Abstract
The results reported in Campbell and Vuolteenaho (2004) suggest that stock markets suffer from massive inflation illusion as suggested by Modigliani and Cohn (1979). That is, investors incorrectly project the same nominal growth during high and low inflation, when they should project the same real growth. As a result stock prices are too high (low) when expected inflation is low (high). We reinvestigate their data and find that their results are sensitive to the sample period studied, the proxy used for expected inflation, the use of dividends versus earnings yields, and the VAR methodology employed. We suggest that it is premature to conclude that the stock market suffers from inflation illusion.

We thank Tuomo Vuolteenaho for numerous helpful conversations and for providing data underlying the Campbell/Vuolteenaho 2004 paper, and received helpful comments from workshop participants at Boston University, Yale IFLIP Lunch, and UNC/FEA 2005 Conference. We also thank Thomson Financial Services, Inc. for the IBES data provided as part of a broad academic program to encourage earnings expectation research.
Inflation illusion and stock prices: A comment

1. Introduction

Campbell and Vuolteenaho (2004), referred to hereafter as CV, is an influential paper that strongly supports the view that investors suffer from massive inflation illusion. Financial economists have been concerned about this possibility because earnings yields appear to comove with expected inflation (see for example, Siegel, 2002, Ritter and Warr, 2002, and Asness, 2003), which implies that nominal earnings growth projected by investors does not vary with expected inflation. This comovement appears to have first been noted in a July 1997 Federal Reserve Monetary Policy Report to Congress and is popularly known as the Fed Model (a term coined by Ed Yardeni, an analyst at Prudential Securities). But that doesn’t make sense, since firms hold real assets and it is real growth not nominal growth that should be invariant to expected inflation. Based on a VAR model CV confirm that US stocks are mispriced, exactly as predicted by the inflation illusion hypothesis of Modigliani and Cohn (1979). We reinvestigate their dataset and find that their results are sensitive to the proxy used for expected inflation, the sample period selected, and the use of earnings or dividend yields.

Our VAR analyses suggest that there is no evidence of mispricing that is consistent with inflation illusion. Turning to the question of real growth, while the prior literature had expected no relation between real growth and expected inflation, CV find a strong positive relation. Our VAR results, however, suggest that real growth is generally strongly negatively related to expected inflation, which is consistent with the view that inflation has a substantial negative impact on real profits and stock value (e.g., Fama, 1981, and Lucas, 1996). This view is also supported by real growth implied by analysts’ forecasts, available since the late 1970’s: real

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growth is strongly negatively related to expected inflation (e.g., Table V in Claus and Thomas, 2001, and Figure 3 in Sharpe, 2002), and those forecasts are supported by observed growth (e.g., Figure 4 of Thomas and Zhang, 2008).

Dividend yields can be linked formally to anticipated growth and expected returns using the log-linear dynamic valuation framework of Campbell and Shiller (1988), which can be described as follows:

\[ d_t - p_t \approx \frac{k}{\rho - 1} + \sum_{j=1}^{\infty} \rho^j E_t r_{t+j}^e - \sum_{j=1}^{\infty} \rho^j E_t \Delta d_{t+j}^e \]

where

- \( d_t \) = log dividends in period \( t \),
- \( p_t \) = log stock price in period \( t \),
- \( \rho \) = constant, approximately equal to 0.97
- \( k \) = constant
- \( r^e \) = log stock return expected for period \( t+j \) less log corresponding risk-free rate, and
- \( \Delta d^e \) = log dividend growth expected for period \( t+j \) less corresponding log risk-free rate.
- \( E_t \) = expectations formed in period \( t \).

We first replicate CV using their specifications and then conduct robustness checks by investigating alternative specifications. Specifically, we examine whether their VAR methodology is sensitive to a) replacing the PPI-based inflation measure (which is a backward looking measure) with the 10-year bond rate (which is a forward looking inflation measure), b) replacing trailing dividend yields with trailing earnings yields, and c) replacing trailing dividend yields with forward earnings yields. We consider these two changes to their specification because the Fed model compares forward earnings yields with the 10-year bond rate.
CV use the following process to estimate objective dividend growth rates and market mispricing. First they estimate the following VAR model that links current and next period values of objective excess rates of return \((r^e)\), the subjective risk premium \((\lambda^{SRC})\), dividend yields \((dy)\), and expected inflation \((\pi)\):\(^2\)

\[
\begin{bmatrix}
    r_{M,t+1}^e \\
    \lambda_{t+1}^{SRC} \\
    dy_{t+1} \\
    \pi_{t+1}
\end{bmatrix} =
\begin{bmatrix}
    c_{01} \\
    c_{02} \\
    c_{03} \\
    c_{04}
\end{bmatrix} +
\begin{bmatrix}
    a_{11} & a_{12} & a_{13} & a_{14} \\
    a_{21} & a_{22} & a_{23} & a_{24} \\
    a_{31} & a_{32} & a_{33} & a_{34} \\
    a_{41} & a_{42} & a_{43} & a_{44}
\end{bmatrix} \cdot
\begin{bmatrix}
    r_{M,t}^e \\
    \lambda_{t}^{SRC} \\
    dy_{t} \\
    \pi_{t}
\end{bmatrix} +
\begin{bmatrix}
    e_{1} \\
    e_{2} \\
    e_{3} \\
    e_{4}
\end{bmatrix}
\]

Based on the coefficient estimates from the VAR model, they project the path of expected excess returns for all future periods, which then allows them to estimate the term representing objective estimates of excess dividend growth \((\Delta d^e)\), using the dividend yield relation in equation (1) as follows:

\[
- \sum \rho^i E(\Delta d_{t+i}^e) = -\frac{k}{\rho^{-1}} + \sum \rho^i E(r_{t+i}^e) - dy_t
\]

They then separate dividend yields into three components: a) the objective estimate of excess dividend growth, as described in equation (4), b) the subjective risk premium term, equal to \(const + \gamma \lambda_t\), and c) market mispricing, as described in equation (5) below.

\[
e_t = \sum \rho^i E(r_{t+i}^e) - (const + \gamma \lambda_t)
\]

To replicate the results in CV, we regress dividend yield and each of these three components on inflation. Table 1 Panel A reports the results of estimating these regression on their sample. Since we follow CV closely and use their data, our results are similar to theirs. We

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\(^2\) Returns, dividend yields, and expected inflation are in the logarithm format, as in Campbell and Vuolteenaho (2004)
find that the coefficient on inflation is negative for the objective expected dividend growth and subjective risk premium terms and positive for the mispricing term. That is, we confirm their findings that expected real dividend growth is positively related to expected inflation and stocks are priced too high (low) when inflation is low (high). Figure 1 Panel A plots the time-series of mispricing and inflation scaled by its regression coefficient. Again, this figure is similar to Figure 1 in CV and illustrates a strong co-movement between the mispricing term and inflation. We also plot the dividend growth term and inflation scaled by its regression coefficient, against time (Figure 1 Panel B). These two series also move together, confirming that inflation is able to explain a large fraction of time-series variation in real expected dividend growth. The substantial comovement in Panels A and B is confirmed by the high $R^2$ values noted in the fourth and second rows of Panel A in Table 1.

The results of replacing the PPI-based inflation measure with the 10-year bond rate in the VAR model are reported in Table 1 Panel B. In direct contrast with the results in Panel A, the coefficient on expected dividend growth in the second row is now a large positive number (7.93 vs. -11.63 in Panel A). In effect, changing the inflation measure reverses the relation between expected dividend growth and inflation: objective estimates of real dividend growth are now significantly negatively related to expected inflation. Another important change in results is that a) the magnitude of the coefficient on the mispricing term in Panel B and the $R^2$ for that regression are substantially lower than the corresponding values in Panel A (which suggests that the relation between mispricing and inflation is now considerably weaker), and b) the sign has

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3 A negative coefficient on the expected dividend growth term implies that excess and real dividend growth is positively related to inflation because the term equals minus dividend growth, and a positive coefficient on the mispricing term implies that the difference between actual and efficient prices is negatively related to inflation because the mispricing term refers to expected rates of return, not prices.

4 We do not consider the CPI-based inflation measure in this section because of the high correlation between the PPI and CPI-based measures.
flipped. This second result is inconsistent with the stock market suffering from inflation illusion, since a negative coefficient on the mispricing term suggests that stock prices are too high (low) when inflation is high (low).

These conclusions are confirmed by the relations reported in Panels A and B of Figure 2. The results in Panel A suggest that the mispricing term is very volatile and the predicted mispricing based on inflation is largely flat, suggesting virtually no co-movement between these two variables. The results in Panel B suggest a strong comovement between expected dividend growth and inflation, which confirms that high R² value reported in the second row of Panel B in Table 1. However, that strong comovement is opposite to that predicted by the inflation illusion hypothesis. Overall, we find that simply switching the proxy for expected inflation from a historic PPI-based inflation measure to a forward looking measure based on bond rates dramatically alters the conclusions of CV.

To understand potential reasons for the observed impact of switching inflation proxies, we plot in Figure 3 values of both series from 1927 to 2002. The major difference between the two inflation proxies relates to the 1930’s and 1940’s: the PPI-based inflation measure is highly negative in the early 1930s and highly positive in the late 1940s, whereas the bond rates are relatively flat through this period. If the PPI-based measure is a better measure of expected inflation than bond yields, the relatively flat profile for the 10-year bond yield during this subperiod suggests that real interest rates were varying dramatically at this point. If, however, the 10-year bond yield is a better measure of expected inflation, the wildly varying profile for PPI_INF suggests that historical inflation was not a good proxy for expected inflation during this subperiod.
While these differences between the results in Panels A and B of Table 1 suggest that conclusions about inflation illusion depend on which inflation proxy is more representative, it turns out that the subperiod before the 1950’s is not the period that raised concerns of inflation illusion. It is the subperiod after the 1950’s where earnings yields comove with expected inflation, which caused Modigliani and Cohn (1979) to suggest that investors were mistakenly projecting nominal growth rates that did not vary with expected inflation (See, for example, Exhibit 6 in Asness, 2003). Since the two inflation proxies are strongly positively related in the post-1950’s period, conclusions regarding inflation illusion need not hinge on the particular inflation proxy chosen. Apparently, the two subperiods are structurally different.5

To probe further the possibility that the results may vary across the CV sample period, we repeat the Panel A analysis on two subperiods: 1927 to 1950 and 1951 to 2002. The results reported in Panel C suggest that the results observed in CV are driven by the first subperiod. The results for the years after 1950 indicate that real dividend growth is negatively, not positively, related to expected inflation. Given that the positive comovement between earnings/dividend yields and expected inflation is observed in the second subperiod, not in the first subperiod (see also first row of Panel C), we find this evidence to be inconsistent with the inflation illusion hypothesis. Why would the data from the first subperiod, where there is no evidence of inflation illusion, be so critical to the results in CV that suggest inflation illusion?

We consider next the impact of replacing trailing dividend yields with trailing earnings yields (taken from Shiller’s data), but using the same inflation PPI-based inflation proxy as in Panel A. The results of repeating the VAR decomposition analysis for this set of variables are reported in Panel D. We find results similar to those reported in Panel B of Table 1 (for dividend

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5 The first subperiod is an unusual period of Govt. intervention, due partly to the Depression and World Wars. Not only were interest rates held low, price controls and rationing affected inflation. See, for example, Evans (1985).
yields and the bond rate inflation proxy) but exactly the opposite of those reported in Panel A of Table 4 in CV. The coefficient on the dividend growth term is strongly positive, which suggests that real dividend growth is strongly negatively related to expected inflation. And the large coefficient on inflation for the mispricing term suggests that while there is evidence of mispricing it is in a direction opposite to that predicted by inflation illusion.

We confirm the CV finding that the results are sensitive to replacing the trailing earnings yield used in Panel D with the 5-year moving average earnings yield (EP5 in CV). Those results are reported in Table 1, Panel E. For the PPI-based inflation proxy, the VAR methodology provides results similar to those reported in Panel A and in CV. That is, the coefficient on excess dividend growth is significantly positive and that on the mispricing term is significantly negative, which is consistent with inflation illusion. We repeated the subperiod analysis of Panel C for the EP5 results reported in Panel E. As before, we find that the overall results reported in Panel E are driven by the first subperiod data (1927 to 1950). Since there is no evidence of comovement between earnings yields and expected inflation in this subperiod, we believe that the EP5 results in Panel E should not be viewed as consistent with inflation illusion.

Our final analysis relates to the impact of switching trailing earnings yields for forward earnings yields, which are constructed from the I/B/E/S sample of firms with non-missing market value of equity and analysts’ earnings forecasts for the next year. Since about 60% of the public firms have calendar year-ends, we use forecasts as of mid April each year to obtain analysts’ forecasts as soon as possible after the previous year annual report has been filed.

Table 2 contains the results of our analysis. Again, we observe results that are consistent with our direct examination of growth rates and consistent with the results in Table 1, Panels B and C, but inconsistent with the conclusions in CV. In effect, the VAR analysis based on forward
earnings yields provides results that are not sensitive to the choice of inflation proxy and we find that real dividend growth rates are strongly negatively related to inflation, not strongly positively related to inflation.

In sum, we find that the results in CV are sensitive to model specifications. Their results hold if the PPI-based inflation measure is used and the subperiod between the mid 1920’s and the 1950’s is included. As discussed earlier, there is no a priori reason to believe that the PPI-based historical proxy is a better measure for expected inflation than bond yields during this subperiod. Moreover, the result is also sensitive to using dividend yields or earnings yields, since the findings are reversed when trailing earning yields and forward earnings yields are used. Overall, we believe it is premature to conclude that the market confuses real and nominal growth rates and suffers from the massive inflation illusion implied by the results in CV.6

6 Based on the decomposition in CV, \( \log(D/P) = -5.878 - \sum \rho^i E(\Delta d_{t+i} e^i) + (\alpha + \gamma \Delta t) + e_t \), where the last term \( e_t \) is mispricing. When inflation is the highest in March 1981 (inflation=9.37%), \( \log(D/P) = -3.074 = -5.878 + 0.342 + 1.405 + 1.057 \). Therefore, \( D/P = 4.622 \) percent, which means that \( P = 21.636D \). If the mispricing term is zero, however, then \( D/P^* = 0.01606 \), which means that \( P^* = 62.276D \). (where \( P^* \) is the efficient price) Taken together, stock prices were 34.74% (=21.636D/62.276D) of what they should be when inflation was at its peak in March 1981.
References


Table 1
Replication of Campbell and Vuolteenaho’s results and robustness checks

Panel A replicates Campbell and Vuolteenaho’s results, and Panels B, C, D, and E provide robustness checks using the 10-year bond yield instead of the PPI-based inflation measure, splitting the sample period into two subperiods, using the earnings yield rather than the dividend yield, and the 5-year moving average earnings yield instead of the dividend yield, respectively. In each panel, we follow Campbell and Vuolteenaho (2004) by estimating a VAR model and decomposing dividend or earnings yield (dy) into three components: the negative of long-term expected dividend growth, the subjective risk premium component, and the mispricing term. Finally, we regress dividend/earnings yield and each of its components on inflation. Inflation (πₜ) is proxied either by the PPI-based inflation measure (PPI_INF) or by the 10-year bond yield (Rbond). We use the same sample data as in Campbell and Vuolteenaho (2004), with the sample period from 1927 to 2002 (303 quarterly data points). The t-statistics in parentheses are adjusted for autocorrelation using the Newey-West correction with three lags.

Panel A: Replication of Campbell and Vuolteenaho’s results

<table>
<thead>
<tr>
<th></th>
<th>Coeff. on πₜ</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>dyₜ</td>
<td>2.87</td>
<td>0.044</td>
</tr>
<tr>
<td>(1.73)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-\sum \rho_{t} E(\Delta d_{t+i}^e))</td>
<td>-11.63</td>
<td>0.944</td>
</tr>
<tr>
<td>(-33.83)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>γλₜ</td>
<td>-1.12</td>
<td>0.119</td>
</tr>
<tr>
<td>(-3.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>εₜ</td>
<td>15.65</td>
<td>0.745</td>
</tr>
<tr>
<td>(13.29)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Panel B: Robustness check using the 10-year bond yield rather than the PPI-based measure.

<table>
<thead>
<tr>
<th></th>
<th>Coeff. on πₜ</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>dyₜ</td>
<td>-2.63</td>
<td>0.029</td>
</tr>
<tr>
<td>(-1.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-\sum \rho_{t} E(\Delta d_{t+i}^e))</td>
<td>7.93</td>
<td>0.872</td>
</tr>
<tr>
<td>(23.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>γλₜ</td>
<td>-8.04</td>
<td>0.457</td>
</tr>
<tr>
<td>(-11.02)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>εₜ</td>
<td>-2.50</td>
<td>0.060</td>
</tr>
<tr>
<td>(-2.57)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Panel C: Robustness check, repeating Panel A analysis for subperiods.

<table>
<thead>
<tr>
<th></th>
<th>1927-1950</th>
<th>1951-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff. on $\pi_t$</td>
<td>$R^2$</td>
</tr>
<tr>
<td>$dy_t$</td>
<td>0.845 (0.70)</td>
<td>0.004</td>
</tr>
<tr>
<td>$-\sum \rho^i E(\Delta d_{t+i})^e$</td>
<td>-34.081 (-69.79)</td>
<td>0.992</td>
</tr>
<tr>
<td>$\gamma^\lambda_t$</td>
<td>2.880 (1.96)</td>
<td>0.109</td>
</tr>
<tr>
<td>$\epsilon_t$</td>
<td>32.010 (13.79)</td>
<td>0.871</td>
</tr>
</tbody>
</table>

Panel D: Robustness check using earnings yield rather than dividend yield

<table>
<thead>
<tr>
<th></th>
<th>Coeff. on $\pi_t$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$dy_t$</td>
<td>7.476 (5.56)</td>
<td>0.340</td>
</tr>
<tr>
<td>$-\sum \rho^i E(\Delta d_{t+i})^e$</td>
<td>10.023 (37.03)</td>
<td>0.958</td>
</tr>
<tr>
<td>$\gamma^\lambda_t$</td>
<td>-1.852 (-3.05)</td>
<td>0.119</td>
</tr>
<tr>
<td>$\epsilon_t$</td>
<td>-0.723 (-0.89)</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Panel E: Robustness check using 5-year moving average earnings yield (EP5 in Campbell and Vuolteenaho, 2004) rather than dividend yield

<table>
<thead>
<tr>
<th></th>
<th>Coeff. on $\pi_t$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$dy_t$</td>
<td>2.409 (1.13)</td>
<td>0.037</td>
</tr>
<tr>
<td>$-\sum \rho^i E(\Delta d_{t+i})^e$</td>
<td>-8.646 (-36.89)</td>
<td>0.958</td>
</tr>
<tr>
<td>$\gamma^\lambda_t$</td>
<td>-1.254 (-3.05)</td>
<td>0.119</td>
</tr>
<tr>
<td>$\epsilon_t$</td>
<td>12.31 (6.83)</td>
<td>0.611</td>
</tr>
</tbody>
</table>
The one-year forward earnings yield is constructed from the I/B/E/S sample of firms with non-missing analysts’ earnings forecasts and market value of equity in I/B/E/S. The sample period is from 1977:2 to 2002:04 (105 quarterly data points). We follow Campbell and Vuolteenaho (2004) by running a VAR model and decomposing the forward earnings yield \( (fey) \) into three components: the negative of long-term expected dividend growth, the subjective risk premium component, and the mispricing term. Finally, we regress the earnings yield and each of its components on inflation. Inflation \( (\pi_t) \) is proxied either by the PPI-based inflation measure \( (PPI_{INF}) \) or by the 10-year bond yield \( (R_{bond}) \). The t-statistics in parentheses are adjusted for auto-correlation using the Newey-West correction with three lags.

<table>
<thead>
<tr>
<th>The PPI-based inflation measure</th>
<th>Coeff. on ( \pi_t )</th>
<th>( R^2 )</th>
<th>The 10-year bond yield</th>
<th>Coeff. on ( \pi_t )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( fey_t )</td>
<td>14.64 ( (12.40) )</td>
<td>0.833</td>
<td>14.40 ( (12.46) )</td>
<td>0.720</td>
<td></td>
</tr>
<tr>
<td>(- \sum_{i} \rho^i E(\Delta d_{t+i}</td>
<td>e) )</td>
<td>16.93 ( (28.18) )</td>
<td>0.962</td>
<td>12.72 ( (17.07) )</td>
<td>0.805</td>
</tr>
<tr>
<td>( \gamma \lambda_t )</td>
<td>-0.96 ( (-2.85) )</td>
<td>0.224</td>
<td>-0.218 ( (-2.94) )</td>
<td>0.246</td>
<td></td>
</tr>
<tr>
<td>( \epsilon_t )</td>
<td>-1.33 ( (-2.46) )</td>
<td>0.145</td>
<td>1.897 ( (4.77) )</td>
<td>0.322</td>
<td></td>
</tr>
</tbody>
</table>
Panel A plots the time-series of the mispricing component of log dividend yield and the fitted value from regressing the mispricing term on inflation. Panel B plots the time-series of the negative of expected dividend growth and the fitted value from regressing the dividend growth component on inflation. The mispricing component and the negative of expected dividend growth are based on the VAR model using the PPI-based inflation measure (Table 6 Panel A).
Figure 2
Expected dividend growth, mispricing, and inflation
-- The VAR model on dividend yield and the 10-year bond yield

Panel A plots the time-series of the mispricing component of log dividend yield and the fitted value from regressing the mispricing term on inflation. Panel B plots the time-series of the negative of expected dividend growth and the fitted value from regressing the dividend growth component on inflation. The mispricing component and the negative of expected dividend growth are based on the VAR model using the 10-year bond yield (Table 6, Panel B).

Panel A: Mispricing and inflation

Panel B: The negative of expected dividend growth and inflation
Figure 3
Relation between two proxies for expected inflation:
PPI-based inflation measure \( (PPI_{INF}) \) and the 10-year bond yield \( (R_{bond}) \)
Based on 303 quarterly data points, from 1927:2 to 2002:4.