Real Cash Flow Expectations and Asset Prices

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ABSTRACT

What drives stock and bond markets? Using survey expectations of inflation and earnings growth, we construct *fundamental prices* for stocks and bonds equal to expected real cash flows discounted at a constant rate. Fundamental prices move 1-1 with the S&P 500 price-earnings ratio, price-dividend ratio, and the ten-year Treasury yield with R^2's of 0.81, 0.79, and 0.66 respectively. Variation in discount rates plays almost no role in aggregate stock prices and only a secondary role in aggregate bond prices. Due to errors in expectations of real cash flows, fundamental prices accurately match key return puzzles for both stocks and bonds: the predictability of stock returns and the rejection of the expectations hypothesis. We document four main facts on the term structure of subjective expectations, highlighting errors in long-term inflation and short-term earnings growth expectations. We propose a model with constant discount rates and diagnostic expectations that matches these facts as well as the two return puzzles.

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What drives prices and return puzzles for stocks and bonds? Movements in prices must reflect changes in expectations of real cash flows or real returns. Empirically, changes in aggregate stock prices and bond yields primarily predict future real returns, rather than future real cash flows.[1] If one assumes rational expectations, this implies that both markets are mainly driven by time-varying discount rates. This result has motivated many models attempting to generate large variation over time in investors' discount rates for safe and risky assets. However, if investors' expectations are not rational, then prices and return puzzles may be driven by errors in expectations of real cash flows.

In this paper, we use subjective expectations of real cash flows measured from surveys to study both stock and bond markets, rather than assuming rational expectations. For stocks, real cash flows depend on inflation as well as nominal earnings growth. For bonds, real cash flows solely depend on inflation. We construct *fundamental prices* for both assets using these subjective expectations and constant discount rates. Fundamental prices move one-for-one with observed aggregate prices, measured as the S&P 500 price-earnings ratio and price-dividend ratio and the ten-year Treasury yield, with R^2's of 0.81, 0.79, and 0.66 respectively. The results imply that time-varying discount rates play almost no role in aggregate stock prices and play only a secondary role in aggregate bond yields. Additionally, the fundamental prices replicate two key puzzles: the predictability of returns for stocks and the rejection of the expectations hypothesis for bonds. We then construct a model of diagnostic expectations based on the representativeness bias that matches these findings as well as our four main facts about the term structure of subjective inflation and earnings growth expectations.

We first establish a single necessary and sufficient condition that allows errors in subjective expectations of real cash flows to explain asset price movements, stock return predictability, and rejection of the expectations hypothesis. The condition is that errors must be predictable using current prices. The generality of this condition allows us to analyze subjective expectations of multiple variables at multiple forecast horizons and determine which expectations are relevant for explaining return puzzles. For stocks, predictable forecast errors for real earnings growth cause price ratios to predict future returns even if discount rates are constant. For bonds, predictable forecast errors for inflation cause holding returns to be

[1] See Campbell and Shiller (1988); Campbell (1991); Ang and Piazzesi (2003); Buraschi and Jiltsov (2005); Cochrane and Piazzesi (2005); Cochrane (2011); Koijen and Van Nieuwerburgh (2011); Abrahams et al. (2016).

excessively volatile relative to the expectations hypothesis, even if term premia are constant.

Using survey expectations of CPI inflation and nominal earnings growth for the S&P 500, we document four key facts on the term structure of subjective inflation and earnings growth expectations. First, movements in subjective inflation expectations are concentrated at long horizons. Short-term and long-term inflation expectations move closely together, implying that inflation is believed to have a high persistence. Second, movements in earnings growth expectations are concentrated at short horizons. Compared to short-term earnings growth expectations, long-term expectations are relatively flat, implying a low believed persistence. Third, predictable forecast errors for inflation are primarily concentrated at long horizons. Fourth, predictable forecast errors for earnings growth are primarily concentrated at short horizons. These four facts highlight that the term structure of subjective expectations can differ substantially between variables and provide useful targets for a general model of expectation formation. Additionally, these results indicate that subjective expectations and predictable errors for *long-term inflation* and *short-term earnings growth* are the most important drivers of asset prices movements, stock return predictability, and excess bond return volatility.

Given these errors, we test how well fundamental prices, measured as subjective expectations of real cash flows discounted at constant rates, match stock and bond prices. Specifically, we calculate the fundamental value for the S&P 500 price-earnings and price-dividend ratios and the ten-year zero-coupon Treasury yield. Over our 1976-2018 sample, which spans more than four decades, these fundamental prices closely match the observed prices, with regression coefficients near 1 and high R^2's of 0.81, 0.79, 0.66 respectively. A direct corollary to this finding is that discount rates play only a minor role in price movements. Even if we attribute all residual variation in the observed prices to movements in discount rates, this discount rate variation would only account for 19-21% of variation in aggregate stock price ratios and 34% of variation in aggregate bond yields.

Despite having constant discount rates, these fundamental prices also replicate two key return puzzles in the asset pricing literature: the predictability of stock returns and the rejection of the expectations hypothesis.[2] Empirically, movements in the price-earnings ratio primarily predict future returns, with regression coefficients of -0.77 and -0.59 for ten-year

[2]See Campbell and Shiller (1988); Shiller (1979) for the original puzzles and Cochrane (2011); Gürkaynak and Wright (2012) for reviews of the literature.

nominal and real returns respectively. Movements in the fundamental price-earnings ratio also primarily predict future returns, with nearly identical coefficients of -0.77 and -0.54.[3] Intuitively, the fundamental price-earnings ratio predicts future returns because it reflects errors in expectations of real cash flows. For bonds, we focus on excess volatility in holding returns as documented in Shiller (1979); Singleton (1980).[4] If expectations are rational, then the expectations hypothesis places a bound on the variance of holding returns which is violated in the data by a factor of 5.60. Holding returns based on fundamental yields also violate the bound by a factor of 5.22. Even though the expectations hypothesis holds for fundamental yields, variation in errors in expectations increase the volatility of holding returns.

Lastly, we propose a model based on a single bias, the representativeness bias, that successfully accounts for all of our main results. This bias causes agents to exaggerate the objective relationship between current and future values for forecasted variables. For a process with a high (low) objective persistence, this causes errors to be concentrated in long-term (short-term) expectations. This allows this one bias to match the stark differences in the term structure of inflation expectations and earnings growth expectations. In the model, agents have constant discount rates and price stocks and bonds based on their expectations of real earnings growth and inflation. Due to predictable errors in their forecasts, stock price ratios predict future returns and holding returns on bonds are excessively volatile. We set the degree of representativeness bias to match subjective expectations of long-term inflation and short-term earnings growth. The model quantitatively matches our four facts on the term structure of expectations as well as the magnitude of both return predictability and the violation of the variance bound.

Our paper contributes to a growing literature in finance which directly uses survey expectations, rather than rational expectations based on regressions, to understand aggregate asset price movements. This literature primarily focuses on expectations of returns and price growth (Bacchetta, Mertens, and van Wincoop (2009); Greenwood and Shleifer (2014); Piazzesi, Salomao, and Schneider (2015); Koijen, Schmeling, and Vrugt (2015)). We emphasize the importance of cash flow expectations, in line with De la O and Myers (2020)

[3] We also get almost identical coefficients of -0.88, -0.69 for the observed price-dividend ratio and -0.92, -0.69 for the fundamental price-dividend ratio.

[4] The holding return is the return from buying a multiperiod bond and selling it one period later.

and Bordalo, Gennaioli, La Porta, and Shleifer (2020) which study expectations of nominal earnings growth for stocks. We make three key contributions. First, we analyze both stock and bond prices using expectations of real cash flows based on inflation and earnings growth. Second, using accounting identities, we derive a single condition that determines whether subjective expectations of earnings growth and inflation will differ from rational expectations in their ability to explain asset price movements, return predictability, and excess holding return volatility. Applied to our sample, this condition demonstrates that only errors in long-term inflation and short-term earnings growth will be relevant. Third, rather than comparing qualitative features, we directly test how well the fundamental prices fit the observed prices through regressions and measure their ability to explain to quantitatively match the magnitude of the two return puzzles.

Additionally, we contribute to a large behavioral finance literature attempting to explain return puzzles through mispricing rather than rational time-varying discount rates.[5] We focus on mispricing through errors in expectation formation and document four salient features of the term structure of subjective inflation and earnings growth expectations. The substantial differences in the term structure of expectations for these two variables are valuable for disciplining a general model of expectation formation. We demonstrate that these features can be reconciled by a single bias, namely the representativeness bias of Tversky and Kahneman (1974). Our model is a special case of a general form of diagnostic expectations where the background context is the unconditional mean and is closely related to existing models of diagnostic expectations (Bordalo, Gennaioli, and Shleifer (2018); Bordalo, Gennaioli, La Porta, and Shleifer (2019)).

More broadly, many papers have studied the accuracy of inflation expectations. Focusing on short-term expectations, Ang, Bekaert, and Wei (2007); Del Negro and Eusepi (2011); Chernov and Mueller (2012) do not find any significant errors and Cieslak (2018) finds that forecast errors in short-term inflation expectations do not contribute to return predictability in bonds. We study both short-term and long-term inflation expectations and document significant predictable errors in long-term expectations. These errors are predictable with yields for long-term bonds and stock prices, indicating that these errors influence both risk-free and risky asset prices and contribute to return puzzles. More generally, this demonstrates that errors in inflation may still play an important role whenever agents care about long-term

[5] For a survey of this literature, see Hirshleifer (2015)

outcomes.

The sections are organized as follows. Section I links asset price movements, return predictability, and rejection of the expectations hypothesis to a single condition for forecast errors of real cash flows. Section II describes the data and establishes our four findings on the term structure of inflation and earnings growth expectations. Section III constructs fundamental prices and measures their ability to match observed asset prices and return puzzles. Section IV proposes a model based on the representativeness bias which matches our main findings. Section V concludes.

I. Prices and Returns under Subjective Expectations

Movements in bond and stock markets must be due to changes in investors' expectations of real cash flows or real returns. For bonds, the real cash flow only depend on inflation, as the nominal cash flow is known. For stocks, expectations of real cash flows depend on expectations of inflation and expectations of earnings. In this section, we first show how subjective expectations of real cash flows can explain price movements, even if rational expectations of real cash flows are uncorrelated with prices. We then derive two additional identities which show that stock return predictability and excess volatility of bond returns can be explained by forecast errors in real cash flow expectations rather time-varying discount rates. For all three identities, the key condition is that forecast errors must be predictable with current prices.[6]

We start with price identities based on the definition of returns. For stocks, we use the approximate log-linearized return, which states the one-period real return in terms of real earnings growth $\Delta\tilde{e}_{t+1}$ and the price-earnings ratio pe_{t+1}, all in logs:

$$\tilde{r}_{t+1} \approx \kappa + \Delta\tilde{e}_{t+1} - pe_t + \rho pe_{t+1} \tag{1}$$

where κ is a constant, $\rho = e^{\bar{pd}}/\left(1+e^{\bar{pd}}\right) < 1$ and $\bar{pd}$ is the mean value of the log price-dividend ratio. By imposing a no-bubble condition, $\lim_{T\to\infty} \rho^T pe_{t+T} = 0$, we can iterate this equation and apply subjective expectations to get

$$pe_t \approx \frac{1}{1-\rho}\kappa + \sum_{j=1}^{\infty} \rho^{j-1} E_t^* \left[\Delta\tilde{e}_{t+j}\right] - \sum_{j=1}^{\infty} \rho^{j-1} E_t^* \left[\tilde{r}_{t+j}\right]. \tag{2}$$

[6]The Appendix gives the full derivation of all equations in this section.

Equation (2) states that an increase in the price-earnings ratio must reflect an increase in subjective real earnings growth expectations or a decrease in subjective real return expectations. These subjective expectations do not need to be rational. Because equation (2) is derived from the definition of real returns, it holds under any probability distribution.

For bonds, we use the return from holding an n-period zero-coupon bond for one period. Expressing all variables in logs, the holding return from t to $t+1$ is defined as

$$h_{t+1}^{(n)} = n y_t^{(n)} - (n-1)\, y_{t+1}^{(n-1)}. \tag{3}$$

Iterating and applying subjective expectations, the yield is

$$y_t^{(n)} = \frac{1}{n}\sum_{j=1}^{n} E_t^* \left[\pi_{t+j}\right] + \frac{1}{n}\sum_{j=1}^{n} E_t^* \left[\tilde{h}_{t+j}^{(n+1-j)}\right] \tag{4}$$

where $\tilde{h}_t^{(n)}$ is the real holding return. Intuitively, an increase in the bond yield must be due to higher subjective inflation expectations or higher subjective real holding return expectations. This is analogous to equation (2), where prices depend on expectations of real cash flows and real returns. For bonds, real cash flows only depend on inflation, as the nominal cash flow is known, whereas for stocks this will depend on inflation and nominal earnings growth Δe_{t+j}. For the zero-coupon bond, there is a single real cash flow at maturity, so inflation in different years all have the same impact on the yield. For stocks, there are real cash flows every period, so real earnings growth in earlier years will have a larger impact on prices than real earnings growth in later years, which is reflected in the ρ^{j-1} terms.

Given these asset prices, we establish three identities which demonstrate the effect of predictable forecast errors in expectations of real cash flows. First, the comovement of prices with subjective expectations of real cash flows is

$$Cov\left(pe_t, E_t^*\left[\Delta\tilde{e}_{t+j}\right]\right) = Cov\left(pe_t, E_t\left[\Delta\tilde{e}_{t+j}\right]\right) - Cov\left(pe_t, f_t^{\Delta e_{t+j}} - f_t^{\pi_{t+j}}\right) \tag{5}$$

$$Cov\left(y_t^{(n)}, E_t^*\left[\pi_{t+j}\right]\right) = Cov\left(y_t^{(n)}, E_t\left[\pi_{t+j}\right]\right) - Cov\left(y_t^{(n)}, f_t^{\pi_{t+j}}\right) \tag{6}$$

where $E_t\left[\cdot\right]$ represents rational expectations under the objective probability distribution, $f_t^{\pi_{t+j}}$ is the forecast error for inflation $\pi_{t+j} - E_t^*\left[\pi_{t+j}\right]$, and $f_t^{\Delta e_{t+j}}$ is the forecast error for earnings growth. Second, from equations (1)-(2), the ability of the price-earnings ratio to

predict future real returns is

$$\begin{aligned} Cov\left(pe_t, \sum_{j=1}^{\infty} \rho^{j-1} \tilde{r}_{t+j}\right) &= Cov\left(pe_t, \sum_{j=1}^{\infty} \rho^{j-1} E_t^* \left[\tilde{r}_{t+j}\right]\right) \\ &+ Cov\left(pe_t, \sum_{j=1}^{\infty} \rho^{j-1} \left[f_t^{\Delta e_{t+j}} - f_t^{\pi_{t+j}}\right]\right). \end{aligned} \tag{7}$$

Note that identities (5) and (7) on comovement with prices and return predictability also hold if we replace the price-earnings ratio pe_t with the price-dividend ratio pd_t. Third, using equations (3)-(4), we generalize the Shiller (1979) variance bound for holding returns,

$$\begin{aligned} Var\left(h_{t+1}^{(n)}\right) &\leq \eta Var\left(y_t^{(1)}\right) + 2nCov\left(E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}, y_t^{(n)}\right) \\ &- 2nCov\left(\sum_{j=2}^{n} f_t^{\pi_{t+j}} + f_t^{\tilde{h}_{t+j}^{(n+1-j)}}, y_t^{(n)}\right) \end{aligned} \tag{8}$$

where $\eta = n^2/(2n-1)$.

If one assumes rational expectations, then equations (7)-(8) provide simple tests of time-varying discount rates and the expectations hypothesis. Forecast errors are unpredictable so the final terms in both equations are zero. Therefore, the observed comovement between prices and future returns in (7) must be due to time-variation in investors' discount rates, $E_t^*\left[\tilde{r}_{t+j}\right]$. Similarly, under the expectations hypothesis, which posits that expected term premia $E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}$ are constant, equation (8) reduces to the standard variance bound proposed in Shiller (1979). This bound restricts the variance of holding returns to be less than $\eta Var\left(y_t^{(1)}\right)$. Therefore, the observed excess volatility of holding returns beyond this bound rejects the expectations hypothesis and implies that expected term premia must be time-varying.

If we allow for more general subjective expectations, then equations (5)-(8) show how expectations of real cash flows can explain asset prices, predictable stock returns, and excess volatility in bond holding returns. Equations (5)-(6) show that subjective expectations of real cash flows can comove with prices even if prices are uncorrelated with rational expectations of real cash flows. Similarly, predictable forecast errors for real earnings growth can cause stock prices to predict future returns even if discount rates are constant over time.[7] Finally, predictable forecast errors relax the bound in equation (8), implying that

[7]By extension, these forecast errors also increase the comovement between prices and nominal returns

excess volatility of holding returns beyond $\eta Var\left(y_t^{(1)}\right)$ does not violate the expectations hypothesis. Predictable forecast errors can generate excess volatility even if the expectations hypothesis holds, i.e. expected term premia $E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}$ are constant.

Importantly, all of these phenomena share a single necessary and sufficient condition, namely that forecast errors for real cash flows are correlated with current prices.[8] Errors in subjective expectations that are not correlated with current prices will have no impact on equations (5)-(8). This provides a useful metric for determining if subjective expectations can account for return predictability and excess volatility. Additionally, this allows us to measure the relative importance of subjective expectations at different horizons j by comparing the covariance of the forecast errors with current prices.

II. Term Structure of Subjective Expectations

In this section, we analyze nominal earnings growth expectations and inflation expectations at short and long horizons. We then test whether forecast errors are predictable using current stock prices and bond yields, which is the key condition from Section I. We summarize the results into four key findings on the term structure of subjective expectations.

First, short-term and long-term inflation expectations move closely together, implying that inflation is believed to have a high persistence. Second, in contrast, short-term and long-term earnings growth expectations do not show a strong comovement with each other, implying a low believed persistence. Third, predictable forecast errors for inflation are primarily concentrated at long horizons. Fourth, predictable forecast errors for earnings growth are concentrated at short horizons. The last two results indicate that mistakes in expectations of long-term inflation and short-term earnings growth are the most important sources of return predictability and excess volatility. Section IV matches all four results with a model based on the representativeness bias.

$Cov\left(pe_t, \tilde{r}_{t+j}\right) + Cov\left(pe_t, \pi_{t+j}\right)$.

[8] For stocks, this condition translates to pe_t negatively predicting forecast errors for real earnings growth. For bonds, this condition translates to yields negatively predicting forecast errors for inflation.

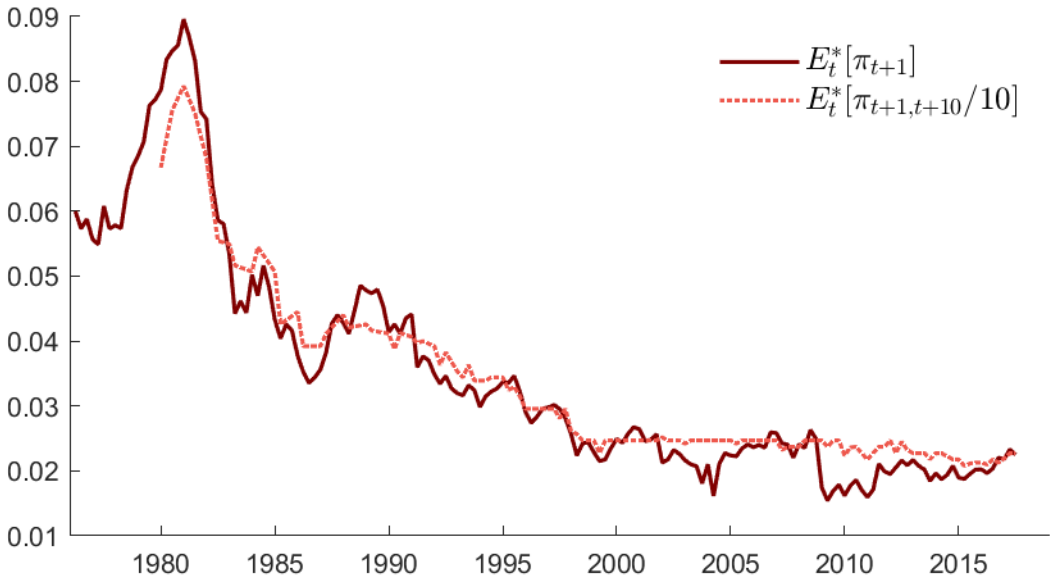


Figure 1. Subjective inflation expectations. The figure compares subjective expectations for one-year inflation (solid) and subjective expectations for annualized ten-year inflation (dotted). All variables are in logs.

A. Inflation Expectations

We use quarterly median inflation forecasts from the Survey of Professional Forecasters. To understand the relation between short-term and long-term inflation expectations, we analyze one-year inflation expectations from 1976Q1-2018Q2 and average ten-year inflation expectations from 1979Q4-2018Q2. Figure 1 shows that one-year expectations, denoted as $E_t^*[\pi_{t+1}]$, rise sharply in the late 1970's. These expectations reach a peak of 9% before falling steadily during the Volcker period in the 1980's and stabilize after 2000. Importantly, average ten-year expectations, denoted as $E_t^*[\pi_{t+1,t+10}/10]$, closely follow one-year expectation movements. When short-term expectations are high, average ten-year expectations are high and when short-term expectations are low long-term expectations are low. This relationship suggests that analysts believe movements in expected one-year inflation will largely persist and be observed in long-term inflation.

To quantify the relationship between expectations of short-term and long-term inflation, we measure the believed annual persistence ϕ_π from

$$E_t^*\left[\pi_{t+1+j}\right] = \alpha_{\pi,j} + \phi_\pi^j E_t^*\left[\pi_{t+1}\right] + \varepsilon_{t,j}^\pi. \tag{9}$$

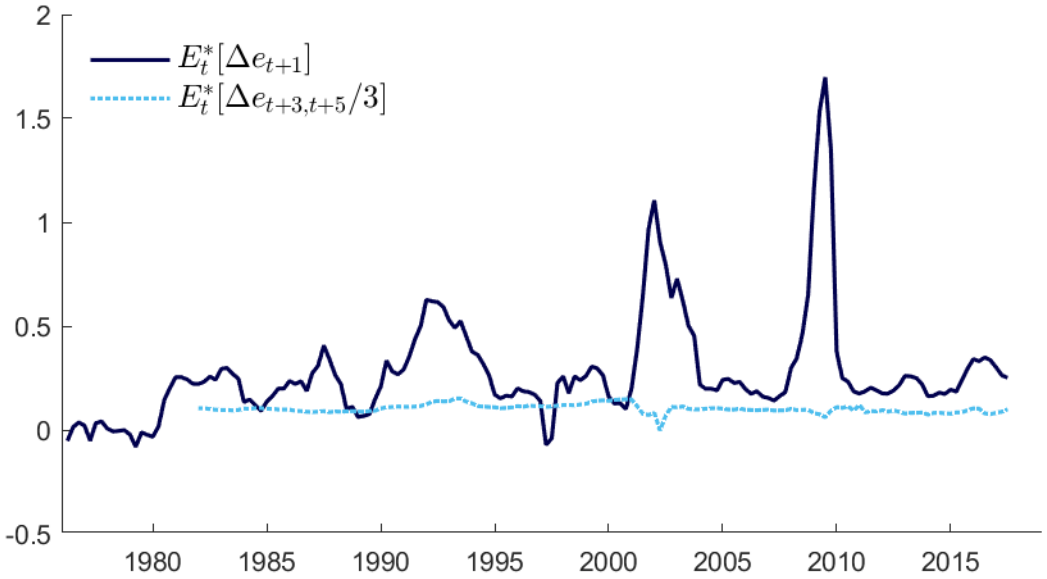


Figure 2. Subjective earnings growth expectations. The figure compares subjective expectations of one-year earnings growth (solid) and the subjective expectations for annualized three to five year earnings growth (dashed) for the S&P 500. All variables are in logs.

An increase in one-year expectations is associated with a ϕ_π increase in two-year expectations, ϕ_π^2 increase in three-year expectations, and so on. Using the one-year and average ten-year expectations, we estimate ϕ_π as 0.96 (0.01). We choose this form because of its simplicity and the fact that it nests standard AR(1) processes. The constants $\alpha_{\pi,j}$ will not matter for our analysis as they will not affect comovements or variances.

B. Nominal Earnings Growth Expectations

We follow De la O and Myers (2020) to construct short–term (1-year) expectations from the Thomson Reuters I/B/E/S individual firm forecasts. Following a similar procedure, we also construct long-term (3-5 year) expectations using the long-term growth forecasts in the same database. Construction details can be found in the Appendix. Figure 2 shows one-year earnings growth expectations from 1976Q1 up to 2018Q2, and average three-to-five-year earnings growth expectations from 1986Q1 to 2018Q2. Expectations of one-year earnings growth are volatile, ranging from -8.1% to 169.8%, reaching their peak during the low earnings observed in the financial crisis. In comparison, expectations of three-to-five

year earnings growth have much lower volatility, ranging from -0.2% to 15.2%, peaking in 1999 during the dot-com bubble.

Expectations of one-year earnings growth are volatile, with a standard deviation of 26.4%, rising substantially after the large decline in earnings during financial crisis. In comparison, expectations of three-to-five year earnings growth have much lower volatility, with a standard deviation of only 2.0%. This suggests that movements in earnings growth expectations are primarily concentrated at short horizons. The fact that movements in short-term expectations are not matched by similar movements in long-term expectations indicates that analysts believe movements in expected one-earnings growth will not persist through to long-term earnings growth.

We quantify the relationship between expectations of short-term and long-term earnings growth by measuring the believed annual persistence ϕ_e from

$$E_t^* \left[\Delta e_{t+j}\right] = \alpha_{e,j} + \phi_e^j E_t^* \left[\Delta e_{t+1}\right] + \varepsilon_{t,j}^e. \tag{10}$$

Using the one-year and 3-5 year expectations, we estimate a small, insignificant ϕ_e of 0.03 (0.02).[9] This sharply contrasts with the large, significant estimate of ϕ_π of 0.96.

C. Forecast error predictability

Section I establishes a single necessary and sufficient condition for subjective expectations of real cash flows to explain asset prices, stock return predictability, and excess bond return volatility: current prices must predict forecast errors for real cash flows. For stocks, this means that the current price-earnings ratio positively predicts forecast errors for inflation and negatively predicts forecast errors for earnings growth. The Appendix shows that the results are virtually unchanged if we use the price-dividend ratio. For bonds, this means that the current yield negatively predicts forecast errors for inflation.

We first confirm that our results for one-year expectations align with the previous literature, then establish new facts on longer horizon expectations. Table I shows the comovement of prices with expected and realized inflation and earnings growth, as well as the comovement with the forecast error. Under rational expectations, the comovement of expectations with prices should be equal to the comovement of realizations with prices. Panel A shows that

[9] As with the estimation of the believed persistence of inflation, the constants $\alpha_{\pi,j}$ will not matter for our analysis as they will not affect comovements or variances.

Table I

Forecast error predictability

This table shows the covariance of price ratios and bond yields with expected and realized inflation and earnings growth. In *Panel A*, the first row shows the covariance of the S&P 500 price-earnings ratio with short-term inflation expectations $E_t^*[\pi_{t+1}]$, realized short-term inflation π_{t+1}, and the forecast errors $\pi_{t+1} - E_t^*[\pi_{t+1}]$ from 1976Q1 to 2018Q2. The second shows the covariance of the S&P 500 price-earnings ratio with long-term inflation expectations $E_t^*[\pi_{t+1,t+10}]$, realized long-term inflation $\pi_{t+1,t+10}$, and the forecast errors $\pi_{t+1,t+10} - E_t^*[\pi_{t+1,t+10}]$using quarterly data from 1979Q4 to 2018Q2. The third and fourth rows show analogous results using the ten-year Treasury yield instead of the S&P 500 price-earnings ratio. In *Panel B* , the first row shows the covariance of the S&P 500 price-earnings ratio with short-term earnings growth expectations $E_t^*[\Delta e_{t+1}]$, realized short-term earnings growth Δe_{t+1}, and the forecast errors $\Delta e_{t+1} - E_t^*[\Delta e_{t+1}]$ from 1976Q1 to 2018Q2. The second row shows the covariances of the S&P 500 price ratios with long-term earnings growth expectations $E_t^*[\Delta e_{t+3,t+5}]$, realized long-term earnings growth $\Delta e_{t+3,t+5}$ and their forecast errors $\Delta e_{t+3,t+5} - E_t^*[\Delta e_{t+3,t+5}]$ from 1986Q1 to 2018Q2. Expectations expressed in percentages. Small-sample adjusted Newey-West standard errors in parenthesis.

Panel A: Inflation				
	Horizon	Expected	Realized	Forecast Error
$Cov(pe_t, \cdot)$	Short-term (π_{t+1})	-0.66^{***}	-0.82^{***}	-0.16
	Long-term ($\pi_{t+1,t+10}$)	-3.97^{**}	-1.66^{*}	2.31^{***}
$Cov\left(y_t^{(10)}, \cdot\right)$	Short-term (π_{t+1})	0.04^{***}	0.04^{***}	0.00
	Long-term ($\pi_{t+1,t+10}$)	0.25^{***}	0.13^{***}	-0.13^{***}
Panel B. Earnings Growth				
$Cov(pe_t, \cdot)$	Short-term (Δe_{t+1})	9.44^{***}	5.18	-4.26^{***}
	Long-term ($\Delta e_{t+3,t+5}$)	0.23	2.71	2.48

one-year expected inflation negatively covaries with the price-earnings ratio and positively covaries with the ten-year yield. Because these covariances closely match the covariance of realized inflation with current prices, forecast errors for one-year inflation do not significantly comove with either the price-earnings ratio or the yield. This is consistent with a large literature documenting the accuracy of short-term inflation expectations.[10] Panel B shows that one-year earnings growth expectations significantly positively comove with the price-earnings ratio, while realized earnings growth does not. This means that the price-earnings ratio predicts forecast errors for one-year earnings growth, in line with the findings of De la O and Myers (2020).

Moving to longer horizons, we document new findings on irrationality in inflation expectations and earnings growth expectations. Compared to one-year expectations, long-term inflation expectation have large covariances with both the price-earnings ratio and yield, at -3.97 and 0.25 respectively. This is consistent with our estimate of a high believed persistence ϕ_π of 0.96, as $E_t^* [\pi_{t+1}] (1 - \phi_\pi^{10}) / (1 - \phi_\pi)$ has nearly identical covariances of -3.85 and 0.23 over the same sample. This significantly overstates the covariance of prices with realized future inflation, leading to significant forecast errors that are predictable with current prices.

In contrast with the results for inflation, the covariance of long-term earnings growth expectations with the price-earnings ratio is insignificant. In line with our low estimate for the believed persistence ϕ_e of 0.03, the covariance is two orders of magnitude smaller than the covariance of one-year earnings growth expectations with the price-earnings ratio. Importantly, this low covariance does not lead to predictable forecast errors as realized long-term earnings growth is also insignificantly related to the price-earnings ratio. While expectations of long-term earnings growth may fail other tests of rationality, the inability of the price-earnings ratio to predict the forecast errors implies that these deviations from rationality will not help in matching the observed prices or explaining the two puzzles.

To summarize, we find that current prices significantly predict forecast errors for long-term inflation and short-term earnings growth, satisfying the necessary and sufficient condition from Section I. By analyzing expectations at multiple horizons, we document new errors in inflation expectations and a lack of predictable errors for expectations of long-term earnings growth. Additionally, we confirm that the estimates for the believed persistence of inflation and earnings growth accurately capture the comovement between long-term expec-

[10] Ang, Bekaert, and Wei (2007); Del Negro and Eusepi (2011); Chernov and Mueller (2012); Cieslak (2018)

tations and prices. These results for the believed persistence and the concentration of errors at long or short horizons will be important targets for a model of expectation formation.

III. Asset Prices and Puzzles

In this section, we propose a simple measure of fundamental stock and bond prices based on equations (2) and (4) using subjective expectations of real cash flows and constant discount rates. We focus on aggregate stock and bond prices, specifically the S&P 500 price-earnings ratio and price-dividend ratio and the ten-year zero-coupon Treasury yield. Fundamental prices closely match all three time-series. The quantitative results imply that time-varying discount rates play almost no role in aggregate stock prices and play only a secondary role in aggregate bond yields.

We then test whether these fundamental prices replicate two key puzzles in the asset pricing literature on stocks and bonds: the predictability of stock returns and the rejection of the expectations hypothesis for bonds. Specifically, we study the comovement of future stock returns with current price ratios and the excess volatility of bond holding returns. Under rational expectations, the magnitude of these two puzzles is evidence that discount rates must vary over time and that this variation is substantial. In both cases, the fundamental prices closely match the observed puzzles despite having constant discount rates.

A. Price movements

Movements in observed asset prices are closely matched by fundamental prices based on subjective expectations of real cash flows and constant discount rates. Setting the discount rate to a constant and using the believed persistence for inflation and earnings growth measured in Section II, the fundamental price-earnings ratio is

$$pe_t^{fun} = c + \frac{1}{1-\rho\phi_e} E_t^* \left[\Delta e_{t+1}\right] - \frac{1}{1-\rho\phi_\pi} E_t^* \left[\pi_{t+1}\right] \tag{11}$$

where the discount rate simply falls into the constant c.[11] Note that the fundamental price-earnings ratio is simply a linear function of two time-series, $E_t^* \left[\Delta e_{t+1}\right]$ and $E_t^* \left[\pi_{t+1}\right]$, and the

[11] The term c conveniently condenses all of the constants. Given the constant discount rate $\tilde{r}$, the full expressions is $c = \frac{\kappa - \tilde{r}}{1-\rho} + \sum_{j=1}^{\infty} \rho^{j-1} \left(\alpha_{e,j} - \alpha_{\pi,j}\right)$.

parameters ϕ_e and ϕ_π are estimated directly from the survey data. The mean price-earnings ratio is used to set c, but no other information about the observed price-earnings ratio is used when constructing the fundamental price-earnings ratio. By extension, the fundamental price-dividend ratio is

$$pd_t^{fun} = pe_t^{fun} + e_t - d_t. \tag{12}$$

Similarly, using a constant discount rate, the fundamental ten-year yield is

$$y_t^{(10),fun} = c^y + \frac{1}{10}\frac{1-\phi_\pi^{10}}{1-\phi_\pi} E_t^* \left[\pi_{t+1}\right] \tag{13}$$

where the second term represents the average expectation of inflation over the next ten years. The results are almost identical if we use the survey one-to-ten year inflation expectations $E_t^* \left[\pi_{t+1,t+10}\right]$. This is because the R^2 between one-year and ten-year inflation expectations is above 0.95 and ϕ_π is estimated to match the one-to-ten year expectations. The constant c^y is set to match the mean ten-year yield, but no other information about the observed yield is used in the fundamental yield.

Table II shows regressions of the observed stock price ratios and bond yield on the fundamental price ratios and bond yield. In short, fundamental prices based on constant discount rates and subjective expectations of real cash flows explain virtually all movements in stock price ratios and 2/3 of movements in bond yields. For the price-earnings ratio and the price-dividend ratio, the observed values move almost 1-1 with the fundamental values with coefficients of 0.96 in both regressions and high R^2's of 0.81 and 0.79, respectively. Even for bond yields, which one may expect to be strongly driven by discount rates, we find a significant coefficient of 1.55 and an R^2 of 0.66. Additionally, we cannot reject that the observed prices and yields are equal to the fundamental prices and yields plus noise, i.e. $a = 0$ and $b = 1$. In this constrained case of $a = 0$ and $b = 1$, we continue to find high R^2's of roughly 0.8 for the stock price ratios and 0.58 for the bond yield.

The results of Table II leave little room for time-varying discount rates. The high R^2 values demonstrate that the majority of price movements for both stocks and bonds are attributed to subjective expectations of real cash flows discounted at constant rates. Even if we ascribe all of the residual variation to movements in discount rates, the discount rate variation would play almost no role in stock prices and only a secondary role in bond yields.

To emphasize how closely fundamental prices match observed stock prices, we calcu-

Table II

Asset prices

This table shows a comparison between observed stock and bond prices and the *fundamental* prices constructed with the subjective expectations of inflation and earnings growth. The table shows linear regressions of observed prices on *fundamental* prices and reports the intercept a, the slope b, and the R^2 of the regression. Additionally, we report the constrained R^2 obtained from the residuals of the constrained regression where the intercept is forced to be zero $a = 0$ and the slope is one $b = 1$. The first two rows show the results for the S&P 500 price-earnings ratio and price-dividend ratio. The third row shows the results for the 10-year Treasury yield. The fourth and fifth row show the results for the long-term component pe_t^{LT} and the short-term component pe_t^{ST} of the S&P 500 price-earnings ratio. The short-term and long-term component were obtained by applying a Hodrick-Prescott filter on both the observed and the *fundamental* price-earnings ratio with a smoothing parameter of 1600. All calculations use quarterly data. Small-sample adjusted Newey-West standard errors in parenthesis.

Regression	a	b	R^2	Constrained R^2 $(a = 0, b = 1)$
$pe_t = a + bpe_t^{fun} + \varepsilon_t$	0.12	0.96	0.81	0.81
	(0.21)	(0.09)		
$pd_t = a + bpd_t^{fun} + \varepsilon_t$	0.16	0.96	0.79	0.79
	(0.39)	(0.12)		
$y_t = a + by_t^{fun} + \varepsilon_t$	−0.03	1.55	0.66	0.58
	(0.02)	(0.30)		
$pe_t^{LT} = a + bpe_t^{fun,LT} + \varepsilon_t$	0.03	0.99	0.82	0.82
	(0.14)	(0.06)		
$pe_t^{ST} = a + bpe_t^{fun,ST} + \varepsilon_t$	0.00	0.91	0.81	0.80
	(0.01)	(0.05)		

late two additional measures and test how well the fundamental prices explain long-term changes in the price-earnings ratio as well as short-term business cycle fluctuations. Using a standard Hodrick-Prescott filter, we calculate the long-term and short-term components of the observed price-earnings ratio, pe_t^{LT} and pe_t^{ST}, and the fundamental price-earnings ratio, $pe_t^{fun,LT}$ and $pe_t^{fun,ST}$. The final two rows of Table II show that the fundamental values continue to move almost 1-1 with the observed values, with coefficients of 0.99 and 0.91 and high R^2's of 0.82 and 0.80 for the long-term and short-term components respectively.

Figures 3 and 4 show the fundamental and observed price-earnings ratio, as well as the short-term and long-term components. Figure 3 shows that the fundamental price-earnings ratio pe_t^{fun} accurately tracks the observed price-earnings ratio pe_t. Additionally, Figure 4

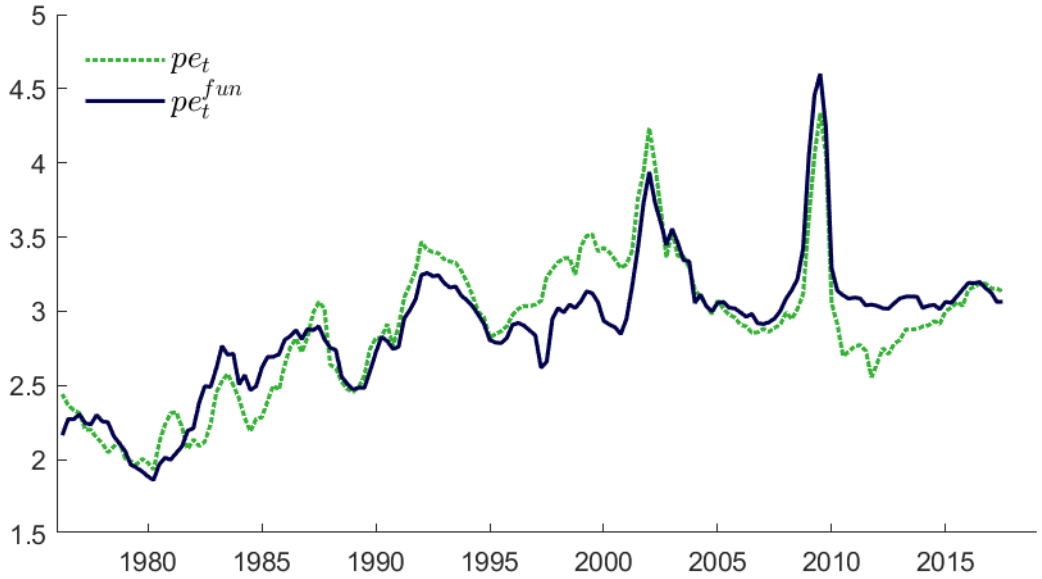


Figure 3. Fundamental and observed price-earnings ratio. The figure compares the observed price-earnings ratio for the S&P 500 (dotted green) with the fundamental price-earnings ratio (solid blue). The fundamental price-earnings ratio is the value of subjective expectations of real earnings growth discounted at a constant rate. All variables are in logs.

shows that the fundamental price-earnings ratio captures almost all short-term business-cycle variation in the price-earnings ratio, as well as the long-term secular increase in the price-earnings ratio over the last 40 years.

B. Return predictability

A central argument for time-varying discount rates is the empirical fact that future stock returns comove significantly with current price ratios. As shown in equation (7), under rational expectations this comovement must be due to substantial variation in discount rates. In Table III, we test whether this comovement is matched by fundamental price ratios. Intuitively, if predictable returns are driven by errors in subjective expectations of real cash flows, then fundamental prices with constant discount rates will also predict returns.

The first row of Table III shows the results of univariate regressions of future nominal returns for the next ten years on current price ratios. Changes in the observed price ratios are almost completely reflected in future returns. All variables are in logs, so a 1% increase in the

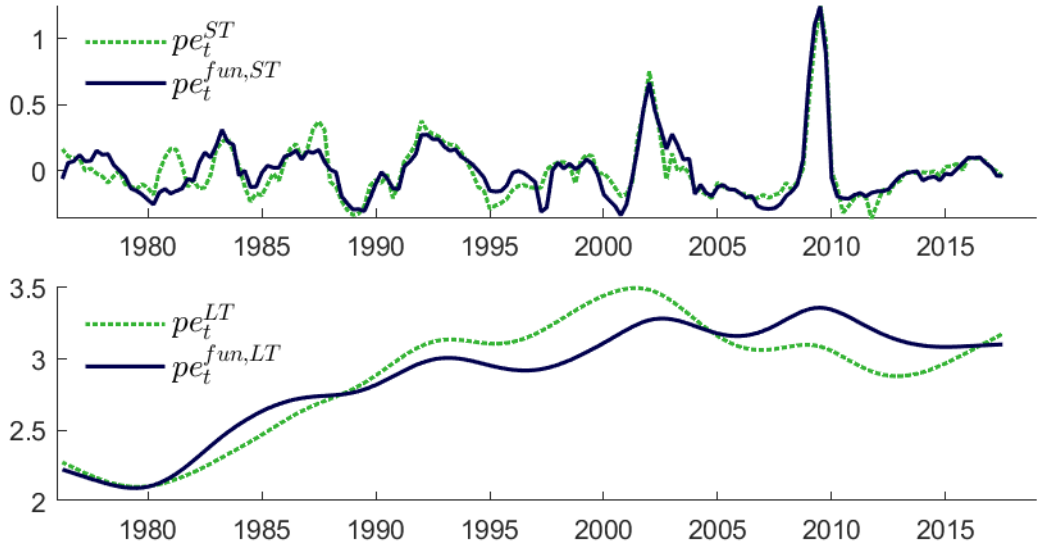


Figure 4. Short-term and long-term price movements. The top panel compares the short-term component of the price-earnings ratio for the S&P 500 (dotted green) with the short-term component of the fundamental price-earnings ratio (solid blue). The fundamental price-earnings ratio is the value of subjective expectations of real earnings growth discounted at a constant rate. The bottom panel compares the long-term component of the price-earnings ratio and the long-term component of the fundamental price-earnings ratio. All variables are in logs.

price ratios is associated with a 0.77% and 0.88% percent decrease in future ten-year returns, respectively. Importantly, increases in the fundamental price ratios are also reflected in future returns, with nearly identical coefficients of -0.77 and -0.92 respectively. The second row shows the analogous results using real returns for the next ten years. Again, the coefficients for the observed price ratios, -0.59 and -0.69, are nearly identical to the coefficients for the fundamental price ratios, -0.54 and -0.69, and all coefficients are significant. In all cases, we cannot reject that the coefficients for the fundamental price ratios exactly equal the coefficients for the observed price ratios.

Further, looking at the R^2 values, we see that the majority of the R^2 for the observed price ratios is generated by the fundamental price ratios. For example, the observed price-dividend ratio explains 81% of variation in future returns and the fundamental price-dividend ratio explains 64%. Thus, even if we attribute the entire difference to time-variation in discount rates, subjective expectations of real cash flows would still be the primary factor driving

Table III

Stock return predictability

This table shows the ability of real cash flow expectations to predict stock returns. The first and third columns show the coefficients from univariate linear regressions of ten-year nominal and real stock returns on the observed price-earnings ratio (pe_t) and price-dividend ratio (pd_t) The second and fourth columns show the coefficients from univariate linear regressions of ten-year nominal and real stock returns on the fundamental price-earnings ratio (pe_t^{fun}) and price-dividend ratio (pd_t^{fun}), which are constructed using real cash flow expectations and constant discount rates. For each regression, the table reports the slope coefficient β and the R^2. Small-sample adjusted Newey-West standard errors in parenthesis.

		Price-earnings ratio		Price-dividend ratio	
		Observed	Fundamental	Observed	Fundamental
Nominal returns $\sum_{j=1}^{10} r_{t+j}$	β	-0.77	-0.77	-0.88	-0.92
		(0.11)	(0.09)	(0.11)	(0.17)
	R^2	0.60	0.42	0.81	0.64
Real returns $\sum_{j=1}^{10} \tilde{r}_{t+j}$	β	-0.59	-0.54	-0.69	-0.69
		(0.14)	(0.13)	(0.15)	(0.19)
	R^2	0.45	0.26	0.65	0.46

return predictability.

Combined, the results of Table II and Table III imply that statistical forecasts of future returns based on observed price ratios are nearly identical to statistical forecasts based on fundamental price ratios. Fundamental price ratios move nearly 1-1 with observed price ratios with high R^2's and have the virtually identically coefficients for predicting future returns. In other words, an econometrician using observed price ratios and an econometrician using subjective expectations of real cash flows produce almost the same forecasts for future returns. This means that rather than reflecting time-variation in investors' discount rates, movements in statistical expectations of returns primarily reflect predictable errors in subjective expectations of inflation and earnings growth.

C. Rejection of expectations hypothesis

The expectations hypothesis posits that n-period yield $y_t^{(n)}$ is the expectation of the average one-period yield $y_{t+j}^{(1)}$ over the next n periods, plus a constant term premium.[12] If expectations are rational, then movements in yields must ultimately be related to movements in $y_{t+j}^{(1)}$

[12]Rejecting the expectations hypothesis is equivalent to stating that term premia $E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}$ vary over time.

Table IV

Rejection of expectations hypothesis

This table compares the excess volatility of holding returns for the observed yields and the fundamental yields. The variance ratio measures the variance of one-period holding returns on a ten-year bond divided by the variance of the one-period yield multiplied by a constant $\eta = 10^2/(20-1)$. Under rational expectations and the expectations hypothesis, this ratio has an upper bound of 1. The first column shows this ratio in the observed detrended data. The second column shows the variance ratio based on fundamental yields constructed using detrended inflation expectations and constant discount rates. The second row shows the significance of the one-sided F-test for equality of variance adjusted for autocorrelation of samples as in Priestley (1981).

	Observed yields	Fundamental yields
$Var\left(h_{t+1}^{(10)}\right)/\eta Var\left(y_t^{(1)}\right)$	5.60	5.22
F-test	0.00001	0.00046

and the volatility of holding returns is constrained by the volatility of movements in the one-period yield. Specifically, equation (8) shows that under rational expectations and the expectations hypothesis, the variance of holdings returns $h_{t+1}^{(n)}$ is bounded by $Var\left(y_t^{(1)}\right)$ scaled by a constant η. The first column of Table IV shows that this bound is decisively violated in the data by a factor of 5.6. Under rational expectations, these large movements in $h_{t+1}^{(n)}$ must be due to large movements in term premia.

In this section, we show that fundamental yields with constant term premia violate this bound to nearly the same degree. The fundamental yield $y_t^{(n),fun}$ is simply equal to the expected average inflation over the next n-periods plus a constant, meaning that the expectations hypothesis holds by definition. The holding return using fundamental yields is then measured from equation (3).[13] The second row of Table IV shows that fundamental yields violate this bound by a factor of 5.22, almost exactly matching the violation in the observed data. Using a one-sided F-test for equality of variance, we confidently reject that $Var\left(h_{t+1}^{(10)}\right)$ is below the bound for both the observed yields and the fundamental yields. We cannot reject that the two variance ratios are equal.

Equation (8) demonstrates how fundamental yields can violate this bound. Even when the expectations hypothesis holds and expected term premia are constant, $Var\left(h_{t+1}^{(10)}\right)$ can exceed $\eta Var\left(y_t^{(1)}\right)$ if yields predict forecast errors. Intuitively, if long-term inflation expec-

[13] Using the believed persistence ϕ_π, the holding return reduces to a constant plus $\frac{1-\phi_\pi^{10}}{1-\phi_\pi}E_t^*\left[\pi_{t+1}\right] - \frac{1-\phi_\pi^{9}}{1-\phi_\pi}E_{t+1}^*\left[\pi_{t+2}\right]$.

tations are too high when yields are high, then these inflation expectations will have to be revised downwards as investors realize their mistake. This downward revision in long-term inflation expectations lowers yields, which produces a high holding return following equation (3). To an econometrician assuming rational expectations, it appears as if the high yield and the high holding return are due investors demanding a high term premia. Time-variation in these predictable inflation errors similarly appears as time-variation in term premia.

The results of Table IV indicate that rejections of the expectations hypothesis may be due to errors in long-term inflation expectations, rather than time-variation in term premia. This is consistent with the results of Piazzesi, Salomao, and Schneider (2015), who find that survey expectations of the term premia $E_t^* \left[h_{t+1}^{(n)} \right] - y_t^{(1)}$ are relatively flat compared statistical measures of term premia. This is also consistent with Barr and Campbell (1997), which finds that holding returns on inflation protected bond are much less volatile.

IV. Expectations with Representativeness Bias

In this section we provide a simple model of expectation formation that accurately replicates our four facts on the term structure of subjective inflation and earnings growth expectations in Section II and our results on return predictability and excess volatility of holding returns from Section III. This model is based on the representativeness bias of Tversky and Kahneman (1974) and is a special case of diagnostic expectations, similar to the models of Bordalo, Gennaioli, and Shleifer (2018); Bordalo, Gennaioli, La Porta, and Shleifer (2019). Given that we are only interested in variances and covariances, we demean all variables without loss of generality.

Objectively, inflation and earnings growth are AR(1) processes,

$$\pi_{t+1} = \hat{\phi}_\pi \pi_t + \varepsilon_{\pi,t+1} \tag{14}$$

$$\Delta e_{t+1} = \hat{\phi}_e \Delta e_t + \varepsilon_{e,t+1}. \tag{15}$$

We use $\hat{\phi}_\pi, \hat{\phi}_e$ to distinguish from the values of ϕ_π, ϕ_e used earlier in the empirical sections. Agents understand that inflation and earnings growth are AR(1) but exaggerate the persistence of both processes. Specifically, agents believe the persistences are $\hat{\phi}_\pi^*, \hat{\phi}_e^*$ where $\frac{\hat{\phi}_\pi^*}{\hat{\phi}_\pi}, \frac{\hat{\phi}_e^*}{\hat{\phi}_e} \geq 1$. Agents have constant discount rates, so the price-earnings ratio and yield are

simply equal to their expectation of real earnings growth and average inflation,

$$pe_t = \frac{\hat{\phi}_e^*}{1-\rho\hat{\phi}_e^*}\Delta e_t - \frac{\hat{\phi}_\pi^*}{1-\rho\hat{\phi}_\pi^*}\pi_t \quad (16)$$

$$y_t^{(n)} = \frac{1}{n}\hat{\phi}_\pi^*\frac{1-\hat{\phi}_\pi^{*n}}{1-\hat{\phi}_\pi^*}\pi_t. \quad (17)$$

The condition $\frac{\hat{\phi}_\pi^*}{\hat{\phi}_\pi}, \frac{\hat{\phi}_e^*}{\hat{\phi}_e} \geq 1$ reflects representativeness bias, which states that when the current condition objectively makes a certain outcome more likely, individuals overweight the likelihood of that outcome.[14] For example, given $\hat{\phi}_\pi > 0$, a high value for current inflation makes high future inflation much more likely than it would be in the unconditional distribution. Agents understand the direction of this effect but exaggerate how much the current inflation increases the likelihood of high future inflation, believing the expected value for future inflation is $\hat{\phi}_\pi^*\pi_t$ rather than $\hat{\phi}_\pi\pi_t$.

A. Term structure of subjective expectations

We estimate the objective persistences $\hat{\phi}_\pi, \hat{\phi}_e$ from the observed inflation and earnings growth. Inflation is persistent with a coefficient of 0.76, while future earnings growth tends to be negatively related to current earnings growth giving a coefficient of -0.20. For $\hat{\phi}_\pi^*$, we use the value measured from the survey data in Section II of 0.96. We estimate $\hat{\phi}_e^*$ from the comovement of one-year expectations with current realized earnings growth to get -0.45. Consistent with the results of Section II, this implies that long-term expectations are relatively flat compared to short-term expectations while also matching the significant negative relationship between current earnings growth and short-term expectations. In line with the representativeness bias, $\hat{\phi}_\pi^*, \hat{\phi}_e^*$ exaggerate the true persistences.[15] The values for $\hat{\phi}_e, \hat{\phi}_e^*$ are also consistent with the earnings growth reversal model of De la O and Myers (2020), where subjective expectations overstate how much negative current earnings growth will be reversed by higher future earnings growth.

Figure 5 shows that this simple model matches all four of our findings on the term structure of subjective expectations from Section II. Specifically, Figure 5 shows the be-

[14] The Appendix gives a microfoundation for the model expectations similar to (Shleifer credit paper) where the background context is based on the unconditional mean.

[15] The Appendix confirms that forecast errors for inflation are negatively correlated with current inflation and forecast errors for earnings growth are positively correlated with current earnings growth.

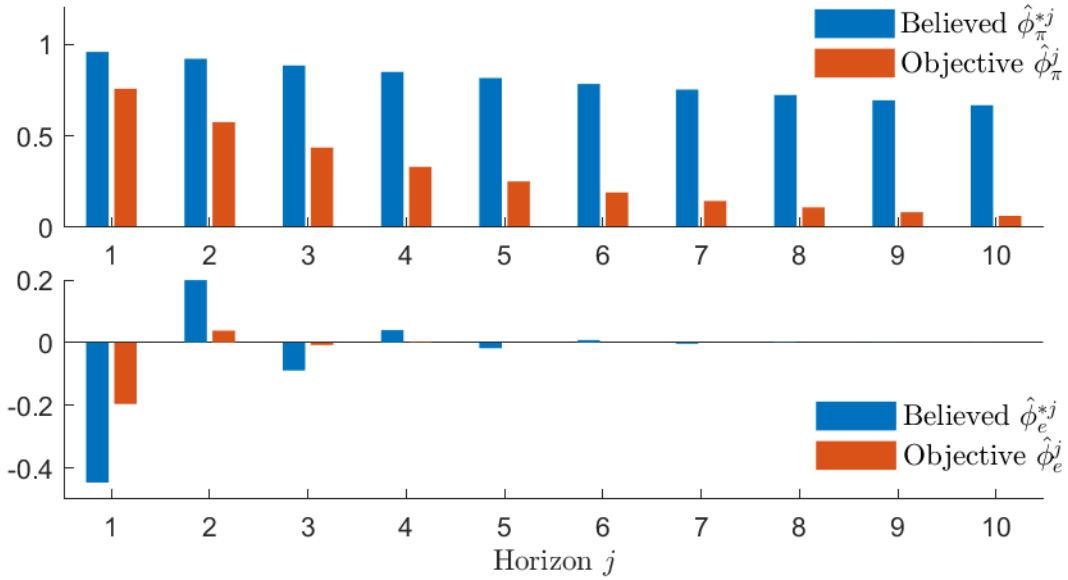


Figure 5. Term structure of expectations. The top panel compares the believed persistence of inflation $\hat{\phi}_{\pi}^{*j}$ (blue) with the objective persistence $\hat{\phi}_{\pi}^{j}$ (red) at multiple horizons. The bottom panel compares the believed persistence of earnings growth $\hat{\phi}_{e}^{*j}$ (blue) with the objective persistence $\hat{\phi}_{e}^{j}$ (red).

lieved persistence $\hat{\phi}_{\pi}^{*j}, \hat{\phi}_{e}^{*j}$ and the objective persistence $\hat{\phi}_{\pi}^{j}, \hat{\phi}_{e}^{j}$ at multiple horizons j. First, the values for $\hat{\phi}_{\pi}^{*j}$ demonstrate that long-term inflation expectations move almost 1-1 with short-term expectations. Second, the values for $\hat{\phi}_{e}^{*j}$ show that long-term earnings growth expectations are flat relative to short-term expectations. Movements in one-year expectations are 20 times larger than movements in average three-to-five year expectations, matching the results of Figure 2. Third, predictable errors in expectations of inflation, which are represented by $\hat{\phi}_{\pi}^{*j} - \hat{\phi}_{\pi}^{j}$, are primarily concentrated at long horizons. Fourth, predictable errors in expectations of earnings growth, $\hat{\phi}_{e}^{*j} - \hat{\phi}_{e}^{j}$, are primarily concentrated at short horizons.

Intuitively, the representativeness bias relates the term structure of subjective expectations to the objective persistence, which is why this one bias is able to match the starkly different results for inflation expectations and earnings growth expectations. For an objectively persistent process like inflation, a bias that magnifies the persistence primarily impacts long-term expectations. As shown in Figure 5, the error in one-year expectations is relatively small compared to the size of the objective and subjective expectations. It is only at longer horizons that the difference between a high and a very high persistence becomes apparent, as the objective persistence $\hat{\phi}_{\pi}^{j}$ steadily declines more rapidly than the believed persistence

$\hat{\phi}_\pi^{*j}$. For an objectively transitory process like earnings growth, a bias that magnifies the persistence primarily impacts short-term expectations. Even though $\hat{\phi}_e^*$ has a greater magnitude than $\hat{\phi}_e$, both persistences are still low and $\hat{\phi}_e^{*j}, \hat{\phi}_e^j$ quickly converge towards zero. As a result, differences between the objective and subjective expectations are concentrated almost entirely at short horizons.

B. Return predictability

Let $\alpha_e = \frac{\hat{\phi}_e}{1-\rho\hat{\phi}_e}$ and $\alpha_\pi = \frac{\hat{\phi}_\pi}{1-\rho\hat{\phi}_\pi}$. Similarly, let $\alpha_e^* = \frac{\hat{\phi}_e^*}{1-\rho\hat{\phi}_e^*}$ and $\alpha_\pi^* = \frac{\hat{\phi}_\pi}{1-\rho\hat{\phi}_\pi}$ be the analogous values using the believed persistences. For this section, we impose that shocks are independent which provides a useful representation for return predictability. See the Appendix for all proofs.

Proposition 1. *Total future returns are* $\sum_{j=1}^{\infty}\rho^{j-1}\tilde{r}_{t+j} = \beta pe_t + \upsilon_{t,t+\infty}$ *where* $\upsilon_{t,t+\infty}$ *is uncorrelated with* pe_t *and* β *is the weighted average bias,*

$$\beta = w\left(\frac{\alpha_e}{\alpha_e^*}-1\right)+(1-w)\left(\frac{\alpha_\pi}{\alpha_\pi^*}-1\right). \tag{18}$$

The terms $\frac{\alpha_e}{\alpha_e^*}-1$, $\frac{\alpha_\pi}{\alpha_\pi^*}-1$ capture how much the subjective expectations deviate from the objective distribution. The representativeness bias $\frac{\hat{\phi}_\pi^*}{\hat{\phi}_\pi}, \frac{\hat{\phi}_e^*}{\hat{\phi}_e} \geq 1$ implies that $\frac{\alpha_e}{\alpha_e^*}, \frac{\alpha_\pi}{\alpha_\pi^*} \leq 1$, guaranteeing that the price-earnings ratio negatively predicts future returns. The weight $w = (\alpha_e^{*2}\sigma_e^2) / (\alpha_e^{*2}\sigma_e^2 + \alpha_\pi^{*2}\sigma_\pi^2)$ represents the portion of the variation in pe_t that comes from variation in subjective earnings growth expectations where σ_e^2, σ_π^2 are the objective variances of earnings growth and inflation.

This relationship between returns and the price-earnings ratio can easily be extended to average returns over a finite horizon.

Corollary 1. *Future returns over a finite horizon are* $\sum_{j=1}^{10}\tilde{r}_{t+j} = \beta^{(10)}pe_t + \upsilon_{t,t+10}$ *where* $\upsilon_{t,t+10}$ *is uncorrelated with* pe_t*,*

$$\beta^{(10)} = w\left(\frac{\alpha_e}{\alpha_e^*}-1\right)\gamma_e+(1-w)\left(\frac{\alpha_\pi}{\alpha_\pi^*}-1\right)\gamma_\pi, \tag{19}$$

and $\gamma_e = \left(1-\rho\hat{\phi}_e\right)\frac{1-\hat{\phi}_e^{10}}{1-\hat{\phi}_e}$, $\gamma_\pi = \left(1-\rho\hat{\phi}_\pi\right)\frac{1-\hat{\phi}_\pi^{10}}{1-\hat{\phi}_\pi}$.

The first row of Table V shows that the model coefficient for predicting future returns $\beta^{(10)}$ matches the large, negative regression coefficient measured in the data. Even though

Table V

Return puzzles in data and model

This table compares the return predictability and rejection of expectations hypothesis observed in the data with that generated by our constant discount rate model. The first row shows the coefficient from a univariate linear regression of ten-year real stock returns on the price-earnings ratio (pe_t) in the observed detrended data and the model. The second row shows the variance of holding returns ($Var\left(h_{t+1}^{(10)}\right)$) relative to the upper bound imposed by rational expectations and the expectations hypothesis ($\eta Var\left(y_t^{(1)}\right)$).

	Data	Model
$Cov\left(\sum_{j=1}^{10}\tilde{r}_{t+j}, pe_t\right)/Var\left(pe_t\right)$	-0.59	-0.79
$Var\left(h_{t+1}^{(10)}\right)/\eta Var\left(y_t^{(1)}\right)$	5.60	6.01

the model price-earnings ratio uses constant discount rates, increases in the model price-earnings ratio predict future ten-year real returns with a coefficient of -0.79, in line with the data value of -0.59. This occurs because increases in the price-earnings ratio largely reflect errors in subjective expectations of real earnings growth. Because these price increases are not matched by future increases in real earnings growth, the price increases instead lead to lower future returns.

C. Rejection of expectations hypothesis

By construction, the expectations hypothesis holds for the model yields. The model yields are simply expectations of average future inflation and therefore are also expectations of the average future short rate $y_t^{(1)}$. However, holding returns can still violate the variance bound of Shiller (1979); Singleton (1980), leading an econometrician that assumes expectations are rational to reject the expectations hypothesis.

Proposition 2. *The variance of holding returns relative to the variance of the short-rate is*

$$\frac{Var\left(h_{t+1}^{(n)}\right)}{Var\left(y_t^{(1)}\right)} = \left[1+\lambda\left(\hat{\phi}_\pi^* - \hat{\phi}_\pi\right)\right]^2 + \left(1-\hat{\phi}_\pi^2\right)\lambda^2 \tag{20}$$

where $\lambda = \frac{1-\left(\hat{\phi}_\pi^*\right)^{n-1}}{1-\hat{\phi}_\pi^*}$.

Given a positive objective persistence $\hat{\phi}_\pi$, the representativeness bias $\hat{\phi}_\pi^* \geq \hat{\phi}_\pi$ raises the

variance ratio in two ways: (i) by increasing $\hat{\phi}_{\pi}^{*} - \hat{\phi}_{\pi}$, (ii) by increasing λ.

The second row of Table V shows that the model closely matches the empirical violation of the variance bound. The variance of $Var\left(h_{t+1}^{(10)}\right)$ exceeds the bound $\eta Var\left(y_t^{(1)}\right)$ by a factor of 6.01 in the model, compared to 5.60 in the data. This excess volatility in bond holding returns is driven by errors in inflation expectations. Movements in long-term yields can be split into changes in objective expectations of future inflation, which also represent changes in objective expectations of the future short rate, and changes in the gap between subjective and objective expectations of inflation. Whenever the objective expectation of future inflation increases, the representativeness bias causes the gap to also increase, which magnifies the movement in long-term yields and increases the volatility of holding returns.

V. Conclusion

Movements in bond and stock prices must reflect changes in expectations of real cash flows or discount rates. In this paper, we use survey expectations of real cash flows rather than assuming rational expectations and construct fundamental prices for stocks and bonds using these expectations of real cash flows and constant discount rates. We find that these prices accurately match the observed price-earnings ratio and price-dividend ratio for the S&P 500, as well as the ten-year Treasury yield. Despite having constant discount rates, fundamentals prices accurately match the predictability of stock returns and the rejection of the expectations hypothesis.

Combined, these results indicate that errors in subjective expectations of real cash flows drive asset prices and return puzzles, rather than time-varying discount rates. Rather than focusing on models that attempt to explain why investors' discount rates would fluctuate significantly over time, this evidence argues that research should focus on how investors form expectations of real cash flows.

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Appendix

A. Derivation of formulas

In order to arrive to equation (2) 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 nominal price and nominal dividends of the S&P 500 index. 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, Δd_{t+1}, future returns, r_{t+1}, and the future price-dividend ratio, pd_{t+1}, all in logs:

$$r_{t+1} \quad = \quad \kappa^d + \Delta d_{t+1} - pd_t + \rho pd_{t+1}, \tag{A1}$$

where κ^d is a constant, $\rho = e^{\bar{pd}}/\left(1 + e^{\bar{pd}}\right) < 1$ and $\bar{pd}$ is the mean value of the log price-dividend ratio. Using the log payout ratio de_t, we can insert the identity $pe_t = pd_t + de_t$[16] into (A1) to obtain:

$$\tilde{r}_{t+1} \quad \approx \quad \kappa + \Delta\tilde{e}_{t+1} - pe_t + \rho pe_{t+1} \tag{A2}$$

where we approximate $(1-\rho)\, de_{t+1}$ as 0 given that $1-\rho$ is close to 0.

To establish identities (5) and (6) we just need to use the fact that forecast errors are unpredictable with information at time t, meaning that

$$Cov(pe_t, \Delta\tilde{e}_{t+j}) \quad = \quad Cov\left(pe_t, E_t\left[\Delta\tilde{e}_{t+j}\right]\right). \tag{A3}$$

Under subjective expectations, the predictability of forecast errors with the price-earnings ratio is:

$$Cov(pe_t, f^{\Delta\tilde{e}_{t+j}}) \quad = \quad Cov(pe_t, \Delta\tilde{e}_{t+j}) - Cov\left(pe_t, E_t^*\left[\Delta\tilde{e}_{t+j}\right]\right) \tag{A4}$$

Equation (A3) and (A4) lead to equation (5) with expresses the comovement of price-earnings ratio with subjective real earnings growth expectations in terms of its comovement with rational expectations and the predictability of forecast errors for real earnings growth. In a similar fashion, the covariance of the 10-year bond yield with subjective inflation ex-

[16] Because we are using the aggregate S&P 500, we do not need to worry about very small or negative values for earnings.

pectations can be expressed in terms of its covariance with rational expectations and the predictability of forecast errors for inflation as in equation (6).

To establish identity (7), we start from the fact that equation (2) is satisfied under any probability distribution. Hence

$$\sum_{j=1}^{\infty} \rho^{j-1} \tilde{r}_{t+j} - \rho^{j-1} E_t^* \left[\tilde{r}_{t+j} \right] = \sum_{j=1}^{\infty} \rho^{j-1} \Delta \tilde{e}_{t+j} - \rho^{j-1} E_t^* \left[\Delta \tilde{e}_{t+j} \right].$$

By covarying both sides with the price-earnings ratio we arrive to equation (7). Finally, to establish the inequality in equation (8) we generalize the Shiller (1979) variance bound. From equation (3) we have that the variance of one-period holding returns can be expressed as

$$Var\left(h_{t+1}^{(n)}\right) = n^2 Var\left(y_t^{(n)}\right) + (n-1)^2 Var\left(y_{t+1}^{(n-1)}\right) - 2n(n-1) Cov\left(y_t^{(n)}, y_{t+1}^{(n-1)}\right).$$

The covariance term in the above equation can be expressed as:

$$\begin{aligned} Cov\left(h_{t+1}^{(n)} - y_t^{(1)}, y_t^{(n)}\right) &= Cov\left(E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}, y_t^{(n)}\right) - Cov\left(f^{h_{t+1}^{(n)}}, y_t^{(n)}\right) \\ \Rightarrow (n-1) Cov\left(y_{t+1}^{(n-1)}, y_t^{(n)}\right) &= nVar\left(y_t^{(n)}\right) - Cov\left(y_t^{(1)}, y_t^{(n)}\right) \\ &- Cov\left(E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}, y_t^{(n)}\right) + Cov\left(f^{h_{t+1}^{(n)}}, y_t^{(n)}\right). \end{aligned}$$

We plug this value for the covariance back into the variance of $h_{t+1}^{(n)}$ to get

$$\begin{aligned} Var\left(h_{t+1}^{(n)}\right) &= -n^2 Var\left(y_t^{(n)}\right) + (n-1)^2 Var\left(y_{t+1}^{(n-1)}\right) + 2nCov\left(y_t^{(1)}, y_t^{(n)}\right) \\ &+ Cov\left(E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}, y_t^{(n)}\right) - 2nCov\left(f^{h_{t+1}^{(n)}}, y_t^{(n)}\right). \end{aligned} \tag{A5}$$

Under rational expectations and the expectations hypothesis, the fourth and fifth term of the equation would be zero. The hypothethical variance under these conditions, denoted as $\overline{Var}\left(h_{t+1}^{(n)}\right)$ is

$$\overline{Var}\left(h_{t+1}^{(n)}\right) = -n^2 Var\left(y_t^{(n)}\right) + (n-1)^2 Var\left(y_{t+1}^{(n-1)}\right) + 2nCov\left(y_t^{(1)}, y_t^{(n)}\right).$$

From Shiller (1979), we know that under these conditions the variance has an upper bound

defined by

$$\overline{Var}\left(r_{t+1}^{(n)}\right) \leq \frac{n^2}{2n-1} Var\left(y_t^{(1)}\right).$$

This means that the generalized bound from (A5) is

$$Var\left(h_{t+1}^{(n)}\right) \leq \frac{n^2}{2n-1} Var\left(y_t^{(1)}\right) + Cov\left(E_t^*\left[h_{t+1}^{(n)}\right] - y_t^{(1)}, y_t^{(n)}\right) - 2nCov\left(f^{h_{t+1}^{(n)}}, y_t^{(n)}\right)$$

as expressed in equation (8).

B. Data sources for Inflation and Nominal Earnings Growth Expectations

B.1. Inflation Expectations

Our main source for inflation expectations is the Survey of Professional Forecasters (SPF). The SPF contains quarterly median inflation forecasts of one-year inflation expectations from 1976Q1-2018Q2 and average ten-year inflation expectations from 1991Q1-2018Q2. As suggested by the technical documentation in the SPF, the average ten-year inflation expectation series is complemented backwards to 1979Q3 with the average ten-year inflation expectations from the Philadelphia Fed's Livingston Survey and from the Blue Chip Economic Indicators Survey.

For robustness, we also analyze an alternative measure of inflation expectations from the Survey of Consumer Finance which has both one-year inflation expectations and five-to-ten year average inflation expectations. This alternative measure ranges from 1979Q3 to 2015Q4 and gives qualitatively very similar results.

B.2. Nominal Earnings Growth Expectations

We construct cash flow expectations for the S&P 500 index following the aggregating procedure in De la O and Myers (2020). The Summary Statistics of the Thomson Reuters I/B/E/S database contains the median analyst forecasts for DPS (dividends per share) since 2003 and EPS (earnings per share) since 1976.[17] Using these individual forecasts, we build measures of aggregate dividend and earnings expectations at different horizons using the constituents of the S&P 500 at each point in time. After obtaining the aggregate expectations for dividends and earnings, we calculate earnings growth and dividend growth at

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

Table AI

Forecast error predictability with price-dividend ratio

This table shows the covariance of the price-dividend ratio and bond yields with expected and realized inflation and earnings growth. In *Panel A*, the first row shows the covariance of the S&P 500 price-dividend ratio with short-term inflation expectations $E_t^*[\pi_{t+1}]$, realized short-term inflation π_{t+1}, and the forecast errors $\pi_{t+1} - E_t^*[\pi_{t+1}]$ from 1976Q1 to 2018Q2. The second shows the covariance of the S&P 500 price-dividend ratio with long-term inflation expectations $E_t^*[\pi_{t+1,t+10}]$, realized long-term inflation $\pi_{t+1,t+10}$, and the forecast errors $\pi_{t+1,t+10} - E_t^*[\pi_{t+1,t+10}]$using quarterly data from 1979Q4 to 2018Q2. In *Panel B* , the first row shows the covariance of the S&P 500 price-dividend ratio with short-term earnings growth expectations $E_t^*[\Delta e_{t+1}]$, realized short-term earnings growth Δe_{t+1}, and the forecast errors $\Delta e_{t+1} - E_t^*[\Delta e_{t+1}]$ from 1976Q1 to 2018Q2. The second row shows the covariances of the S&P 500 price-dividend ratio with long-term earnings growth expectations $E_t^*[\Delta e_{t+3,t+5}]$, realized long-term earnings growth $\Delta e_{t+3,t+5}$ and their forecast errors $\Delta e_{t+3,t+5} - E_t^*[\Delta e_{t+3,t+5}]$ from 1986Q1 to 2018Q2. Expectations expressed in percentages. Small-sample adjusted Newey-West standard errors in parenthesis.

Panel A: Inflation				
	Horizon	Expected	Realized	Forecast Error
$Cov(pd_t, \cdot)$	Short-term (π_{t+1})	-0.70^{***}	-0.77^{***}	-0.08
	Long-term ($\pi_{t+1,t+10}$)	-5.13^{***}	-2.25^{***}	2.88^{***}
Panel B. Earnings Growth				
$Cov(pd_t, \cdot)$	Short-term (Δe_{t+1})	2.52	-0.90	-3.43^{***}
	Long-term ($\Delta e_{t+3,t+5}$)	0.60	0.84	0.24

different horixons. The online appendix of De la O and Myers (2020) shows in detail the tests of using this methodology for the I/B/E/S database.

C. Robustness analysis of forecast error predictability

Table AI shows that the four key findings on the term structure of subjective expectations are also satisfied when the comovement of the price-dividend ratio with expected and realized inflation and earnings growth is analyzed.

Table AII shows the forecast error predictability of subjective expectations of inflation and earnings growth with current realizations of inflation and earnings growth. Similar to the results in Table I, we find large and significant predictable forecast errors of long-term inflation and short-term earnings growth expectations and insignificant errors for short-term

Table AII

Forecast error predictability with fundamentals

This table shows the covariance of current inflation and earnings growth with expected and realized inflation and earnings growth. In *Panel A*, the first row shows the covariance of current inflation with short-term inflation expectations $E_t^*[\pi_{t+1}]$, realized short-term inflation π_{t+1}, and the forecast errors $\pi_{t+1} - E_t^*[\pi_{t+1}]$ from 1976Q1 to 2018Q2. The second shows the covariance of current inflation with long-term inflation expectations $E_t^*[\pi_{t+1,t+10}]$, realized long-term inflation $\pi_{t+1,t+10}$, and the forecast errors $\pi_{t+1,t+10} - E_t^*[\pi_{t+1,t+10}]$using quarterly data from 1979Q4 to 2018Q2. In *Panel B* , the first row shows the covariance of current one-year earnings growth with short-term earnings growth expectations $E_t^*[\Delta e_{t+1}]$, realized short-term earnings growth Δe_{t+1}, and the forecast errors $\Delta e_{t+1} - E_t^*[\Delta e_{t+1}]$ from 1976Q1 to 2018Q2. The second row shows the covariances of current one-year earnings growth with long-term earnings growth expectations $E_t^*[\Delta e_{t+3,t+5}]$, realized long-term earnings growth $\Delta e_{t+3,t+5}$ and their forecast errors $\Delta e_{t+3,t+5} - E_t^*[\Delta e_{t+3,t+5}]$ from 1986Q1 to 2018Q2. Expectations expressed in percentages. Small-sample adjusted Newey-West standard errors in parenthesis.

Panel A: Inflation				
	Horizon	Expected	Realized	Forecast Error
$Cov(\pi_t, \cdot)$	Short-term (π_{t+1})	0.04^{***}	0.05^{***}	0.01
	Long-term ($\pi_{t+1,t+10}$)	0.22^{***}	0.09^{***}	-0.13^{***}
Panel B. Earnings Growth				
$Cov(\Delta e_t, \cdot)$	Short-term (Δe_{t+1})	-6.47^{***}	-2.83	3.63^{***}
	Long-term ($\Delta e_{t+3,t+5}$)	0.80^{**}	-4.77	-5.57

infaltion and long-term earnings growth expectations.