# Trend-Chasing and home price dynamics: evidence from a novel index measure of housing sentiment

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**Abstract**

*Previous studies suggest the housing asset class is vulnerable to sentiment, particularly over extrapolation bias (Shiller (1990)). I specify home price dynamics as a function of over extrapolation-based trend-chasing, and a sentiment-correction when the mispricing becomes large and more recognizable. To calibrate this specification and avoid the difficulties with measuring fundamental values directly, I construct indices of housing sentiment called HSENT. I find momentum dominates the sentiment correction component of price dynamics until HSENT becomes extreme. Over 3-10 years HSENT negatively predicts housing returns, but positively predicts various housing risks, consistent with HSENT capturing bias in expectations.*

## 1. Introduction

In the economic and financial media, the large run up in home prices in the early 2000s followed by the dramatic fall in the late 2000s has popularized the hypothesis that such price swings are driven, at least in part, by sentiment. The most prominent scholar to advance this hypothesis has been Nobel laureate Robert Shiller who, at least as early as 2005, discusses what he saw as a sentiment-based housing bubble in Irrational Exuberance (Shiller (2005)).

Despite the intuitive and popular appeal of Shiller's "irrational exuberance" explanation of the record home prices of 2005-2006, scholarly work has been mixed over whether such price swings can be interpreted as sentiment-driven. A central problem with measuring sentiment-based mispricing in the housing market is that a dollar amount for fundamental value is much harder to obtain compared to many income generating equity and fixed-income, and commercial real estate assets. I define investor sentiment as bias in investor expectations about future returns and risks in the housing market. In a market such as single-family housing where fundamental value is difficult to define, it is also difficult to identify the degree to which a discrepancy between the market price and fundamental value can be explained by investor sentiment (Ling, Ooi, and Le (2013b)).

Although traditional fundamental variables such as income, employment, and population are widely available, they do not necessarily allow investors to make a straight forward and uncontroversial estimate of what the specific fundamental value is in dollars. While fundamental variables may explain prices in a regression context, their ability to explain the rational and sentiment based components of prices is confounded within the estimated coefficients; investor sentiment can be easily hidden within the component of prices explained by fundamentals when investors overreact to changes in fundamentals or exhibit other forms of sentiment.

Without a dollar amount for fundamental value, it is difficult to argue whether prices are too high or too low. Yet, this difficulty in calculating fundamental value in the housing market gives reason to suspect that investor sentiment, particularly overextrapolation bias (Shiller (1990)) may have a significant impact on home prices. Survey evidence from the mid-2000s documents a significant presence of trend chasers in the housing market while prices grew to historic highs (Piazzesi and Schneider (2009)).

I argue that the housing market is vulnerable to trend-chasing because market participants have difficulty in valuing homes on the basis of discounted cash flows or by generating a dollar estimate of fundamental value from fundamental variables. In this paper trend-chasing is defined as

buying or selling behavior motivated by interpreting recent price changes as a same-signed signal of future price changes; both Case and Shiller (2003) and Himmelberg, Mayer, and Sinai (2005) use this definition of trend-chasing specifically in regards to price increases as their definition of a housing bubble. The informational conditions under which many trend-chasing models operate such as incomplete or noisy private information about fundamentals, over-extrapolative expectations, and profit opportunities for momentum traders early in the cycle are all present in the housing market.

The combination of (1) a documented presence of trend chasers in the housing market, and (2) the difficulty with discerning single-family housing fundamental values motivates my specification of home price dynamics in which trend-chasing (equivalently, positive feedback investment, or momentum investing) can exacerbate mispricing. There are also several underlying psychological reasons why we might expect trend-chasing in the housing market, such as over extrapolation bias (Case and Shiller, (1988; Barberis (2012), or herding (Baddeley (2005).

I specify home price growth as positively autocorrelated with past growth, and mean reverting with respect to sentiment-based mispricing. The autocorrelation component captures the widely documented trend-chasing behavior of homebuyers that leads to momentum in the housing market. Under my specification, when trend-chasing causes the magnitude of sentiment-based mispricing to increase, the sentiment component of prices becomes more recognizable. As a result, the correction of the sentiment component of prices gets stronger, and the trend-chasing component of price dynamics momentum diminishes.

However, only when the magnitude of sentiment becomes sufficiently large relative to the magnitude of past returns does a corrective reversal occur in the direction of home price growth. This is because as sentiment-based mispricing becomes more extreme it becomes increasingly recognizable, so investments based on the increasingly perceptible differences between home prices and fundamental value begin to counter-balance, then eventually dominate investments based on trend-chasing. When this happens, prices begin to return toward fundamental value. The first main contribution of this paper is to show that the well-known momentum and reversal patterns in housing cycles can be explained by a dynamic tension between trend-chasing and corrections in sentiment-based mispricing.

To resolve the dilemma in measuring mispricing by first estimating a dollar amount for fundamental value, I take a principle components approach similar to the stock market sentiment proxies in Baker and Wurgler (2006, 2007). I use established theories concerning housing economics and price dynamics to create several individual proxies of housing sentiment. I then combine these individual variables into annual indices of housing sentiment, called HSENT, for each city in my sample using principle components analysis (PCA). The value of this approach is that the HSENT proxy of housing sentiment does not require estimating fundamental value as a first step; Ling, Ooi, and Le (2013b) also recognize this important advantage in developing a survey based measure of housing sentiment.

The HSENT measure is negatively related to subsequent home price returns over the next decade. However, over the same period HSENT is positively related to housing return volatility, the covariance of housing returns with stock market excess returns, and the covariance of housing returns with GDP growth. This is evidence that the HSENT proxy does indeed capture bias in expectations about the housing market, i.e., housing sentiment. Overall, my housing sentiment measures are consistent with the popular hindsight that home prices entered a bubble during the mid-2000s; however, I also find that price levels in several major cities were actually below fundamental value in this same period. While HSENT has only moderate predictive power in the short run (1-3 years), it is clear that it negatively predicts returns over a longer period (5-0years), while also predicting higher housing market risk. This risk-reward dynamic is consistent with HSENT capturing investor sentiment.

I use my annual housing sentiment indices to calibrate the autocorrelation and sentiment mean reversion parameters of the linear home price growth specification. I find that annual home price growth autocorrelation coefficients are between 0.76 and 0.91. After controlling for home price autocorrelation, I find a one standard deviation change in sentiment is associated with between a 1.1% and 1.5% opposite signed change in home prices in the following year. Hence the HSENT proxy is able to disentangle trend-chasing from sentiment correction in home price dynamics.

Economically, these calibration results mean that trend-chasing exacerbates mispricing until it becomes quite large. For example, when a housing market experiences rising prices that lead to moderate overpricing according to the HSENT proxy, then in the next year the amount of overpricing would, on average, grow even more from trend-chasing, rather than correct. As home prices and sentiment-based overpricing continue to increase, price growth slows down. However, only when sentiment is sufficiently large relative to current price growth does a reversal in growth become likely.

Typically, my mean zero measures of sentiment reach between one and three standard deviations from zero before corrections occur. Based on inflation adjusted price levels when HSENT is near zero, this means prices are usually between 20% and 60% away from fundamental value before corrections occur.

## 2. Related Literature

Piazzesi and Schneider (2009) show that a small number of overly optimistic buyers can drive up the housing market's general price level. They also provide survey evidence that during the housing boom of the 2000s there was always a group of investors who believed it was a good time to buy a home because they believed home prices would rise even further. The existence of these trend-chasing investors supports the idea that directly observable price increases continued to motivate some housing investment during this period, even as prices rose far above fundamentals. Lai and Van Order (2010) also find strong evidence of momentum in the U.S. housing market, which they conclude has at times driven prices away from fundamentals, especially in the 2002- 2005 period.

Momentum can also cause housing sentiment to expand rather than correct in the model of Burnside, Eichenbaum, and Rebelo (2012). In their model, agents with relatively stronger beliefs about the housing market are more likely to convert others to their views, which then leads to a fad in expectations about home prices. An important aspect of their model is that fundamental value in the housing market is difficult to observe. This makes it understandable why social dynamics can cause people to alter their outlook on home prices. Strong housing momentum and trend-chasing also are consistent with the self-enhancing transmission bias form of social dynamics modeled in Han and Hirshleifer (2012).

My central finding, that on average trend-chasing causes sentiment to grow in magnitude, rather than correct, until sentiment becomes extreme, is consistent with several prior stock market related studies. In Hong and Stein (1999), trend-chasing investors cause prices to eventually overreact, even if prices initially underreact to news about fundamentals. Models such as those in De Long, Shleifer, Summers, and Waldmann (1990) and Cutler, Poterba, and Summers (1990) show how positive feedback from trend-chasing investors can push prices further and further away from fundamental value, resulting in bubbles and adding volatility to markets. Daniel, Hirshleifer, and Subrahmanyam (1998) show how overconfidence about private information and self- attribution bias can lead to short-run overreaction and momentum. As public information about fundamentals comes out, there is eventually a long-run reversal in asset prices.

Unlike the stock market, which has regular news about earnings and cash information about housing fundamentals is less straightforward. As a result, price momentum and mispricing appear to last much longer in the housing market. Single- family housing market sentiment is less likely to correct as quickly as stock market sentiment because real estate markets have the following traits: (1) illiquidity, (2) high transaction costs, (3) a high share of non-institutional investors, (4) no direct

method to establish short positions (Ling, Naranjo, and Scheick (2013a)), (5) significant information asymmetry (e.g., Garmaise and Moskowitz (2004) and Levitt and Syverson (2008)), and (6) an incomplete market lacking liquid derivatives (Case, Shiller, and Weiss (1993)).

Thus, the main elements to support arbitrage trade against housing mispricing are largely absent in single-family housing markets. In regards to housing markets, Abraham and Hendershott (1996) argue that \the larger bubbles grow, the more likely they are to burst." They focus on the tendency for bubbles to burst and for prices to revert back toward fundamentals. Although I take a very different approach to measuring mis- pricing, my results are consistent with their's; the more extreme mispricing becomes, the more likely a correction will occur. Capozza, Hendershott, and Mack (2004) examine how housing momentum can cause prices to come overshoot equilibrium, and also calibrate serial correlation and mean reversion coefficients for housing price dynamics which my results are similar to.

Despite the housing market's importance to the overall economy, it has failed most tests of semi-strong form market efficiency. In the 1980s, several studies tested whether the housing market was efficient (see Maier and Herath (2009) for a survey). Case and Shiller (1989) was the first multi-city study to argue that the single-family housing market was not semi-strong form efficient. Although research has offered evidence of mispricing, few attempts have been made to quantify housing sentiment. In order to quantify housing sentiment, my paper adopts the methodology of Baker and Wurgler (2006, 2007). I use principle components analysis (PCA) to compile a set of variables designed to capture housing market sentiment into housing market sentiment indices for several cities.

In comparison with Baker and Wurgler's stock sentiment index, the housing sentiment index has an advantage in that data is available to construct indices for a cross-section of several cities, measuring sentiment at the city level. Prior research documents significant differences in home appreciation rates and home price variance across cities (e.g., Gyourko and Voith (1992)). In support of these findings, I find significant differences in housing sentiment across cities. The cross-sectional variation that I find in sentiment is useful for disentangling the influence of home price momentum and sentiment corrections on home price dynamics.

My study contributes to a growing literature concerning housing-related behavioral finance (Mayer and Sinai (2009) provide an overview). In addition to self-enhancing transmission bias, overconfidence, and self-attribution bias, several other underlying psychological traits may also be relevant to the housing market. Case and Shiller (1988) provide survey-based evidence of overextrapolation bias in the housing market. Barberis (2012) suggests that overextrapolation can help explain the housing-related financial crisis of the late 2000s. Goetzmann, Peng, and Yen (2012) also propose that over extrapolation, as a result of simplistic econometric models, contributed significantly to inflated home prices in the early and mid-2000s. Genesove and Mayer (2001) and Engelhardt (2003) show evidence of loss-aversion in the housing market. Korniotis and Kumar (2011) find that behavioral biases can explain suboptimal local risk-sharing. Choi, Hong, and Scheinkman (2013) find that homeowners often have mistaken expectations of how home improvement projects will increase the value of home, partially due to over extrapolating a trend of rising home prices.

Recently, Chauvet, Gabriel, and Lutz (2013) develop a measure of investor fear in the residential market based on Google searches. However, compared to the residential market, more attention has been given to developing quantitative measures of investor sentiment for commercial real estate and real estate investment trusts (RE- ITs). Hendershott and MacGregor (2005) find that when net operating income (NOI) grows above trend, property sale prices also grow, even though trend deviations in commercial property rents negatively predict future rents. Clayton, Ling, and Naranjo (2009) examine investor sentiment in commercial real estate, focusing on a model of sentiment based on error-corrections in capitalization rates. Lin, Rahman, and Yung (2009) demonstrate that investor stock sentiment has incremental explanatory power on REIT returns, after

including conventional control variables. A spillover between stock market sentiment and REIT returns is also demonstrated through the increased correlation between REITs and stock sentiment following the inclusion of some REITs in stock indices (Ambrose, Lee, and Peek (2007)).

**3. Home Price Growth as a Function of Momentum and Housing Sentiment Correction**

My central hypothesis is that trend-chasing behavior in the housing market can push prices significantly away from fundamental value because fundamental value is difficult to discern; as sentiment increases in magnitude its impact on prices becomes more recognizable, hence reducing and eventually correcting the trend-chasing behavior. A simple way to capture this idea is to specify growth in home prices as a linear function of price momentum and sentiment mean reversion:

$$g_{t+1} = \gamma(\mathbf{f}_{t+1}) + \rho g_t - \phi HSENT_t + \epsilon_{t+1}, \quad 0 < \rho, \quad 0 < \phi \qquad (1)$$

In Equation 1 gt+1 is the rate of real home price growth during period t + 1. (ft+1) is the growth in fundamental value function; its input is ft, a vector of fundamental supply and demand variables. HSENTt is the housing sentiment level reflected in prices in period t, and _t is an unexplained random mean zero shock to the home price growth rate. The positive growth autocorrelation constant, ρ, captures housing momentum.

While there may be other phenomenon that contribute to housing momentum, prior studies give evidence of a strong link between momentum and trend-chasing (e.g. Shiller (1990), and Piazzesi and Schneider (2009)). Even if a trend is initiated by a change in fundamentals, trend-chasing is likely to follow. Abraham and Hendershott (1996) write, "The lagged appreciation rate is an obvious bubble builder; once appreciation accelerates, because of, say, stronger fundamentals, the lagged variable magnifies the increase." Besides the survey evidence of trend-chasing, prior studies have also concluded the housing market also lends itself to the type of psychological biases that can generate trend-chasing such as over-extrapulation (e.g. Case and Shiller (1988), Barberis (2012), and Goetzmann, Peng, and Yen (2012)) and herding (Baddeley (2005), Baddeley (2011)).

In equation 1, φ is the sentiment mean reversion constant. The entire sentiment mean reversion term, φHSENTt, captures the idea that the magnitude of sentiment-based mispricing determines how large the sentiment correction forces will be on housing dynamics. Low levels of sentiment go unrecognized by most investors, and thus have only a weak effect on price dynamics. Extreme levels of sentiment are recognized by most investors, and affect price dynamics more significantly.

This specification is similar to that of Abraham and Hendershott (1996) who use fundamentals plus an error term to explain equilibrium home price levels in cities. Their error term is comprised of an autocorrelation term, and a second term which mean reverts based on the differential between equilibrium prices and actual prices. Their mean reversion term caries similar intuition as my HSENT mean reversion term. My approach differs in that I capture a proxy of mispricing without first estimating a dollar amount for fundamental value.

I define HSENT--the impact of housing sentiment on home prices--as the standardized divergence between home prices and fundamental value[1]. Hence if prices grow more (less) than fundamental value does, this is an increase (decrease) in HSENT. HSENT is the standardized percentage of overpricing or underpricing:

$$HSENT_t \equiv \frac{P_t/V_t - \mu}{\sigma}, \quad \mu = 1, \qquad (2)$$

[1]To make the model parameters independent from the dollar amount of home price levels, which varies between cities, I will focus on sentiment in the form of the ratio between prices and fundamental value.

where Pt is the real home price in period t, Vt is the real fundamental value in period t, μ is the long-run average ratio between prices and fundamental value, which I assume to be 1, and σ is the standard deviation in the price-to-value ratio. The main obstacle to calibrating the specification in Equation 1 is that fundamental value is difficult to measure directly. But with a good proxy for HSENT, this specification is testable. A successful proxy of sentiment-based mispricing in this specification must: (1) be able to predict risk and return dynamics inconsistent with risk-averse rational expectations, and (2) exert a mean reversion force on home prices.

An assumption underlying my hypothesis is that most housing market participants do not know the true form of the component of price growth justified by fundamentals, (ft). Even for the econometrician with data on housing fundamentals, it is not a straightforward task to determine how changes in fundamentals translate to changes in fundamental value. Even if one can determine exactly how fundamental variables (e.g. income, population, or construction costs) explain prices in a regression context, this does not necessarily mean that the portion of home prices explained by fundamental variables can be interpreted as representing fundamental value. Shiller (1990) and others provide evidence that investors overextrapolate and overshoot the impact of changes in fundamentals on fundamental value's dollar amount, which is consistent with the large swings in home prices observed in many cities. Such biases in investors' expectation will end up being captured in inflated magnitudes of the coefficients on the fundamental variables used to explain home prices.

The dollar amount for fundamental value is, by definition, orthogonal to biases such as over extrapolation, but the portion of home prices explained by fundamental variables on prices is not. Over extrapolation, over optimism and other biases may be ignited by changes in fundamentals, thus making it difficult for the econometrician to know if fundamental value is actually taking such large swings, or if overshooting and mispricing are being imbedded into the portion of home prices explained by fundamental variables. Nevertheless, it is not essential to my specification that the function transforming fundamental variables into the growth rate of fundamental value is unknown; it just keeps the specification consistent with the idea that trend-chasing is more likely when fundamental value is difficult to estimate.

The two following Propositions organize the idea that when investors chase visible past returns, then the return momentum can cause small amounts mispricing to become more extreme.

*Proposition 3.1. On average, a housing market with growing prices (gt > 0) and positive sentiment (HSENTt > 0) will experience continued increases in prices and sentiment until:*

$$\phi HSENT_t > \rho g_t, \quad 0 < \rho, \quad 0 < \phi. \tag{3}$$

*Proposition 3.2. On average, a housing market with falling prices (gt < 0) and negative sentiment (HSENTt < 0) will experience continued decreases in prices and sentiment until:*

$$\phi HSENT_t < \rho g_t, \quad 0 < \rho, \quad 0 < \phi, \tag{4}$$

To more clearly portray the tension between return momentum that can move prices away from fundamental value, and the increasing magnitude of sentiment-based mispricing, I substitute the definition of the price impact of sentiment (Equation 2) into the home price growth specification (Equation 1).

$$
\begin{aligned}
g_{t+1} &= \gamma(\mathbf{f}_{t+1}) + \rho g_t - \phi HSENT_t \\
&= \gamma(\mathbf{f}_{t+1}) + \rho g_t - \phi \left( \frac{P_t/V_t - 1}{\sigma} \right) \\
&= \gamma(\mathbf{f}_{t+1}) + \rho g_t - \phi \left( \frac{P_{t-1}(1+g_t)/V_{t-1}(1+\gamma(\mathbf{f}_t)) - 1}{\sigma} \right). \qquad (5)
\end{aligned}
$$

Because the home price growth is part of both the trend-chasing term and the sentiment mean reversion term, the overall effect of price growth on subsequent price growth depends on the relative sizes of price momentum and sentiment-based mispricing. The cumulative effect of multiple periods of trend-chasing is to push the price-to-value ratio significantly away from 1. However as the price-to-value ratio ratio moves away from 1, the mispricing becomes more noticeable, and the sentiment mean reversion force on price dynamics becomes stronger. This captures the idea that larger magnitudes of sentiment are more likely to be recognized and thus lead to larger corrective forces on prices.

The growth in fundamental value cannot be directly backed out from observable home price growth because: (1) the noise of the unexplained component _t, and (2) housing sentiment is also not directly observable to most investors since it is quite difficult for most homebuyers to translate information about aggregate population, income, employment, housing construction, and many other fundamentals into a specific dollar value for homes in an area. The basic intuition is that when housing sentiment is very high (low), more investors sense that the market is overpriced (underpriced); momentum based buying (selling) slows down, eventually stops, then prices begin to correct.

One important feature of the home price growth specification is that even if initial price changes are attributable to fundamentals, subsequent growth from trend-chasing investors can generate mispricing. This feature is similar to the Hong and Stein (1999) model. The second main feature of my home price growth specification is that sentiment will on average continue to become more extreme, until sentiment is extreme enough relative to recent price growth for a reversal in the direction of price growth to occur.

## 4. Housing Sentiment Index Factors

Both homebuyers and researchers face similar problems in estimating a specific dollar amount for fundamental value in housing. When prices are regressed on variables considered fundamentals, the resulting coefficient estimates capture both the rational and biased components of how price changes relate to changes in fundamental variables. Investor sentiment is not only potentially captured by the residuals of such a regression, but the bias in investor expectations may also be confounded within the coefficients on fundamentals.

Because the component of prices explained by fundamental variables cannot be straightforwardly interpreted as fundamental value in the presence of over-extrapolation and other forms of investor sentiment, I take an alternative approach to measure housing sentiment's impact on home prices. To operationalize my home price dynamics specification in Equation 1, I use principle component analysis (PCA) to construct a novel index measure of single-family housing sentiment, hence avoiding the complications with directly calculating a specific dollar amount for fundamental value. The resulting index, called HSENT, is based on the following individual factors[2]: the number

[2] The individual variables used in PCA are often called factors, not to be confused with traditional asset pricing model factors.

of home sales per capita (SALES), home price appreciation relative to growth rates in employment (HPIg-EMPg), price-to-income ratios (PRICE/INC), loan-to-value ratios (LTV), the spread between mortgage and Treasury interest rates (EIR-TSRY), and the rent-to-price ratio (RENT/PRICE). The basic rationale is to design sentiment factors that are fairly stationary and for which deviations from the mean capture deviations from long run equilibrium.

Based on prior research, these variables are designed to proxy for housing sentiment. Previous studies and news media sometimes use "sentiment" and "confidence" to reference survey-based measures of investors' outlook (e.g., the NAHB-Wells Fargo Housing Market Index and the Knight Frank and Markit's House Price Sentiment Index). I use sentiment in a stricter sense to refer specifically to the bias in expectations of housing returns (first and higher moments) held by housing market participants.[3] In this sense sentiment proxies have important differences from variables that proxy for fundamental value. Sentiment proxies provide information about the divergence between fundamental value and price, but not necessarily direct information about the absolute level of the fundamental value. My sentiment measures are standardized, hence they do not directly give information on the dollar level of fundamental value. Next, I address the rationale for the direction in which each variable is a proxy for sentiment.

The SALES factor is the number of single-family existing home sales in an MSA divided by the MSA's population. A high (low) number of per capita sales can indicate high (low) housing sentiment if homeowners are reluctant to sell their home when the price is relatively low. Engelhardt (2003) suggests that homeowners may be reluctant to realize losses. Previous research suggests that housing turnover will proxy for investor bias when investors are subject to nominal-loss aversion (Genesove and Mayer (2001)), or use anchoring heuristics based on home price reference points (Leung and Tsang
(2011)).

The local employment rate, population growth, and income growth are widely considered the main macroeconomic and demographic drivers of local home prices (e.g. Reichert (1990)). In both the US and the UK housing markets, Meen (2002) finds that population and income variables have co-integration properties with home prices and predictive power on future home prices. Home price appreciation in comparison to the employment rate, population growth, and income growth are common ways to evaluate where home prices are in relation to fundamental values (e.g., Wheaton and Nechayev (2008)). These prior studies suggest sentiment proxies based on the employment rate, population growth, and income growth.

The HPIg-EMPg factor is the percent change in home prices minus the percent change in the employment rate. It stands to reason that it is not sustainable for home prices and the employment rate to move in opposite directions in a city, all else equal. I expect a positive (negative) differential to indicate positive (negative) sentiment. For any periods in which the employment rate grew but the labor force shrunk at a greater rate, I instead use the percent change in home prices minus the percent change in the labor force. I make this adjustment because unemployed individuals who stop looking for work are no longer considered part of the labor force; hence, employment rates could actually increase because many people stop looking for work.

The PRICE/INC factor is the ratio of home prices to per-capita income. Because this ratio can have a different long-run level across cities, I compare a city's price-to- income ratio with its own long-run average. I expect a high (low) ratio to indicate positive (negative) sentiment. Traditionally, home prices and income are regarded as cointegrated (e.g., Holly and Jones (1997) and Malpezzi

[3] Soo (2013) recently develops a measure of housing sentiment in this stricter sense based on the qualitative tone in local newspapers.

(1999)), making their ratio stationary. Again, this is convenient since divergences away from the long run mean of the ratio can be understood as departures from a long run statistical equilibrium. Following the dramatic rise and fall in home prices across many U.S. markets in over the 1987-1991 period, many real estate practitioners believed that, \using local income it's possible to calculate an equilibrium home price that shows when-and by how much-a local home market is overpriced" (Winzer (1992)). Shiller (2005) also uses the price- to-income ratio as a measure for how prices are diverging from fundamental value.

The LTV factor is the ratio of the initial loan balance to the purchase price. Goetzmann, Peng, and Yen (2012) note that "past home price increases are associated with more subprime applications, higher loan to income ratios and lower loan to value ratios of applications for both prime and subprime mortgages." Taking this argument from the stand point of home price declines implies that high LTVs at the time of sale may result from recent home price decreases and lesser willingness on behalf of borrowers to invest equity in a home purchase. My empirical results confirm the intuition of Goetzmann et al.; the component of LTV incremental to other sentiment factors is 15 inversely related to housing sentiment and likely captures a reluctance on the part of homebuyers to invest equity.

The EIR-TSRY factor is the effective mortgage interest rate[4] minus yield to maturity on the 10-year Treasury note yield to maturity[5]. Housing sentiment can be reflected in this interest rate spread in on both the credit demand and credit supply side. Home purchases driven by high sentiment can increase the demand for mort- gages and drive the spread up. Ambrose, LaCour-Little, and Sanders (2004) find that non-conforming mortgages, which became a popular financing choice among home purchasers during the most recent housing bubble, have spreads about 5.5% higher than conforming home loans. On the supply side, high sentiment among mortgage originators can increase the spread as lenders issue to higher risk borrowers. Based on a loan-level study, Demyanyk and Van Hemert (2011) conclude that \ the rise and fall of the subprime mortgage market follows a classic lending boom-bust scenario, in which unsustainable growth leads to the collapse of the market." Mian and Sufi (2009) also document that increased credit to riskier borrowers was associated with initial increases in home prices followed by later increases in defaults and subsequent decreases in home prices.

The RENT/PRICE factor is the annual owner equivalent rent divided by home price. Brunnermeier and Julliard (2008) recognize the price-to-rent ratio to contain both a rational component and a mispricing component. The inverse of this ratio functions as a residential capitalization rate. Capitalization rates have been used in several studies as measures of investor sentiment in the commercial real estate market (e.g. Clayton, Ling, and Naranjo (2009), Chervachidze, Costello, and Wheaton (2009)). In these studies low (high) capitalization rates are associated with high (low) sentiment. This logic carries over to the residential market; a low (high) rent-to-price ratio re that home prices are high (low) relative to their income generating, or rent saving capabilities.

While each individual factor may not be a perfect housing sentiment proxy, it is their joint commonality that I exploit in developing a housing sentiment proxy. Using various combinations of the individual sentiment factors, I am able to capture about 40% of the sample variance in the first principal component, which indicates that a source of common variation is well identified within the set of variables I use. In comparison, for the stock sentiment index of Baker and Wurgler (2006), they

[4] The effective interest rate is the annual percentage rate on conventional mortgages based on the initial financing the borrower actually receives, which is the loan amount minus initial fees and charges.

[5] [5]I use the 10-year note because it has a duration similar to that of the average mortgage duration and is highly liquid.

state, \The first principal component explains 49% of the sample variance, so we conclude that one factor captures much of the common variation."

## 5. Calibration Results of the Home Price Growth Model

The main application of the sentiment indices developed in this study is to calibrate the home price growth specification. Using the housing sentiment indices, I estimate the autocorrelation and sentiment mean reversion coefficients from Equation 1 with ordinary least squares (OLS) as follows:

$$g_{i,t+1} = \bar{\gamma} + \rho g_{it} - \phi HSENT_{it} + \epsilon_{i,t+1}, \tag{6}$$

where subscript i indicates MSA and subscript t is the year. The results, displayed in Table 5, show strong autocorrelation between 0.7 and 0.9 (Beracha and Skiba (2011) also find significant price momentum across a wide sample of US housing markets).

Table 5: **Estimated home price growth model.** I use OLS to estimate $g_{t+1} = \bar{\gamma} + \rho g_t + \phi HSENT_t + \epsilon_{t+1}$, where $g_t$ is the growth rate in real home prices from period $t-1$ to period $t$, and $HSENT_t$ is the housing sentiment level in period $t$. I estimate the autocorrelation coefficient, $\rho$, and the sentiment mean reversion coefficient, $\phi$. The intercept $\bar{\gamma}$ is the average of $\gamma(\mathbf{f}_{t+1})$, the growth in fundamental value. The columns indicate which housing sentiment index is used. T-statistics are in parentheses, and N is the number of MSA-year observations.

| | 2 factor | 3 factor | 4 factor | 5 factor | 6 factor |
|---|---|---|---|---|---|
| $\gamma$ | -0.0014 | -0.0014 | -0.0009 | 0.0009 | 0.0009 |
| | (-1.02) | (-1.00) | (-0.54) | (0.40) | (0.26) |
| $\rho$ on real g | 0.7566 | 0.7515 | 0.8828 | 0.8898 | 0.8251 |
| | (35.80) | (35.47) | (31.72) | (26.40) | (15.88) |
| $-\phi$ on $HSENT_t$ | -0.0125 | -0.0117 | -0.0126 | -0.0153 | -0.0070 |
| | (-9.11) | (-8.50) | (-6.93) | (-6.01) | (-2.06) |
| N | 1005 | 1005 | 657 | 456 | 179 |
| Adjusted $R^2$ | 0.56 | 0.56 | 0.62 | 0.63 | 0.60 |

The sentiment mean reversion is also strong with the coefficients between 1.1% and 1.5%. Given that the housing sentiment indices have unit standard deviation, the mean reversion coefficient indicates that a one standard deviation increase in sentiment is associated with a .07%-1.5% lower home price growth rate. The average real fundamental growth rate, which is represented by the intercept term γ, is statistically indistinguishable from zero. This makes sense given that housing assets provide a great deal of consumption utility. The calibration of the standard deviation of unexplained shocks to housing growth is captured by root of the mean square error which is 3.9%-4.5%. As an example, a calibrated specification using in range coefficient estimates takes the following form:

$$g_{t+1} = \gamma(\mathbf{f}_{t+1}) + .8g_t - .0125HSENT_t + \epsilon_{t+1}, \quad \sigma_\epsilon = .2, \quad \bar{\gamma} = 0, \tag{7}$$

where σe is the standard deviation of unexplained shocks to housing growth, and γ is the average growth in real fundamental value. The estimated model coefficients support Propositions 3.1 and 3.2. Only when sentiment is extreme does the mean reversion term overpower the trend-chasing term in the calibrated home price growth specification.

For example, with ρ = 0.8 and φ = 0.0125 we can see what happens following a 5% shock to home price growth unrelated to fundamentals. The trend-chasing term would contribute .8(5%) to subsequent growth, while the sentiment mean reversion term would induce -.0125(HSENT) = -

.0125(1.05 - 1)/σ in corrective forces. Hence, on average, sentiment would actually become more positive rather than being corrected in the period subsequent to a shock if one standard deviation of HSENT, σ, is at least 1.5625% in terms of percent of fundamental value. This key result of positive feedback between home prices and sentiment in the short-run is corroborated in the findings of Ling, Ooi, and Le (2013b).

The question of just how much mispricing (as a percentage or dollar amount) is rep- resented by the housing sentiment measures (which are in abstract standardized units) must still be answered in order to numerically evaluate the inequalities in Propositions 3.1 and 3.2. To calibrate a percentage mispricing value for one unit of HSENT, σ, I take the average real home price level when the sentiment proxies are nearly zero (-0.25 < HSENTt < 0.25) in each MSA. In other words, I take the price levels when HSENT is near the zero guide lines in Figure 13 below as an estimate for fundamental value level. Since the estimate of the average fundamental real growth rate is zero, the average fundamental price level in real terms is fairly stationary. I then calculate the standard deviation of real prices from this zero sentiment price level for each MSA.

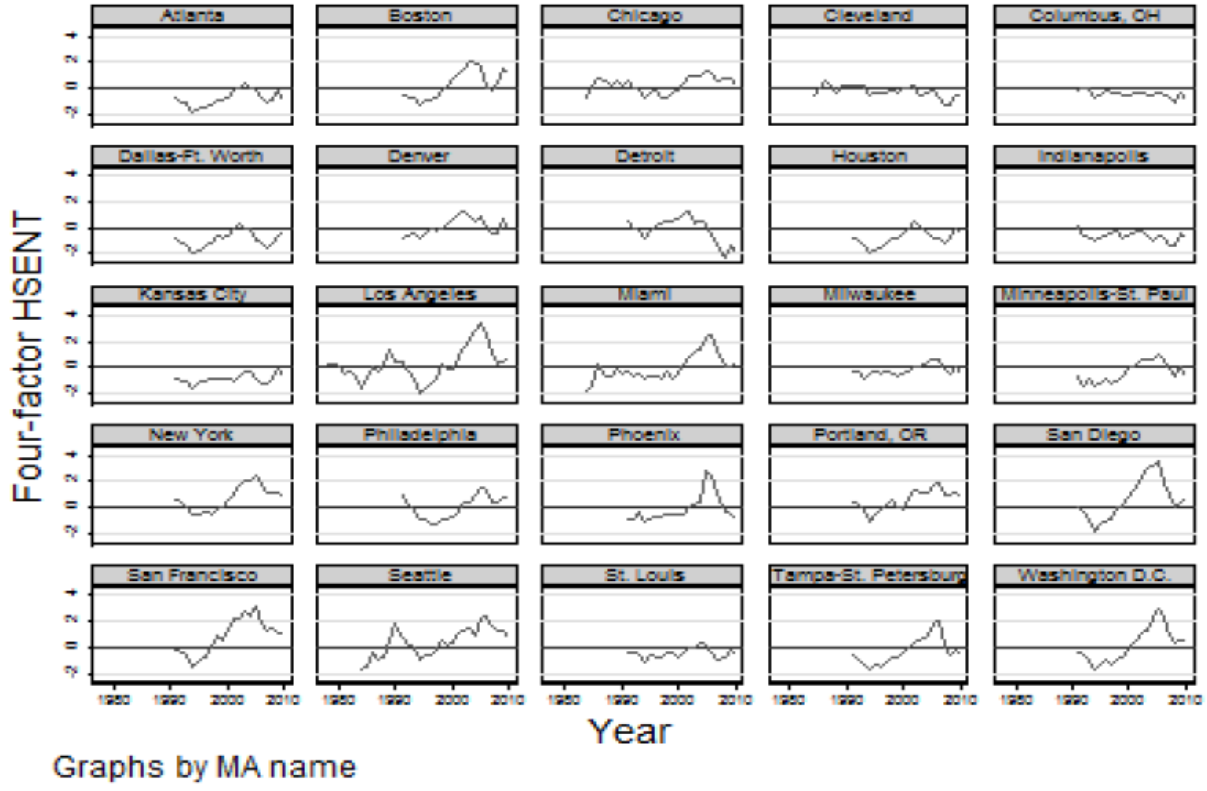


Figure 13: **Four–factor housing sentiment index over time by MSA**. The four–factor housing sentiment (HSENT) index is shown for the 25 MSAs with at least 20 years of data. A horizontal guide line at the zero housing sentiment level is provided. The four–factor housing sentiment (HSENT) index includes the price–to–income (PRICE/INC) ratio, loan-to-value ratios (LTV), the spread between mortgage and Treasury interest rates (EIR–TSRY), and the difference between home price employment growth (HPIg–EMPg) factors.

Across all MSAs and indices, the average deviation from the zero sentiment price level is approximately 20% in the 1978-2010 sample period. Considering that average growth in real home prices is not statistically different from zero, a value of 20% for σ is a fairly large amount of mispricing, certainly enough for Propositions 3.1 and 3.2 to hold. The large amount of mispricing required relative to recent growth, before fundamental based investment finally dominates price

momentum may help explain why the ability to predict the timing or location of reversals in housing bubbles is weak (Mayer (2011)).

**6. Conclusion**

Unlike stocks, bonds, and commercial properties, single-family homes often do not generate cash flows that can be used in typical cash ow discount valuation methods. In addition homebuyers may not be able to easily translate macroeconomic fundamental variables into a dollar valuation. Although housing has unique valuation challenges, past returns are easily observable; I therefore hypothesize that housing returns reflect investments based on chasing past returns, i.e. momentum, more so than value investing. Shiller (1990) and Piazzesi and Schneider (2009) provide survey evidence consistent with overextrapolation-based trend-chasing.

In my specification, investor sentiment--which I define as bias in expectations of housing returns and risks--becomes reflected in home prices as a result of trend-chasing. This momentum slows when the divergence between price and fundamental value be- comes large enough to be more recognizable. Only as sentiment becomes extreme will a corrective reversal in the direction of home price growth occur.

Using principle component analysis, I combine individual proxies of housing sentiment into indices. The ratio of home prices to per-capita personal income, the spread between effective mortgage interest rates and Treasury-note rates, the difference in growth rates of home prices and employment, and the number of home sales per capita are positive proxies of housing sentiment. Initial loan-to-value ratios, and rent-to-price ratios are negative proxies of sentiment.

I specify home price growth as a linear function of both previous home price growth and sentiment mean reversion. Estimates of home price growth autocorrelation are between 0.7 and 0.9. A one standard deviation increase in sentiment is associated with between -.07% and -1.5% real home price growth, and real home price growth is only 0.5% on average, making the magnitude of sentiment mean reversion economically significant. These estimates confirm that sentiment must be extreme relative to past home price growth before it can eclipse the effect of home price momentum. Additional predictions that momentum effects will be the strongest in appreciating markets due to shorting constraints are also confirmed.

In Midwestern underpriced markets with low or negative price growth, prices tend to remain depressed for long periods. This finding suggests that small positive returns in underpriced markets are not enough to attract momentum buyers, but the underpricing is not severe enough to attract value investors either. Hence, these markets stagnate. Overall, my results are consistent with investors being drawn to high past returns and investing based on fundamental value only when the difference between prices and fundamental value becomes more extreme, and hence recognizable.

To evaluate the possibility that the HSENT measures are somehow capturing rationally priced housing risk instead of bias in expectations, I measure the relationship between HSENT and subsequent realized housing returns and risks. HSENT has a strong inverse relationship with realized housing returns over the subsequent decade. Over the same period HSENT has a strong positive relationship with home foreclosure rates, housing return volatility, covariance between housing returns and stock market excess returns, and covariance between housing returns and GDP growth. This is consistent with the HSENT measures capturing bias in investor expectations rather than some form of housing insurance.

Overall, the results suggest that the large swings in prices in many U.S. cities, especially on the East and West coast, reflect overextrapolation biases in investor expectations that are eventually corrected when the mispricing becomes obvious enough. The development of the HSENT housing sentiment indices allows for further work on the underlying sources and causes of housing sentiment. Researchers may also further explore the role of sentiment in systematic risk, and the nature of any possible spillover effects between mispricing in the housing markets and other financial markets.

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