Abstract

We examine two hypotheses to explain stock mispricing: (a) the money illusion hypothesis (Modigliani and Cohn (1979)) and (b) the resale option hypothesis (Scheinkman and Xiong (2003)). We find that the money illusion hypothesis may explain the level, but not the volatility of mispricing in the US market. By contrast, the stock resale option hypothesis, which stems from heterogeneous beliefs about future dividend growth rates and short-sales constraints, can explain both the level and the volatility of mispricing. The evidence suggests that while the two hypotheses complement each other in explaining the level of mispricing, the resale option hypothesis provides a more coherent explanation for asset price bubbles, in which extraordinarily high price levels are often accompanied by excessive volatility and frenzied trading.

JEL classification: E31, E44, G12, G14

Keywords: stock mispricing, overconfidence, heterogeneous beliefs, resale option, money illusion, short-sales constraints, share turnover, implied volatility differential, asset price bubbles
I. Introduction

To what extent stock prices reflect their fundamental value is a question that has challenged investors as well as academics for decades. Fama (1970) proposes the efficient market hypothesis, in which prices fully reflect available information. Later, Shiller (1981) finds evidence that stock price volatility appears to be far too high to be attributed to new information about future dividends. De Bondt and Thaler (1985) find evidence that the stock market as a whole tends to overreact to dramatic news events, leading them to propose the overreaction hypothesis, as an alternative to the efficient market hypothesis.

Summarizing his view on this issue, Campbell (2000, p. 1557-1558) wrote “It is unrealistic to hope for a fully rational, risk-based explanation of all the empirical patterns...A more reasonable view is that rational models of risk and return describe a long-run equilibrium toward which financial markets gradually evolve.” In this context, the long-run value of a stock may be considered its fundamental value component, while the part of the stock price that deviates from the long-run value is its mispricing component.

In this paper, we ask what might explain stock market mispricing. In the valuation framework of discounted dividend models (e.g., Campbell and Shiller (1988)), fundamental value is determined by objective expectations of future dividend growth rates and future discount rates, given observed data. Under the rational expectations paradigm, all investors’ subjective probability measures are assumed to coincide with corresponding objective measures and hence, by construction, there is no mispricing. In this study, we relax this assumption and consider the possibility that investors are not fully rational. Under the limits of arbitrage (Shleifer and Vishny (1997)), stock mispricing can arise to reflect such irrational beliefs.

We formalize investor irrationality into two alternative hypotheses—money illusion and resale option—to explain stock mispricing. Modigliani and Cohn (1979) propose the money illusion hypothesis; that is, investors suffer from money illusion by discounting real dividends at nominal interest rates. This error leads to an inflation-induced mispricing such that stock prices are above (below) the stock’s underlying fundamental value when expected inflation is low (high). Following Harrison and Kreps (1978), Scheinkman and Xiong (2003) propose the resale option hypothesis, which states that differences of opinion about future dividend growth rates, together with short-sales constraints, create a situation where stock prices are higher than even
the most optimistic investor’s assessment of their fundamental value. This causes a bubble in stock prices. Mei, Scheinkman, and Xiong (2005) show that this hypothesis can explain Chinese A–B share premia.

We test the resale option hypothesis for the US stock market with a more general framework based on Campbell and Shiller’s (1988) dynamic valuation model. In this framework, we separate the fundamental value component from the mispricing component and examine to what extent the mispricing component can be explained by the resale option hypothesis. According to Scheinkman and Xiong (2003), the resale option hypothesis predicts that both the level and the volatility of mispricing are positively related to heterogeneous beliefs, as manifested in share turnover. Along with share turnover, we use the implied volatility differential (IVD) between out-of-the-money and at-the-money S&P 500 put options as a proxy for heterogeneous beliefs in our empirical analysis. To our knowledge, we are the first to employ the Campbell-Shiller framework to test the resale option hypothesis for the US stock market.

We employ S&P 500 index data both for the quarterly sample (1962–2004) and the monthly sample (1926–2004) to conduct our empirical analysis. Our results show that the level of mispricing is positively related to both share turnover and IVD, and negatively related to inflation expectations. These results suggest that the two hypotheses complement each other in explaining the level of mispricing. However, our results also show that while mispricing volatility is positively related to share turnover and IVD, it is not related to inflation expectations. Thus, the differential influence on mispricing volatility suggests that the resale option hypothesis may provide a more coherent explanation for asset price bubbles, in which extraordinary price levels are often accompanied by excess volatility and frenzied trading.

This paper proceeds as follows. Section II introduces two hypotheses to explain stock mispricing. Section III discusses the methodologies employed in our empirical analysis. Section IV describes the data and proxies for heterogeneous beliefs. Section V presents the main empirical results. Section VI reports a variety of robustness tests. Section VII concludes.

II. Explaining Stock Mispricing

We follow the approach of Brunnermeier and Julliard (2007) to define mispricing. That is, we adopt Campbell and Shiller’s (1988) dynamic valuation model (ignoring a constant term)
for the price-dividend ratio, but allow investors to have subjective (possibly distorted) probability measures. The mispricing term, denoted by $\varepsilon_t$, is defined as the difference between the realized price-dividend ratio, denoted by $p_t - d_t$, given investors’ subjective probability measures, and the estimated price-dividend ratio (i.e., the “fundamental value” component), $\hat{p}_t - \hat{d}_t$, based on objective probability measures consistent with available information, i.e.,

$$
\begin{align*}
    p_t - d_t &= \sum_{t=1}^{\infty} \rho^{-t} E_t^{S}(\Delta d_{t+\tau}^e - r_{t+\tau}^e), \quad \hat{p}_t - \hat{d}_t = \sum_{t=1}^{\infty} \rho^{-t} E_t(\Delta d_{t+\tau}^e - r_{t+\tau}^e), \\
    \varepsilon_t &= (p_t - d_t) - (\hat{p}_t - \hat{d}_t),
\end{align*}
$$

where the constants $\rho = 1/(1 + \exp(\bar{d} - \bar{p}))$; $\bar{d} - \bar{p}$ denotes the average log dividend-price ratio for the period; $\Delta d$ denotes log dividend growth rate; $r$ denotes log stock return; $\Delta d^e$ denotes $\Delta d$ less the log risk-free rate for the period; $r^e$ denotes $r$ less the log risk-free rate. To distinguish differences in expectations, we use $E$ as the objective expectation operator, and $E^S$ as the subjective expectation operator. Below we consider two hypotheses to explain the mispricing measure, $\varepsilon_t$, in stock markets.

A. Money Illusion Hypothesis

Modigliani and Cohn (1979) propose the money illusion hypothesis, which holds that investors discount real dividends by nominal discount rates, but fail to recognize that an increase in expected inflation also leads to an increase in the nominal dividend growth rate. Denoted by $\pi_t$, inflation at time $t$, investors’ subjective expectations under the money illusion hypothesis may be written as

$$
E_t^S(\Delta d_{t+\tau}^e - r_{t+\tau}^e) = E_t(\Delta d_{t+\tau}^e - r_{t+\tau}^e - \pi_{t+\tau}), \text{ for } \tau = 1, 2, \ldots
$$

Thus, the money illusion hypothesis implies that mispricing is given by

$$
\begin{align*}
    \varepsilon_t &= \sum_{t=1}^{\infty} \rho^{-t} (E_t^S - E_t)(\Delta d_{t+\tau}^e - r_{t+\tau}^e) = -\sum_{t=1}^{\infty} \rho^{-t} E_t(\pi_{t+\tau}),
\end{align*}
$$

3
where \((E^S_r - E_r)(x) \equiv E^S_r(x) - E_r(x)\). Equation (3) indicates that the mispricing measure, \(\epsilon_r\), is negatively related to expected inflation.\(^1\) Thus, the money illusion hypothesis yields a testable implication that the mispricing, \(\epsilon_r\), and the price-dividend ratio, \(p_r - d_r\), both decrease with expected inflation. Basak and Yan (2007) examine the money illusion hypothesis in a general equilibrium model and obtain the same prediction that the price-dividend ratio, \(p_r - d_r\), is negatively related to expected inflation when investors are sufficiently risk averse. The money illusion hypothesis has been used to explain stock mispricing in various contexts (Ritter and Warr (2002), Campbell and Vuolteenaho (2004), Cohen, Polk, and Vuolteenaho (2005), and Chordia and Shivakumar (2005)).

B. Resale Option Hypothesis

Scheinkman and Xiong (2003) propose the resale option hypothesis to explain stock mispricing or speculative bubbles. They argue that investors have heterogeneous, subjective probability measures for dividend growth rates. Such subjective beliefs may stem from investor overconfidence in their own private signals (Kyle and Wang (1997), Wang (1998), and Daniel, Hirshleifer, and Subrahmanyam (1998)). To capture such differences in opinion, it is sufficient to consider two heterogeneous groups of investors, A and B, such that each group’s subjective expectations of dividend growth rates may be written as

\[
E^A_t(\Delta d^e_{t+\tau}) = E_t(\Delta d^e_{t+\tau} + f^A_{t+\tau}); \quad E^B_t(\Delta d^e_{t+\tau}) = E_t(\Delta d^e_{t+\tau} + f^B_{t+\tau}), \quad \text{for } \tau = 1, 2, \ldots,
\]

where \(f^A_{t+\tau}\) and \(f^B_{t+\tau}\) represent the subjective components of the dividend growth rates for groups A and B, respectively. Furthermore, consider that these investors are also subject to short-sales constraints (Miller (1977) and Chen, Hong, and Stein (2002)). Such short-sales constraints imply that only the opinion of the owner group is prominently reflected in the market. This means that the identity of the owner group may switch between the two groups, A and B, depending on which group is relatively more optimistic. Hence, the subjective expectations of the dividend growth rate for the owner group, denoted by \(E^o_r\), may be written as

\[^1\] It appears that money illusion causes only a negative mispricing error, \(\epsilon_r\), in (3). But this is not true if investors have a reference level of inflation as noted in Brunnermeier and Julliard (2007). In that case, the relevant inflation term in (3) is the deviation of inflation expectations from the reference level, and hence the mispricing error can be either positive or negative. In our analysis, we do use a demeaned measure for inflation expectations.
Thus, the resale option hypothesis implies that the mispricing is given by

\[
\varepsilon_t = \sum_{r=1}^{\infty} \rho^{r-1} (E_t^{\infty} - E_t)(\Delta d_{t+r} - \hat{d}_{t+r}) = \sum_{r=1}^{\infty} \rho^{r-1} E_t(\max(f_{t+r}^A, f_{t+r}^B))
\]

Equation (6) highlights that the mispricing measure, \( \varepsilon_t \), captures the more optimistic belief, i.e., \( \max(f_{t+r}^A, f_{t+r}^B) \), or “excess optimism” about future dividend growth rates. Both Scheinkman and Xiong (2003) and Hong, Scheinkman, and Xiong (2006) show that such excess optimism causes greater share turnover and gives rise to a “resale option” value, which reflects an upward bias that the owner group is willing to pay above their fundamental value. Furthermore, they also show that such excess optimism leads to greater mispricing volatility or “excess” volatility, denoted by \( \sigma_\varepsilon \).

Dumas, Kurshev, and Uppal (2005) extend the work of Scheinkman and Xiong (2003) into a general equilibrium model of sentiment and show that such “excess optimism” can indeed lead to excess volatility in stock prices. The resale option hypothesis thus yields two related testable implications that both the level of mispricing (\( \varepsilon_t \)) and the volatility of mispricing (\( \sigma_\varepsilon \)) increase with the degree of heterogeneous beliefs among investors, which are manifested by share turnover. To our knowledge, this paper is the first to test both these predictions of the resale option hypothesis for the US stock market.

### III. Empirical Methodology

In this section, we describe the basic VAR model that is used to decompose the realized log price-dividend ratio, \( p_t - d_t \), into the estimated log price-dividend ratio (i.e., the fundamental value component), \( \hat{p}_t - \hat{d}_t \), and the mispricing component, \( \varepsilon_t \). We then discuss our regression models used to test the two hypotheses.

#### A. First Pass Analysis: the VAR Model

Following previous studies (Campbell and Shiller (1988), Campbell (1991), and Campbell and Voulteenaho (2004)), we use a reduced form VAR model to obtain the
fundamental value component of the log price-dividend ratio and thereby to extract the corresponding mispricing component. Specifically, we employ a VAR system with four variables, all of which are demeaned: (a) the log price-dividend ratio \( p_t - d_t \); (b) the excess log dividend growth rate, \( \Delta d_t^e \);\(^2\) (c) the excess log return, \( r_t^e \); and (d) the smoothed moving average of inflation, \( \pi_t \).\(^3\)

Given the estimated parameters of the VAR model, we calculate the estimated log price-dividend ratio, \( \hat{p}_t - \hat{d}_t \), as follows,

\[
\hat{p}_t - \hat{d}_t = \sum_{t=1}^{\infty} \rho^{t-1} \hat{E}_t(\Delta d_{t+\tau}^e) - \sum_{t=1}^{\infty} \rho^{t-1} \hat{E}_t(r_{t+\tau}^e),
\]

where the discounted expected excess log dividend growth rates, \( \sum_{t=1}^{\infty} \rho^{t-1} \hat{E}_t(\Delta d_{t+\tau}^e) \), and the discounted expected excess log stock returns, \( \sum_{t=1}^{\infty} \rho^{t-1} \hat{E}_t(r_{t+\tau}^e) \), are computed using the estimated parameters of the VAR model. The mispricing term, \( \varepsilon_t \), is obtained as the difference between the realized log price-dividend ratio, \( p_t - d_t \), and the estimated log price-dividend ratio, \( \hat{p}_t - \hat{d}_t \).

**B. Second Pass Regression Analysis**

The money illusion hypothesis suggests that the level of mispricing (\( \varepsilon \)) is negatively related to expected inflation. Following Campbell and Vuolteenaho (2004), we use the smoothed moving average of inflation (\( \pi \)) to measure expected inflation. The resale option hypothesis suggests that both the level of mispricing (\( \varepsilon \)) and the volatility of mispricing (\( \sigma_{\varepsilon} \)) are positively related to the degree of heterogeneous beliefs among investors. We use two proxies for the level of heterogeneous beliefs among investors: (a) share turnover, \( \text{Turnover} \), and (b) implied volatility.

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2 Since raw dividend data exhibit seasonality, we adjust the raw dividend growth rate for seasonality. To diagnose seasonality in the raw data, we employ autocorrelation diagnoses, the stable seasonality test, the moving seasonality test, and the joint test. All test results confirm the presence of seasonality in the raw dividend data. Without losing the economic meaning of the dividend growth rate, we replace the raw dividend growth rate with a simple moving average of the dividend growth rate using the past four quarterly dividends. After this adjustment, we perform all diagnoses and tests for seasonality again, and find that the adjusted dividend growth rate no longer exhibits seasonality. To save space, we do not report the test results here but they are available upon request. We thank the reviewer for suggesting the seasonality adjustment.

3 The inflation variable is exponentially smoothed using 12-month lags. The 3-month log T-bill rate is used to compute the excess log return and the excess log dividend growth rate.
differential, \textit{IVD} (i.e., the SPX put volatility smirk). The rationales and measurements for these two proxies are detailed in Section IV below.

Specifically, we compare the two hypotheses in explaining the level of mispricing based on the following regression model

\begin{align}
\epsilon_t &= \alpha + \beta_1 \cdot \text{Turnover}_t + \beta_2 \cdot \text{IVD}_t + \beta_3 \cdot \pi_t + \epsilon_t.
\end{align}

The resale option hypothesis implies that the coefficients of the heterogeneous beliefs measures are positive; that is, $\beta_i > 0$ $(i = 1, 2)$. By contrast, the money illusion hypothesis implies that the coefficient of the inflation measure is negative; that is, $\beta_3 < 0$. The two hypotheses need not be mutually exclusive in explaining the level of mispricing.

Likewise, we compare the two hypotheses in explaining the volatility of mispricing based on the following regression model

\begin{align}
\sigma_{\epsilon_t} &= \alpha + \gamma_1 \cdot \text{Turnover}_t + \gamma_2 \cdot \text{IVD}_t + \gamma_3 \cdot \pi_t + \mu_t.
\end{align}

The mispricing volatility, $\sigma_{\epsilon_t}$, is the conditional volatility of the mispricing measure, $\epsilon_t$, derived from a GARCH(1,1) model. The resale option hypothesis implies that mispricing volatility reflects differences of opinion and that the coefficients of the heterogeneous beliefs measures are positive; that is, $\gamma_j > 0$ $(j = 1, 2)$. The original money illusion hypothesis does not yield any specific prediction for the coefficient of the inflation measure, $\gamma_3$. It is conceivable, however, that the source of heterogeneous beliefs may be inflation expectations (e.g., Piazzesi and Schneider (2007)). As such, by including the inflation variable along with turnover and \textit{IVD} in the regression, we may partially control for this alternative source of heterogeneous beliefs.

High price levels, excess volatility, and concurrent frenzied trading are the most salient characteristics of historical episodes of asset price bubbles. By testing the two hypotheses for both the level and the volatility of mispricing, we may gauge their usefulness as a unified framework to explain the asset price bubble phenomenon.

IV. Data

A quarterly data sample for the period 1962–2004 forms the foundation of our empirical analysis, although we also employ monthly data for the period 1926–2004 for a robustness test. Specifically, for each component stock of the S&P 500, quarterly data on price, dividend, trading
volume, and shares outstanding are obtained from CRSP and COMPUSTAT for the period 1962–2004. Corresponding SPX options data are obtained from the Time and Sales database provided by the Chicago Mercantile Exchange for the period 1990–2004. Inflation rates and 3-month T-bill rates are obtained from the Federal Reserve Bank of St. Louis.

A. Share Turnover

We use share turnover as our first proxy for heterogeneous beliefs, following Scheinkman and Xiong (2003), who suggest that greater heterogeneous beliefs lead to more frequent trading and thereby a higher turnover rate. In addition, this measure is consistent with previous models of overconfidence (Shefrin and Statman (1994), Kyle and Wang (1997), Wang (1998), and Odean (1998)) and differences of opinion (Harris and Raviv (1993)).

Specifically, we employ a value-weighted approach to estimate the quarterly S&P 500 Index turnover ratio using all component stocks in the index

\[
\text{Turnover Ratio}_t = \frac{\sum_{n=1}^{500} \text{Volume}_{n,t} \times \text{MV}_{n,t}}{\sum_{n=1}^{500} \text{MV}_{n,t}},
\]

where \(\text{Volume}_{n,t}\) is the trading volume, \(\text{Shares}_{n,t}\) is the total shares outstanding, and \(\text{MV}_{n,t}\) is the market value for stock \(n\) at time \(t\). Similar to the procedure used by Campbell and Voulteenaho (2004) to construct the smoothed inflation measure, the turnover ratio is exponentially smoothed using 12 monthly lags. The smoothed measure is further detrended to eliminate any additional trend influence to arrive at the new turnover ratio, denoted \(\text{Turnover}\).

B. Implied Volatility Differential (IVD)

We use the Implied Volatility Differential (IVD) between out-of-the-money (OTM) and at-the-money (ATM) SPX put options (i.e., the S&P put volatility smirk) as our second proxy for heterogeneous beliefs among investors. Similar proxies based on the options literature are

\[\text{IVD} = \text{IV}_{	ext{OTM}} - \text{IV}_{	ext{ATM}}\]

\footnote{The Chicago Mercantile Exchange started recording tick-by-tick trading in S&P 500 Futures Index options in 1987. However, because of a change of record format in 1990, we employ data beginning in 1990 to ensure data consistency.}

\footnote{The volatility smirk in index options markets refers to the phenomenon that implied volatilities are negatively related to option exercise prices. The literature has shown that, for SPX index options, OTM put options have greater implied volatility than ATM put options.}
used in previous studies (e.g., De Bondt (1993), Shefrin (1999), Bollen and Whaley (2004), and Buraschi and Jiltsov (2006)). The literature suggests that the SPX put volatility smirk is an effective proxy for heterogeneous beliefs between investors.

Specifically, we first calculate the difference between the implied volatility of the OTM SPX put, denoted $IV_{OTM}$, and the implied volatility of the ATM SPX put, denoted $IV_{ATM}$. Note however that the implied volatility of each options contract may co-move with overall market volatility. To mitigate this effect, we scale the difference using the Chicago Board Options Exchange volatility index, VIX, and the resulting scaled measure, IVD, is given by

$$IVD = \frac{IV_{OTM} - IV_{ATM}}{VIX}.$$  

Implied volatility is estimated based on Black (1976). Similar to Bollen and Whaley (2004), ATM and OTM are defined as options with a delta measure between –0.45 and –0.55 and between –0.02 and –0.45, respectively. Both options have 6-month remaining maturities. The data of IVD are available only from the first quarter of 1990 to the last quarter of 2004. This limited data availability confines our analysis of the effect of the IVD to this sub-period.

V. Empirical Results

A. Decomposition of the Price-dividend Ratio

As described in III.A, we first estimate a four-variable VAR model using lagged $pd$, $\Delta d^e$, $r^e$, and $\pi$ as independent variables. Table 1 reports the regression output of the VAR model. The first row reports the results of the log price-dividend ratio. Both lagged $pd$ and $\pi$ Granger cause $pd$. Lagged $pd$ is positive and significant at the 1% level. The near unity parameter suggests persistency in dividend yield. Lagged inflation carries a negative sign and is

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6 We also classify options into different maturities (1 month, 2 months, and 3 months). Test results using these differing maturities are qualitatively similar.

7 Despite the advantage of the put volatility smirk in capturing heterogeneous beliefs, we construct a new IVD to incorporate the remote possibility that index calls may also play a role in the measurement of heterogeneous beliefs. Specifically, we define a new IVD as the sum of the volatility smirk of the index puts and the index calls, again scaled by VIX. Our empirical results are qualitatively similar, albeit slightly weaker, perhaps due to the dilution effect of index calls as bulls can always bet in the underlying stock markets, thus diluting the call’s ability to capture heterogeneous beliefs.

8 Based on Bayesian information criteria and consistent with Campbell and Vuolteenaho (2004), we employ one lag in the VAR model. A three-lag VAR is also investigated and reported in Section V.
significant at the 5% level. The model explains almost 97% of the variations in log price-dividend ratio. The second row shows that past excess log dividend growth Granger causes excess log dividend growth. The model explains 42% of the variations in excess log dividend growth. The third row shows regression results of the excess log return equation. The low $R^2$ value is consistent with the notion that stock returns are hard to predict. Lagged log price-dividend ratio, $p – d$, is the only variable that is statistically significant (at the 5% level). Finally, the fourth row reports results for the inflation equation. Lagged stock return and inflation Granger causes inflation. The model explains almost 91% of the variations in inflation.

Once the VAR model is estimated, we decompose the realized log price-dividend ratio into the estimated log price-dividend ratio (i.e., the fundamental value component), and the mispricing component. The demeaned decomposition result based on the quarterly S&P 500 index sample from 1962 to 2004 is plotted in Figure 1. Relative to fundamental value, the stock market was fairly priced before the 1974 oil embargo, undervalued during the double-digit inflation era, fairly priced again from the mid-1980s to the mid-1990s, but increasingly overvalued after 1996, until the market crashed at its peak around March 2000. After the crash and until 2004, the market remained overvalued, albeit with a decreasing magnitude. Figure 1 also indicates that substantial variation in the price-dividend ratio is driven by variation in the mispricing component, whereas the fundamental value component is comparatively smooth.

B. Unit Root Test and Shifting Steady-State

Although Campbell and Vuolteenaho (2004) do not address the issue of persistency, we treat this problem in this subsection. Following Campbell and Vuolteenaho, we first demean mispricing and share turnover and further detrend the share turnover to mitigate the potential issue of persistency. We then conduct unit root tests on mispricing, mispricing volatility, share turnover, inflation, and IVD to detect whether these variables are stationary. Shocks to these variables are likely to produce transitory (permanent) effects if the variables are stationary (nonstationary). An augmented Dicky– Fuller (ADF) test is used for this purpose. The MacKinnon critical value for rejection of a unit root hypothesis is –2.88 at the 5% confidence level. For the longer sample (1962–2004), we find that all variables are stationary except mispricing and share turnover, which have ADF test statistics of –2.38 and –1.97, respectively.
For the shorter sample (1990–2004), both mispricing and share turnover remain nonstationary with ADF test statistics of −1.90 and −1.038, respectively.

A classic, econometric method of converting these series into stationary ones is to use the first or second difference of these variables. This approach, however, alters the meaning of mispricing and share turnover, and hence would make the economic interpretation of our results very difficult. A direct comparison of our results with prior studies would also not be possible. Therefore, we consider Lettau and Nieuwerburgh’s (2007) shifting steady-state approach. Lettau and Nieuwerburgh argue that the controversial evidence for stock return predictability using financial ratios can be reconciled if the assumption of a fixed steady-state mean of the economy is relaxed. According to their argument, although financial ratios are nonstationary, deviations in such ratios from their steady-state means are stationary. Financial ratios adjusted for shifting steady-state are less persistent and volatile than unadjusted ones.

Adopting the Lettau and Nieuwerburgh (2007) approach, we first test for the shift of steady-state using the methodology of Bai and Perron (1998, 2003, 2004), which allows for testing unknown structural breaks for time series. Test results are reported in Table 2. Because only mispricing and share turnover exhibit nonstationarity, they are subject to the structural break test and must be adjusted for shifting steady-state. UDmax tests the null hypothesis of no structural breaks against the alternative hypothesis of an unknown number of structural breaks (with an upper bound of five breaks). Because UDmax is statistically significant at the 1% level, the null hypothesis of no structural breaks is rejected.

Following Bai and Perron (2004), we determine the number of breaks based on $SupF(i+1|i)$ statistics with the largest value of $i$ that rejects the null. For the longer sample (1962–2004), both mispricing and turnover display three breaks (or four regimes). Mispricing exhibits regime shifts in June 1973, December 1982, and December 1995, whereas turnover shows similar breakpoints in March 1974, December 1982, and March 1996. For the shorter sample (1990–2004), two breaks (or three regimes) are detected. Mispricing shows regime shifts in September 1994 and December 1996, whereas turnover shows in June 1995 and December 1998. With the number of steady-states determined, we follow Lettau and Nieuwerburgh (2007) to subtract the respective steady-state means from the row data of each series for further analysis. To ensure that the demeaned series are now stationary, we rerun the unit root test for these steady-state adjusted data. After the adjustment, all variables are now stationary. For example,
the ADF test statistics of mispricing and turnover in the longer sample are now –9.08 and –7.29, respectively, both of which are well below the critical value of –3.47 at the 1% level.

C. Mispricing, Inflation, and Heterogeneous Beliefs

In this subsection, we show the effects of inflation and heterogeneous beliefs on the level of mispricing. Before presenting the regression results, it is useful to visualize the relation between the dependent variable (mispricing) and two independent variables (turnover and inflation). To this end, Figure 2 plots quarterly time-series data for mispricing, turnover, and inflation for the period 1962–2004. The figure shows that turnover generally moves in tandem with the mispricing measure, whereas inflation moves in the opposite direction. Because the data series are demeaned, the positive turnover shown for the periods before 1970, briefly around 1987, and post-1998 indicate heavier trading during these periods. The surge in trading around 1987 and after 1998 coincided with the 1987 stock market crash, and the Internet bubble trading frenzy, respectively. Although inflation exhibited a strong negative relation with mispricing for most time periods, this relation has substantially diminished since the 1990s.

Table 3 reports the results of the effects of inflation and heterogeneous beliefs on the level of mispricing based on steady-state adjusted data. All \( t \) statistics reported are White heteroskedasticity-consistent. In Panel A, in which the longer sample (1962–2004) is used, rows 1 and 2 show the results from regressions of mispricing (\( \varepsilon \)) on inflation (\( \pi \)) and turnover, respectively. Consistent with the money illusion hypothesis, inflation carries the expected negative sign and is statistically significant at the 1% level. Similarly, turnover exhibits a positive relation with mispricing and is statistically significant at the 1% level, which is consistent with the prediction of the resale option hypothesis. The univariate results hold even when both inflation and turnover are included in the same regression as shown in row 3. The multivariate result suggests the coexistence of money illusion and resale option effects on mispricing. In this regard, Figure 2 indicates that inflation fits the data well for the 1970s and 1980s, but share turnover plays a more important role during the Internet bubble period. Thus, taken together, the two hypotheses complement each other in explaining mispricing level.

9 Time-series data in Figures 2, 3, and 4 are rescaled for better view.
Table 3, Panel B reports results for a more recent time period (1990–2004), when options implied volatility data are available. Rows 1 to 3 report a univariate analysis, where inflation (\(\pi\)), turnover, and IVD each enters the regression as an independent variable. While both measures of heterogeneous beliefs still carry the expected signs and are statistically significant at the 5% level or better, the ability of inflation to explain mispricing level becomes insignificant. The multivariate regression results reported in row 4 are very similar to the univariate results, in which turnover and IVD continue to be highly significant, and the inflation effect continues to be weak. Note from the adjusted \(R^2\) value that IVD is the most influential explanatory variable in the shorter sample—alone, it explains 13% of the variation in mispricing. These results lend support to the resale option hypothesis in explaining stock mispricing. Although the inflation hypothesis works well in the longer sample, it fails to explain the mispricing in the more recent Internet bubble period.

D. Mispricing Volatility, Inflation, and Heterogeneous Beliefs

In this subsection, we examine the effects of inflation and heterogeneous beliefs on the volatility of mispricing. Before presenting the regression results, again, it is useful to visualize the relation between the dependent variable (mispricing volatility) and two independent variables (turnover and inflation). To this end, Figure 3 plots the quarterly time-series data of mispricing volatility, turnover, and inflation, respectively. The figure shows that mispricing volatility was actually quite stable from 1962 to the early 1970s. After the 1974 oil embargo, mispricing volatility increased significantly and continued into the double-digit inflation era. Mispricing volatility was mild again from the early 1980s to the mid-1990s. Since late 1996, mispricing volatility has increased drastically and coincided with the Internet bubble trading frenzy. Volatility peaked around 2000 when the bubble burst. Inflation tracked mispricing volatility well during the periods of double-digit inflation, but failed to display a coherent relationship during other periods. Turnover generally moves in tandem with mispricing volatility, especially during the more recent decades.

Table 4 reports the results of the effects of inflation and heterogeneous beliefs on the volatility of mispricing based on steady-state adjusted data. All \(t\) statistics reported are White heteroskedasticity-consistent. Panel A shows test results using the longer sample (1962–2004).
Both univariate and multivariate analyses show that turnover displays a positive and significant relation with mispricing volatility, consistent with the prediction of the resale option hypothesis. Inflation, however, does not show a significant relation with mispricing volatility. Table 4, Panel B presents the results using the shorter sample (1990–2004), when the data of IVD are available.

The first three rows report the results of univariate analysis where each independent variable enters the regression separately. Compared with the results from the longer sample, during this period the impact of turnover on mispricing volatility is substantially weakened. The IVD, nevertheless, is positive and significant at the 1% level, consistent with the prediction of the resale option hypothesis. IVD alone explains almost 13% of the variation in mispricing volatility. The inflation measure ($\pi$), similar to the results in the longer sample, is not statistically significant.

The last row of Table 4, Panel B shows the results of multivariate analysis where inflation ($\pi$) enters the equation with both measures of heterogeneous beliefs. Now both turnover and IVD are positive and significant at the 1% level, and inflation ($\pi$) continues to be insignificant. The results reported in Table 4, therefore, are more consistent with the second prediction of the resale option hypothesis that heterogeneous beliefs on dividend growth can explain mispricing volatility with the predicted sign. By contrast, the money illusion hypothesis does not produce a significant empirical relation in this regard.

To sum up, as in Campbell and Vuolteenaho (2004), the money illusion hypothesis is able to explain the level of stock mispricing. But the resale option hypothesis is better able to provide a more coherent explanation for both the level and the volatility of stock mispricing.\footnote{The results shown thus far are based on static models in which the contemporaneous relation between mispricing and inflation, and heterogeneous beliefs are reported. These static results, however, show only the association between these variables, not the causality between them or their dynamic relations. To examine the dynamic relations, we test models in a multiperiod setting where the VAR model is employed. Impulse response functions and variance decomposition methods are used to trace the path of economic shocks. The dynamic results are generally consistent with the static results reported above. Interestingly, both turnover and IVD, but not inflation Granger cause mispricing level and mispricing volatility. To save space, these results are not reported here but are available upon request.}

VI. Robustness Tests

In this section, we conduct three robustness tests. The impact of time-varying liquidity is incorporated in Subsection A below; Subsection B reports results based on a three-lag VAR
model; and additional evidence based on the monthly data sample for the period 1926–2004 is presented in Subsection C.

A. Time-Varying Liquidity

Although the turnover measure is employed as a proxy for heterogeneous beliefs in our study, it has also been used in the literature as a proxy for time-varying liquidity. Could the positive relation between turnover and mispricing reported herein be driven by time-varying liquidity instead of heterogeneous beliefs? We address this issue by conducting a robustness test for this alternative interpretation.

To do so, we employ proxies of market-wide time-varying liquidity that are relevant for low-frequency data such as ours. In addition, we are mindful about the distinction between liquidity risk and liquidity characteristics (or level of liquidity) in the literature (see, e.g., Hasbrouck (2005)). To this end, we employ two distinct liquidity proxies: (a) Pastor and Stambaugh’s (2003) liquidity risk measure, Gamma, a return reversal measure that captures the association between stock return and lagged order flow; and (b) a liquidity characteristic measure, Gibbs, a Bayesian version of Roll’s (1984) transaction cost measure that captures the bid-ask bounce that is not related to information (Hasbrouck (2005)). Both Gamma and Gibbs are adjusted for sample frequency in our tests.

Specifically, we add the two liquidity measures, Gamma and Gibbs, to control for time-varying liquidity in our empirical tests for the long sample (1962–2004), where turnover is the only measure for heterogeneous beliefs. We rerun our test for the level of mispricing as

\[ e_t = \alpha + \beta_1 \cdot \text{Turnover}_t + \beta_2 \cdot \pi_t + \beta_3 \cdot \text{Gamma}_t + \beta_4 \cdot \text{Gibbs}_t + \epsilon_t. \]

The resale option hypothesis implies that the coefficient of the turnover measure should be positive, \( \beta_1 > 0 \), after controlling for time-varying liquidity. The money illusion hypothesis implies that the coefficient of the inflation measure (\( \pi \)) should be negative, \( \beta_2 < 0 \).

The regression of the volatility of mispricing is also extended as

\[ \sigma_{e,t} = \alpha + \gamma_1 \cdot \text{Turnover}_t + \gamma_2 \cdot \pi_t + \gamma_3 \cdot \text{Gamma}_t + \gamma_4 \cdot \text{Gibbs}_t + \mu_t. \]
The resale option hypothesis implies that the coefficient of the turnover measure is positive, $\gamma_1 > 0$, after controlling for time-varying liquidity. The money illusion hypothesis offers no specific prediction for the coefficient, $\gamma_2$, of the inflation measure.

We report the results of regressions (12) and (13) in Table 5. Panel A shows the results of mispricing level, controlling for time-varying liquidity. Turnover and inflation are paired with each of the two liquidity measures individually in rows 1 and 2. After this control, inflation is still negatively correlated and turnover is still positively correlated with mispricing, and both variables remain statistically significant at the 1% level. In row 3, both measures of liquidity are included in the same regression, and the results show that the basic conclusion reported above remains unchanged. Therefore, the efficacy of both money illusion and resale option hypotheses in explaining the level of stock mispricing is robust after controlling for time-varying liquidity.

Panel B of Table 5 presents the results of excess volatility, controlling for time-varying liquidity. Similar to the arrangement in Panel A, turnover and inflation are first paired with each of the two liquidity measures individually in rows 1 and 2. After controlling for time-varying liquidity effects, turnover remains positive and statistically significant at the 1% level, supporting the resale option hypothesis. Similar to the results reported in Table 4, inflation still fails to explain mispricing volatility. In row 3, both measures of liquidity are included in the same regression, and the conclusions are similar to those reported in the first two rows. Interestingly, Gibbs is significant at the 1% level in both rows 2 and 3. This result is consistent with the finding of Chordia et al. (2000) that volatile stocks post higher inventory risk and hence are less liquid.

In sum, after controlling for time-varying liquidity, the credibility of turnover as a measure of heterogeneous beliefs is upheld and, hence, the marginal contribution of the resale option hypothesis in explaining stock mispricing is strengthened.

**B. Choice of Optimal Lags**

The results reported so far are based on a VAR model estimated with one lag. The choice of one lag is based on Bayesian information criteria (BIC), which happens to be consistent with the models used in Campbell and Shiller (1988) and Campbell and Vuolteenaho (2004). However, Campbell (1991) and Campbell and Mei (1993) note that VAR specification often needs several lags to fully capture this dynamic relationship. In this section, we conduct an
alternative test, Akaike information criteria (AIC), to determine the optimal lags. Each of BIC
and AIC has its own merits, but neither has a clear-cut advantage (Diebold (1998)), although it is
known that BIC will favor a simpler model. Since AIC determines the optimal lag length to be
three, we rerun previous tests based on a three-lag VAR model for a robustness test.

Table 6 presents the test results. In Panel A, rows 1 and 2 show the results from
regressions of mispricing ($\varepsilon$) on inflation ($\pi$) and turnover, respectively. Consistent with the
results of the one-lag VAR model, the results of the three-lag VAR model show that inflation is
negatively correlated, and turnover is positively correlated with mispricing. The same conclusion
holds in a multivariate analysis, shown in row 3, where both inflation ($\pi$) and turnover are
included in the same regression. Comparing Table 6 to Table 3, we find that the adjusted $R^2$
for inflation ($\pi$) drops to 4.33% from 10.34%. The adjusted $R^2$ for multivariate analysis decreases as
well. This result confirms Campbell and Vuoletteenaho’s (2004) finding that adding more lags to
the VAR model produces more noise to the estimates and reduces the explanatory power of
inflation expectations. In Panel B we regress the mispricing volatility ($\sigma_\varepsilon$) on inflation and
turnover. Consistent with the results from the one-lag VAR model, inflation does not explain the
variation in the mispricing volatility, whereas turnover carries the expected positive sign and is
statistically significant at the 1% level in both univariate and multivariate analyses. Thus, the
choice of the optimal number of lags does not alter our conclusion.

C. Results Based on Monthly Data Sample

While our primary results focus on quarterly data in order to maintain comparability with
previous studies, e.g., Campbell and Vuoletteenaho (2004), we now repeat our analysis using
monthly data for additional evidence and robustness check. To this end, we obtain the S&P 500
monthly data from CRSP for the period 1926–2004. The VAR model for the monthly data is
estimated with 3 lags according to Bayesian information criteria. Since our quarterly data sample
covers the period 1962–2004, by extending the monthly sample back to 1926, we essentially
perform a back-test to further validate our main findings above.

Before presenting the regression results, it is useful to visualize the relation between
mispricing and turnover as well as inflation. To this end, Figure 4 plots monthly mispricing,
turnover, and inflation from January 1927 to December 2004. The figure suggests that the money illusion hypothesis, implying a negative relation between inflation and mispricing, works best from the 1940s to the 1980s. Inflation, however, fails to produce a consistent relation with mispricing during the two major historical bubbles, i.e., the late 1920s and the late 1990s. By contrast, the hypothesized positive relation between share turnover and mispricing is most evident during these bubble periods. The figure suggests that money illusion and resale option hypotheses complement each other and, taken together, they provide a more complete story about stock mispricing.

Table 7 reports the results of the effects of inflation and heterogeneous beliefs on the level and the volatility of mispricing, respectively, based on steady-state adjusted data. In Panel A, rows 1 and 2 show results from the regressions of mispricing ($\varepsilon$) on inflation ($\pi$) and turnover, respectively. Similar to the quarterly data sample, the monthly results show that inflation is negatively correlated, and turnover is positively correlated with mispricing, consistent with both the money illusion and the resale option hypotheses. Both variables are statistically significant at the 1% level. The same conclusion holds in a multivariate analysis, shown in row 3, where inflation ($\pi$) and turnover are both included in the same regression. Thus, our previous results using quarterly data are robust in the monthly sample as well. In fact, the quarterly results are strengthened by the confirming evidence in the monthly results since the monthly sample extends data from 1962 all the way back to 1926.

In Table 7, Panel B, we regress the mispricing volatility ($\sigma_\varepsilon$) on inflation and turnover. Consistent with the quarterly result, inflation cannot explain the variation in mispricing volatility, whereas turnover carries the expected positive sign and is statistically significant at the 5% level in both the univariate and multivariate analyses. Thus, the monthly results strengthen the quarterly evidence established earlier that the resale option hypothesis provides a more coherent explanation for the asset bubble phenomenon than does the money illusion hypothesis.

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11 The sample begins in January 1926. Because we use the 12-month moving average to calculate dividend growth rate, the first observation for the monthly sample analysis starts in January 1927.
VII. Conclusions

We document substantial mispricing in the US stock market from 1926 to 2004 using Campbell and Shiller (1988) as a benchmark valuation model. Furthermore, we examine two hypotheses to explain the mispricing phenomenon: (a) the money illusion hypothesis (Modigliani and Cohn (1979)), which suggests that stock mispricing is negatively related to expected inflation, and (b) the resale option hypothesis (Scheinkman and Xiong (2003)), which suggests that investors’ heterogeneous beliefs about dividend growth rates, together with short-sales constraints, lead to a bubble or mispricing component in stock prices.

We employ S&P 500 index data both for the quarterly sample (1962–2004) and the monthly sample (1926–2004) to conduct our empirical analysis. Two proxies are used for heterogeneous beliefs among investors: (a) the index share turnover and (b) the implied volatility differential (IVD) between out-of-the-money and at-the-money S&P 500 put options. Because some variables are persistent, we test for shifting steady-state and adjust data to obtain stationarity following the procedure of Lettau and Nieuwerburgh (2007).

Our results show that the level of mispricing is positively related to both share turnover and IVD, and negatively related to expected inflation. While the money illusion hypothesis works well from the 1940s to the 1980s, the resale option hypothesis provides stronger evidence during the two major historical bubble periods, the late 1920s and the late 1990s. The evidence suggests that the two hypotheses complement each other in explaining the level of mispricing.

In addition, our results show that both share turnover and IVD significantly impact mispricing volatility, but expected inflation does not. This differential influence on mispricing volatility suggests that the resale option hypothesis may better explain asset price bubbles in which extraordinarily high price levels are accompanied by excess volatility and frenzied trading. Finally, our empirical results hold well under various robustness checks, including incorporating time-varying liquidity, the choice of the optimal lag in the VAR model, and the use of monthly data in an extended period.

Our finding of a strong resale option effect in stock mispricing underscores the importance of further research in this direction for asset price bubbles. For example, real estate markets are naturally subject to short-sales constraints and heterogeneous beliefs about housing appreciation rates. It would be interesting to investigate whether the resale option effect is
typically at work in driving run-ups in housing prices and concurrent trading frenzies during historical episodes of housing bubbles. In addition, by examining the cross-sectional variation of heterogeneous beliefs and short-sale constraints in different industries or sectors, the resale option hypothesis may explain why the technology sector exhibited a price bubble in the late 1990s (Ofek and Richardson (2003)), whereas other more traditional sectors experienced a lesser degree of mispricing during the same time period. Finally, to the extent that stock mispricing is corrected in the long run, the cross-sectional variation in the mispricing may predict future stock returns. Chen, Lung, and Wang (2007) examine this issue and find evidence that our mispricing measure is distinctly related to the cross-section of stock returns in the future. In particular, stocks with low (high) mispricing outperform (underperform) otherwise similar stocks.
References


Table 1. Vector Autoregressive (VAR) Parameter Estimates

This table presents the four-variable VAR parameter estimates. The VAR model is estimated with one lag based on Bayesian information criteria. Dependent variables are shown in the first column and regressors (lagged 1 period) are shown in the first row. $p – d$ is the log price-dividend ratio, $\Delta d^e$ is the excess log dividend growth rate, $r^e$ is the excess log stock return, and $\pi$ refers to exponentially smoothed inflation. $T$ statistics are in parentheses. ** and * denote significance at the 1% and 5% levels, respectively.

<table>
<thead>
<tr>
<th></th>
<th>$p – d$</th>
<th>$\Delta d^e$</th>
<th>$r^e$</th>
<th>$\pi$</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p – d$</td>
<td>0.9636</td>
<td>-0.6766</td>
<td>0.0532</td>
<td>-2.3769</td>
<td>96.75</td>
</tr>
<tr>
<td></td>
<td>(54.68)**</td>
<td>(-1.55)</td>
<td>(0.71)</td>
<td>(-2.31)*</td>
<td></td>
</tr>
<tr>
<td>$\Delta d^e$</td>
<td>-0.0012</td>
<td>0.6163</td>
<td>0.0159</td>
<td>-0.2338</td>
<td>41.56</td>
</tr>
<tr>
<td></td>
<td>(-0.50)</td>
<td>(10.31)**</td>
<td>(1.55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r^e$</td>
<td>-0.0381</td>
<td>-0.1145</td>
<td>-0.0629</td>
<td>-2.6629</td>
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<tr>
<td></td>
<td>(-2.17)*</td>
<td>(-0.26)</td>
<td>(-0.84)</td>
<td>(-1.73)</td>
<td></td>
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<tr>
<td>$\pi$</td>
<td>3.115E-6</td>
<td>0.0235</td>
<td>-0.0043</td>
<td>0.9511</td>
<td>90.79</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(1.83)</td>
<td>(-1.97)*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Bai and Perron Tests for Multiple Structural Breaks

This table reports Bai and Perron statistics for unknown multiple structure breaks in variables. UDmax tests the null of zero breaks against the alternative of multiple breaks with an upper bound of 5. The 10%, 5%, and 1% critical values are 7.46, 8.88, and 12.37, respectively. $SupF(i+1|i)$ tests for the null of $i + 1$ structural breaks against the alternative of $i$ break, where $i = 1, \ldots 4$. $SupF(5|4)$ is not reported because none of these statistics are significant. * and ** denote significance at the 5% and 1% levels, respectively (upper tail). For the longer quarterly sample, the breakpoint dates for mispricing are June 1973, December 1982, and December 1995; for turnover, they are March 1974, December 1982, and March 1996. For the shorter sample, two breaks (three regimes) are detected. Mispricing showed regime shift in September 1994 and December 1996, and turnover in June 1995 and December 1998.

| Variables            | UDmax  | SupF(2|1) | SupF(3|2) | SupF(4|3) |
|----------------------|--------|---------|---------|---------|
| Mispricing (1962 ~ 2004) | 46.32** | 19.91** | 18.26** | 1.77    |
| Turnover (1962 ~ 2004)    | 130.79** | 7.51    | 10.35** | 0.12    |
| Mispricing (1990 ~ 2004)    | 78.19** | 16.87** | 4.65    | 2.38    |
| Turnover (1990 ~ 2004)    | 70.98** | 20.06** | 2.55    | 0.07    |
Table 3. Effects of Inflation, Turnover, and IVD on Mispricing Level

This table presents steady-state-shift-adjusted results of the two hypotheses of equity mispricing: the money illusion and resale option hypotheses. Panel A presents results for the S&P 500 quarterly data sample from 1962 to 2004, and Panel B presents results for the S&P 500 quarterly data from 1990 to 2004. The dependent variable is the mispricing level of equity valuation, $\varepsilon$. Explanatory variables are $\pi$, inflation, implied volatility differential (IVD), and turnover, a measurement of share turnover rate. White heteroskedasticity-consistent $t$ statistics are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

**Panel A. 1962–2004 (Quarterly Data)**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$\pi$</th>
<th>Turnover</th>
<th>IVD</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon$</td>
<td>-6.3059</td>
<td>-0.0793</td>
<td>-5.9408</td>
<td>10.34</td>
</tr>
<tr>
<td></td>
<td>(-4.50)**</td>
<td>(3.86)**</td>
<td>(-4.39)**</td>
<td></td>
</tr>
</tbody>
</table>

**Panel B. 1990–2004 (Quarterly Data)**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$\pi$</th>
<th>Turnover</th>
<th>IVD</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon$</td>
<td>-5.0542</td>
<td>0.0450</td>
<td>52.2576</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>(-1.22)</td>
<td>(2.09)*</td>
<td>(3.16)**</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>0.0471</td>
<td>59.5132</td>
<td>18.28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.30)*</td>
<td>(3.48)**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

26
Table 4. Effects of Inflation, Turnover, and IVD on Mispricing Volatility

This table presents the steady-state-shift-adjusted results of the univariate and multivariate analyses of the money illusion and resale option hypotheses on mispricing volatility. Panel A presents results for the S&P 500 quarterly data sample from 1962 to 2004; Panel B presents results for the S&P 500 quarterly data sample from 1990 to 2004. The dependent variable is the conditional volatility of mispricing, $\sigma_e$. Explanatory variables are $\pi$, smoothed inflation; turnover, a measurement of share turnover rate; and the implied volatility differential (IVD). The White heteroskedasticity-consistent $t$ statistics are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

### Panel A. 1962–2004 (Quarterly Data)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$\pi$</th>
<th>Turnover</th>
<th>IVD</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_e$</td>
<td>2.2703</td>
<td>(1.35)</td>
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<td>0.48</td>
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<tr>
<td>$\sigma_e$</td>
<td>0.0888</td>
<td></td>
<td></td>
<td>7.30</td>
</tr>
<tr>
<td>$\sigma_e$</td>
<td>2.2577</td>
<td>(1.39)</td>
<td>0.0917</td>
<td>8.33</td>
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</table>

### Panel B. 1990–2004 (Quarterly Data)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$\pi$</th>
<th>Turnover</th>
<th>IVD</th>
<th>Adj. $R^2$ (%)</th>
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</thead>
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<tr>
<td>$\sigma_e$</td>
<td>–17.2246</td>
<td>(–1.76)</td>
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<tr>
<td>$\sigma_e$</td>
<td>0.0937</td>
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<td>3.68</td>
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<tr>
<td>$\sigma_e$</td>
<td>127.0233</td>
<td>(3.13)**</td>
<td></td>
<td>12.98</td>
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<tr>
<td>$\sigma_e$</td>
<td>–13.5638</td>
<td>(–1.53)</td>
<td>0.1615</td>
<td>140.3217</td>
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<tr>
<td>$\sigma_e$</td>
<td></td>
<td>(3.48)**</td>
<td>(3.62)**</td>
<td>30.11</td>
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</table>
Table 5. Effects of Inflation and Turnover on Mispricing Level and Mispricing Volatility after Controlling for Time-Varying Liquidity

This table presents the results from analysis of the money illusion and resale option hypotheses on mispricing after controlling for time-varying liquidity. The S&P 500 quarterly data sample from 1962 to 2004 is used for this purpose. The dependent variable is the mispricing level. Explanatory variables are $\pi$, inflation; share turnover rate; Gamma, liquidity risk measure; and Gibbs, a liquidity characteristic measure. Mispricing and turnover are steady-state shift adjusted. White heteroskedasticity-consistent $t$ statistics are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

Panel A. 1962–2004 (Quarterly Data): Mispricing Level

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\pi$</th>
<th>Turnover</th>
<th>Gamma</th>
<th>Gibbs</th>
<th>Adj. $R^2$ (%)</th>
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<tbody>
<tr>
<td>$\varepsilon$</td>
<td>$-6.0463$</td>
<td>$0.0817$</td>
<td>$-8.3259$</td>
<td></td>
<td>18.82</td>
</tr>
<tr>
<td></td>
<td>($-4.49$)**</td>
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<td>($-1.91$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>$-5.2860$</td>
<td>$0.0811$</td>
<td></td>
<td>$4.4591$</td>
<td>20.44</td>
</tr>
<tr>
<td></td>
<td>($-3.87$)**</td>
<td>(4.18)**</td>
<td></td>
<td>(1.66)</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>$-5.2929$</td>
<td>$0.0872$</td>
<td>$-7.6810$</td>
<td>$4.2833$</td>
<td>21.50</td>
</tr>
<tr>
<td></td>
<td>($-3.90$)**</td>
<td>(4.46)**</td>
<td>($-1.79$)</td>
<td>(1.6011)</td>
<td></td>
</tr>
</tbody>
</table>

Panel B. 1962–2004 (Quarterly Data): Mispricing Volatility

| $\sigma_\varepsilon$ | 2.8591 | 0.0950 | $-5.3975$ | 8.25 |
|                       | (1.47) | (3.94)** | ($-1.01$) |  |
| $\sigma_\varepsilon$ | 3.1891 | 0.1013 |       | 7.6372 | 15.35 |
|                       | (1.51) | (4.42)** |       | (3.83)** |  |
| $\sigma_\varepsilon$ | 3.0353 | 0.1047 | $-4.2624$ | 7.5396 | 15.19 |
|                       | (1.57) | (4.49)** | ($-0.83$) | (3.78)** |  |
Table 6. Effects of Inflation and Turnover on Mispricing Level and Mispricing Volatility Using the Three-Lag VAR Model

This table presents steady-state-shift-adjusted results of the two hypotheses of equity mispricing: the money illusion and resale option hypotheses based on a three-lag VAR model. Panel A shows the results of the mispricing level for the S&P 500 quarterly data sample from 1962 to 2004, and Panel B presents the results of the mispricing volatility for S&P 500 quarterly data from 1962 to 2004. The dependent variables are the mispricing level and mispricing volatility of equity valuation, $\varepsilon$. Explanatory variables are $\pi$, inflation, implied volatility differential (IVD), and turnover, a measurement of share turnover rate. White heteroskedasticity-consistent $t$ statistics are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

Panel A. 1962–2004 (Quarterly Data): Mispricing Level

<table>
<thead>
<tr>
<th>Dependent</th>
<th>$\pi$</th>
<th>Turnover</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon$</td>
<td>$-4.451$</td>
<td>$0.0864$</td>
<td>$4.33$</td>
</tr>
<tr>
<td></td>
<td>$(-2.91)$**</td>
<td>$(3.99)$**</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>$-4.101$</td>
<td>$0.0827$</td>
<td>$11.95$</td>
</tr>
<tr>
<td></td>
<td>$(-2.79)$**</td>
<td>$(3.90)$**</td>
<td></td>
</tr>
</tbody>
</table>

Panel B. 1962–2004 (Quarterly Data): Mispricing Volatility

| $\sigma_{\varepsilon}$ | $-1.4422$ | $0.1518$ | $-0.40$  |
| | $(-0.61)$ | $(4.67)$** |  |
| $\sigma_{\varepsilon}$ | $0.1511$ | $11.20$  |
| | $(4.63)$** |  |
| $\sigma_{\varepsilon}$ | $-0.7886$ | $10.73$  |
| | $(-0.35)$ | $(4.63)$** |  |
Table 7. Effects of Inflation and Turnover on Mispricing Level and Mispricing Volatility Using the Monthly Data Sample

This table presents steady-state-shift-adjusted results of the univariate and multivariate analysis of the money illusion and resale option hypotheses on mispricing and mispricing volatility using the S&P 500 monthly data from 1926 to 2004. The VAR model is estimated with 3 lags based on Bayesian information criteria. Panel A reports the results for mispricing; Panel B shows the results for mispricing volatility. The dependent variables are the mispricing, $\varepsilon$, and the conditional volatility of mispricing, $\sigma_\varepsilon$, respectively. Explanatory variables are $\pi$, smoothed inflation; and turnover, a measurement of share turnover rate. White heteroskedasticity-consistent $t$ statistics are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively.

### Panel A. 1926–2004 (Monthly Data): Mispricing Level

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Regressors</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon$</td>
<td>$\pi$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>–6.8953</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>(–3.05)**</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>0.2261</td>
<td>2.83</td>
</tr>
<tr>
<td></td>
<td>(5.31)**</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>–6.3516</td>
<td>3.56</td>
</tr>
<tr>
<td></td>
<td>(–2.84)**</td>
<td></td>
</tr>
</tbody>
</table>

### Panel B. 1926–2004 (Monthly Data): Mispricing Volatility

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Regressors</th>
<th>Adj. $R^2$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>$\pi$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turnover</td>
<td></td>
</tr>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>–6.3972</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(–1.40)</td>
<td></td>
</tr>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>0.1996</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>(2.31)*</td>
<td></td>
</tr>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>–5.9178</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>(–1.30)</td>
<td></td>
</tr>
<tr>
<td>$\sigma_\varepsilon$</td>
<td>0.1944</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.24)*</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2: Mispricing, Turnover, and Inflation (1962-2004)
Figure 3: Mispricing Volatility, Turnover, and Inflation (1962-2004)
Figure 4: Mispricing, Turnover, and Inflation
(1927-2004)