growth expectations are pinned down by the comovement of one- and two-year dividend growth expectations. If agents believe that dividend growth is a combination of a volatile, quickly decaying component and a slow-moving, persistent component, then the simple decay functional form will underestimate the movements in their long-horizon dividend growth expectations.[14] While the first and third rows of Table VI show that large movements in long-horizon expectations are not needed to account for the variation in the price-dividend ratio, it is still possible that long-horizon expectations could be more volatile under a different functional form for expectations.

[14] For example, Giglio and Kelly (2017) find empirical evidence that risk-neutral expectations of cash flow growth in the equity market decay more slowly than a simple decay function would imply. In this case, our estimates reported in Tables VI and VII would be lower bounds on cash flow news, strengthening our finding that cash flow news is large. This will not change our result that short-term cash flow growth expectations explain the majority of price ratio movements, since we directly estimate two-year cash flow news in Section IV.A without assuming a functional form for expectations.

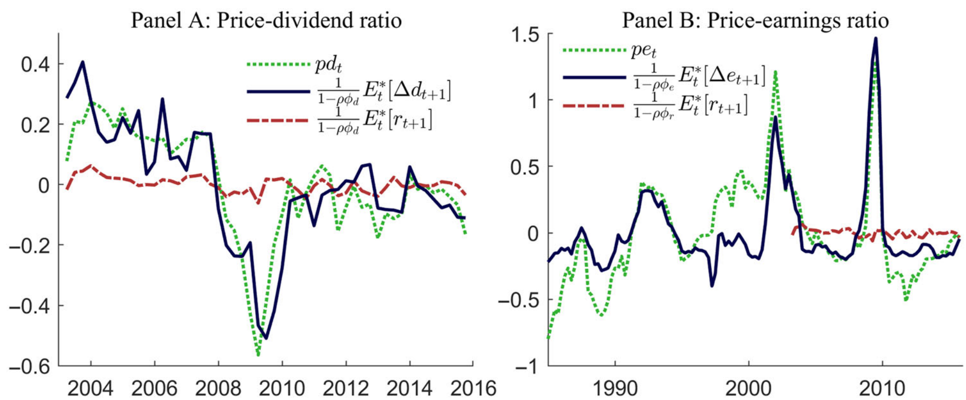


**Figure 4. Price ratios and subjective expectations**. Panel A compares the price-dividend ratio to the full-horizon dividend growth expectations and full-horizon return expectations for 2003 to 2015. To show the comovement, all variables are demeaned. The solid line plots the full-horizon dividend growth expectations estimated solely from dividend survey data. The dash-dotted line plots the full-horizon return expectations estimated solely from return survey data. The dotted line plots the observed price-dividend ratio. Panel B is identical but uses the full-horizon earnings growth expectations and price-earnings ratio for 1985 to 2015. (Color figure can be viewed at wileyonlinelibrary.com)

To better understand why the estimated cash flow news is so large, Panel A of Figure 4 compares the price-dividend ratio to the full horizon dividend growth expectations $\frac{1}{1-\rho\phi_d}\mathrm{E}_t^*[\Delta d_{t+1}]$ measured solely from dividend survey data and the full-horizon return expectations $\frac{1}{1-\rho\phi_r}\mathrm{E}_t^*[r_{t+1}]$ measured solely from return survey data. Cash flow growth expectations explain the high but declining price-dividend ratio before 2008, the sharp drop and recovery during 2008 to 2010, and the leveling off in 2010 to 2016.

For the price-earnings ratio, we use a similar methodology to calculate the full-horizon decomposition. First, we estimate the long horizon subjective earnings growth expectations using the simple decay functional form,

$$\mathrm{E}_t^*[\Delta e_{t+1+j}] - \mu_e = \phi_e^j\left(\mathrm{E}_t^*[\Delta e_{t+1}] - \mu_e\right) + \varepsilon_{t,j}^e. \tag{17}$$

Just as we did for subjective dividend growth expectations, we estimate the persistence $\phi_e$ of subjective earnings growth expectations using the one- and two-year expectations constructed from the I/B/E/S data. Analogous to the price-dividend ratio decomposition, the full-horizon cash flow news and discount rate news for the price-earnings ratio are $CF = \frac{\mathrm{cov}(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta e_{t+j}], pe_t)}{\mathrm{var}(pe_t)}$ and $DR = \frac{\mathrm{cov}(-\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}], pe_t)}{\mathrm{var}(pe_t)}$. With this simple decay functional form, the full-horizon cash flow news and discount rate news can be simplified to $CF = \frac{1}{1-\rho\phi_e}CF_1$ and $DR = \frac{1}{1-\rho\phi_r}DR_1$, where $CF_1$ and $DR_1$ are the one-year cash flow and discount rate news for the price-earnings ratio.

**Table VII**

## Variance Decomposition of Price-Earnings Ratio into Full-Horizon *CF* and *DR*

This table calculates the full-horizon variance decomposition using different subsets of data sources. In the first row, we use exclusively the one- and two-year subjective earnings growth expectations from I/B/E/S and estimate the persistence $\phi_e$. We then estimate $CF$ as $CF_1/(1-\rho\phi_e)$ and infer $DR$ as $1-CF$. In the second row, we use exclusively the one- and 10-year subjective return expectations from Graham-Harvey and estimate the persistence $\phi_r$. We then estimate $DR$ as $DR_1/(1-\rho\phi_r)$ and infer $CF$ as $1-DR$. The third row uses both sources of data to perform a maximum likelihood estimation constrained by the identity $1=CF+DR$ and jointly estimate the persistences $\phi_e$ and $\phi_r$, which determine $CF$ and $DR$. We estimate $CF_1$ and $DR_1$ by regressing one-year earnings growth expectations and one-year return expectations on the price-earnings ratio. All rows use quarterly data from 2003Q1 to 2015Q3. Standard errors are reported in parentheses. For the first and second rows, standard errors for $\phi_e$ and $\phi_r$ are small-sample adjusted Newey-West. For all rows, standard errors for $CF$ and $DR$ are calculated from the standard errors for $CF_1$, $DR_1$, $\phi_e$, and $\phi_r$ assuming independence of the errors.

| Subjective Expectations Data | $\phi_e$ (1) | $\phi_r$ (2) | $CF$ (3) | $DR$ (4) |
|---|---|---|---|---|
| Earnings growth | 0.06 | | 0.99 | 0.01 |
| | (0.01) | | (0.10) | (0.10) |
| Returns | | 0.48 | 1.01 | −0.01 |
| | | (0.39) | (0.02) | (0.02) |
| Earnings growth and returns | 0.07 | 0.47 | 1.01 | −0.01 |
| | (0.10) | (0.15) | (0.01) | (0.01) |

Using equation (7), we again have three equations that determine the two persistence measures, $\phi_e$ and $\phi_r$. The first equation is (15), which uses the short-term and long-term return expectations to pin down $\phi_r$. The two other equations are analogous to (14) and (16), except they involve earnings instead of dividends,

$$\mathrm{E}_t^*[\Delta e_{t+2}] - \mu_e = \phi_e\big(\mathrm{E}_t^*[\Delta e_{t+1}] - \mu_e\big) + \nu_t^e, \tag{18}$$

$$1 \approx \frac{1}{1-\rho\phi_e} CF_1 + \frac{1}{1-\rho\phi_r} DR_1. \tag{19}$$

Just like the price-dividend ratio decomposition, the decomposition for the price-earnings ratio can be estimated in three ways. We can estimate $\phi_e$ using just the one- and two-year subjective earnings growth expectations, calculate $CF$, and infer $DR \approx 1 - CF$. Conversely, we can estimate $\phi_r$ from the subjective return expectations, calculate $DR$, and infer $CF \approx 1 - DR$. We can also use the subjective earnings growth and return expectations to jointly estimate $\phi_e$ and $\phi_r$ with the restriction that the approximation holds exactly, $CF + DR = 1$. The estimates from these three different methods are reported in Table VII. In the Internet Appendix, we show that estimating the exact decomposition including expectations of future payout ratios, rather than the approximated decomposition, has almost no effect on our results. In Table VII, we can also see that our directly measured cash flow news ($CF = 0.99$) and our directly measured discount rate news ($DR = -0.01$) sum almost exactly to one, which means that our approximation holds quite well.

Our results for the price-earnings ratio are similar to the results for the price-dividend ratio. Both the earnings growth expectations and the return expectations indicate that cash flow news accounts for almost all of the price-earnings ratio movement. Using the earnings growth surveys, we directly observe that earnings growth expectations explain 99% of the movement in the price-earnings ratio. This is almost exactly the value that we get from the return surveys. For the return surveys, we estimate that return expectations account for $-1\%$ of price-earnings ratio movements, implying that earnings growth expectations must account for 101%.

When both the earnings growth and return surveys are used, the result is similar to when only the return surveys are used. This is again due to the fact that $DR_1$ is quite small, which means it takes large changes in $\phi_r$ to alter the full-horizon discount rate news $DR$. Because this is true for both the price-dividend and price-earnings ratios, changes in $\phi_r$ do not have a large impact on $\phi_d$ in Table VI or $\phi_e$ in Table VII, since $\phi_r$ only affects the other persistence measures through the $CF + DR = 1$ restriction. The result is that $\phi_r$ is mainly determined by equation (15), which is shared by the price-dividend ratio and price-earnings ratio decompositions and explains why the joint estimate for $\phi_r$ is similar in both decompositions. Since it takes only a small change in $\phi_e$ to raise $CF$ but a large change in $\phi_r$ to increase $DR$, it is much more likely that the direct estimation of $CF$ slightly underestimates cash flow news than that the indirect estimate of $CF$ overstates cash flow news.

Where the results differ from the price-dividend ratio decomposition is in the persistence of cash flow growth expectations. Subjective earnings growth expectations show almost no persistence, $\phi_e = 0.06$, compared to the already low persistence of subjective dividend growth expectations, $\phi_d = 0.59$. This result is consistent with the idea that changes in dividends are smoothed compared to changes in earnings. Instead of immediately altering dividends to match changes in earnings, investors may believe that companies will spread these changes over several years. This would explain why two-year dividend growth expectations typically rise when one-year dividend growth expectations rise, but two-year earnings growth expectations do not rise substantially when one-year earnings growth expectations rise. The two-year cash flow news of 0.98 that we estimate in Section IV.A fits this low persistence well, given that one-year cash flow news is 0.94.

This low persistence holds in longer samples. We have two-year earnings growth expectations for the period of 1985 to 2015. Over this sample, the estimated persistence of earnings growth expectations is still only 0.06, with a standard deviation of 0.02. This low persistence is still enough for subjective earnings growth expectations to account for the majority of price-earnings ratio movements over the longer sample. For 1985 to 2015, we estimate that full-horizon cash flow news accounts for 63% of the movements in the price-earnings ratio, with a standard deviation of 15%.

Panel B of Figure 4 compares the price-earnings ratio to the full-horizon earnings growth expectations $\frac{1}{1-\rho\phi_e}\mathrm{E}_t^*[\Delta e_{t+1}]$ measured solely from earnings survey data and the full-horizon return expectations measured solely from the return data. While earnings growth expectations do not fully explain the gradual rise in the price-earnings ratio during the late 1990s, they do explain the rise and fall in the early 1990s, early 2000s, and late 2000s and partially explain the rise and fall in the late 1980s.

## V. Modeling Subjective Expectations

Summarizing the results of the previous sections, we document three key facts for subjective expectations. First, subjective cash flow growth expectations are time-varying and explain the majority of price movements. Second, subjective return expectations are significantly less volatile and do not play a large role in explaining price movements. Third, subjective cash flow growth expectations have low persistence, which means that changes in short-term cash flow growth expectations account for most price movements. To see how these findings compare to standard asset pricing models in the literature, we select four models and calculate the full-horizon cash flow news $CF$, the full-horizon discount rate news $DR$, and the short-horizon cash flow news $CF_1$ and $CF_2$. We then present the Earnings Growth Reversal model of subjective expectations to match the expectations series and these findings.

### A. Existing Asset Pricing Models

To understand how our findings relate to existing asset pricing models, we select four leading models from various branches of the asset pricing literature. Specifically, we consider the Campbell and Cochrane (1999) external habit formation model, the Bansal, Kiku, and Yaron (2012) long-run risk model, the Collin-Dufresne, Johannes, and Lochstoer (2016) learning model, and the Barberis et al. (2015) return extrapolation model. All of these consumption-based asset pricing models have theoretical predictions about the facts documented in this paper. Table VIII, Panel A, shows the decomposition of price ratio movements into movements in return expectations and cash flow growth expectations at different horizons using the headline calibrations of each model. Additional details are provided in the Internet Appendix.

The first model we examine is the habit formation model of Campbell and Cochrane (1999). In this model, agents believe that dividend growth is i.i.d., so there is no variation in dividend growth expectations over time. As a result, cash flow news at all horizons is exactly zero and all variation in the price-dividend ratio is due to changes in expected returns.

Next, we examine the long-run risk model of Bansal, Kiku, and Yaron (2012), where cash flow growth has a long-run component and time-varying

**Table VIII**

**Variance Decomposition in Different Asset Pricing Models**

This table calculates the implied full-horizon cash flow news ($CF$) and full-horizon discount rate news ($DR$), as well as one- and two-year cash flow news ($CF_1, CF_2$), in the variance decomposition of different asset pricing models. Panel A shows the decomposition of the price-dividend ratios derived in Campbell and Cochrane (1999) (habit formation), Bansal, Kiku, and Yaron (2012) (long-run risk), Collin-Dufresne, Johannes, and Lochstoer (2016) (learning), and Section V.B of this paper (earnings growth reversal), as well as the empirical decomposition measured in the 2003 to 2015 sample. At the request of the authors, the row for Barberis et al. (2015) (return extrapolation) uses a decomposition of the price-dividend difference. Our analysis in Panel B shows the decomposition of the price-earnings ratio derived in the earnings growth reversal (EGR) model in Section V.B and the empirical counterpart measured in the 2003 to 2015 sample. All models are solved and estimated using the original author calibrations and simulated over the sample lengths proposed in each paper. The coefficients for the first four models are estimated by directly solving for the relationship between the price-dividend ratio and cash flow growth expectations ($CF_1, CF_2, CF$) and then inferring discount rate news ($DR$) as $1 - CF$. The coefficients of the EGR model for the price-dividend ratio decomposition are obtained using the closed-form solution derived in Section V.B.2. The coefficients for the EGR model for the price-earnings ratio decomposition are estimated using the model price ratios and subjective expectations series for 2003 to 2015 calculated in Section V.B.3. Standard errors are n/a when decomposition terms are functions of fixed parameters.

| Panel A: Price-Dividend Ratio | | | | |
|---|---|---|---|---|
| | $CF$ (1) | $DR$ (2) | $CF_1$ (3) | $CF_2$ (4) |
| Data 2003 to 2015 | 1.09 | −0.09 | 0.39 | 0.65 |
| | (0.04) | (0.04) | (0.03) | (0.12) |
| Habit formation | 0.00 | 1.00 | 0.00 | 0.00 |
| | n/a | n/a | n/a | n/a |
| Long-run risk | 0.38 | 0.62 | 0.11 | 0.19 |
| | (0.19) | (0.19) | (0.06) | (0.09) |
| Learning | 0.07 | 0.93 | 0.00 | 0.00 |
| | (0.16) | (0.16) | (0.01) | (0.01) |
| Return extrapolation | $\infty$ | $-\infty$ | 0.87 | 1.74 |
| | n/a | n/a | n/a | n/a |
| Earnings growth reversal | 1.09 | −0.09 | 0.39 | 0.64 |
| | n/a | n/a | n/a | n/a |
| **Panel B: Price-Earnings Ratio** | | | | |
| Data 2003 to 2015 | 1.01 | −0.01 | 0.94 | 0.98 |
| | (0.01) | (0.01) | (0.09) | (0.10) |
| Earnings growth reversal | 0.95 | 0.05 | 0.95 | 0.95 |
| | (0.01) | (0.01) | (0.01) | (0.01) |

volatility. Because of this component, cash flow growth expectations vary over time and explain some of the price-dividend ratio variation. However, due to recursive preferences, discount rate expectations also depend heavily on the long-run component and time-varying volatility, and account for 62% of the price-dividend ratio variation. As a result, cash flow growth expectations play a secondary role, explaining 38% of price-dividend ratio variation.

One- and two-year cash flow growth expectations explain only 11% and 19% of the variation, respectively.

The third model is the learning model of Collin-Dufresne, Johannes, and Lochstoer (2016). Here, the agent knows that cash flow growth is i.i.d. but is uncertain about its mean value $\mu$. After observing realized cash flow growth, the agent updates her expected value of $\mu$ and her uncertainty about $\mu$. Similar to the long-run risk model, changes in the expected value of $\mu$ alter her cash flow growth expectations and discount rates, and changes in uncertainty about $\mu$ alter her discount rates. Uncertainty about $\mu$ varies substantially over time, and as a result changes in discount rates explain 93% of the variation in the price-dividend ratio. Changes in cash flow growth expectations explain only 7% of the variation. We also calculate their more quantitative case, where the agent knows $\mu$ but is uncertain about whether there is a long-run component to cash flow growth.[15] This gives a similar *CF* of 0.1.

Finally, we evaluate the return extrapolation model of Barberis et al. (2015). When prices increase, agents increase their expectations for future dividend changes and price changes. The model generates a low volatility for one-year return expectations in line with the survey data but understates the standard deviation of our survey one-year dividend growth expectations by a factor of 12. At the suggestion of the authors, Table VIII reports the variance decomposition for the price-dividend *difference*, rather than the standard variance decomposition for the price-dividend *ratio*, as the model is additive in nature.[16] Because model dividend change expectations are only slightly more volatile than model price change expectations, any movements in dividend change expectations are almost completely negated by movements in price change expectations. This leads to low variation in the price-dividend difference and extremely large values for *CF* and *DR*. Under this decomposition, full-horizon cash flow news and discount rates are both infinite, $CF = \infty$ and $DR = -\infty$. To give a finite estimate of long-horizon cash flow news and discount rate news, we use a horizon of 10 years. This gives long-horizon values for cash flow news of 8.69 and discount rate news of $-8.19$.[17]

We now consider the possibility of altering these models to incorporate more volatile cash flow growth expectations. To match the survey data, the volatility of cash flow growth expectations would need to be similar to the volatility of the price-dividend ratio, and these expectations would need to account for virtually all price-dividend ratio movements. We can rearrange equation (2)

[15] This more quantitative case features cyclical variation in uncertainty. In the case in which the agent is uncertain only about $\mu$, uncertainty monotonically declines as the agent obtains more data.

[16] The Internet Appendix provides details of this decomposition.

[17] For robustness, we also calculate the variance decomposition for the price-dividend ratio, which also gives extremely large values of $CF = 13.11$ and $DR = -12.11$.

and take variances to get the relationship

$$\operatorname{var}\left(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}]\right) = \operatorname{var}(pd_t) + \operatorname{var}\left(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta d_{t+j}]\right) - 2\cdot\operatorname{cov}\left(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta d_{t+j}], pd_t\right). \tag{20}$$

Dividing by $\operatorname{var}(pd_t)$ and using the definition of $CF$ gives

$$\frac{\operatorname{var}\left(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}]\right)}{\operatorname{var}(pd_t)} = 1 + \frac{\operatorname{var}\left(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta d_{t+j}]\right)}{\operatorname{var}(pd_t)} - 2CF. \tag{21}$$

Thus, altering a model to push $\operatorname{var}(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[\Delta d_{t+j}])$ toward $\operatorname{var}(pd_t)$ and $CF$ toward one implies that we also need to push $\operatorname{var}(\sum_{j=1}^{\infty}\rho^{j-1}\mathrm{E}_t^*[r_{t+j}])/\operatorname{var}(pd_t)$ toward zero.

In other words, we cannot alter these models to match our findings on cash flow growth expectations without also altering the models so that there is little variation in return expectations.[18] This is true not just for these four models, but for any model in which agents' expectations satisfy the no-bubble condition, $\lim_{j\to\infty}\rho^{j-1}\mathrm{E}_t^*[pd_{t+j}] = 0$. It is important to reiterate that these models were designed to match a different set of facts than those presented here. In particular, they were focused on how asset price behavior can be explained by the effect of preferences, consumption risk, learning, or extrapolation on marginal utility and expected returns. The identity in equation (21) shows that models intended to generate large time-variation in expected returns, such as the four models above, cannot match the survey data on cash flow growth expectations without substantially dampening the key features that make these models different from simple models of constant discount rates.

### *B. Model of Subjective Cash Flow Expectations*

Given the difficulty for standard asset pricing models to replicate our results, we construct a simple model of subjective cash flow expectations and asset prices that is able to closely match our decompositions. In addition, the model matches asset pricing moments and closely replicates the survey expectations series for both dividend growth and earnings growth. In this model, agents believe that shocks to current earnings will be partly transitory and that these shocks will be gradually incorporated into dividends. Because changes in earnings are believed to be partly transitory, agents expect that changes in earnings growth will be partially reversed by future earnings growth. This matches the significant negative correlation (−0.64) in the survey data between current earnings growth and one-year earnings growth expectations.

[18] See Jin and Sui (2019) for an example with a return extrapolation model.

In contrast, after a significant drop in earnings, agents' dividend growth expectations fall. This matches the opposing responses of dividend growth and earnings growth expectations to the financial crisis observed in Figure 4.

### *B.1. Earnings Growth Reversal Model*

Specifically, agents believe that earnings and dividends evolve according to

$$e_t = x_{t-1} + \varepsilon_t^e, \tag{22}$$

$$x_t = \mu + x_{t-1} + \theta \varepsilon_t^e, \tag{23}$$

$$d_t = (1-w)e_t + w d_{t-1} + \varepsilon_t^d, \tag{24}$$

where all variables are in logs. Earnings are the sum of a permanent component $x_{t-1}$ and a shock $\varepsilon_t^e$. Portion $\theta$ of the shock is permanent, as it shows up in $x_t$, while portion $1-\theta$ is transitory. Agents believe that dividends will be a weighted sum of current earnings and previous dividends, plus a shock $\varepsilon_t^d$. The shocks are believed to be mutually independent and i.i.d.

This structure is meant to capture several of the key features that we find using the survey forecasts data. First, investors believe that shocks to earnings will be largely transitory. Even during the financial crisis, investors believed that the massive drop in earnings would be mostly offset by higher next-year earnings growth. Second, survey earnings growth expectations have virtually no persistence, which we show is consistent with believing that shocks are partly permanent and partly transitory. Third, investors believe that changes in dividends will be smoother than changes in earnings. While investors report large short-lived expected changes in earnings, they report smaller but more persistent expected changes in dividends, implying that they believe companies will spread the change in earnings over multiple periods rather than immediately adjust dividends. The parameters $\theta$ and $w$ control how much shocks to earnings will be reversed in the future and how quickly they expect dividends will be adjusted when earnings change.

Importantly, we do not make any assumptions about the objective distribution for earnings and dividends. Each period, agents observe earnings and dividends and infer the values of $\varepsilon_t^e, \varepsilon_t^d$, and $x_t$ using equations (22) to (24). Since this paper focuses on comovements, we demean all variables for the sake of simplicity. Using equations (22) and (23), after observing realized earnings, agents update their belief about the permanent component $x_t$ according to

$$\Delta x_t = \theta(e_t - x_{t-1}), \tag{25}$$

and the subjective expectations in the model for earnings growth evolve according to

$$\begin{aligned} \mathrm{E}_t^*[\Delta e_{t+1}] &= x_t - e_t \\ &= (1-\theta)\big(\mathrm{E}_{t-1}^*[\Delta e_t] - \Delta e_t\big). \end{aligned} \tag{26}$$

Unexpected earnings growth at time $t$ is expected to be partially reversed by earnings growth in $t+1$,with the magnitude of this reversal controlled by the extent to which the shock is expected to be permanent $\theta$.[19] Model subjective expectations for earnings growth beyond one year are constant. Intuitively, agents expect their future forecast errors to be zero. Formally, for $j > 1$,

$$\mathrm{E}_t^*\left[\Delta e_{t+j}\right] = \mathrm{E}_t^*\left[\Delta x_{t+j-1}\right] = 0. \tag{27}$$

Finally, from equation (24), the model subjective dividend growth expectations are

$$\mathrm{E}_t^*\left[\Delta d_{t+j}\right] = w^{j-1}(1-w)\left(x_t - d_t\right). \tag{28}$$

To summarize, from equation (25), the perceived permanent component $x_t$ moves $\theta$-to-one with realized earnings. For $\theta > 0$, a positive shock to earnings increases the perceived permanent component. This raises expectations of future earnings and consequently raises expectations of future dividends. The parameter $w$ controls how quickly agents believe dividends will grow to reflect the change in the permanent component. As shown in equation (28), a share $1-w$ of the change in $x_t$ shows up in one-year dividend growth expectations. Dividend growth expectations then gradually decay back to zero with persistence $w$, ensuring that changes in $x_t$ are eventually fully incorporated into dividends in a smoothed manner. For $\theta < 1$, a positive shock to earnings increases $x_t$ less than one-to-one. As a result, expected earnings growth $x_t - e_t$ falls. Thus, for $\theta \in (0, 1)$ we can replicate the fact that survey expectations of earnings growth tend to rise after bad shocks while survey expectations of dividend growth fall.

To calculate agents' discount rates, we assume that agents have power utility with risk aversion $\gamma$ and discount factor $\delta$.[20] Agents believe that consumption growth follows

$$\Delta c_{t+1} = \eta \Delta d_{t+1} + \varepsilon_{t+1}^c. \tag{29}$$

The price-dividend ratio is determined by the agents' first-order condition for holding the stock market, $\mathrm{E}_t^*[\delta \exp(-\gamma[\eta \Delta d_{t+1} + \varepsilon_{t+1}^c] + r_{t+1})] = 1$.[21] Using the log-linearized return approximation (1), this gives the demeaned price-dividend ratio

$$pd_t = \frac{1-\chi}{1-\rho w}\mathrm{E}_t^*\left[\Delta d_{t+1}\right], \tag{30}$$

[19] For $\theta < 0$, agents' expectations would appear extrapolative, where unexpectedly high earnings growth raises subjective expectations of future earnings growth.

[20] We find similar results if discount rates are simply assumed to be constant.

[21] In this framework, the variation in return expectations comes from variation in the risk-free rate rather than expected excess returns. This is consistent with our survey data. For our estimated $DR_1 = -0.05$, less than 0.001 comes from comovement of expected excess returns with the price-dividend ratio.

where $\chi = \gamma\eta$. All terms related to the variance of the shocks are captured in the mean value of the price-dividend ratio and thus do not appear in the demeaned equation (30).

Similarly, agents' return expectations are

$$\mathrm{E}_t^*[r_{t+j}] = \chi \mathrm{E}_t^*[\Delta d_{t+j}]. \tag{31}$$

For positive values of $\chi$, an agent's discount rates will rise with her dividend growth expectations because she expects higher future consumption.[22] The price-earnings ratio reduces to a weighted sum of the one-year earnings growth expectations and the payout ratio,

$$pe_t = \frac{1-w}{1-\rho w}(1-\chi)\mathrm{E}_t^*[\Delta e_{t+1}] + \left[1 - \frac{1-w}{1-\rho w}(1-\chi)\right] de_t. \tag{32}$$

We estimate a small value for $\chi$ and $\rho$ is close to one, so the price-earnings ratio will depend primarily on earnings growth expectations, with the payout ratio playing a secondary role.

### B.2. Distribution-Independent Results

We can calculate the variance decomposition for the price-dividend ratio without making any assumptions about the objective distribution for earnings and dividends. From equation (30), the price-dividend ratio is a linear function of one-year subjective dividend growth expectations. Therefore, the covariance $\mathrm{cov}(\mathrm{E}_t^*[\Delta d_{t+1}], pd_t)$ is simply $\frac{1-\rho w}{1-\chi}\mathrm{var}(pd_t)$. Using equation (28), full-horizon cash flow news is

$$CF = \frac{\mathrm{cov}\left(\sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[\Delta d_{t+j}], pd_t\right)}{\mathrm{var}(pd_t)} = \frac{1}{1-\chi}. \tag{33}$$

Similarly, equation (31) pins down full-horizon discount rate news as

$$DR = \frac{\mathrm{cov}\left(-\sum_{j=1}^{\infty} \rho^{j-1} \mathrm{E}_t^*[r_{t+j}], pd_t\right)}{\mathrm{var}(pd_t)} = -\frac{\chi}{1-\chi}. \tag{34}$$

One- and two-year cash flow news can also be easily calculated as

$$CF_k = \frac{\mathrm{cov}\left(\sum_{j=1}^{k} \rho^{j-1} \mathrm{E}_t^*[\Delta d_{t+j}], pd_t\right)}{\mathrm{var}(pd_t)} = \frac{1-(\rho w)^k}{1-\chi}. \tag{35}$$

Thus, to calculate the decomposition in this model, we only need to know $\chi$ and $w$. Using equation (31), $\chi$ determines the comovement of model subjective dividend growth expectations and return expectations. Specifically, $\chi$ equals

[22] Note that high earnings growth raises dividend growth expectations and by extension return expectations when $\chi > 0$.

$\frac{\text{cov}(\text{E}_t^*[r_{t+1}],\text{E}_t^*[\Delta d_{t+1}])}{\text{var}(\text{E}_t^*[\Delta d_{t+1}])}$. Using the survey data on one-year return expectations and one-year dividend growth expectations, we calculate $\chi = 0.08$. The low value of $\chi$ implies that the agent has low risk aversion or believes that consumption growth is only weakly related to dividend growth. This means that the agent's discount factor for the stock market will not fluctuate much over time, which matches the low volatility of return expectations that we find in the survey data. From equation (28), $w$ is simply the persistence of dividend growth expectations, which we estimated earlier to be 0.66 in Table VI.

Table VIII shows that this model accurately captures the key results from our decomposition using the survey data. The full-horizon cash flow news of 1.09 and the full-horizon discount rate news of $-0.09$ are virtually identical to the values measured from the survey data. Similarly, the one- and two-year cash flow news of 0.39 and 0.64, respectively, almost perfectly match the measured one- and two-year cash flow news in the survey data of 0.39 and 0.65, respectively, despite the fact that none of these decomposition values are targeted. In addition, the model generates one-year discount rate news of $-0.03$, which is quite close to the value of $-0.05$ from Table IV.

To understand how this departs from the decomposition obtained by an econometrician using realized cash flows, suppose as a simple example that the true earnings growth and dividend growth processes are both i.i.d. This occurs if earnings and dividends follow equations (22) to (24), but with objective values of $\theta$ and $w$ both equal to one. While this would have no impact on the decomposition using subjective expectations, an econometrician measuring cash flow news using realized cash flow growth and returns would calculate that cash flow news is exactly zero and that discount rate news is one. Estimating these equations using the realized data, we find empirical values for $\theta$ and $w$ of 0.81 and 0.88, respectively, which are much closer to i.i.d. than the survey-implied values of 0.4 and 0.66. Thus, investors appear to overestimate the extent to which shocks to earnings impact future earnings growth $(1-\theta)$ and short-term dividend growth $\theta(1-w)$.

### *B.3. Results for 1985 to 2015*

Equation (32) shows that the model price-earnings ratio depends on model subjective expectations of earnings growth and the realized payout ratio, unlike the model price-dividend ratio, which depends only on model subjective expectations of dividend growth. To calculate the variance decomposition for the model price-earnings ratio, we take the realized earnings growth and payout ratio from the data and then calculate the model subjective earnings growth expectations and model price-earnings ratio using equations (26) and (32).[23] Since the model is motivated by low persistence in earnings growth

[23] Alternatively, one could choose an objective distribution for earnings growth and the payout ratio and then calculate the variance decomposition over simulated paths. For any objective distribution that matches the dynamics of earnings growth and the payout ratio over 1985 to 2015, the results will be identical.

expectations, we focus on the 1985 to 2015 sample, where we are able to measure the persistence of survey earnings growth expectations.

Using these model subjective expectations and model price ratios, we also show that this relatively simple model is able to replicate the main findings of the previous sections on top of matching the variance decompositions. First, the time series for model subjective earnings growth and dividend growth expectations match the volatility and movements in the survey cash flow growth expectations. Second, the model persistences of expectations are low and the volatility of the price ratios, changes in the price ratios, and returns are quite high, in line with what we find in the data. Third, the model generates predictable forecast errors for cash flow growth expectations in the pre-2003 sample but not in the 2003 to 2015 sample, in line with what we find in Section III.B and offering a potential explanation for why this occurs. Interestingly, the model also generates two of the findings of the return extrapolation literature, namely, that return expectations are more correlated with current returns than future returns (Greenwood and Shleifer (2014)) and that the ability of the price-dividend ratio to predict next-year returns is stronger when return expectations are more related to recent returns than earlier returns (Cassella and Gulen (2018)).

To start, we set the initial demeaned expectation $\mathrm{E}^*_{t-1}[\Delta e_t]$ to zero for 1985 and measure the value of $\mathrm{E}^*_t[\Delta e_{t+1}]$ using the realized earnings growth and equation (26). Using the realized payout ratio $de_t$, we then calculate the model price-earnings ratio from (32). Importantly, no information from the realized data other than $\Delta e_t, de_t$ is used to calculate the model variables. To choose a value for $\theta$, we note that expanding equation (26) shows that model earnings growth expectations are a decaying sum of current and past earnings growth. We estimate $\theta = 0.4$ from the relative weight that survey earnings growth expectations place on current- and prior-year earnings growth.

Table VIII shows the results for the variance decomposition of the model price-earnings ratio. We estimate the variance decomposition over the 2003 to 2015 sample to match the sample for the survey estimation, but the results are virtually identical if we estimate the decomposition over the 1985 to 2015 sample. Because model subjective earnings growth expectations are constant for all horizons beyond one year, the one-year, two-year, and full-horizon cash flow news are all the same at 0.95. While the model values for $CF_2$ and $CF$ are slightly lower than the values from the data, the model accurately captures the fact that virtually all movements in the price-earnings ratio are explained by earnings growth expectations and that cash flow news is more heavily concentrated at short horizons for the price-earnings ratio than for the price-dividend ratio. In the survey data, the full-horizon discount rate news $DR = -0.01$ (0.01) is not significantly positive or negative, but we can confidently say that it is small in magnitude. This is matched by the model, where full-horizon discount rate news accounts for only 5% of the price-earnings ratio variation.

The model is also able to match the large fluctuations in survey cash flow growth expectations, despite the fact that $w$ and $\theta$ do not target these volatilities. Figure 5 shows the one-year cash flow growth expectations from

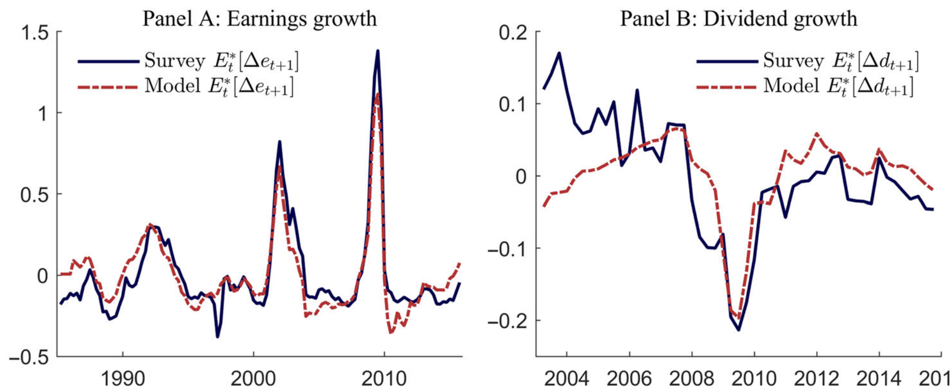


**Figure 5. Survey and model cash flow growth expectations**. Panel A compares the survey and model one-year subjective earnings growth expectations for 1985 to 2015. Panel B compares the survey and model one-year subjective dividend growth expectations for 2003 to 2015. The solid line plots the expectations measured from I/B/E/S survey data. The dashed line plots the model expectations. (Color figure can be viewed at wileyonlinelibrary.com)

the survey data and the model subjective cash flow growth expectations constructed from $\Delta e_t, de_t$. The model expectations for one-year earnings growth match the survey expectations well, capturing virtually all of the movements in the survey earnings growth expectations over this 30-year period, including the massive spikes in expected earnings growth during the dot-com bust and the financial crisis. Earnings growth expectations spiked during those periods because there were large negative shocks to earnings growth and investors believed these would be reversed to a large extent by next year's earnings growth. Similarly, while the model dividend growth expectations miss the slight decline in dividend growth expectations in the early 2000s, they accurately replicate the timing and magnitude of the drop and quick recovery in survey expectations during the financial crisis and the leveling off of dividend growth expectations from 2010 to 2015.

Beyond the decompositions and the time series for cash flow growth expectations, the model is able to match the dynamics of subjective expectations and price ratios measured in the data, as shown in Table IX. For variables related to earnings growth and the price-earnings ratio, we use the full 1985 to 2015 sample. For variables related to dividend growth and the price-dividend ratio, we use the 2003 to 2015 sample, for which we have data on subjective dividend expectations. Panel A shows that the persistence measures of model cash flow growth and return expectations align with the values measured in the survey data. These persistence measures capture the extent to which two-year expectations increase when one-year expectations increase by one. We use the term autocorrelation to refer to the actual relationship between realized values in $t+1$ and $t+2$.

The persistence of model earnings growth expectations $\phi_e$ is zero since agents believe current shocks will only affect one-year earnings growth. This is

**Table IX**

## Dynamics of Expectations and Price Ratios

This table compares moments in the data and the model. Panel A shows the persistence of subjective expectations across the forecast horizon as well as the annual autocorrelation of the price-dividend and price-earnings ratios. The expressions $AC(\cdot)$ and $\sigma(\cdot)$ refer to the annual autocorrelation and the standard deviation. Panel B shows the standard deviations for the price ratios, the annual change in the price ratios, and realized returns. Panel C shows the correlation of the price-earnings ratio with subjective one-year earnings growth expectations, realized one-year earnings growth, and the forecast error. All rows use quarterly data. Small-sample adjusted Newey-West standard errors are reported in parentheses. Standard errors are n/a when variables are functions of fixed parameters.

| | | Data | | Model | |
|---|---|---|---|---|---|
| | Sample (1) | Estimate (2) | SE (3) | Estimate (4) | SE (5) |
| **Panel A: Persistence and Autocorrelation** | | | | | |
| $\phi_d$ | 2003 to 2015 | 0.66 | (0.03) | 0.66 | n/a |
| $\phi_r$ | 2003 to 2015 | 0.47 | (0.21) | 0.66 | n/a |
| $\phi_e$ | 1985 to 2015 | 0.06 | (0.02) | 0.00 | n/a |
| $AC(pd_t)$ | 2003 to 2015 | 0.44 | (0.18) | 0.23 | (0.07) |
| $AC(pe_t)$ | 1985 to 2015 | 0.43 | (0.17) | 0.17 | (0.16) |
| **Panel B: Volatility** | | | | | |
| $\sigma(pd_t)$ | 2003 to 2015 | 0.18 | (0.02) | 0.14 | (0.03) |
| $\sigma(\Delta pd_t)$ | 2003 to 2015 | 0.19 | (0.03) | 0.18 | (0.03) |
| $\sigma(pe_t)$ | 1985 to 2015 | 0.38 | (0.03) | 0.26 | (0.03) |
| $\sigma(\Delta pe_t)$ | 1985 to 2015 | 0.40 | (0.05) | 0.34 | (0.05) |
| $\sigma(r_t)$ | 1985 to 2015 | 0.17 | (0.01) | 0.15 | (0.02) |
| **Panel C: Forecast Error Predictability** | | | | | |
| $Corr(pe_t, \mathrm{E}_t^*[\Delta e_{t+1}])$ | 1985 to 2002 | 0.74 | (0.18) | 1.00 | (0.02) |
| | 2003 to 2015 | 0.93 | (0.09) | 1.00 | (0.01) |
| $Corr(pe_t, \Delta e_{t+1})$ | 1985 to 2002 | 0.22 | (0.12) | 0.29 | (0.15) |
| | 2003 to 2015 | 0.61 | (0.11) | 0.50 | (0.13) |
| $Corr(pe_t, fe_{t+1})$ | 1985 to 2002 | −0.37 | (0.12) | −0.31 | (0.13) |
| | 2003 to 2015 | 0.07 | (0.07) | −0.03 | (0.14) |

very close to the empirical estimate of 0.06. In contrast, agents expect changes in dividend growth to be persistent because the shocks to earnings are expected to be spread out over multiple years. In other words, the model is able to generate accurate persistence in dividend growth expectations without generating persistence in earnings growth expectations. The model persistence of dividend growth expectations $\phi_d$ is exactly the weight $w = 0.66$, which determines how quickly dividends are expected to react to changes in earnings. Finally, the model persistence of return expectations is also $w$, since return expectations depend only on the agent's dividend growth expectations. While higher than the estimated value of $\phi_r = 0.47$, this low persistence of $w$ still captures the fact that movements in returns are not expected to be persistent.

The fourth and fifth rows of Panel A show the autocorrelations for both price ratios. The model autocorrelations for the price-dividend and price-earnings ratios are 0.23 and 0.17, respectively. Although the differences are not statically significant, the autocorrelation of the price ratios in the data is slightly higher at 0.44 and 0.43, respectively. As discussed in Section IV.B, assuming that agents believe cash flow growth decays geometrically back to a constant mean may underestimate the movements in long-horizon subjective expectations.[24] If agents believed that cash flow growth depends on a slow-moving component as well as a short-lived but volatile component, then the model could potentially match the low autocorrelation for both price ratios over our samples, as well as the high autocorrelations over 0.8 documented for longer samples. For example, if mean earnings growth changes slowly over time, the price ratios will have low autocorrelations over short samples, due to volatile short-horizon cash flow growth expectations, and high autocorrelations over long samples, due to small but persistent movements in long-horizon expectations.

In Panel B, we see that the model matches the volatility of the price ratios, price ratio changes, and realized returns. For both the price-dividend ratio and price-earnings ratio, the substantial time-variation in model cash flow growth expectations generates large price ratio variation. Since the price ratios have low autocorrelations, these movements are relatively short-lived, implying that one-year changes in the price ratios $\Delta pd_t$ and $\Delta pe_t$ and realized one-year returns $r_t$ also have high volatilities both in the model and in the data.

Finally, the model also explains why we find predictable forecast errors for the early parts of the sample, but not in more recent years. Panel C shows the correlation of earnings growth expectations, realized earnings growth, and forecast errors with the price-earnings ratio in the data and in the model for the 1985 to 2002 and 2003 to 2015 periods. In both samples, model earnings growth expectations are almost perfectly correlated with the model price-earnings ratio, matching the high correlations we find in the data. In the model, agents price the stock market based primarily on their belief that shocks to earnings growth will be reversed by future earnings growth. As a result, the correlation of the model price-earnings ratio with realized future earnings growth depends on the accuracy of this belief.

In the 1985 to 2002 sample, this belief was largely incorrect, as movements in earnings growth were only partly reversed. This results in a low insignificant correlation between the model price-earnings ratio and future realized earnings growth of 0.29 and a significant negative correlation between agents' forecast errors and the price-earnings ratio of −0.31. This matches the data quite well, where the correlations are an insignificant 0.22 and a significant −0.37. In the 2003 to 2015 sample, however, this belief was more accurate, as movements in earnings growth were largely reversed, particularly during the financial crisis. This means that the model price-earnings ratio is more highly

[24] Equations (27) to (28) show that model subjective expectations follow our simple decay functional form.

correlated with future earnings growth over this sample and agents' forecast errors are not significantly correlated with the model price-earnings ratio. The model correlations of 0.50 (0.13) and −0.03 (0.14) are once again quite close to the values from the data, 0.61 (0.11) and 0.07 (0.07), respectively.

To summarize, in both samples agents believe that shocks to earnings growth will be largely reversed the next year. In samples in which this does not turn out to be true, the price-earnings ratio will mostly predict agents' forecast errors. In samples in which this does turn out to be true, the price-earnings ratio will mainly predict future earnings growth.

Combining these results, we find that this model is able to replicate the large movements in cash flow growth expectations of Section III.A, the forecast error predictability results of Section III.B, the short-horizon cash flow news and discount rate news of Section IV.A, and the persistences and full-horizon decompositions of Section IV.B. Interestingly, in addition to matching the findings of this paper, this model is also able to match two of the findings on return expectations from the return extrapolation literature. A core finding from this literature is that survey expectations of returns are more correlated with current and past returns than future returns, as shown by Greenwood and Shleifer (2014). We know from equations (30) and (31) that model return expectations are simply $\chi \frac{1-\rho w}{1-\chi} > 0$ multiplied by the price-dividend ratio.[25] Since the price-dividend ratio is stationary, a high value for the price-dividend ratio means recent returns must be high since returns are primarily related to changes in the price-dividend ratio. As a result, return expectations will be high when recent returns are high. Using the 1985 to 2015 sample, we find that the correlation between model return expectations and model current realized returns is 0.57 (0.11). In comparison, the correlation between model return expectations and model next-year realized returns is an insignificant −0.14 (0.12).[26]

Second, our model is consistent with the finding from Cassella and Gulen (2018) that the price-dividend ratio predicts future returns more strongly when the degree of extrapolative weighting in return expectations is high. They define the degree of extrapolative weighting ($DOX_t$) as referring to the relative weight placed on recent returns compared to earlier returns when regressing survey return expectations on the past five years of returns. A higher value of $DOX_t$ means that return expectations are more strongly related to recent returns than earlier returns. We take their methodology for measuring $DOX_t$ using survey return expectations and realized returns and apply it to our model return expectations and model realized returns.[27]

We next regress the realized next year return from the model $r_{t+1}$ on the current model price-dividend ratio $pd_t$, the degree of extrapolative weighting $DOX_t$, and the interaction between these two terms $pd_t * DOX_t$. The coefficient

[25] Furthermore, the positive relationship between the price-dividend ratio and return expectations is not driven solely by the dividend component of returns. Model capital gains expectations are also positively related to the model price-dividend ratio.

[26] The 2003 to 2015 sample gives similar results.

[27] The Internet Appendix contains details on this estimation.

on the interaction term is significant and negative −1.06 (0.43) while the coefficient on $pd_t$ is insignificant at 0.02 (0.12). This means that the ability of the price-dividend ratio to predict next year returns is stronger when the measured value of $DOX_t$ is high. The intuition for this result is as follows. During periods of high measured $DOX$, current return expectations are related more to recent realized returns than earlier returns. Since earlier return expectations are mostly related to those earlier returns, this means that current return expectations are not strongly related to earlier return expectations. In the model, return expectations are given as $\chi \frac{1-\rho w}{1-\chi} pd_t$, so the measured value of $DOX$ will be high during periods in which the autocorrelation of the price-dividend ratio is low. Low autocorrelation means that one-year return predictability will be larger. This is because lower autocorrelation in the price-dividend ratio strengthens the negative relationship between the current price-dividend ratio and next-year returns, following equation (1). Thus, the model is able to simultaneously replicate the findings on return expectations from Greenwood and Shleifer (2014) and Cassella and Gulen (2018) on top of our findings on cash flow growth expectations.

## VI. Conclusion

Stock price movements must be explained by changes in expected cash flows or changes in expected returns. Using subjective expectations based on survey data, we find that changes in subjective cash flow growth expectations account for the vast majority of movements in both the price-dividend ratio and the price-earnings ratio for the S&P 500. Subjective cash flow growth expectations vary significantly over time and rise with price ratios, even when price ratios do not predict future cash flows. Subjective return expectations are less volatile and do not move substantially with price ratios. Both subjective cash flow growth and return expectations show low persistence, and the price ratio movements are explained primarily by changes to short-term cash flow growth expectations.

To explain these findings, we propose an asset pricing model with subjective beliefs about earnings growth reversal. Agents' cash flow growth expectations are driven by their belief that shocks to earnings growth will be reversed by future earnings growth and that changes in earnings will be gradually integrated into dividends. This model accurately replicates the measured time series for subjective cash flow growth expectations and the joint dynamics of subjective cash flow growth expectations and price ratios, as well as findings from the return extrapolation literature. These results highlight the importance of time-varying subjective cash flow growth expectations in determining aggregate stock prices.

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## Appendix

### A. Data Aggregation for Dividend and Earnings Expectations

This section describes the process for the dividend expectations calculation. Earnings expectations are constructed analogously. We begin by defining the following variables for each period $t$:

$D_{i,t}$ = ordinary dividend per share paid by company $i$ at time $t$

$P_{i,t}$ = price per share of company $i$ at time $t$

$S_{i,t}$ = shares of company $i$ at time $t$

$x_t$ = set of companies in S&P 500 at time $t$.

The total market value $M_t$ and dividends $D_t$ paid by S&P 500 constituents are defined as

$$M_t = \sum_{i \in x_t} P_{i,t} S_{i,t},$$

$$D_t = \sum_{i \in x_t} D_{i,t} S_{i.t}.$$

Standard & Poor's defines the S&P 500 index ($SP500_t$) as the total market capitalization of the constituents $M_t$ adjusted by a divisor. The divisor is defined by Standard & Poor's at each period to satisfy the identity

$$\sum_{i \in x_t} P_{i,t} S_{i,t} / Divisor_t = SP500_t = \sum_{i \in x_{t-1}} P_{i,t} S_{i,t-1} / Divisor_{t-1} \tag{A1}$$

or

$$Divisor_t / Divisor_{t-1} = \sum_{i \in x_t} P_{i,t} S_{i,t} / \sum_{i \in x_{t-1}} P_{i,t} S_{i,t-1}. \tag{A2}$$

In other words, the divisor adapts so that the value of the S&P 500 index is not affected by changes in the S&P 500 constituents or the number of outstanding shares issued. One result of this is that the index is not affected by share repurchases. In addition, the divisor is also adjusted whenever a special dividend is issued. Standard & Poor's assumes that the share price drops by the amount of the special dividend and adjusts the divisor to offset this change in share price. Since the S&P 500 index is not affected by share repurchases or special dividends, we can think of the index as the value of a portfolio that automatically reinvests any special dividends or payments from share repurchases back into the portfolio. Thus, the only cash flow from this portfolio is the ordinary dividends paid by S&P 500 constituents. This is why we do not include special dividends or share repurchases in our measure of dividends.

The divisor is not publicly available, but we can back out the value of the divisor by using (A1) to obtain the simple ratio

$$\widehat{Divisor}_t = M_t / SP500_t.$$

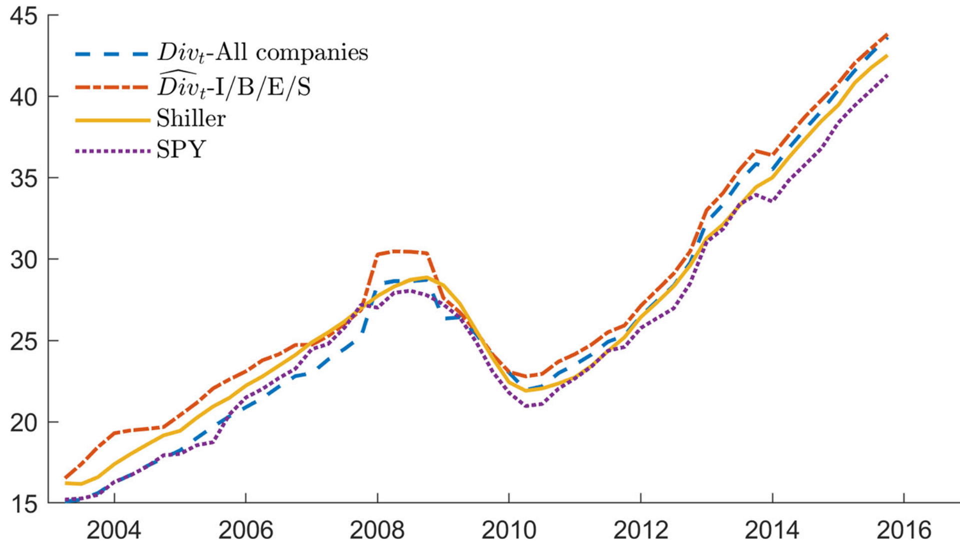


**Figure A1. Comparison of aggregate dividend measures**. The figure compares four measures of the aggregate dividend for the S&P 500. The solid line (Shiller) plots the quarterly S&P 500 dividends obtained from Shiller (2015). The dashed line (All Companies) plots the aggregate quarterly dividends paid out by all S&P 500 companies. The dash-dotted line (I/B/E/S) plots the aggregate quarterly dividends paid out only by S&P 500 companies for which a one-year subjective dividend expectation exists. This value is then scaled by the ratio of the market value of all S&P 500 companies to the market value of S&P 500 companies for which a one-year subjective dividend expectation exists. The dotted line (SPY) plots the quarterly dividends paid out by the SPDR S&P 500 ETF. (Color figure can be viewed at wileyonlinelibrary.com)

Once an estimate of $Divisor_t$ is obtained for each quarter, we construct an aggregate dividend index for the S&P 500, which we expressed as

$$Div_t = D_t / \widehat{Divisor}_t.$$

This dividend measure is constructed "bottom-up" from the individual ordinary dividend payments of each company. Figure A1 compares the performance of our dividend measure against the S&P 500 dividend reported by Shiller and the dividends paid by SPY, the largest replicating ETF of the S&P 500. The correlation of $Div_t$ and the other dividend estimates in levels is very high ($>0.99$).

If, instead of an aggregate dividend measure, we want to build an aggregate expected dividend measure, we can use a similar logic. The one-year subjective expected dividend for the S&P 500 can be described as

$$\mathrm{E}_t^*[Div_{t+1}] = \mathrm{E}_t^*\left[\sum_{i \in x_{t+1}} D_{i,t+1} S_{i,t+1} / \widehat{Divisor}_{t+1}\right]. \tag{A3}$$

Because dividend forecasts are made in levels, rather than in logs, we approximate subjective expected dividend growth as $\mathrm{E}_t^*[\Delta d_{t+1}] \approx$

**Table AI**

## Correlations of S&P 500 Earnings Measures

The table shows the correlations for three quarterly time series from 1976Q1 to 2015Q3. The first series, All Companies, contains the aggregate quarterly earnings reported by all S&P 500 companies. The second series, I/B/E/S, contains the aggregate quarterly earnings reported only by S&P 500 companies for which a one-year subjective earnings expectation exists. The third series, Shiller, contains the quarterly S&P 500 earnings obtained from Shiller (2015). Under columns (1) to (2), we calculate the correlation of the three series. Under columns (3) to (4), we calculate the log annual change of each of the three series and then take the correlations.

| | Levels | | Growth | |
|---|---|---|---|---|
| | I/B/E/S (1) | Shiller (2) | I/B/E/S (3) | Shiller (4) |
| All Companies | 0.999 | 0.994 | 0.991 | 0.968 |
| I/B/E/S | | 0.990 | | 0.946 |

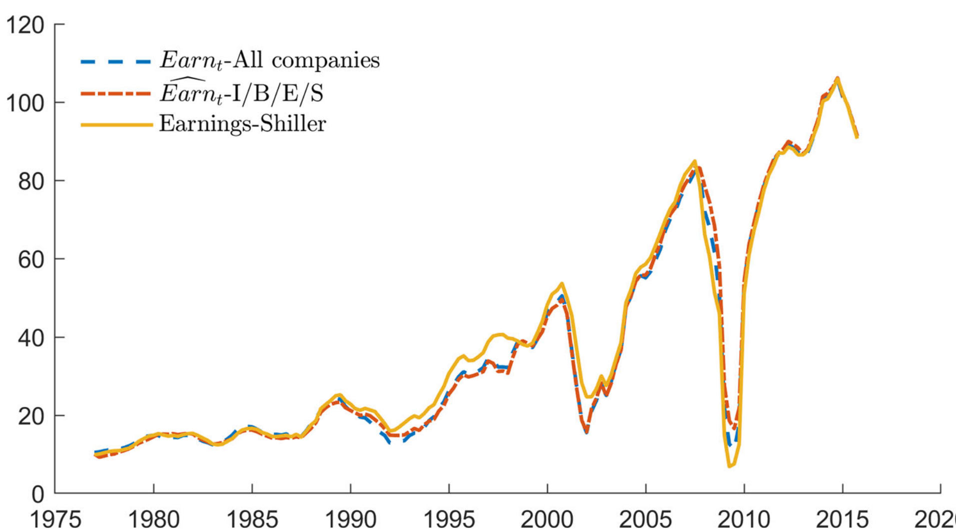


**Figure A2. Comparison of aggregate earnings measures**. The figure compares three measures of aggregate earnings for the S&P 500. The solid line (Shiller) plots the quarterly S&P 500 earnings obtained from Shiller (2015). The dashed line (All Companies) plots the aggregate quarterly earnings reported by all S&P 500 companies. The dash-dotted line (I/B/E/S) plots the aggregate quarterly reported only by S&P 500 companies for which a one-year subjective earnings expectation exists. This value is then scaled by the ratio of the market value of all S&P 500 companies to the market value of S&P 500 companies for which a one-year subjective earnings expectation exists. (Color figure can be viewed at wileyonlinelibrary.com)

$\log(\mathrm{E}_t^*[Div_{t+1}]) - \log(Div_t)$. As long as volatility is countercyclical, accounting for the Jensen terms from this approximation would only increase the procyclicality of $\mathrm{E}_t^*[\Delta d_{t+1}]$ and strengthen our result that subjective cash flow news is large.

To build our aggregate estimator $\mathrm{E}_t^*[Div_{t+1}]$, we need to make an assumption about how people form expectations about the future constituents and shares outstanding of the S&P 500. We assume that people expect that any changes in constituents or shares outstanding that may affect total dividends will be offset by changes in the divisor. Since the divisor adjusts to offset changes in total market value due to changes in constituents or shares outstanding, this simply means that people expect changes in constituents or shares outstanding to have the same proportional effect on total dividends as total market value. In other words, we assume that people do not expect changes in constituents or shares outstanding to affect the price-dividend ratio of the S&P 500. A stronger assumption that would also be consistent with our methodology is to simply assume that people do not expect the constituents or shares outstanding to change over the next year. Assumption 1 implies that $\mathrm{E}_t^*[\sum_{x_{t+1}} D_{i,t+1}S_{i,t+1}/Divisor_{t+1}]=\mathrm{E}_t^*[\sum_{x_t} D_{i,t+1}S_{i,t}/Divisor_t]=\sum_{x_t} \mathrm{E}_t^*[D_{i,t+1}]S_{i,t}/Divisor_t$.

ASSUMPTION A1: $\mathrm{E}_t^*[\frac{\sum_{x_{t+1}} D_{i,t+1}S_{i,t+1}}{\sum_{x_t} D_{i,t+1}S_{i,t}}] = \mathrm{E}_t^*[\frac{\sum_{x_{t+1}} P_{i,t+1}S_{i,t+1}}{\sum_{x_t} P_{i,t+1}S_{i,t}}]$.

Given that we sometimes do not have expectations data for all firms in the S&P 500, we make a second assumption to construct $\mathrm{E}_t^*[Div_{t+1}]$. Denote by $x_t^j \subset x_t$ the set of companies that have an expected value for horizon $j$. We normalize by the ratio of total market value, $M_t$, to the market value of the firms that have an expected dividend for horizon $j$, $M_t^j$. To do this, we assume that the firms that have an expected dividend are a representative sample of the S&P 500. It then follows that $\mathrm{E}_t^*[Div_{t+1}] =(M_t/M_t^1)\sum_{x_t^1} \mathrm{E}_t^*[D_{i,t+1}]S_{i,t}/Divisor_t$.

ASSUMPTION A2: $\frac{\sum_{i\in x_t} \mathrm{E}_t^*[D_{i,t+1}]S_{i,t}}{\sum_{i\in x_t^j} \mathrm{E}_t^*[D_{i,t+1}]S_{i,t}} = \frac{M_t}{M_t^j}$, *where* $M_t^j$ *is the market value of firms in* $x_t^j$.

Assumption 2 becomes easier to satisfy the higher the coverage of firms with valid forecasts we have. To check that the firms included in the forecast are representative of the S&P 500 index, we show a fourth measure in Figure A1. The behavior of $\widehat{Div}_t = (M_t/M_t^1)\sum_{i\in x_t^1} D_{i,t}S_{i,t}/Divisor_t$ is very similar to $Div_t$. This means that aggregate dividend constructions using only those companies with a forecast for a certain horizon look very similar to the main aggregate dividend $Div_t$. Furthermore, the correlation of all of the measures both in growth and levels is very close to one, as shown in Table I.

The process to construct earnings expectations is identical to the dividend expectation construction. The time series for earnings span a longer time period and we have more firms with earnings forecasts than dividend forecasts in each quarter. The correlation tests for our earnings measure are shown in Table AI and Figure A2.

### B. Horizon Interpolation

Not all firms in the I/B/E/S estimates database share the same fiscal year-end date. To properly construct a one-year forecast, different forecasts were used depending on the fiscal year-end of each firm.

For instance, if the estimates are taken on April 15, 2004 for a firm with fiscal year ending in December, $FY_1$ will show a forecast for December 31, 2004 and $FY_2$ will present a forecast for December 31, 2005. Given that we want an estimate for March 31, 2005, we will interpolate $FY_1$ and $FY_2$ to obtain the firm's 12-month estimate. When possible, we make use of forecasts for quarterly horizons $Q_1$ through $Q_4$ to improve the interpolation procedure. The exclusion of the quarterly forecasts does not affect the results.

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## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

**Appendix S1:** Internet Appendix.
**Replication Code.**

# Internet Appendix for Subjective Cash Flow and Discount Rate Expectations

Ricardo De la O and Sean Myers*

This appendix provides robustness checks for our main results as well as additional detail on the data sources and model calculations. Section A relaxes the assumptions made in Section I to allow for bubbles and to include expectations of the payout ratio. Section B calculates an alternative decomposition that measures the importance of cash flow and return expectations for explaining the variance of return surprises. Section C provides details on the additional return surveys used in Table II. Section D addresses the possibility that survey respondents are reporting risk-neutral expectations. Section E provides additional detail on the variance decomposition in the models of Campbell and Cochrane (1999), Bansal, Kiku, and Yaron (2012), Collin-Dufresne, Johannes, and Lochstoer (2016), and Barberis et al. (2015). Finally, Section F details the calculation of the degree of extrapolative weighting used in Section V.B based on Cassella and Gulen (2018).

## A. *Relaxing Assumptions*

In Section I, we made three assumptions to establish our two decompositions, equations (3) and (7). In this section, we remove these assumptions and show that our results do not change noticeably. These three assumptions are the two no-bubble conditions, $E_t^*\left[\lim_{T\to\infty}\rho^T pd_{t+T}\right] = 0$ and $E_t^*\left[\lim_{T\to\infty}\rho^T pe_{t+T}\right] = 0$, and the approximation in equation (5) that we could ignore expectations of the future payout ratio.

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We start by using the exact decomposition for the price-earnings ratio. When we include expectations of the future payout ratio, the definitions for $CF_1$, $DR_1$, and $LT$ remain unchanged from equation (8) and the exact one-year decomposition becomes

$$1 = CF_1 + DR_1 + LT + (1-\rho)\frac{Cov\left(E_t^*\left[de_{t+1}\right], pe_t\right)}{Var\left(pe_t\right)}, \tag{IA1}$$

where the fourth term is the one-year payout news. We calculate expectations of the future payout ratio using the current payout ratio, one-year dividend growth expectations, and one-year earnings growth expectations. Because we estimated $CF_1$ and $DR_1$ directly from the earnings growth expectations and return expectations in Section IV.A, including this payout term will not change these values. Thus, earnings growth expectations will still account for 93.7% of the variation in the price-earnings ratio over 2003 to 2015 and return expectations will still account for $-0.4\%$. Over the 2003 to 2015 period, we find that one-year payout news accounts for only 0.3% of the variation in the price-earnings ratio.

We find similar results for the full horizon decomposition. Including the payout ratio terms, the full horizon decomposition for the price-earnings ratio is

$$1 = CF + DR + \underbrace{(1-\rho)\frac{Cov\left(\sum_{j=1}^{\infty}\rho^{j-1}E_t^*\left[de_{t+j}\right], pd_t\right)}{Var(pd_t)}}_{PO}, \tag{IA2}$$

where the definitions of $CF$ and $DR$ come from equation (7). The third term is the full-horizon payout news. As with the one-year decomposition, including this term will not alter our direct estimate of the full horizon cash flow news, $CF = 0.99$, or our direct estimate of the full-horizon discount rate news, $DR = -0.01$, because these were estimated solely from the earnings growth expectations and return expectations. Using our simple decay functional form for earnings growth and dividend growth expectations from Section IV.B, we estimate the payout ratio expectations and find that they account for $-1\%$ of the variation in the price-earnings ratio. So, for both the one-year and full horizon decompositions, including expectations of the future payout ratio does not change our result that price-earnings ratio variation is primarily explained by earnings growth expectations. Expectations of the future payout ratios simply do not play a large role in explaining price movements, which is not surprising given that $1-\rho$ is close to zero.

Next, we remove our no bubble-conditions, $E_t^*\left[\lim_{T\to\infty}\rho^T pd_{t+T}\right] = 0$ and $E_t^*\left[\lim_{T\to\infty}\rho^T pe_{t+T}\right] =$

0. This means that we will allow for the possibility that investors believe the price-dividend ratio or price-earnings ratio will be nonstationary and will grow faster than $1/\rho$. For the price-dividend ratio, this means there would be a third element in our full-horizon decomposition. A high price-dividend ratio could be explained by high expected dividend growth, low expected returns, or a high value of the "bubble" term. The new decomposition is

$$1 \quad = \quad CF + DR + \frac{Cov\left(E_t^*\left[\lim_{T\to\infty} \rho^T pd_{t+T}\right], pd_t\right)}{Var(pd_t)}, \tag{IA3}$$

where the definitions of $CF$ and $DR$ come from equation (3).

To estimate the three terms in the decomposition, we can use the value of $CF$ derived from the dividend survey data and the value of $DR$ derived from the return survey data in Section IV.B. We estimated $CF = 0.93$ and $DR = -0.09$, which means that under this specification, 16% of the variation of the price-dividend ratio could be attributed to movements in the bubble term. This is a nontrivial contribution, but it does not change our main result that cash flow news accounts for most price movements, explaining 93% of the volatility of the price-dividend ratio.

For the price-earnings ratio, removing the no-bubble condition means that our decomposition now has four terms,

$$1 \quad = \quad CF + DR + PO + \frac{Cov\left(E_t^*\left[\lim_{T\to\infty} \rho^T pe_{t+T}\right], pe_t\right)}{Var(pe_t)}, \tag{IA4}$$

where $CF$, $DR$, and $PO$ are defined in equation (IA2). Analogous to the price-dividend ratio decomposition, we can use the value of $CF$ measured directly from the earnings survey data and the value of $DR$ measured directly from the return survey data in Section IV.B. In addition, we directly measured the payout news $PO$ earlier in this section using the earnings and dividend survey data. This gives $CF = 0.99$, $DR = -0.01$, and $PO = -0.01$, which implies that 3% of the variation in the price-earnings ratio could be attributed to movements in the bubble term. This clearly does not change the result that earnings growth expectations account for the vast majority of price-earnings ratio variation.

To summarize, removing our assumptions about the limit terms or expectations of future payout ratios does not change our result that cash flow growth expectations explain virtually all price movements and that return expectations play a negligible role. Including additional terms in the decompositions for potential bubbles or future payout ratios does not change the fact that we can directly observe large comovement between cash flow growth expectations and price ratios and a lack of comovement between return expectations and price ratios.

## *B. Return Decomposition*

This paper focuses primarily on determining how much of the variation in the price ratios is due to changes in cash flow growth expectations or return expectations. Another popular decomposition in the literature that comes from Campbell (1991) measures the importance of revisions in cash flow growth expectations and return expectations for explaining unexpected returns. This decomposition splits unexpected returns into revisions in dividend growth expectations and revisions in return expectations. We find that revisions in cash flow growth expectations also explain the vast majority of unexpected returns.

Starting with the log-linearized return identity (1), we plug in equation (2) for $pd_t$ and $pd_{t+1}$ to derive the unexpected return as

$$r_{t+1} - E_t^*\left[r_{t+1}\right] = \sum_{j=1}^{\infty} \rho^{j-1}\left(E_{t+1}^*\left[\Delta d_{t+j}\right] - E_t^*\left[\Delta d_{t+j}\right]\right) - \sum_{j=2}^{\infty} \rho^{j-1}\left(E_{t+1}^*\left[r_{t+j}\right] - E_t^*\left[r_{t+j}\right]\right). \tag{IA5}$$

For the sake of simplifying the equation, we simply express $\Delta d_{t+1}$ as $E_{t+1}^*\left[\Delta d_{t+1}\right]$. In words, this equation says that a positive unexpected return must be explained by an upward revision in expected current and future dividend growth or a downward revision in expected future returns. Because equation (2) did not require that these expectations be rational, this relationship can be applied to our subjective expectations.

The variance of the unexpected returns is then split into three terms, namely, (i) the variance of the dividend growth revisions, (ii) the variance of the return revisions, and (iii) the covariance of the dividend growth and return revisions multiplied by $-2$. Using the simple decay functional form from Section IV.B, we estimate the dividend growth and return expectations for 2003 to 2015 and then calculate the one-year revisions. We find that revisions to dividend growth expectations account for 96% of the variation in unexpected returns, revisions to return expectations account for 2%, and the covariance of dividend growth and return revisions accounts for 2%. Given that dividend growth revisions and return revisions are taken from completely independent surveys, it is remarkable that this decomposition sums almost exactly to one. Just as in the other decompositions, the low volatility of the return expectations implies that their revisions are not a major source of variation, while the large movements in dividend growth expectations imply that their revisions account for a substantial amount of the variation. Combining this result with our decomposition in Section IV.B, we conclude that changes in dividend growth expectations account for more than 90% of the variation in both the price-dividend ratio and unexpected returns.

## C. *Additional Surveys*

In addition to the one-year and ten-year return expectations obtained from the Graham-Harvey survey of Duke University (G-H), we use the Federal Reserve Bank of Philadelphia's Livingston Survey (Livingston), the University of Michigan Survey of U.S. consumers (Michigan), and the Survey of Professional Forecasters (SPF) as additional measures of S&P 500 return expectations at different horizons. All surveys report expected annualized returns.

The Livingston Survey is conducted twice a year by the Federal Reserve Bank of Philadelphia and spans 1952 to 2016. The survey elicits forecasts of 18 different variables describing national output, prices, unemployment, and other macroeconomic data from 50 to 60 experts. Our variable of interest is the one-year expectation of stock market prices. Because it is prices and not returns that are forecasted, we can only build capital gains expectations $E_t^*\left[\frac{P_{t+1}}{P_t}\right]$ and not return expectations $E_t^*\left[\frac{P_{t+1}+D_{t+1}}{P_t}\right]$. Since dividends are very small compared to prices, we expect capital gains movements to be a reasonable proxy for the qualitative behavior of the expected returns. During the first years of the Livingston Survey, the S&P 400 industrial index was used as the forecasted index. Starting in 1990, the S&P 500 was forecasted instead. We use this survey due to the generous sampling period and obtain similar results as the rest of the surveys.

The Michigan Survey of Consumers is conducted each month by the Survey Research Center, under the direction of the University of Michigan. The focus of the survey is on three areas: how consumers view prospects for their own financial situation, how they view prospects for the general economy over the near term, and their view of prospects for the economy over the long term. In 22 of the survey months between 2000 and 2005, the expected average return on the S&P 500 over the next two to three years was included in the questionnaire.

The Survey of Professional Forecasters is conducted quarterly by the Federal Reserve Bank of Philadelphia. One of the variables in the questionnaire is the forecast for the annualized average rate of return on the S&P 500 over the next 10 years. This variable is available annually from 1992 to 2015 and the respondents are professional forecasters, that is, forecasters who produce regular forecasts of economic variables as part of their jobs in the business world or on Wall Street.

### *D. Risk-Neutral Probabilities*

One possible concern regarding the cash flow forecast analysis is that respondents may be using risk-neutral probabilities in their expectation process. This would imply that their return expectations are implicitly embedded in their responses. There are two possible reasons why the cash flow forecasts may be using risk-neutral probabilities. The first is that respondents may be intentionally using risk-neutral probabilities, that is, respondents may choose to report an adjusted expectation that overweights bad states. For example, forecasters may receive greater punishment when they fail to predict cash flow decreases than when they fail to predict cash flow increases. This type of asymmetric reward/punishment would cause respondents to knowingly make conservative forecasts that incorporate risk. The second reason is that respondents may be unintentionally using risk-neutral probabilities. It is possible that even when trying to report their expectations under the actual probabilities, respondents subconsciously put too much emphasis on negative potential outcomes.

In both cases, we would see respondents consistently underpredicting future cash flows, either because they are knowingly reporting conservative forecasts or because they are subconsciously overweighting bad outcomes. In other words, if respondents are giving their expectations under risk-neutral probabilities, then these expectations should be pessimistic. That is not what we observe in the cash flow growth expectations. Both dividend growth and earnings growth forecast errors have negative means, significantly different from zero. The expectations are slightly optimistic, the opposite of what we would expect if they were risk-neutral.

## E. Existing Asset Pricing Models in Detail

In this section we explain in more detail our implementation of the Campbell and Cochrane (1999) external habit formation model, the Bansal, Kiku, and Yaron (2012) long-run risk model, the Collin-Dufresne, Johannes, and Lochstoer (2016) learning model, and the Barberis et al. (2015) return extrapolation model. These consumption-based asset pricing models have theoretical predictions about the dynamics of return and dividend growth expectations.

All four models satisfy the no-bubble condition, $\lim_{j\to\infty}\rho^{j-1}E_t^*\left[pd_{t+j}\right]=0$. Thus, cash flow news is $CF=\frac{Cov\left(\sum_{j=1}^{\infty}\rho^{j-1}E_t^*[\Delta d_{t+j}],pd_t\right)}{Var(pd_t)}$ and discount rate news is simply $DR=1-CF$. Each paper provides equations for calculating the price-dividend ratio, so we simply focus on explaining the calculations of the dividend growth expectations $E_t^*\left[\Delta d_{t+j}\right]$ for all horizons $j$.

### E.1. External Habit Formation Model (Campbell and Cochrane (1999))

In the external habit formation model of Campbell and Cochrane (1999), dividend growth behaves according to

$$\Delta d_{t+1}=\mu+\sigma\varepsilon_{t+1},$$

where $\mu$ and $\sigma$ represent the mean and volatility of the dividend growth process and $\varepsilon_{t+1}$ is an i.i.d. process. The representative agent has full information about the process and the parameter values. Hence, the calculation of cash flow news and discount rate news is straightforward. For all horizons, we have $E_t^*[\Delta d_{t+j}]=\mu$, so dividend growth expectations are constant over time. As a result, cash flow news at all horizons is exactly zero and all variation in the price-dividend ratio is due to changes in expected returns.

### E.2. Long-Run Risk Model (Bansal, Kiku, and Yaron (2012))

In the long-run risk model of Bansal, Kiku, and Yaron (2012), cash flow growth has a slow-moving long-run component $x_t$ that affects both consumption growth and dividend growth:

$$
\begin{aligned}
\Delta c_{t+1} &= \mu_c + x_t + \sigma_t \varepsilon^c_{t+1} \\
x_{t+1} &= \psi x_t + \varphi_e \sigma_t e_{t+1} \\
\sigma^2_{t+1} &= \bar{\sigma} + \nu(\sigma^2_t - \bar{\sigma}) + \sigma_w w_{t+1} \\
\Delta d_{t+1} &= \mu + \lambda x_t + \pi \sigma_t \varepsilon^c_{t+1} + \varphi_d \sigma_t \varepsilon_{t+1}.
\end{aligned}
$$

After simulating the long-run component process $x_t$, we can estimate the dividend growth expectations as

$$E^*_t[\Delta d_{t+j}] = \mu + \lambda E^*_t[x_{t+j}] = \mu + \lambda \psi^{j-1} x_t.$$

Because of the long-run component $x_t$, cash flow growth expectations vary over time and explain some of the price-dividend ratio variation. However, changes in $x_t$ also change the agent's discount rate expectations due to recursive preferences. Importantly, dividend growth expectations only move with the long-run component $x_t$. In comparison, the price-dividend ratio, and consequently returns, depend on both $x_t$ and the volatility $\sigma_t$. Due to recursive preferences, changes in expected consumption growth and the risk in consumption growth significantly impact her discount rates. As a result, changes in return expectations explain 62% of price-dividend ratio movements. Cash flow growth expectations play a secondary role, explaining 38% of price-dividend ratio variation. One- and two-year cash flow growth expectations explain only 11% and 19% of the variation, respectively.

## *E.3. Learning Model (Collin-Dufresne, Johannes, and Lochstoer (2016))*

In the basic learning model of Collin-Dufresne, Johannes, and Lochstoer (2016), consumption growth follows an i.i.d. process of the form

$$\Delta c_{t+1} = \mu + \sigma \varepsilon_{t+1},$$

and dividend growth is a leveraged claim on consumption growth $\Delta d_{t+1} = \mu + \lambda(\Delta c_{t+1} - \mu)$. The representative agent with recursive preferences is uncertain about expected consumption growth $\mu$ and updates her expected value of $\mu$, $E^*_t[\mu] \equiv \mu_t$, and her degree of uncertainty about this parameter.

This means that in spite of the data being generated from a fixed parameter i.i.d model, the agent perceives consumption growth to have a time-varying mean and variance. The effect of the time-varying mean $\mu_t$ on the price decomposition is similar to the long-run risk model. Once the model is solved, the cash flow news component can be calculated by estimating $E_t^*[\Delta d_{t+j}] = \mu_t$. In this model, changes in $\mu_t$ alter cash flow news and discount rate news through their effect on $E_t^*[\Delta d_{t+j}]$ and $E_t^*[\Delta c_{t+j}]$, respectively. Because the representative agent has recursive preferences, changes in the degree of uncertainty about $\mu$ also significantly alter the her discount rate expectations. This is similar to the time-varying volatility in the long-run risk model, although the uncertainty in the learning model varies substantially more over time than the time-varying volatility in the long-run risk model. As we can see in Table VIII, this makes discount rate news more important in the learning model.

We now consider a second version of the Collin-Dufresne, Johannes, and Lochstoer (2016) learning model. The basic version of learning about mean consumption growth was introduced by Collin-Dufresne, Johannes, and Lochstoer (2016) for its intuitive appeal, but as stated by the authors, it struggles to match several features in the data. To quantitatively account for several data moments, the authors present another version in which the mean growth $\mu$ is known, but the agent is uncertain as to whether an observed long-run process $x_t$ affects cash flow growth. In other words, the agent is uncertain as to whether the right model in the economy is an i.i.d. model or a long-run risk model. Thus, her perceived cash flow growth process can be expressed as

$$\begin{aligned} \Delta c_{t+1} &= \mu_c + p_t x_t + \sigma \varepsilon_{t+1} \\ x_{t+1} &= \rho x_t + \varphi \sigma \varepsilon_{t+1} \\ \Delta d_{t+1} &= \mu + \lambda(\Delta c_{t+1} - \mu_c) + \sigma_d \varepsilon_{t+1}^d, \end{aligned}$$

where $p_t$ is the agent's inferred probability that the long-run component $x_t$ influences consumption growth. The agent updates her probability each period after observing the realizations of $\Delta c_t$ and $x_t$.

In this second version, the cash flow expectations are computed as $E_t^*[\Delta d_{t+j}] = \mu + \lambda p_t x_t$. Similar to the basic learning model, cash flow growth and return expectations vary over time as the agent updates her inferred probability of a long-run component. Due to her recursive preferences, her discount rate expectations move much more due to the movements in uncertainty about the importance of $x_t$. The results are qualitatively similar to those of the basic learning model, with $DR = 0.9$, $CF = 0.1$, and short horizon cash flow news of

$CF_1 = 0.01$ and $CF_2 = 0.02$.

## *E.4. Return Extrapolation Model (Barberis et al. (2015))*

In a discrete representation of the return extrapolation model of Barberis et al. (2015), the economy consists of a share $\mu$ of rational agents ($r$) and a share $1-\mu$ of extrapolating agents ($x$). Dividends follow a constant expected arithmetic rate $E_t^r\left[D_{t+1}-D_t\right]=g$. The expectation of future price changes for extrapolating agents depends on sentiment $S_t$. A discrete-time representation of their price change expectation formation is

$$E_t^x\left[P_{t+1}-P_t\right]=S_t, \tag{IA6}$$

where the state variable $S_t$ is high when previous price changes have been high and evolves according to

$$S_t = (1-\beta)S_{t-1} + \beta(P_t - P_{t-1}). \tag{IA7}$$

In equilibrium, asset prices depend on both sentiment $S_t$ and the dividend level $D_t$,

$$P_t = A + BS_t + \frac{D_t}{r}, \tag{IA8}$$

where $A$ and $B$ are coefficients determined in equilibrium that depend on the model parameters.

The additive structure of the model implies that the natural quantities to study are the price-dividend difference $P - \frac{D}{r}$, expected dividend changes, and expected price changes. As suggested by one of the authors, we calculate an additive price-dividend difference decomposition. For any horizon $T$, the price-dividend difference can be split into three pieces,

$$P_t - \frac{D_t}{r} = E_t^*\left[(D_{t+T}-D_t)/r\right] + E_t^*\left[(P_{t+T}-P_t)\right] + E_t^*\left[P_{t+T} - \frac{D_{t+T}}{r}\right],$$

where $E^*$ represents the aggregate expectations in the economy, which is a weighted combination of the rational and extrapolating expectations. Cash flow news and discount rate news are then defined as

$$\begin{aligned} CF_T &= \frac{Cov\left(E_t^*\left[(D_{t+T}-D_t)/r\right], P_t - \frac{D_t}{r}\right)}{Var\left(P_t - \frac{D_t}{r}\right)} \\ DR_T &= \frac{Cov\left(-E_t^*\left[(P_{t+T}-P_t)\right], P_t - \frac{D_t}{r}\right)}{Var\left(P_t - \frac{D_t}{r}\right)}. \end{aligned}$$

Given equations (IA6) and (IA7), extrapolating agents believe that sentiment evolves according to a random walk,

$$E_t^x\left[S_{t+T}-S_t\right]=0.$$

Thus, for extrapolators to have time-consistent beliefs about the equilibrium price equation (IA8), they must believe that dividend changes are affected by sentiment,

$$E_t^x\left[D_{t+T}-D_t\right]=rS_tT.$$

This makes the aggregate subjective expectations of the economy $E^*$ follow

$$E_t^*\left[D_{t+T}-D_t\right]/r=\left((1-\mu)S_t+\mu\frac{g}{r}\right)T,$$

where the expected dividend changes are a weighted combination of the rational and extrapolating expectations. From equations (IA7) and (IA8), we can calculate the rational agents' expected price changes and obtain the aggregate expected price changes

$$E_t^*\left[P_{t+T}-P_t\right]=\left((1-\mu)S_t+\mu\frac{g}{r}\right)T-\mu B\left(1-\left(1-\frac{\beta}{1-\beta B}\right)^T\right)\left(S_t-\frac{g}{r}\right).$$

The second term in the equation comes from rational agents understanding that prices revert in the short run whenever sentiment is high relative to the growth rate. This term is small even at short horizons given the estimated parameter $B$ and quickly disappears at longer horizons. As the horizon grows, expected price changes and expected dividend changes converge.

Because dividend change expectations and price change expectations move almost equally with the sole state variable $S_t$, cash flow news and discount rate news have opposite signs and almost equal magnitudes. Further, the price-dividend difference moves relatively little compared to the movements in dividend change or price change expectations, as changes in the two types of expectations mostly negate each other in equation (2). This causes cash flow news and discount rate news to both be large in magnitude, as shown in Table VIII.

The intuition for the results of the ratio-based decomposition is very similar. The terms $A$ and $BS_t$ are quite small relative to $D_t/r$. As a result, expected dividend growth $E_t^x\left[D_{t+1}\right]/D_t=1+\frac{S_t}{D_t/r}$ is almost the same as expected price growth $E_t^x\left[P_{t+}\right]/P_t=1+\frac{S_t}{P_t}$. By extension, expectations of returns are almost the same as expectations of dividend growth.

### F. Measuring Degree of Extrapolative Weighting

We apply the methodology of Cassella and Gulen (2018) to measure the degree of extrapolative weighting ($DOX_t$) in the model return expectations. Specifically, we want to estimate the coefficient $\lambda$ from the equation

$$E_t^* [r_{t+1}] \quad = \quad a + b \sum_{i=0}^{59} w_i R_{t-i}^Q + \varepsilon_t^{Exp}, \tag{IA9}$$

where the weights $w_i$ decay geometrically based on $\lambda$

$$w_i \quad = \quad \frac{\lambda^i}{\sum_{k=0}^{59} \lambda^k}. \tag{IA10}$$

The degree of extrapolative weighting is then defined as $DOX \equiv 1 - \lambda$. A higher $DOX_t$ means that agents' return expectations are more closely related to recent realized returns than previous realized returns.

Using a monthly series for earnings and dividends, we calculate the model one-year return expectations $E_t^* [r_{t+1}]$ and the model price-dividend ratio $pd_t$. Using model prices, we calculate the quarterly model return in levels $R_t^Q$ for each month. For any given month $M$, a value of $\lambda$ can be estimated using nonlinear least squares over the last $\ell$ observations. Rather than use a single value for $\ell$, the final estimate of $DOX_M$ is based on a weighted sum of the $\lambda$ estimates from multiple different window sizes $\ell$. These four windows are the past 24, 36, and 48 months as well as an expanding window that uses all prior observations back to March 1976.

To determine the weights, we first calculate parameter estimates for months $M - 12$ to $M - 1$. For each of these 12 months, we estimate equation (IA9) over each of the four windows. Then, for each window length and each of the 12 months, we calculate the one-step-ahead forecast error. For example, for month $M - 12$ and window length $\ell = 24$, we estimate equation (IA9) for $t \in [M - 36 + 1, M - 12]$ and use these coefficients to calculate the forecast for month $M - 11$. The difference between this forecast and the expectation in $M - 11$ obtained from the model is stored as $\varepsilon_{M-11}^{\{24\}}$. Repeating this for all 12 months, $M - 12$ to $M - 1$, gives a set of 12 forecast errors for each window length $\ell$. We use these twelve values to calculate the mean squared forecast error (MSFE) for each window length $\ell$. The weights are then the inverse of the MSFE, normalized so that the weights sum to one. In other words, window lengths that produce high MSFE over the last 12 months will be given lower weights than window lengths with low MSFE.

Given these weights, we calculate a value for $\lambda$ in month $M$ by estimating equation (IA9) over each of the different window lengths $\ell$ and taking a weighted average. The value of $DOX$ in month $M$ is then $1 - \lambda$.

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