Is mispricing in asset prices due to the inflation illusion?

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Abstract

We examine whether the observed negative relations between stock returns and inflation and between housing returns and inflation can be explained by the inflation illusion hypothesis. We identify the mispricing component in asset prices (i.e., stock prices and housing prices) based on present value models, linear and loglinear models, and we then investigate whether inflation can explain the mispricing component using the data from three countries (the U.S., the U.K., and Korea). When we take into account the potential asymmetric effect of positive and negative inflation on the mispricing components in asset prices, which is an important implication of the inflation illusion hypothesis, none of the asset returns is compatible with the inflation illusion hypothesis in that both positive and negative inflation rates do not have a negative effect on the housing mispricing components. Instead, we find that behavioral factors such as consumer sentiments contribute to the mispricing of asset prices.

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1. Introduction

The relation between asset returns (or asset prices) and inflation has been debated extensively in the literature and has received renewed interest in recent years.¹ In particular, given the recent implosion of the stock market and housing market price bubbles in many economies and various economic stimulus packages including the central bank’s expansionary monetary measures during this economic downturn, there seems little doubt about the possibility of forthcoming inflation. Therefore, the relation between asset returns and inflation becomes a more relevant issue. In this paper, we reexamine the empirical relation between two types of asset returns (i.e., stock returns and housing returns) and inflation using international data of the U.K. and Korea as well as the U.S.

Several hypotheses have been put forward to explain the observed negative correlation between stock returns and inflation.² Modigliani and Cohn (1979) propose the inflation illusion hypothesis, which maintains that stock market investors are subject to inflation illusion. According to the hypothesis, stock market investors fail to understand the effect of inflation on nominal dividend growth rates, and they extrapolate historical nominal growth rates even in periods of changing inflation. This implies that stock prices are undervalued when inflation is high and overvalued when it is low.

Feldstein (1980) proposes the tax hypothesis to explain the inverse relation between higher inflation and lower share prices. Fama (1981, 1983) proposes the proxy hypothesis. According to the proxy hypothesis, high expected inflation proxies for slower expected economic growth. That is, a positive association between stock returns and real activity, combined with a negative association between inflation and real activity based on a money demand model, leads to spurious negative relations between stock returns and inflation. The proxy hypothesis has been extended by Geske and Roll (1983), who emphasize the monetization of government deficits and a fiscal and monetary policy linkage. Given that inflation affects value by way of its effect on the risk premium, Brandt and Wang (2003)

¹ See, for example, Ritter and Warr (2002), Campbell and Vuolteenaho (2004), Cohen, Polk, and Vuolteenaho (2005), Brunnermeier and Julliard (2008), and Wei (2010). While we focus on the relation between stock returns (or prices) and inflation in this paper, some studies focus on the model of equity valuation, the so-called “Fed model”, which implies that dividend yields, the ratio of dividends to stock prices, are highly positively correlated with inflation (e.g., Asness, 2000, 2003; Campbell and Vuolteenaho, 2004).
² Ritter and Warr (2002, Section V) provide a comprehensive review of various hypotheses on the stock return-inflation relation.
propose the time-varying risk aversion hypothesis. They present a model in which inflation makes investors more risk averse, driving up the required equity premium, and thus the real discount rate.

Campbell and Vuolteenaho (2004) revisit the issue of the stock price-inflation relation based on the time-series decomposition of the loglinear dividend yield model, and they provide strong support for Modigliani and Cohn’s (1979) inflation illusion hypothesis for the U.S. stock market. Specifically, they extend the classic static Gordon model to a dynamic valuation model by relating it to a loglinear dividend yield model, and they identify the mispricing component in the log dividend yield. They find evidence of underpricing associated with inflation for the sample period of 1927-2002 for the U.S., which therefore shows the important role played by the mispricing component in explaining the stock return-inflation relation. Additionally, Cohen, Polk, and Vuolteenaho (2005) present cross-sectional evidence supporting Modigliani and Cohn’s hypothesis by simultaneously examining the future returns of Treasury bills, safe stocks, and risky stocks to distinguish inflation illusion from any change in the attitudes of investors toward risk.

However, some recent studies raise questions about the empirical validity of the inflation illusion hypothesis. Thomas and Zhang (2007) find that the results in Campbell and Vuolteenaho (2004) are sensitive to model specifications including the sample period studied, the proxy used for expected inflation, the use of dividends versus earnings yields, and the VAR methodology employed. So they claim that it is premature to conclude that the market confuses real and nominal growth rates and suffers from the massive inflation illusion. Chen, Lung, and Wang (2009) find that the money illusion hypothesis of Modigliani and Cohn (1979) may explain the level, but not the volatility, of mispricing in the U.S. market (see also Wei and Joutz, 2009).

Regarding the housing market, Brunnermeier and Julliard (2008) examine potential mispricing in the housing market, focusing on the price-rent ratio. They argue that people suffer from money illusion and mistakenly assume that real and nominal interest rates move in lockstep. Hence, they wrongly attribute a decrease in inflation to a decline in the

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3 Chen, Lung, and Wang (2009) further find that the stock resale option hypothesis of Scheinkman and Xiong (2003), which stems from heterogeneous beliefs about future dividend growth rates and short-sale constraints, can explain both the level and the volatility of mispricing.
real interest rate and consequently underestimate the real cost of future mortgage payments. Therefore, they cause an upward pressure on housing prices when inflation declines.

Piazzesi and Schneider (2007) consider asset pricing in a general equilibrium model in which some, but not all, agents suffer from inflation illusion. Illusionary investors mistake changes in nominal interest rates for changes in real rates, while smart investors understand the Fisher equation. The presence of smart investors ensures that the equilibrium nominal interest rate moves with expected inflation. The model also predicts a non-monotonic relationship between the price-to-rent ratio on housing and nominal interest rates.

Wei (2010) takes an alternative approach to Campbell and Vuolteenaho (2004). She explores an explanation for the positive association between inflation and dividend yields with no inflation illusion involved. To achieve the goal, she builds a dynamic general equilibrium New-Keynesian model to study the relation between inflation and dividend yields. In contrast to a VAR (vector autoregression) framework used in Campbell and Vuolteenaho (2004), her structural approach achieves internal consistency of business cycle and financial variables in a general equilibrium framework. It thus enables her to study the channels through which fundamental shocks affect both inflation and dividend yields.

Given the recent debate on the empirical validity of the inflation illusion hypothesis as discussed above and recent implosion of asset prices combined with potential inflationary pressure, we reexamine the empirical relation not only between stock returns and inflation but also between housing returns and inflation using international data of the U.K. and Korea as well as the U.S. For our empirical analyses, in addition to the two major economies of the U.S. and the U.K., we include Korea partly because it is one of representative developing countries hosting G-20 meeting in 2010 and partly because residential housing in Korea constitutes a largest portion of household wealth in the world. According to a recent analysis, the value of primary residence (in the case of owner-occupants) and renters’ money deposit (in the case of renters) in Korea is about five

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4 The ratio of non-financial assets, which includes dwellings and land, to household assets in 2007 is 57.5% for the U.S., 67.8% for the U.K., 56.0% for Switzerland, 71.1% for Japan, 77.4% for Germany, 81.8% for France, 60.9% for Canada, and 83.7% for Korea. For details, see [http://stats.oecd.org/Index.aspx?DatasetCode=7HA%20%20SOURCE](http://stats.oecd.org/Index.aspx?DatasetCode=7HA%20%20SOURCE) Our initial attempt to include Japan in our empirical analyses was hindered by the limited availability of housing return data. For Japan, only semi-annual housing return is available.
times of financial assets and represent 83 percent of the total household wealth in 2001 (Kim, 2004; Yoo, 2004). So it would be interesting to see whether developing countries such as Korea show different empirical relations from the U.S. and the U.K.

In testing the empirical validity of the inflation illusion hypothesis, Campbell and Vuolteenaho (2004) and Cohen, Polk, and Vuolteenaho (2005) calculate a mispricing component using the difference between objective and subjective expected dividend growth, which requires a subjective risk-premium proxy. Polk, Thompson, and Vuolteenaho (2006) develop two measures of the subjective risk-premium proxy. The two proxies are based on ordinal association measures between a stock’s beta and its valuation ratios. However, these proxies are not easily available for the housing market and other countries. Therefore, we employ alternative measures of the mispricing component in asset prices (i.e., stock prices and housing prices) and examine whether inflation can explain the mispricing component by using the data from the three countries, the U.S., the U.K., and Korea.

In testing the inflation illusion hypothesis, previous studies tend to focus on the extent that the mispricing component in asset prices can be explained by inflation. However, there are additional important implications in the hypothesis. One is that the inflation should have a negative effect on the mispricing component to explain the observed negative relation between asset returns and inflation. The other is that not only positive inflation but also negative inflation should have a negative effect on the mispricing component because the inflation illusion hypothesis implies that asset prices are undervalued when inflation is high and overvalued when it is low. In this paper, using various measures of the mispricing component in asset prices (i.e., stock prices and

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5 Campbell and Vuolteenaho (2004) recognize the symmetric relation between stock returns and both high and low (or negative) inflation by saying that the central prediction of the Modigliani-Cohn (1979) hypothesis is that high inflation leads to stock market underpricing and low (or negative) inflation leads to overpricing. However, they do not examine potential asymmetric relation explicitly. Bharat and Wahab (2008) find an asymmetric relation between stock returns and inflation by partitioning their sample period into sub-samples of high and low inflation regimes. They find an inverse relation between stock returns and inflation forecasts during only low inflation periods, while a positive relation is detected through high inflation periods.

While Bharat and Wahab (2008) find asymmetric relation over sub sample periods and Wei and Joutz (2009) find evidence for structural instability over time focusing on the stock return-inflation relation, we examine a potential asymmetric relation between mispricing and inflation given the observed negative relation between asset returns (i.e., stock and housing returns) and inflation.
housing prices), we further examine these implications of the inflation illusion hypothesis using international data.

We find some evidence of the inflation illusion hypothesis for the stock return-inflation relation for the U.K. and Korea and for the housing return-inflation relation for Korea in that the inflation rates explain some fraction of mispricing components and their effect on mispricing is negative. However, these findings are obtained assuming a symmetric relation for positive and negative inflation in relation to the mispricing components. When we take into account potential asymmetric effects of positive and negative inflation on the mispricing components in asset prices, which is an important implication of the inflation illusion hypothesis, we find that none of these asset returns is compatible with the inflation illusion hypothesis in that both positive and negative inflation rates do not have a negative effect on the mispricing components. As discussed by Piazzesi and Schneider (2007), one way to understand the finding of limited evidence for the inflation illusion hypothesis is that only a small fraction of investors, if any, suffer from it. As a result we anticipate a non-monotonic relation between asset returns and inflation.

Since we find only limited evidence for the inflation illusion hypothesis, we further examine whether the mispricing in the asset prices is related to behavioral factors such as consumer sentiment in an attempt to find other factors that may explain the mispricing in asset prices. We find evidence that behavioral factors such as consumer sentiment could have contributed to the mispricing in both stock market and housing market asset prices.

The paper is organized as follows. In Section 2, we provide empirical identification of the mispricing component in asset prices using simple present value models, first in a linear model, then in a loglinear model allowing for time-varying discount rates. In Section 3, we present empirical results of the extent of the mispricing due to the inflation illusion using the stock market and housing market data from the U.S., the U.K., and Korea. In section 4, we examine whether the mispricing in the asset prices is related to behavioral factors such as consumer sentiment. We conclude in Section 5.

2. Empirical identification of the mispricing component in asset prices
One way to examine the importance of the inflation illusion in the relation between asset returns and inflation is to see how much of the mispricing (or non-fundamental) component of asset prices is explained by inflation (e.g., Campbell and Vuolteenaho, 2004, for stock market prices; Brunnermeier and Julliard, 2008, for housing prices). In this section, we propose a model that helps identify the mispricing component, which is defined as the part of the asset prices that is not related to fundamentals. Then we can examine how much of the mispricing component is related to inflation as a measure of the inflation illusion.

2.1 Identification of the mispricing component in a linear model

Suppose that $X_t$ represents a fundamental variable (e.g., dividends in stock prices or rents in housing prices). Assuming that the fundamental variable is a non-stationary series, we consider its first-differenced series, and it is assumed to have a MAR (moving average representation) by the Wold representation theorem:

$$\Delta X_t = c_{11}(L) u_{1t} = \sum_{k=0}^{\infty} c_{11}^k u_{1t-k},$$  

where $L$ is the lag operator (i.e., $L^n x_t = x_{t-n}$) and $c_{ij}(L)$ is a polynomial in the lag operator $L$ (i.e., $c_{ij}(L) = \sum_k c_{ij}^k L^k$ with $\sum_{k=0}^{\infty} c_{ij} = \sum_{k=0}^{\infty} c_{ij}^k L^k$).

Assume that asset price $P_t$ (e.g., stock price or housing price) has two components, fundamental and mispricing (i.e., non-fundamental) components:

$$P_t = P_t^* + b_t,$$

where $P_t^*$ is a fundamental component and $b_t$ is a mispricing component, which is part of asset price that is not related to fundamental variable. We further assume that the fundamental component of asset price $P_t^*$ is determined by the expected present discounted value of the fundamental variable $X_t$: 
\[
P_t^* = E_t \sum_{j=1}^{\infty} \beta^j X_{t+j}
\]

\[
= \frac{\beta}{1-\beta} X_t + \frac{1}{1-\beta} E_t \sum_{j=1}^{\infty} \beta^j \Delta X_t + j
\]

where \(\beta\) is a constant discount factor.\(^6\)

Now we consider a case where \(X_t\) and \(P_t\) are cointegrated of order (1, 1), CI(1, 1), and the other case where \(X_t\) and \(P_t\) are not cointegrated.

2.1.1 Cointegrated case

Suppose \([X_t, P_t]'\) are cointegrated of order (1, 1), CI(1,1). We define a spread between (i.e., a linear combination of) \(X_t\) and \(P_t\) as \(S_t\):

\[
S_t = P_t - \theta X_t = (P_t^* - \theta X_t) + b_t
\]

\[
= S_t^* + b_t = \frac{1}{1-\beta} E_t \sum_{j=1}^{\infty} \beta^j \Delta X_t + j + b_t,
\]

by setting \(S_t^* = (P_t^* - \theta X_t) = \frac{1}{1-\beta} E_t \sum_{j=1}^{\infty} \beta^j \Delta X_t + j\) and \(\theta = \frac{\beta}{1-\beta}\). Here, \(b_t\) represents the mispricing component in price \(P_t\).

To calculate the present value of expected future fundamental variables \(\Delta X_{t+j}\), we use the following lemma, whose proof is provided in Hansen and Sargent (1980):

Lemma: Given \(\Delta X_t = a(L)e_t\),

\[
E_t \sum_{j=1}^{\infty} \beta^j \Delta X_{t+j} = \frac{\beta}{L-\beta}[a(L) - a(\beta)]e_t
\]

Using the lemma, it follows that

\(^6\) A model with a time-varying discount rate will be discussed in Section 2.2 with a loglinear model.
\[ S_t = S_t^* + b_t = \frac{\beta}{1 - \beta} \frac{1}{L - \beta} \left[ c_{11}(L) - c_{11}(\beta) \right] u_{1t} + b_t. \quad (6) \]

Let \( b_t = c_{22}(L) u_{2t} \), where \( u_{2t} \) represents a non-fundamental shock that drives \( b_t \). Then, it follows that

\[
Z_t = \begin{bmatrix} \Delta X_t \\ S_t \end{bmatrix} = \begin{bmatrix} c_{11}(L) & c_{12}(L) \\ c_{21}(L) & c_{22}(L) \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}. \quad (7)
\]

Then, the cointegrated model is characterized by

\[
c_{12}(L) = 0, \\
c_{21}(L) = \frac{\beta}{1 - \beta} \frac{1}{L - \beta} \left[ c_{11}(L) - c_{11}(\beta) \right]. \quad (8)
\]

Then, using \( u_{1t} = c_{11}(L)^{-1} \Delta X_t \) from (1), it follows that

\[
S_t = P_t - \theta X_t = (P_t^* - \theta X_t^*) + b_t \\
= c_{21}(L) u_{1t} + c_{22}(L) u_{2t} = c_{21}(L) u_{1t} + b_t \\
= c_{21}(L) c_{11}(L)^{-1} \Delta X_t + b_t \\
= \gamma(L) \Delta X_t + b_t \\
= \sum_{j=0}^{\infty} \gamma_j \Delta X_{t-j} + b_t, \quad (9)
\]

where \( \gamma(L) = c_{21}(L) c_{11}(L)^{-1} \). This implies that \( u_{1t} \) is a fundamental shock, and \( c_{22}(L) u_{2t} \) is a mispricing component \( b_t \) of asset price \( P_t \). That is, when \([X_t, P_t]^\prime\) are cointegrated of order \((1, 1)\), CI(1,1), the mispricing component \( b_t \) of asset price \( P_t \) is extracted from the spread \( S_t \) as residuals after taking into account current and lagged \( \Delta X_{t-j} \):

\[
b_t = c_{22}(L) u_{2t} = S_t - c_{21}(L) u_{1t} = S_t - c_{21}(L) c_{11}(L)^{-1} \Delta X_t \\
= S_t - \gamma(L) \Delta X_t = S_t - \sum_{j=0}^{\infty} \gamma_j \Delta X_{t-j}. \quad (10)
\]
Then we regress the mispricing component of asset prices, $b_t$, on inflation rates to see how much of $b_t$ is explained by inflation:

$$b_t = \alpha + \beta \pi_t + e_t.$$  \hfill (11)

If inflation $\pi_t$ explains a substantial fraction of $b_t$, it can provide support for the inflation illusion hypothesis.

### 2.1.2 Non-cointegrated case

Suppose $[X_t, P_t]'$ are not cointegrated although both series are integrated of order one, I(1), series. Then, we have the following bivariate MAR (moving average representation):

$$Z_t = \begin{bmatrix} \Delta X_t \\ \Delta P_t \end{bmatrix} = \begin{bmatrix} c_{11}(L) & c_{12}(L) \\ c_{21}(L) & c_{22}(L) \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}. \hfill (12)$$

Given that $X_t$ is a fundamental variable, we impose $c_{12}(L) = 0$, which identifies $u_{1t}$ as a fundamental shock and $u_{2t}$ as a non-fundamental shock. Then, it follows

$$S_t = P_t - \theta X_t = (P^*_t - \theta X_t) + b_t \hfill (13)$$

$$= S^*_t + b_t = \frac{1}{1-\beta} \sum_{j=1}^{\infty} \beta^j \Delta X_{t+j} + b_t,$$

by setting $\theta = \frac{\beta}{1-\beta}$.

Since $[X_t, P_t]'$ are not cointegrated, it follows that the spread $S_t$ is integrated of order one, I(1), process. Thus, it follows from (13) that the mispricing component $b_t$ is also an integrated order one, I(1), process:

$$\Delta P_t = c_{21}(L)u_{1t} + c_{22}(L)u_{2t} = c_{21}(L)u_{1t} + (1-L)b_t. \hfill (14)$$
That is, \( c_{22}(L)u_{2t} (= \Delta b_t) \) is a mispricing component of \( \Delta P_t \). Since \( \Delta X_t = c_{11}(L)u_{1t} \), it follows that

\[
\Delta P_t = c_{21}(L) u_{1t} + c_{22}(L)u_{2t} = c_{21}(L)u_{1t} + (1 - L)b_t
\]

\[
= c_{21}(L)c_{11}(L)^{-1}\Delta X_t + c_{22}(L) u_{2t} = \gamma(L)\Delta X_t + (1 - L)b_t
\]

\[
= \sum_{j=0}^{\infty} \gamma_j \Delta X_{t-j} + (1 - L)b_t, \quad (15)
\]

where \( \gamma(L) = c_{21}(L)c_{11}(L)^{-1} \).

Therefore, when stock price \( P_t \) and a fundamental variable \( X_t \) are non-stationary and non-cointegrated, the mispricing component in the price will be non-stationary and it is derived from \( \Delta P_t \) as residuals after taking into account current and lagged \( \Delta X_{t-j} \). \(^7\)

\[
\Delta b_t = c_{22}(L)u_{2t} = \Delta P_t - c_{21}(L)u_{1t} = \Delta P_t - c_{21}(L)c_{11}(L)^{-1}\Delta X_t
\]

\[
= \Delta P_t - \sum_{j=0}^{\infty} \gamma_j \Delta X_{t-j}. \quad (16)
\]

Then, as in (11), we regress the mispricing component of asset prices, \( \Delta b_t \), on inflation rates to see how much of the mispricing component \( \Delta b_t \) is explained by inflation.

**2.2 Identification of the mispricing component in a loglinear model**

Models in Section 2.1 are based on non-logged (real) asset prices and fundamentals with a constant discount rate. Previous studies such as Campbell and Shiller (1988a, 1989b), Campbell (1991), and Campbell and Ammer (1993) develop log-linear models.

\(^7\) Therefore, it is shown that the presence of a cointegration CI(1,1) relation between cash flows (e.g., dividends or rents) and asset prices is a sufficient condition for the absence of a non-stationary mispricing component in the asset prices for the sample period. If we define the non-stationary mispricing component in the asset prices as a bubble in asset prices, this can be used as a condition for the presence of the bubble (see e.g., Lee, 1998).
allowing for time-varying discount rates. They show that the log price-dividend ratio $s_{2t}$ is given by:

$$s_{2t} = p_t - d_t = E_t \sum_{j=0}^{\infty} \rho^j [\Delta d_{t+j} - h_{t+j}] + \eta_t,$$

where $p_t$ and $d_t$ are logged asset price and fundamental variable (e.g., dividend), $h_t$ is time-varying returns, and $\eta_t$ is an approximation error. Equation (17) states that the spread $s_{2t}$, the log price-dividend ratio, is an expected discounted value of all future dividend growth rates less returns discounted at the discount rate $\rho$. That is, the log price-dividend ratio is an expected discounted value of all future one-period ‘discounted rate-adjusted dividend growth rates’, $\Delta d_{t+j} - h_{t+j}$. As such, the log price-dividend ratio provides the optimal forecast of the discounted value of all future dividend growth rates, future returns, or both.

This model is characterized as the restrictions $c_{12}(L)=0$, $c_{13}(L)=0$, and $c_{23}(L)=0$, on the following trivariate MAR model:

$$Z_t = \begin{bmatrix} \Delta d_t \\ \Delta d_{rt} \\ s_{2t} \end{bmatrix} = \begin{bmatrix} c_{11}(L) & c_{12}(L) & c_{13}(L) \\ c_{21}(L) & c_{22}(L) & c_{23}(L) \\ c_{31}(L) & c_{32}(L) & c_{33}(L) \end{bmatrix} \begin{bmatrix} e_{dt} \\ e_{rt} \\ e_{nt} \end{bmatrix},$$

where $\Delta d_t = \Delta d_t - h_t$, $e_{dt}$ = dividend innovation, $e_{rt}$ = stock return innovation, and $e_{nt}$ = non-fundamental innovation (e.g., Lee, 1998).\(^8\) That is, with the above identifying restrictions, we have the following:

$$\Delta d_t = c_{11}(L)e_{dt}, \quad \Delta d_{rt} = c_{21}(L)e_{dt} + c_{22}(L)e_{rt},$$

and

$$s_{2t} = c_{31}(L)e_{dt} + c_{32}(L)e_{rt} + c_{33}(L)e_{nt}.$$ 

\(^8\) As in Campbell and Shiller (1988b), we also assume $E_t h_t = E_t r_t + c$. That is, we assume that there is some variable $r_t$ whose beginning-of-period rational expectation, plus a constant term $c$, equals the ex ante return on stock $h_t$ over the period. While Campbell and Shiller (1988b) consider the hypothesis that the expected real return on stock equals the expected real return on commercial paper plus a constant, we consider that the expected real return on stock equals the expected real return on the long-term government (10-year Treasury) bond plus a constant since we are also investigating the housing market in addition to the stock market. For details, see Section 3.1.
In the above representation, the mispricing component in the logged price, $b_t$, is given by $c_{33}(L)e_{nt}$, which is part of the log price-dividend ratio $s_{2t}$ that is not related to such fundamental variables as dividends and returns. Then, the mispricing component in the logged price, $b_t$, is derived from $s_{2t}$ as residuals after taking into account current and lagged $\Delta d_{t-j}$ and $\Delta d_{t-j}$ for $j=0, 1, 2, \ldots$:

$$b_t = c_{33}(L)e_{nt} = s_{2t} - c_{31}(L)e_{dt} - c_{32}(L)e_{rt}$$

$$= s_{2t} - \sum_{j=0}^{\infty} \gamma_1j^{\Delta d_{t-j}} - \sum_{j=0}^{\infty} \gamma_2j^{r_{t-j}}$$

Then, as in (11), we regress the mispricing component of logged asset prices, $b_t$, on inflation rates to see how much of $b_t$ is explained by inflation.

2.3 Test for the inflation illusion

The inflation illusion hypothesis can be tested, as in the previous studies, by examining whether a substantial fraction of the mispricing component of asset prices is explained by inflation. However, the hypothesis anticipates not only that inflation is playing an important role in explaining the mispricing component but also that inflation and asset prices are negatively related. That is, according to the inflation illusion hypothesis, when inflation is high, real as well as nominal interest rates will be high, future cash flows are heavily discounted, and asset prices will be lower. Therefore, inflation should affect the mispricing component negatively.

In regression (11), we examine the explanatory power of inflation by using only the current inflation rates. In a strict sense, we can consider only the current inflation rate to examine the contemporaneous negative relation between asset returns and inflation. However, to be more flexible, we allow for lagged inflation rates to affect the mispricing components. Therefore, we consider the following three cases with inflation rates: only the current inflation rate, only the lagged inflation rates, and the current and lagged inflation rates.
\[ b_i = \alpha + \beta \pi_i + \epsilon_i. \] 
(11.1)

\[ b_i = \alpha + \sum_{j=1}^{k} \beta_j \pi_{i-j} + \epsilon_i. \] 
(11.2)

\[ b_i = \alpha + \sum_{j=0}^{k} \beta_j \pi_{i-j} + \epsilon_i. \] 
(11.3)

We test for the null hypothesis that inflation rates as a group do not affect the mispricing component and for the null hypothesis that the net cumulative effect of inflation is zero, as follows:

\[ H_{10}: \beta_j = 0 \text{ for each } j, \text{ and } \]

\[ H_{20}: \sum_j \beta_j = 0. \]

We consider another important implication of the inflation illusion hypothesis. According to the hypothesis, asset prices (i.e., stock prices or housing prices) are undervalued when inflation is high and become overvalued when inflation falls.\(^9\) Therefore, the hypothesis anticipates that both positive and negative inflation shocks drive only a negative asset return-inflation relation. This implies that both positive and negative inflation rates are negatively related to the mispricing component in asset prices. To examine this implication of the inflation illusion hypothesis, we employ a dummy variable regression:

\[ b_t = a + b_1 \pi_1 + b_2 \pi_2 + \epsilon_t, \] 
(11.4)

where \( \pi_1 = D_t \times \pi_t = \text{positive inflation} \); \( \pi_2 = (1 - D_t) \times \pi_t = \text{negative inflation} \); and \( D_t = 1 \) when \( \pi_t > 0 \), otherwise 0. That is, the inflation illusion hypothesis anticipates that both \( b_1 < 0 \) and \( b_2 < 0 \).

\(^9\) The latter case is emphasized by Brunnermeier and Julliard (2008) in examining potential mispricing in the housing market. They argue that people suffer from money illusion and mistakenly assume that real and nominal interest rates move in lockstep. Hence, they wrongly attribute a decrease in inflation to a decline in the real interest rate and consequently underestimate the real cost of future mortgage payments. Therefore, they cause an upward pressure on housing prices when inflation declines.
3. Empirical results

3.1 Data and preliminary findings

For our empirical analysis, we use data from the U.S., the U.K., and Korea. For the empirical estimation for the U.S. stock market, we use the monthly S&P real price index and dividend series for the sample period of 1872:01 to 2009:06. The data are from Shiller’s web page: http://www.econ.yale.edu/~shiller/data.htm. For the U.S. housing price index, we use the monthly average price of new one-family house sold during the month (USHOUSEP), which is from the Bureau of the Census. For the U.S. rent series, we use the monthly CPI component of rent for primary residence (USCPHRR.E), which is available from the National Statistics Bureau. For the housing price and rent index, the sample period is from 1981:01 to 2009:06. The rent series is from the Bureau of Labor Statistics. For interest rates, we use the long-term government (10-year Treasury) bond yield on Shiller’s web page.\footnote{See footnote 8 for the discussion of using interest rates for stock returns (see also Campbell and Shiller (1988b)).}

For the empirical estimation for the U.K. stock market, we use the quarterly MSCI return index with and without dividend yield, which allows us to extract dividend series, obtained from Datastream for the sample period of 1988:I to 2008:IV. For the U.K. housing market index, we use the quarterly IPD all property index and the corresponding rent index for the sample period of 1988:I to 2008:IV. For interest rates, we use the yield on the U.K. government 10-year bond.

For the empirical estimation for the Korean stock market prices, we use quarterly MSCI return index with and without dividend yield obtained from Datastream for the sample period of 1988:I to 2008:IV. For the Korean housing market index, we use the housing purchase price composite index and the corresponding CPI component of rent for the sample period of 1987:I- 2009:II. The housing index is from Kookmin Bank and the rent series is from the National Statistics Bureau.\footnote{The housing index is available from Kookmin Bank web page: http://land.kbstar.com/quick?asfilecode=5023&nextPage=page=B002188&weblog=1_gnb_C4 The rent series is available from the National Statistics Bureau web page: http://www.kosis.kr/domestic/theme/do01_index.jsp} For interest rates, we use the five-year...
rate on the Korean National Housing Bond. The CPIs (not seasonally adjusted) for all the countries are originally from the International Financial Statistics of IMF, which are obtained from Datastream.

Table 1 reports the results of the regression of various asset returns on inflation rates and cross correlations between asset returns and inflation for the U.S. (Panel A), the U.K. (Panel B), and Korea (Panel C). We report not only contemporaneous correlations but also the cross correlations with one lag and one lead to allow for a potential mismatch in timing in the compilation of the data.

The regression for the U.S. in Panel A shows that nominal stock returns (SR) are positively related to inflation (coefficient = 0.39) but the coefficient is substantially less than one for the sample period of 1871-2009. As a result, real stock returns (RSR) are significantly negatively related to inflation (coefficient = -0.61), which is confirmed by the cross correlations between stock returns and inflation. For the housing returns, both nominal (HR) and real (RHR) housing returns are negatively related to inflation for the sample period of 1981-2009, which is also confirmed by the cross correlations. Therefore, we find that both (real) asset returns are negatively related to inflation for the U.S.

For the U.K. and Korea, we find that both nominal and real asset returns (i.e., stock returns and housing returns) are negatively related to inflation for the sample period, which is confirmed by cross correlations, while there is some variation in the magnitude of correlations in each country. Therefore, we find that for all three countries, the relation between (real) asset returns and inflation is negative, and thus both stocks and housing in these countries are not a good short-term hedge against inflation for the sample period.

3.2 The U.S.

Both series are also available from the Bank of Korea (http://ecos.bok.or.kr/).

For the Korean housing market index, we also use the quarterly ‘National Apartment Purchase Price Indices’ and the ‘National Apartment Jeonse Price Indices’ for the sample period of 1988 to 2008. The Jeonse price is an up-front lump-sum deposit from the tenant to the owner for the use of the property with no additional requirement for periodic rent payments. The empirical results are similar and they do not change any of our interpretation of the Korean empirical results.

Hartzell, Liu, and Hoesli (1997) investigate whether real estate securities continue to act as a perverse inflation hedge in foreign countries given security design differences. They find that real estate securities provide a worse hedge against inflation relative to common stocks in some countries and are comparable to stocks in other countries. Regarding whether REITs provide an inflation hedge in the long run, previous studies find the lack of a positive relationship between general prices and REIT returns. As in most prior research, Chatrath and Liang (1998) also find no evidence that REIT returns are positively related to temporary or permanent components of inflation measures.
3.2.1 The U.S. stock market

In Table 2, we report the results of unit root tests and cointegration tests for asset prices (i.e., stock prices and housing prices) and fundamental variables (i.e., dividends and rents). Panel A of Table 2 shows that both the S&P prices and dividends are non-stationary, I(1), series; and the linear combination of the stock prices and dividends (i.e., the spread S1) is marginally stationary, implying that they are cointegrated of order (1,1). We further implement Johansen’s cointegration tests using maximum likelihood and trace tests. Both tests show that the null of no cointegration is rejected at the conventional significance level of 10%, which indicates that there is at least one cointegration vector between real stock prices and dividends. This indicates that the mispricing component of the S&P stock price is stationary. This implies that the deviation of stock prices from fundamentals is not non-stationary, and that stock prices and fundamentals tend to move together over time so there is little chance of potential non-stationary bubbles in stock prices for the sample period.

As in equation (10), we regress the spread S1t on current and lagged first-differenced dividends to derive a mispricing component of the S&P prices (i.e., $b_t = NF1_t$), and then we regress the mispricing component on inflation as in equation (11). The estimation results are presented in Panel A of Table 3 under the heading SP (i.e., stock prices). The adjusted $R^2$ is -0.0006 when the current inflation rate is used as the regressor, 0.0069 when six lagged inflation rates are used [i.e., INF(t-1) through INF(t-6)] and 0.0067 when the current and six lagged inflation rates are used. We also look at whether inflation rates as a group have a net (cumulative) effect on the mispricing component. We find that inflation rates tend to have a negative net effect on the mispricing. However, given that inflation explains little variation (i.e., less than 1%) in the mispricing component of the stock market prices, we do not find any substantial evidence for the inflation illusion hypothesis.

When we regress the mispricing component of the first differenced S&P prices, (i.e., $\Delta b_t = NF2_t$), which is more appropriate when stock prices and dividends are not cointegrated, the adjusted $R^2$ is 0.0006 when the current inflation rate is used as the regressor, -0.0010 when six lagged inflation rates are used [i.e., INF(t-1) through INF(t-6)], and -0.0010 when the current and six lagged inflation rates are used. Again we find
that inflation explains little variation (less than 1%) of the mispricing component in the first differenced stock market prices.

When we implement a similar procedure using a loglinear model as discussed above by regressing the mispricing component of the spread (=log(p(t))-log(d(t))), (i.e., $b_t = NF3_t$), on inflation, we find that the adjusted $R^2$ is 0.0050 when the current inflation rate is used as the regressor, 0.0021 when six lagged inflation rates are used [i.e., INF(t-1) through INF(t-6)], and 0.0044 when the current and six lagged inflation rates are used. While inflation rates appear to affect the mispricing component, inflation still explains little variation (less than 1%) in the mispricing component. Further, their net effect is positive rather than negative, which is not consistent with the inflation illusion hypothesis.

Overall, our finding shows that the U.S. S&P stock market prices and fundamentals tend to move together over time, and inflation explains only a small fraction of various mispricing components of stock market prices. This indicates that the inflation illusion hypothesis is not effective in explaining the observed negative U.S. stock return and inflation relation.

### 3.2.2 The U.S. housing market

In Panel A of Table 2, we find that both U.S. housing prices and rent series are nonstationary, I(1), series, and the linear combination of the housing prices and rent series (i.e., the spread S2) is an I(0) series, in particular, by the Phillips-Perron unit root tests, implying that they are cointegrated of order (1,1). We further implement Johansen’s cointegration tests using maximum likelihood and trace tests. Both tests show that the null of no cointegration is rejected at the conventional significance level of 10%, which indicates that there is at least one cointegration vector between real housing prices and rent series. This indicates that the mispricing component of housing price is stationary. This implies that the deviation of housing prices from fundamentals (i.e., rent) is not nonstationary, and that housing prices and fundamentals tend to move together over time so there is little chance of a potential non-stationary bubble in housing prices for the sample period.
We regress the spread $S_{2t}$ on current and lagged first-differenced rent series as in (10) to derive the mispricing component of the housing price (i.e., $b_t = NF_{1t}$), and then we regress the mispricing component on inflation as discussed in (11). The estimation results are presented in Panel A of Table 3 under the heading HP (i.e., housing price). The adjusted $R^2$ is -0.0023 when the current inflation rate is used as the regressor, -0.0163 when six lagged inflation rates are used [i.e., INF(t-1) through INF(t-6)], and -0.0194 when the current and six lagged inflation rates are used. That is, inflation does not explain the mispricing component in U.S. housing prices. Further, inflation rates do not have any significant negative effect on the mispricing component, which is not consistent with the inflation illusion hypothesis.

When we regress the mispricing component of the first differenced housing price (i.e., $\Delta b_t = NF_{2t}$), which is more appropriate when the two variables are not cointegrated, we find a similar result. The adjusted $R^2$ is -0.0030 when the current inflation rate is used as the regressor, -0.0085 when six lagged inflation rates are used [i.e., INF(t-1) through INF(t-6)], and -0.0104 when the current and six lagged inflation rates are used. In addition to having little explanatory power of inflation for the mispricing component, the coefficient of the inflation rate is not significantly negative, which is not consistent with the inflation illusion hypothesis.

When we implement a similar procedure using a loglinear model by regressing the mispricing component of the spread ($= \log(hp(t)) - \log(rent(t))$), (i.e., $b_t = NF_{3t}$), on inflation, the results remain almost the same as the linear model case. We find that the adjusted $R^2$ is -0.0029 when the current inflation rate is used as the regressor, -0.0101 when six lagged inflation rates are used [i.e., INF(t-1) through INF(t-6)], and -0.0129 when the current and six lagged inflation rates are used. Further, inflation rates tend to have an insignificant positive effect on the mispricing component, which is inconsistent with the inflation illusion hypothesis.

Overall, we find a stationary mispricing component in the U.S. housing prices, and inflation does not explain the mispricing component of the housing prices regardless of different modeling of the mispricing component. Further, the effect of inflation on the housing mispricing component is insignificant. This implies that the inflation illusion is not effective in explaining the observed negative U.S. housing return and inflation relation.
3.2.3 Asymmetric relation between mispricing and inflation for U.S. asset prices

Now we examine a potential asymmetric relation between mispricing and inflation as discussed in Section 2.3 with regression (11.4). The estimation results of the asymmetric regression models are presented in Table 4. In Panel A, we report the results for the U.S. stock and housing markets. For the U.S. stock market prices, the regression of the mispricing component in the loglinear model, NF3, has an adjusted $R^2$ of 7.67%, while the regressions of the mispricing component based on linear models, whether cointegrated or not, have an adjusted $R^2$ of less than 1%. In the regression of NF3, positive inflation has a negative effect, but negative inflation has a positive effect on the mispricing, which is not fully consistent with the illusion hypothesis.

For the U.S. housing market, only the mispricing in the linear cointegrated model, NF1, has a positive adjusted $R^2$ of 0.33%. For mispricing, positive inflation has an insignificant positive effect while negative inflation has a significant negative effect on the mispricing component, which is not consistent with the illusion hypothesis. This confirms the finding in the symmetric regression model. That is, the negative relation between housing returns and inflation for the U.S. is not consistent with the inflation illusion hypothesis regardless of whether we take into account the potential asymmetric relations.

3.3 The U.K.

3.3.1 The U.K. stock market

Panel B of Table 2 shows that both stock prices and dividends are nonstationary, I(1), series, and the linear combination of the stock prices and dividends (i.e., the spread S1) is stationary, implying that they are cointegrated of order (1,1).\(^\text{13}\) Johansen’s cointegration tests using maximum likelihood and trace tests also show that the null of no cointegration is rejected at the conventional significance level of 10%, which indicates that there is at least one cointegration vector between real stock prices and dividends. This implies that

\(^{13}\)To be more precise, we obtain somewhat mixed unit root test results. Dividends are stationary by the Phillips-Perron test and the spread between stock prices and dividends is nonstationary by the Dickey-Fuller test. However, the Johansen tests show that they are cointegrated.
the mispricing component of the U.K. stock market price is stationary as in the case of the U.S.

We regress the spread $S_{1,t}$ on the current and lagged first-differenced dividends as in (10) to derive a mispricing component of the stock market prices (i.e., $b_t = NF_{1,t}$), and then we regress the mispricing component on inflation as in (11). The estimation results are presented in Panel B of Table 3 under the heading SP. The adjusted $R^2$ is 0.0874 when the current inflation rate is used as the regressor, 0.2583 when four lagged inflation rates are used [i.e., $INF(t-1)$ through $INF(t-4)$], and 0.2548 when the current and four lagged inflation rates are used. We also find that inflation rates as a group tend to have a significant negative net effect on the mispricing. Overall, we find that inflation explains some percentage (e.g., 9~26%) of the mispricing component in the U.K. stock market prices, and inflation’s effect on the mispricing component is negative, which is in favor of the inflation illusion hypothesis.

When we regress the mispricing component of the first differenced stock prices (i.e., $\Delta b_t = NF_{2,t}$), which is more appropriate when stock prices and dividends are not cointegrated, the adjusted $R^2$ is -0.0003 when the current inflation rate is used as the regressor, 0.0745 when four lagged inflation rates are used [i.e., $INF(t-1)$ through $INF(t-4)$], and 0.1040 when the current and four lagged inflation rates are used. Here, we find that inflation explains some variation (7~10%) in the mispricing component in the first differenced stock market prices. However, inflation rates as a group do not have a significant negative net effect on mispricing.

When we implement a similar procedure using a loglinear model by regressing the mispricing component of the spread ($= \log(p(t)) - \log(d(t))$), (i.e., $b_t = NF_{3,t}$), on inflation, we find that the adjusted $R^2$ is 0.0993 when the current inflation rate is used as the regressor, 0.3114 when four lagged inflation rates are used [i.e., $INF(t-1)$ through $INF(t-4)$], and 0.3108 when the current and four lagged inflation rates are used. Further, inflation rates affect the mispricing component, and their net effect is significantly negative, which is consistent with the inflation illusion hypothesis.

Overall, we find that the U.K. stock market prices and fundamentals tend to move together over time, and inflation explains some fraction of the mispricing component of stock market prices with their net effect being negative. This implies that the inflation
illusion hypothesis helps explain the observed negative relation between U.K. stock returns and inflation.

3.3.2 The U.K. housing market

We now turn to the U.K. housing market prices. Panel B of Table 2 shows that both the housing index and rent series are nonstationary, I(1), series, and the linear combination (i.e., the spread S1) is stationary, implying that they are cointegrated of order (1,1).\textsuperscript{14} Johansen’s cointegration tests in Panel B also show that the null of no cointegration is rejected at the conventional significance level of 10%, which indicates that there is at least one cointegration vector between real housing index and rent series. This indicates that the mispricing component of the U.K. housing index is stationary.

We regress the spread S1\textsubscript{t} on current and lagged first-differenced rent series to derive a mispricing component of the housing market prices (i.e., \( b_t = NF1_t \)), and then we regress the mispricing component on inflation. The estimation results are presented in Panel B of Table 3 under the heading HP. The adjusted R\textsuperscript{2} is -0.0096 when the current inflation rate is used as the regressor, -0.0498 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and -0.0548 when the current and four lagged inflation rates are used. We also find that inflation rates do not have a significant net effect on mispricing. Overall, we find that inflation does not explain the mispricing component in U.K. housing prices, and inflation’s effect on the mispricing component is not significantly negative, which is not consistent with the inflation illusion hypothesis.

When we regress the mispricing component of the first differenced housing prices (i.e., \( \Delta b_t = NF2_t \)), the adjusted R\textsuperscript{2} is -0.0072 when the current inflation rate is used as the regressor, -0.0470 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and -0.0400 when the current and four lagged inflation rates are used. Here, we find again that inflation does not explain the mispricing component in the first differenced

\textsuperscript{14} To be more precise, we obtain somewhat mixed unit root test results. Housing prices are stationary by the Dickey-Fuller test and the spread between housing prices and dividends is nonstationary by the Phillips-Perron test. However, the Johansen tests show that they are cointegrated.
housing prices. Further, inflation rates as a group do not have any significant net effect on mispricing.

When we implement a similar procedure using a loglinear model by regressing the mispricing component of the spread (= \log(\text{hp}(t)) - \log(\text{rent}(t))), (i.e., b_t = NF3_t), on inflation, we find that the adjusted $R^2$ is -0.0124 when the current inflation rate is used as the regressor, -0.0476 when four lagged inflation rates are used [i.e., INFT(t-1) through INFT(t-4)], and -0.0619 when the current and four lagged inflation rates are used. Further, inflation rates as a group do not affect the mispricing component, and their net effect is insignificant, which is not consistent with the inflation illusion hypothesis.

Overall, we find that the U.K. housing prices and fundamentals tend to move together over time, and inflation does not explain the mispricing component of housing prices with their net effect being insignificant. This indicates that the inflation illusion hypothesis does not help explain the U.K. housing return and inflation relation.

### 3.3.3 Asymmetric relation between mispricing and inflation for U.K. asset prices

Now we examine a potential asymmetric relation between mispricing and inflation as discussed in section 2.3 with regression (11.4). In Panel B of Table 4, we report the results for the U.K. For the U.K. stock prices, as in the case of the symmetric regressions, inflation rates have some explanatory power for the mispricing component of the linear model with cointegration, NF1, and that of the loglinear model, NF3, with adjusted $R^2$ of 7.65% and 8.77%, respectively. However, in both regressions, while positive inflation has a negative effect on mispricing components, negative inflation does not have a significant negative effect on the mispricing component, which is not fully consistent with the illusion hypothesis. For the U.K. housing prices, inflation rates have little explanatory power for any of the three regressions. Overall, when we take into account the potential asymmetric relation for positive and negative inflation, we do not find any significant evidence in favor of the inflation illusion hypothesis either for the U.K. stock market or for the U.K. housing market.

### 3.4 Korea

#### 3.4.1 Korean stock market
In Panel C of Table 2, we find some mixed results for the unit root tests for Korean stock market prices and dividends. Still, we find some evidence that both stock prices and dividends are nonstationary, I(1), series, and the linear combination (i.e., the spread S1) is marginally stationary, implying that they are cointegrated of order (1,1). Johansen’s cointegration tests in Panel C also show that the null of no cointegration is rejected at the conventional significance level of 10%, which indicates that there is at least one cointegration vector between real stock prices and dividends. This implies that the mispricing component of stock price is stationary as in the case of the U.S. and the U.K.

We regress the spread S1_t on current and lagged first-differenced dividends to derive a mispricing component of the stock market prices (i.e., $b_t = NF1_t$), and then we regress the mispricing component on inflation. The estimation results are presented in Panel C of Table 3 under the heading SP. The adjusted R$^2$ is -0.0030 when the current inflation rate is used as the regressor, 0.1101 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and 0.0990 when the current and four lagged inflation rates are used.

We also find that inflation rates as a group tend to have a significant negative net effect on mispricing. Overall, we find that inflation explains some fraction (e.g., 10~11%) of the mispricing component in the stock market prices, and inflation’s effect on the mispricing component is negative, which is in favor of the inflation illusion hypothesis.

When we regress the mispricing component of the first differenced stock prices (i.e., $\Delta b_t = NF2_t$), the adjusted R$^2$ is 0.0282 when the current inflation rate is used as the regressor, 0.0421 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and 0.0543 when the current and four lagged inflation rates are used. Here, we find that inflation explains a small variation in the mispricing component in the first differenced stock market prices. However, inflation rates as a group do not have a significant negative net effect on mispricing.

When we implement a similar procedure using a loglinear model by regressing the mispricing component of the spread (= log(p(t))-log(d(t))), (i.e., $b_t = NF3_t$), on inflation, we find that the adjusted R$^2$ is 0.1897 when the current inflation rate is used as the regressor, 0.3723 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and 0.3731 when the current and four lagged inflation rates are used. Further, inflation
rates as a group affect the mispricing component, and their net effect is significantly negative, which is consistent with the inflation illusion hypothesis.

Overall, we find that Korean stock market prices and fundamentals tend to move together over time, and inflation explains some fraction (up to 37% in the loglinear model) of the mispricing component of stock market prices with their net effect being negative. This indicates that the inflation illusion hypothesis helps explain the Korean stock return and inflation relation.

3.4.2 Korean housing market

We now turn to Korean housing market. Panel C of Table 2 shows that although both the housing index and rent series are nonstationary, I(1), series, the linear combination of housing prices and rent series (i.e., the spread $S_1$) is not stationary by either unit root test, implying that they are not cointegrated of order (1,1). However, Johansen’s cointegration tests in Panel C show mixed results. The null of no-cointegration is rejected by the maximum likelihood test but is not rejected by the trace test at the conventional significance level of 10%. This implies that the mispricing component of housing prices is marginally nonstationary. This suggests that Korean housing prices may deviate from fundamentals so there is some chance of a potential bubble in Korean housing prices, and we should pay attention to not only a cointegrated model but also a non-cointegrated model.

We regress the spread $S_1$, on current and lagged first-differenced rent series to derive a mispricing component of the housing market prices (i.e., $b_t = NF_1$), and then regress the mispricing component on inflation. The estimation results are presented in Panel C of Table 3. The adjusted $R^2$ is 0.0354 when the current inflation rate is used as the regressor, 0.0170 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and 0.0498 when the current and four lagged inflation rates are used. In other words, we find that inflation rates explain a small fraction of the mispricing. However, inflation rates have a significantly positive effect on the mispricing, which is not consistent with the inflation illusion hypothesis.
When we regress the mispricing component of the first differenced housing prices (i.e., $\Delta b = NF2_t$), which can be appropriate for the Korean housing market because housing prices and rent series are not strongly cointegrated, the adjusted $R^2$ is -0.0109 when the current inflation rate is used as the regressor, 0.1167 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], and 0.1175 when the current and four lagged inflation rates are used. Here we find that inflation explains some variation in the mispricing component in the first differenced housing prices in particular when lagged inflation rates are included. Further, inflation rates as a group have a significant negative effect on the mispricing, which is consistent with the inflation illusion hypothesis.

When we implement a similar procedure using a loglinear model by regressing the mispricing component of the spread (= log(hp(t))-log(rent(t))), (i.e., $b_t = NF3_t$), on inflation, we find that the adjusted $R^2$ is 0.0742 when the current inflation rate is used as the regressor, 0.1078 when four lagged inflation rates are used [i.e., INF(t-1) through INF(t-4)], but 0.0000 when the current and four lagged inflation rates are used. Therefore, we find that inflation explains some fraction of the mispricing in Korean housing prices. However, inflation rates’ net effect on the mispricing component is significantly positive, which is not consistent with the inflation illusion hypothesis.

Overall, we find that Korean housing prices and fundamentals are not strongly cointegrated, leaving a potential bubble in housing prices. While inflation explains some fraction of the mispricing of the housing prices, the effect of inflation on the mispricing tends to be positive when we use linear or log-linear cointegrated models. However, when we use linear non-cointegrated model, inflation has significant negative effect on the mispricing component. This indicates that the inflation illusion hypothesis has some chance to explain Korean housing return and inflation relation.

3.4.3 Asymmetric relation between mispricing and inflation for Korean asset prices

Now we examine a potential asymmetric relation between mispricing and inflation as discussed in Section 2.3 with regression (11.4). In Panel C of Table 4, we report the results for Korea. For Korean stock prices, as in the case of the symmetric regressions, inflation rates have some explanatory power for the mispricing component of the loglinear model, NF3, with adjusted $R^2$ of 21.47%. However, in the regression of NF3, while
positive inflation has a significant negative effect on the mispricing component, negative inflation has a significant positive effect on the mispricing component, which is not fully consistent with the illusion hypothesis.

For Korean housing prices, as in the case of the symmetric regressions, inflation rates have some explanatory power for the linear model with cointegration, NF1, and for the loglinear model, NF3, with adjusted $R^2$ of 2.62% and 6.48%, respectively. However, a positive inflation rate has a significant positive effect on the mispricing component, which is not consistent with the illusion hypothesis. For the linear non-cointegrated model with NF2, adjusted $R^2$ is -0.0224 and neither positive nor negative inflation has any significant effect on the mispricing component. Overall, when we take into the potential asymmetric relation for positive and negative inflation, we do not find any significant evidence in favor of the inflation illusion hypothesis for either the Korean stock market or for the Korean housing market.

4. **Further analysis with consumer sentiments**

Since we find only limited evidence for the inflation illusion hypothesis, we further examine whether the mispricing in the asset prices is related to behavioral factors such as consumer sentiment in an attempt to find other factors that may explain the mispricing in asset prices. An interesting question would be which variable, between inflation and consumer sentiment, has more explanatory power for the mispricing component. To answer this question, we include both the current inflation and consumer sentiment index in the regression of mispricing components:

$$NF_i = \alpha_i + \beta_i \ INF_i + \gamma_i \ CS_i + \epsilon_{i,t}, \quad \text{for } i = 1, 2, \text{and } 3,$$

(11.5)

where NF1 = mispricing component in asset prices (e.g., stock prices or housing prices), NF2 = mispricing component in the first differenced asset prices, and NF3 = mispricing component in the difference in log prices and log dividends (or rents).\(^\text{15}\)

\(^{15}\)The consumer sentiment index data are obtained from the University of Michigan for the U.S. for the sample period of 1978:1 through 2009:6 (http://www.sca.isr.umich.edu/main.php), from the web page of the European Commission for the U.K. for the sample period of 1989:I through 2008:III (http://ec.europa.eu/economy_finance/db_indicators/surveys/index_en.htm), and from Bank of Korea for Korea for the sample period.
The estimation results are presented in Table 5. In Panel A for the U.S. stock market (under the heading of SP), for the mispricing component of stock prices based on linear models of NF1 and NF2, inflation does not explain the mispricing component while the consumer sentiment index is significant. Further, the consumer sentiment has a positive effect on both mispricing components. In the mispricing component of stock prices based on loglinear model (NF3), both inflation and consumer sentiment are significant. Overall, for the U.S. stock market, we find that consumer sentiment is more important than inflation in explaining the mispricing component.

In the column of the U.S. housing market (under the heading of HP), for the mispricing component of NF1 and NF3, consumer sentiment has a significantly positive effect on the housing mispricing component while inflation does not have any significant effect. Again, consumer sentiment seems to dominate in explaining U.S. housing market mispricing component. For NF2, the mispricing component based on non-cointegrated linear model, the model appears to be inappropriate given that the adjusted $R^2$ is negative.

In Panel B for the U.K. stock market, for both NF1 and NF3, consumer sentiment has stronger effect on the mispricing component than inflation. NF2 model appears to be inappropriate in this context given that the adjusted $R^2$ is negative. For the housing market, again consumer sentiment has significant positive effect on the mispricing component of NF1 and NF2 while inflation is insignificant in both mispricing component. Therefore, consumer sentiment seems to dominate inflation in explaining U.K. stock market and housing market mispricing components.

In Panel C for Korean stock market, consumer sentiment has significant positive effect on both NF1 and NF3 while inflation is insignificant in both models. In Korean housing market, in all three mispricing components, consumer sentiment is significant while inflation is insignificant. However, the sign of the consumer sentiment is weakly negative in NF1 and NF3 with relatively low adjusted $R^2$ (0.93% and 2.23%, respectively). But in NF2 model, consumer sentiment has strong positive effect on the housing mispricing component with relatively high adjusted $R^2$ of 19.30%. Therefore, overall, consumer
sentiment seems to dominate inflation in explaining both Korean stock market and housing market mispricing components.

Overall, our finding shows that, between inflation rates and consumer sentiment indexes, the latter has a stronger explanatory power for the mispricing components in asset prices of the U.S. the U.K. and Korea regardless of the stock market or the housing market. This suggests that the mispricing in asset prices is more likely due to consumer sentiment than inflation illusion, although both may be behavioral factors.

5. Concluding remarks

Given the recent debate on the empirical validity of the inflation illusion hypothesis and recent implosion of asset prices combined with potential inflationary pressure, we have examined whether the observed negative relations between stock returns and inflation and between housing returns and inflation can be explained by the inflation illusion. A subjective risk-premium proxy that is used for the calculation of the mispricing component for the U.S. stock market is not easily available for the housing market and other countries. Therefore, we identify the mispricing component in the asset prices (i.e., stock prices and housing prices) based on present value models, both linear and loglinear models, and then investigate whether inflation can explain the mispricing component by using the data from the three countries, the U.S., the U.K., and Korea. We examine not only the extent of the explanatory power of inflation rates for the mispricing components but also the negative effect of inflation rates, as the inflation illusion hypothesis anticipates.

We find some evidence for the inflation illusion hypothesis for the stock return-inflation relation for the U.K. and Korea and for the housing return-inflation relation for Korea in that the inflation rates explain some fraction of mispricing components and their effect on mispricing is negative. When we take into account a potential asymmetric effect of positive and negative inflation on the mispricing components in asset prices, which is an important implication of the inflation illusion hypothesis, we find that none of these asset prices is compatible with the inflation illusion hypothesis in that both positive and negative inflation rates do not have a negative effect on the mispricing components.
Therefore, we find only limited evidence for the inflation illusion hypothesis, which is consistent with recent studies that cast doubt on the empirical validity of the hypothesis for various reasons (e.g., Jacob and Zhang, 2007; Chen, Lung, and Wang, 2009; Wei and Joutz, 2009). As discussed by Piazzesi and Schneider (2007), one way to understand the finding of limited evidence for the inflation illusion hypothesis is that a very small fraction of investors, if any, suffer from it and as a result we anticipate a non-monotonic relation between asset returns and inflation.

We further examine whether behavioral factors such as consumer sentiment can better explain the mispricing components in asset prices. When we include both the inflation rate and the consumer sentiment index in the regression of the mispricing components, the consumer sentiments tend to have a significant positive effect on the mispricing component while inflation loses its explanatory power. This observation is made for both stock market prices and housing market prices for the three countries we consider. Therefore, we find evidence that behavioral factors such as consumer sentiment could have contributed to the mispricing in asset prices.
References


Table 1
Regressions and cross correlations

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<th>dependent variable</th>
<th>constant (t-stat)</th>
<th>INF (t-stat)</th>
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<th>cross correlations with INF(t-k)</th>
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Panel A: The U.S.

Sample period: 1871:01 To 2009:06 (monthly)

SR                   0.3375  (3.3053)  0.3883  (4.1392)  0.0096  0.0968***  0.1011***  0.0092  32.73***
                     (3.3053)  (4.1392)  

RSR                  0.3440  (3.3699)  -0.6110  (-6.5150)  0.0243  0.0223  -0.1579***  -0.0635**  49.01***
                     (3.3699)  (-6.5150)  

Sample period: 1981:01 To 2009:06 (monthly)

HR                   0.4736  (1.7772)  -0.1511  (-0.2404)  -0.0028  -0.0140  -0.0131  0.0087  1.75
                     (1.7772)  (-0.2404)  

RHR                  0.4745  (1.7838)  -1.1516  (-1.8353)  0.0069  -0.0567  -0.0992**  0.0259  4.71
                     (1.7838)  (-1.8353)  

Panel B: The U.K.

Sample period: 1988:i To 2008:iv (quarterly)

SR                   2.4077  (1.9373)  -0.0512  (-0.0505)  -0.0124  -0.0917  -0.0056  -0.1445  2.52
                     (1.9373)  (-0.0505)  

RSR                  2.4046  (1.9492)  -1.0543  (-1.0478)  0.0012  -0.1003  -0.1164  -0.1525  4.02
                     (1.9492)  (-1.0478)  

HR                   0.5360  (1.2315)  -0.9435  (-2.6574)  0.0696  0.0233  -0.2848***  -0.1133  8.05**
                     (1.2315)  (-2.6574)  

RHR                  0.5082  (1.1827)  -1.8868  (-5.3832)  0.2567  0.0020  -0.5157***  -0.1203  23.85***
                     (1.1827)  (-5.3832)  

Panel C: Korea

Sample period 1988:i To 2008:iv (quarterly)

SR                   5.6645  (1.7111)  -2.5788  (-1.1306)  0.0034  -0.2032*  -0.1246  -0.3260***  14.02***
                     (1.7111)  (-1.1306)  

RSR                  5.6733  (1.7272)  -3.5762  (-1.5802)  0.0179  -0.2084*  -0.1729  -0.3330***  15.83***
                     (1.7272)  (-1.5802)  

Sample period 1987:i To 2009:ii (quarterly)

HR                   0.7133  (2.0470)  -0.7437  (-3.3908)  0.1066  0.2617***  -0.3417***  0.1128  18.10***
                     (2.0470)  (-3.3908)  

RHR                  0.6971  (2.0255)  -1.6989  (-7.8425)  0.4074  0.2822***  -0.6436***  0.1598  47.37***
                     (2.0255)  (-7.8425)  

Notes: SR = nominal stock return; RSR = real stock return; HR = nominal housing return; RHR = real housing return; INF= inflation rate; Q-stat = Ljung-Box statistics for the test of the significance of three cross-correlations as a group.
***, ** and * denote significance at 1%, 5%, and 10%, respectively.
Table 2
Unit root and cointegration tests

Panel A. The U.S.

A.1 Unit Root Tests

(i) Augmented Dickey-Fuller regression
\[
\Delta x_t = \alpha_0 + \alpha_{t-1} + \sum_{i=1}^m \gamma_i \Delta x_{t-i} + \nu_t
\]

(ii) Phillips-Perron regression
\[
x_t = \beta_0 + \beta x_{t-1} + \nu_t
\]

<table>
<thead>
<tr>
<th>Variables ($x_t$)</th>
<th>Dickey-Fuller test</th>
<th>Phillips-Perron test</th>
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A.2 Cointegration tests

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Notes:
P = real stock prices; D = dividends; HP = housing prices; rent= rent series.
1. Monthly Data From 1872:01 to 2009:06 (non-logged real series)
P_t = -322.4787 + 57.4843 D_t + S1_t
   (-26.4518) (44.2457)  R Bar **2  0.7211
   Critical values: 1%= -3.437; 5%= -2.864; 10%= -2.568
2. Monthly Data From 1981:01 to 2009:06 (non-logged real series)
HP_t = -2233.6807 + 0.3487 Rent_t + S2_t
   (-15.8347) (22.5187)  R Bar **2  0.7370
   Critical values: 1%= -3.451; 5%= -2.870; 10%= -2.571
(Fuller (1976, Tables 8.5.1 and 8.5.2, pp. 371-373)). The details of the adjusted $t$-statistics $Z(t_b)$ can be found in the work of Phillips and Perron (1988).
Panel B. The U.K.

B.1 Unit Root Tests

\( \Delta x_t = a_0 + \alpha x_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta x_{t-i} + v_t \)  \hspace{1cm} \text{(ii) Phillips-Perron regression}  \hspace{1cm} x_t = b_0 + bx_{t-1} + v_t

<table>
<thead>
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<th>Variables ( (x_t) )</th>
<th>Dickey-Fuller test</th>
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B.2 Cointegration tests

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Notes:
P = real stock prices; D = dividends; HP = housing prices; rent = rent series.
1. Monthly Data From 1888:1 to 2008:IV (non-logged real series)
P_t = 70.7287 + 84.2442 D_t + S1_t
(4.4399 ) (10.09119)  \hspace{1cm} R Bar **2 \hspace{1cm} 0.5469
Critical values: 1% = -3.512 5% = -2.897 10% = -2.586
2. Quarterly Data From 1988:1 to 2008:IV (non-logged real series)
HP_t = 104.0368 - 0.0534 Rent_t + S2_t
(14.0155 ) (-1.2164 )  \hspace{1cm} R Bar **2 \hspace{1cm} 0.0103
Critical values: 1% = -3.512 5% = -2.897 10% = -2.586
(Fuller (1976, Tables 8.5.1 and 8.5.2, pp. 371-373)). The details of the adjusted \( t \)-statistics \( Z(t_b) \) can be found in the work of Phillips and Perron (1988).
Panel C. Korea

C.1 Unit Root Tests

(i) Augmented Dickey-Fuller regression  
(ii) Phillips-Perron regression

\[ \Delta x_t = a_0 + \alpha x_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta x_{t-i} + \nu_i \]

\[ x_t = b_0 + bx_{t-1} + \nu_t \]

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<th>Variables ( ( x_t ) )</th>
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C.2 Cointegration tests

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<th>p-r</th>
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Notes:
P = real stock prices; D = dividends; HP = housing prices; rent = rent series.
P_t = 89.0082 + 12.9584 D_t + S1_t
(21.0537) (2.6088)  R Bar \*\*2 0.0435
Critical values: 1\%= -3.512 5\%= -2.897 10\%= -2.586
2. Quarterly Data From 1987:I to 2009:II (non-logged real series)
HP_t = -11.4036 + 1.0165 Rent_t + S2_t
(-1.9096) (8.1871)  R Bar \*\*2 0.3917
Critical values: 1\%= -3.505 5\%= -2.894 10\%= -2.584
(Fuller (1976, Tables 8.5.1 and 8.5.2, pp. 371-373)). The details of the adjusted \( t \)-statistics \( Z(t_b) \) can be found in the work of Phillips and Perron (1988).
Table 3
Explanatory power of inflation for the mispricing component in asset prices

This table reports estimates of the regression of mispricing component on current inflation rate, lagged inflation rates, and current and lagged inflation rates:

\[ NFi_t = \alpha + \beta_1 \ INF_t + e_{t}, \]  

\[ NFi_t = \alpha + \sum_{i=1}^{m} \beta_i \ INF_{t-i} + e_{t}, \]  

\[ NFi_t = \alpha + \sum_{i=0}^{m} \beta_i \ INF_{t-i} + e_{t}, \]  

for \( i = 1, 2, 3, \)

where \( NF1 = \) mispricing component in asset prices (e.g., stock prices or housing prices), \( NF2 = \) mispricing component in the first differenced asset prices, and \( NF3 = \) mispricing component in the difference in log prices and log dividends (or rents).

***, **, and * represent significance at 1%, 5%, and 10% level, respectively.

For model (11.1) with the current inflation, we report a constant and coefficient of the current inflation. Adjusted \( R^2 \) is in percentage. For model (11.2) with lagged inflation rates, we report \( \chi^2 \) test of the null that each coefficient is zero, and the sum of coefficients with the \( \chi^2 \) test that the sum is zero. Adjusted \( R^2 \) is in percentage. For model (11.3) with the current and lagged inflation rates, we report \( \chi^2 \) test of the null that each coefficient is zero, and the sum of coefficients of the current and lagged inflation rates with the \( \chi^2 \) test that the sum is zero. Adjusted \( R^2 \) is in percentage. SP and HP denote mispricing component in stock price and housing price, respectively.

Panel A. The U.S.

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<th>SP</th>
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<td>NF3</td>
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<tr>
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<td>0.44</td>
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Panel B. The U.K.

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<tr>
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<td>Adj. R²(%)</td>
<td>8.74</td>
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<td>Sum of coeff.</td>
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<tr>
<td>Adj. R²(%)</td>
<td>25.83</td>
<td>7.45</td>
<td>31.14</td>
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<td>Adj. R²(%)</td>
<td>25.48</td>
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<td>31.08</td>
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Panel C. Korea

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<td>-2.92</td>
<td>-0.45 ***</td>
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<td>Adj. R²(%)</td>
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<td>Each coeff. = 0</td>
<td>18.71 ***</td>
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<td>Sum of coeff.</td>
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<td>Each coeff. = 0</td>
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<td>Sum of coeff.</td>
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<td>-4.87 *</td>
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<tr>
<td>Adj. R²(%)</td>
<td>9.90</td>
<td>5.43</td>
<td>37.31</td>
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Table 4  
Asymmetric relation between mispricing and inflation

\[ NF_{i,t} = a + b_1 \pi_{1,t} + b_2 \pi_{2,t}, \text{ for } i = 1, 2, 3, \]  
\[ (11.4) \]

where \( \pi_{1,t} \) = positive inflation; \( \pi_{2,t} \) = negative inflation,  
\( NF_1 \) = mispricing component in asset prices (e.g., stock prices or housing prices),  
\( NF_2 \) = mispricing component in the first differenced asset prices, and  
\( NF_3 \) = mispricing component in the difference in log prices and log dividends (or rents).  
SP and HP denote mispricing component in stock price and housing price, respectively.  
***, **, and * represent significance at 1%, 5%, and 10% level, respectively.

Panel A. The U.S.

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<tr>
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<tr>
<td>Coeff. of ( \pi_{1,t} )</td>
<td>7.26</td>
<td>-1.81</td>
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<tr>
<td>Coeff. of ( \pi_{2,t} )</td>
<td>-7.76</td>
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<td>Adj. R^2(%)</td>
<td>-0.02</td>
<td>0.27</td>
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<td>( \chi^2 ) (1) test</td>
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<td>Signi. Level(%)</td>
<td>5.80</td>
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Panel B. The U.K.

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<tr>
<td>constant</td>
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<td>**</td>
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<tr>
<td>Coeff. of ( \pi_{1,t} )</td>
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<td>***</td>
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<td>Coeff. of ( \pi_{2,t} )</td>
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<td>-17.52</td>
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<td>Adj. R^2(%)</td>
<td>7.65</td>
<td>-0.32</td>
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<td>( \chi^2 ) (1) test</td>
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<td>Signi. Level(%)</td>
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Panel C. Korea

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<tr>
<td>Signi. Level(%)</td>
<td>68.98</td>
<td>78.29</td>
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Table 5
Explanatory power of inflation and consumer sentiment for the mispricing component in asset prices

This table reports estimates of the regression of mispricing component on current inflation rate and current consumer sentiment index:

\[ NFi_t = \alpha_i + \beta_i \ \text{INF}_t + \gamma_i \ \text{CS}_t + \epsilon_{it}, \quad (11.5) \]

where NF1 = mispricing component in asset prices (e.g., stock prices or housing prices), NF2 = mispricing component in the first differenced asset prices, and NF3 = mispricing component in the difference in log prices and log dividends (or rents).

***, **, and * represent significance at 1%, 5%, and 10% level, respectively.

For model (11.5), for each mispricing component, we report a constant and coefficients of the current inflation and the current consumer sentiment index. Adjusted R² is in percentage. SP and HP denote mispricing component in stock price and housing price, respectively.

Panel A. the U.S.

<table>
<thead>
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<td>Adj. R²(%)</td>
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Panel B. The U.K.
1989:1 – 2008:3

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Panel C. Korea  

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<td>5.10</td>
<td>-1.50**</td>
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<td>0.04</td>
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<td>-0.08*</td>
<td>0.02***</td>
<td>-0.002*</td>
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<td>Adj. R²(%)</td>
<td>10.26</td>
<td>-3.14</td>
<td>8.91</td>
<td>0.93</td>
<td>19.30</td>
<td>2.23</td>
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