Economics Working Paper Series

2025/008

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Bubbling Up? What Consumer Expectations Reveal About U.S. Housing Market Exuberance

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Abstract

We investigate the presence of speculative bubbles in the U.S. housing market after the global financial crisis. Unlike standard approaches that rely on observed economic fundamentals, our method leverages subjective price expectations from the University of Michigan Survey of Consumers to test for exuberance without imposing a specific model of intrinsic housing values. By applying recursive least-squares and quantile-based unit root tests to cumulative expectational errors, we uncover novel evidence of speculative dynamics at the aggregate level and across broad demographic and socioeconomic groups. A date-stamping exercise reveals widespread exuberance in the second half of the 2010s, which paused before the pandemic recession and resurfaced amid the subsequent housing boom in 2021. For the Covid-19 period, we document notable differences in the timing of exuberance between observed house prices and survey-based indicators—a finding that underscores the importance of controlling for fundamentals when identifying speculative behavior. A complementary analysis using the New York Fed's Survey of Consumer Expectations corroborates the baseline results. Overall, our findings highlight the value of survey data for monitoring housing markets.

Keywords: U.S. housing market; rational bubbles; consumer demographics; right-tailed recursive unit root tests; quantile autoregressions
JEL Classification: C12, C22, G10, R30

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*The views expressed in this paper are our own and do not necessarily reflect those of the Federal Open Market Committee, its principals, or any individuals associated with the Federal Reserve Bank of Dallas or the Federal Reserve System.

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1 Introduction

Boom-bust episodes in housing markets are a recurring feature of many advanced economies, posing persistent challenges to macroeconomic and financial stability, as well as policy design (Duca et al., 2021; Jordà et al., 2015). As a result, interest in understanding their drivers has intensified over recent decades, particularly in the aftermath of the 2007–09 global financial crisis. A promising literature that has emerged assigns a central role to house price expectations in shaping housing market dynamics (Case and Shiller, 2003; Kaplan et al., 2020; Kuchler et al., 2023; Piazzesi and Schneider, 2009).

One strand of this literature has focused on the role of subjective expectations using survey data. In this context, empirical studies have shown that expectations about future house prices influence households' decisions to buy or sell, as well as the prices they are willing to pay (Armona et al., 2019; Bailey et al., 2018; Bottan and Perez-Truglia, 2025). Studies based on survey data also document systematic patterns in expectational errors, such as the tendency of individuals to underpredict house price inflation during booms and overpredict during downturns (Kuchler and Zafar, 2019; Shiller and Thompson, 2022), which can amplify housing cycles (Adam et al., 2025).

Another strand of literature, grounded in asset pricing theory, examines whether housing market dynamics are driven by speculative bubbles. In this framework, exuberance arises from self-fulfilling, rational beliefs about future price increases. These speculative beliefs cause market and intrinsic asset values to disconnect, with the gap between the two growing exponentially over time. Consistent with this theoretical prediction, a large number of empirical studies show that house prices display excess volatility compared to observed economic fundamentals and the predictions of conventional macroeconomic models (Mayer, 2011). There is also substantial evidence of episodes of explosive dynamics in price-to-fundamental ratios and related valuation metrics (Engsted et al., 2016; Hansen et al., 2024; Pavlidis et al., 2016; Shi, 2017). However, despite the central role of beliefs in the formation of housing bubbles, there is no study to the best of our knowledge that employs actual measures of expectations to formally test for bubble dynamics.

The present paper bridges the above two strands by examining whether the behavior of survey expectations is consistent with the presence of speculative bubbles in the U.S. housing market. To do so, we build on the rational expectations framework of Pavlidis et al. (2017). A key advantage of this framework, compared to existing approaches, is that it does not require the explicit specification of economic fundamentals. Instead, it utilizes forward-looking information embedded in expectations and exploits the periodically collapsing nature of bubbles to identify speculative dynamics. As shown in Section 2, within this framework, a bubble expansion is characterized by a growing divergence between expectations and actual realizations of future house prices that is not tied to fundamentals. As an implication, explosive dynamics in cumulative expectational errors, unlike price-to-fundamental ratios, offer a clean signal of non-fundamental exuberance.

To empirically investigate the presence of non-fundamental exuberance in the U.S. housing market, we employ survey data on expected house price inflation from the Michigan Survey of Consumers. This survey provides the longest-running continuous record of monthly home price inflation expectations, beginning in 2007, which makes it well-suited for analyzing household forecast errors across different phases of the housing cycle.

In line with previous studies using survey data, we document that differences between actual and expected house price inflation are substantial in magnitude and persistent. In turn, we apply two recent unit root testing procedures for bubble detection to the time series of aggregate cumulative expectational errors. The first is the sequential least-squares test developed by Phillips et al. (2015a,b), and the second is a modified version of the quantile-based unit root test of Koenker and Xiao (2004) proposed by Pavlidis (2024). By incorporating a direct measure of aggregate beliefs into bubble testing, we offer compelling empirical evidence of speculative dynamics in the U.S. housing market.

Regarding the chronology of exuberance, the recursive unit root test results reveal two distinct episodes: one from late 2016 to 2018, and another from early to mid-2021. Both episodes occurred during periods of accelerated asset price growth, accommodative macroeconomic conditions, and elevated sentiment among prospective home buyers. The earlier episode coincided with a broad and prolonged rise in asset valuations, commonly referred to as part of an "everything bubble", and was sustained by a shift from bank deposit funding toward more fragile capital markets through privately securitized (PLS) mortgages (Drechsler et al., 2022). During this period, consumers' perception of housing market conditions became increasingly more favorable with the Fannie Mae's home purchase sentiment index steadily rising from around 60 in the early 2010s to nearly 90 in 2018, thus reflecting widespread optimism in the housing market. The boom ultimately dissipated as the Federal Funds rate peaked in late 2018.

The latter episode of exuberance emerged in the wake of the pandemic, when large-scale fiscal transfers and a return to ultra-loose monetary policy fueled a sharp rebound in housing demand amid constrained supply. We find that exuberance faded during the Covid-19 pandemic in parallel to the gradual subsiding of fiscal support and rising expectations of a shift in the stance of monetary policy—signaled by the Federal Reserve's plans to raise interest rates from the zero lower bound and to slow the pace of quantitative easing.[1] Notably, the date-stamping results indicate that exuberance ended as consumer sentiment entered a phase of steep decline in mid-2021, while house prices continued to rise in 2021 and well into 2022, drawing significant attention from both media and policymakers.[2]

Recent research has also emphasized the heterogeneity of house price expectations across individuals. Using micro-level survey data, studies have documented that expectations vary with, among other characteristics, gender, education, and experience (Armona et al., 2019; Fang et al., 2024; Kuchler and Zafar, 2019; Kuchler et al., 2023; Niu and van Soest, 2014). These differences in beliefs can influence housing decisions and contribute to the overall dynamics of housing markets. To assess the sensitivity of our findings to potential heterogeneity in beliefs, we construct

[1] For an overview of the Federal Reserve's policies during and after the Covid-19 pandemic, see Ihrig and Waller (2024).

[2] Fannie Mae's home purchase sentiment index dropped by 24 points between March 2021 and October 2022, reaching a sample-period low of 56.7.

broad, disaggregated expectation series based on individual characteristics. Our results indicate that the time series properties of group-specific expectational errors closely mirror that of the aggregate series. Thus, there is no evidence that exuberance in housing markets was concentrated in a particular segment of the population.

As an additional robustness exercise, we employ data from the more recently established Federal Reserve Bank of New York's Survey of Consumer Expectations. We show that the null hypothesis of no bubbles can be rejected for the aggregate expectation series as well as for the vast majority of demographic and socioeconomic groups, reinforcing the evidence from our baseline analysis. Furthermore, we find that the timing of identified exuberance closely aligns between the two datasets.

In summary, this paper contributes to the growing literature on house price dynamics and housing market surveillance by utilizing an agnostic approach regarding economic fundamentals based on survey expectations. Compared to traditional monitoring tools that rely on price-to-fundamental ratios, this approach leverages forward-looking, survey data to provide a richer signal of market overheating. The use of micro-level expectations also enables granular surveillance, helping to identify whether exuberance is widespread or confined to specific socioeconomic and demographic groups. Taken together, these features make expectation-based indicators a valuable complement to existing housing market monitoring tools, with clear relevance for policy oversight and early warning systems.

The rest of the paper is structured as follows. Section 2 describes the theoretical asset pricing framework. Section 3 presents the Michigan Survey data on aggregate and group-specific expectations. Section 4 provides an outline of the unit root testing procedures employed in the empirical analysis. Section 5 discusses the empirical findings from the baseline analysis and the accompanying robustness exercise. The final section provides concluding remarks.

2 House Prices, Fundamentals and Market Expectations

This section lays out the theoretical foundation for our empirical strategy to identify non-fundamental dynamics in house prices using survey data. The framework that we adopt builds on the standard present value model with risk-neutral agents, which underpins the prevailing body of empirical work on speculative bubbles in housing markets (see, e.g., Glaeser and Nathanson, 2015; Meese and Wallace, 1994; Pavlidis et al., 2016). In this model, the price of housing, P_t, is derived from the no-arbitrage condition

$$P_t = \frac{\mathbb{E}_t(P_{t+1}) + \mathbb{E}_t(F_{t+1})}{1+r}, \tag{1}$$

where $(1+r)^{-1} \in (0,1)$ is the discount rate, $\mathbb{E}_t(\cdot)$ denotes expectations conditional on information at time t, and F_t is the payoff (pecuniary or otherwise) from holding the asset from time t to $t+1$. We refer to F_t as the economic fundamentals of the housing market. A common specification equates F_t to the overall benefit accruing to homeowners from economic rents (including housing services) and an additional component that is either unobserved or arises due to mismeasurement.[3]

By recursively substituting forward, the entire class of solutions to (1) takes the form

$$P_t = P_t^* + B_t, \tag{2}$$

where P_t^* is the economic fundamentals solution

$$P_t^* = \sum_{i=1}^{\infty} (1+r)^{-i} \mathbb{E}_t(F_{t+i}), \tag{3}$$

and B_t is a non-fundamental, bubble term that satisfies the submartingale property

$$\mathbb{E}_t(B_{t+1}) = (1+r)B_t, \tag{4}$$

and, hence, is on expectation explosive. A direct implication of (2) and (4) is that, if the first difference of fundamentals ΔF_t is stationary, then the behavior of home prices will be dominated by the explosive root $1+r$ of the bubble process. This theoretical prediction has motivated a large number of empirical studies to test for bubbles by applying (co-)integration tests to asset prices, observed fundamentals, and asset-price-to-fundamental ratios.

Although widely used, such direct approaches require strict assumptions on the structure of the model generating economic fundamentals. As argued by many authors (see, e.g., Gürkaynak, 2008), exuberance in asset markets inherited from unobserved fundamental factors or model misspecification may confound bubble tests and lead to false inference. To circumvent this obstacle, more recent studies have employed indirect approaches that, on the one hand, exploit information about economic fundamentals incorporated in price expectations and, on the other, make use of the probabilistic nature of periodically collapsing bubbles (Pavlidis et al., 2017, 2018). These studies show that, during a bubble expansion, actual realizations of future spot prices and expectations diverge. Under general conditions, this wedge between actual and expected prices is solely driven by the bubble process. As an implication, instead of using observed fundamentals to proxy for intrinsic asset values, researchers can employ measures of expectations.

To illustrate the basic idea underlying indirect approaches, let P_{t+h}^e denote expected house prices h periods ahead

$$P_{t+h}^e = \mathbb{E}_t(P_{t+h}^*) + \mathbb{E}_t(B_{t+h}), \tag{5}$$

[3] Alternatively, one can link economic fundamentals to macroeconomic variables and an unobserved factor. This formulation arises from linear expenditure systems, where the demand for housing is proportional to disposable income. The relationship between prices and income captures the affordability determinants of housing and, like housing rents, has been widely examined in the literature (Pavlidis et al., 2016).

and B_t follow the periodically collapsing bubble process of Blanchard (1979)[4]

$$B_{t+1} = \begin{cases} \frac{(1+r)}{\pi} B_t + \epsilon_{t+1}, & \text{with prob. } \pi, \\ \epsilon_{t+1}, & \text{with prob. } 1-\pi, \end{cases} \tag{6}$$

where $\epsilon_t \sim iid(0, \sigma_\epsilon^2)$. This bubble data-generating process has two regimes that occur with probabilities π and $1-\pi$. In the first regime, the bubble grows at the gross rate of $(1+r)/\pi$; while in the second, it collapses to a white noise.

It follows from (4) and (6) that, during bubble eruptions, the forecast error for the speculative component of the asset price is given by

$$B_{t+h} - \mathbb{E}_t(B_{t+h}) = (1+r)^h \left(\frac{1}{\pi^h} - 1\right) B_t + \epsilon^\star_{t+h}, \tag{7}$$

where $\epsilon^\star_{t+h} = \sum_{i=1}^{h} \left(\frac{(1+r)}{\pi}\right)^h \epsilon_{t+i}$ is a stationary moving average process. Equation (7) implies a systematic downward bias in forecasts. The bias arises because rational agents at time t correctly attach a probability to the bubble bursting in the future. As a consequence, the expected growth of the bubble component falls short of the actual growth. Notice that this theoretical prediction is in line with the well-documented short-term momentum in house price growth and the fact that survey expectations tend to underestimate its strength (Kuchler et al., 2023).

For our analysis, a key property of the expectational error process $B_{t+h} - \mathbb{E}_t(B_{t+h})$ is that, being a function of B_t, it displays explosive dynamics during bubble episodes—a property that is propagated to cumulative forecast errors, P^f_{t+h}, defined as[5]

$$P^f_{t+h} = \sum_{i=1}^{t} (P_{i+h} - P^e_{i+h}) = \sum_{i=1}^{t} (P^*_{i+h} - \mathbb{E}_i(P^*_{i+h})) + \sum_{i=1}^{t} (B_{i+h} - \mathbb{E}_i(B_{i+h})). \tag{8}$$

Conditional on the forecast error for the fundamental component not growing exponentially in-sample, explosiveness in P^f_{t+h} provides conclusive evidence in favor of bubbles. Compared to direct approaches, examining the time series properties of P^f_t has the major advantage of not necessitating the specification of economic fundamentals. Furthermore, it allows us to examine data at higher frequencies than observed fundamentals, such as income.

In practice, expectations can be inferred from either derivative prices or survey data. Regarding derivative prices, the Chicago Mercantile Exchange introduced housing futures and options contracts based on the S&P CoreLogic Case-Shiller U.S. national home price indices in May 2006. However, these instruments have faced persistently low trading volumes and liquidity constraints

[4]Similar results can be obtained for other types of rational, periodically collapsing bubble processes, such as the process proposed by Evans (1991).

[5]Intuitively, this approach serves as a filtering mechanism by reconstructing the price series net of its predictable bubble and fundamental components. Alternatively, one could work with the raw forecast errors. However, this would result in lower power of right-tailed unit root tests because the raw forecast error process alternates between being stationary, I(0), in the absence of bubbles and explosive during bubble episodes. By contrast, the partial sum of forecast errors switches between an I(1), consistent with the null hypothesis, and an explosive regime.

since their inception (Shiller and Thompson, 2022). Hence, they have not functioned as a reliable price discovery mechanism. Given the limited reliability of derivative prices, we employ survey data to capture expectations.

3 House Price Expectations

A growing number of surveys elicit household expectations about the housing market (for a extensive review, see Kuchler et al., 2023). Among them, the University of Michigan Survey of Consumers is the longest-standing. Established in the 1940s, it is conducted monthly with a sample of over 500 households that is designed to be statistically representative of the U.S. population. The survey collects information on current perceptions and future expectations for the housing market, including whether it is a good or bad time to buy or sell a home, as well as households' anticipated changes in local home prices. While qualitative questions date back to the inception of the survey, questions designed to elicit numerical expectations of home price inflation were introduced in January 2007. These questions gauge one- and five-year-ahead point forecasts. We focus on the one-year horizon to achieve the greatest sample coverage of forecast errors over time.

[INSERT TABLE 1]

Aggregate Expectations. The left panel of Figure 1 shows the time evolution of the aggregate (mean) expected home price inflation together with actual home price inflation, computed using the S&P CoreLogic Case-Shiller U.S. national home price index, from January 2007 to December 2023. It is evident from the figure that consumer expectations varied with the housing cycle over the sample period. Anticipated home price changes turned negative during the global financial crisis of 2007-09 and remained low during the entire housing bust that lasted until 2011. They then gradually increased during the expansion phase of 2012-18 and, following a temporary drop at the onset of the Covid-19 pandemic, they rose again during the spectacular 2020-2022 housing boom, reaching their peak in mid-2021. The end of the Covid-19 housing expansion was accompanied by a sharp reversal in expectations, which dropped to zero in July 2022.

[INSERT FIGURE 1]

Although expected and realized inflation appear to comove, it is also apparent from the figure that aggregate consumer expectations are substantially smoother. That is, similar to fundamentals like rents and income, expectations do not display the large swings characterizing actual home prices (Fama and French, 2025). As shown in the right panel of Figure 1, this implies large and persistent expectational errors. For the first expansion, from 2012 to 2018, actual inflation consistently exceeded expectations by up to 10 percentage points. During the second expansion between 2020 and 2022, the gap reached nearly 20 points at its peak in mid-2021. These persistent mismatches motivate a deeper investigation into whether speculative factors underlie the observed price behavior.

Expectations by Demographic and Socioeconomic Group. In addition to point forecasts, the Michigan Survey provides individual-level information on the respondents' demographic and socioeconomic characteristics. We employ this data to construct group-specific expectation series and investigate the presence of speculative bubbles across different population segments. In particular, we focus on the responders' age, gender, marital status, education, income, and wealth in the stock market. Table 1 summarizes the variables used in this study, along with their mnemonics and data sources.

To avoid imprecise expectation measurements due to outliers and extremely small samples, we trim the data at the 1^{st} and 99^{th} percentiles (see also, Shiller and Thompson, 2022) and focus on broad categories. Specifically, we divide the sample into the following groups: age bands [30–50] and (50–70]; male and female; married and not married; without a college degree and with a college degree or higher; income above and below the sample median; and stock investments above and below the sample median.

[INSERT FIGURE 2]

Figure 2 depicts the expectation series by demographic and socioeconomic category. Overall, the trends in expectations across groups closely mirror the pattern of the aggregate. All series decline in the early part of the sample period, gradually increase during the recovery phase of 2012-18, and then exhibit a hump-shaped pattern between 2019 and 2023, reaching a peak around mid-2021. A closer look at the figure reveals that differences in expectations across demographic groups specified by age and marital status are, in general, small and short-lived. On the contrary, we observe pronounced differences between individuals with and without a college degree and between those with high and low incomes and stock investments. Notably, respondents with higher education, higher incomes and higher investments anticipated faster house price growth during most of the housing expansion of 2012-18, with differences in expectations frequently exceeding one percentage point during this period. With regard to gender, we observe moderate differences again during the first housing expansion, with male responders displaying higher expectations.

The observed patterns broadly align with the existing literature on economic beliefs, which shows that men, as well as individuals with higher income and educational attainment, tend to express more optimistic views (Dominitz and Manski, 2004; Hurd et al., 2011; Jacobsen et al., 2014; Niu and van Soest, 2014). Irrespective of the expectation series considered, however, a visual comparison with actual house price inflation rates suggests that consumers' forecast errors remain large and persistent. The following section outlines the econometric methods employed to test for exuberance.

4 Right-Tailed Unit Root Tests

It is well established that standard integration tests, such as the Augmented Dickey-Fuller (ADF), have extremely low power to detect explosive dynamics when bubbles periodically collapse. This is so because the alternation between bubble build-ups and crashes frequently leads these tests to produce spurious evidence of stationarity. Recent econometric methodologies have been developed in the literature that are specifically designed to capture such dynamics, accounting for both explosive growth phases and abrupt corrections (Astill et al., 2023; Phillips and Shi, forthcoming). Among those, we employ the popular Generalized Supremum ADF (GSADF) of Phillips et al. (2015a,b) and the quantile autoregression based unit root test of Pavlidis (2024). Both testing procedures constitute extensions of the standard ADF regression

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum\nolimits_{j=1}^{k} \alpha_{j+1} \Delta y_{t-j} + u_t, \tag{9}$$

where y_t is a generic time series, Δ denotes the first-difference operator, and α_j, with $j = 0, \ldots, k+1$, are regression coefficients.

Recursive Least-Squares Tests. To address the effect of market crashes on the test performance, the procedure of Phillips et al. (2015a,b) employs a recursive least-squares algorithm that estimates ADF regressions on subsamples of the data

$$y_t = \alpha_0^{r_1,r_2} + \alpha_1^{r_1,r_2} y_{t-1} + \sum\nolimits_{j=1}^{k} \alpha_{j+1}^{r_1,r_2} \Delta y_{t-j} + u_t, \tag{10}$$

where the superscripts r_1 and r_2 denote fractions of the total sample size T that specify the starting and ending points of a subsample period. The proposed algorithm is highly flexible in that it involves estimating (10) for all possible subsamples (r_1, r_2) given a minimum window size r_0.

In this setting, the null hypothesis of interest is that of a unit root over the full sample, H_0 : $\alpha_1 = 1$, against the alternative of explosive behavior in y_t in a subperiod, $H_1 : \alpha_1^{r_1,r_2} > 1$. The test statistic corresponding to the null is defined as the supremum of the sequence of ADF statistics

$$\text{GSADF}(r_0) = \sup_{r_2 \in [r_0,1], r_1 \in [0, r_2 - r_0]} \text{ADF}_{r_1}^{r_2},$$

where

$$\text{ADF}_{r_1}^{r_2} = \frac{\widehat{\alpha}_1^{r_1,r_2} - 1}{\text{s.e.}(\widehat{\alpha}_1^{r_1,r_2})}, \tag{11}$$

and has a non-standard limit distribution under the null. As shown by Phillips et al. (2015b), due to its flexibility, the GSADF test is remarkably more powerful than standard unit root tests when there are multiple regime changes.

An additional attractive feature of this recursive procedure is that it inherently enables date-stamping. Conditional on rejection of the null hypothesis in the first stage, Phillips et al. (2015a) propose a date-stamping strategy based on the sequence of backward supremum ADF (BSADF) statistics

$$\mathrm{BSADF}_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \mathrm{ADF}_{r_1}^{r_2}. \tag{12}$$

The origination date of an episode of exuberance is simply defined as the first observation where the BSADF statistic surpasses its critical value, and the end date as the first observation after which the statistic falls below its critical value.

Quantile-Autoregression Based Tests. An alternative to sequential least-squares unit root testing is provided by quantile autoregression methods. Rather than examining variations in the degree of persistence in subsamples of data, these methods look at the entire sample to explore the presence of heterogeneous dynamics across conditional quantiles (Koenker and Xiao, 2004; Wu et al., 2024). Pavlidis (2024) demonstrates that this feature is particularly well-suited for bubble identification. Intuitively, in the case of periodically collapsing bubbles, the value of the autoregressive coefficient α_1 varies across quantiles—falling below unity at lower quantiles, which reflect market crashes, and exceeding unity at higher quantiles, which capture periods of bubble expansion.

Quantile autoregression-based tests have two advantages over their recursive least-squares counterparts. First, they provide a more robust and efficient approach in the presence of outliers and non-normal error distributions. Second, they use information from all bubble episodes collectively, i.e., they are full-sample tests. This is not the case for recursive least-squares test statistics that are based on a single subsample of data and, thereby, may fail to detect exuberance in the presence of multiple short-lived bubble episodes (see, Phillips et al., 2011). Recursive least-squares tests, on the other hand, have the major advantage of allowing date-stamping periods of exuberance.

The unit root quantile autoregression model corresponding to (9) is given by

$$Q_{y_t}(\tau | y_{t-1}, \Delta y_{t-1}, \ldots, \Delta y_{t-k}) = \alpha_0(\tau) + \alpha_1(\tau) y_{t-1} + \sum_{j=1}^{k} \alpha_{j+1}(\tau) \Delta y_{t-j}. \tag{13}$$

In the above model, the τ-th conditional quantile of y_t, $Q_{y_t}(\tau | y_{t-1}, \Delta y_{t-1}, \ldots, \Delta y_{t-k})$, is a linear function of the lagged value of the series and k lagged first differences. Because regression parameter values are allowed to vary across quantiles, the null hypothesis of a unit root, $H_0 : \alpha_1(\tau) = 1$, may be rejected in favour of the one-sided alternative of explosive dynamics, $H_1 : \alpha_1(\tau) > 1$, at some but not all quantiles.

To examine the presence of bubbles, we employ the right-sided version of the Quantile Kolmogorov-Smirnov type test (QKS_t) proposed by Koenker and Xiao (2004)

$$\mathrm{QKS}_t = \sup_{\tau \in \mathcal{T}} t(\tau), \tag{14}$$

where

$$t(\tau) = \frac{f(\widehat{F^{-1}(\tau)})}{\sqrt{\tau(1-\tau)}} (Y_{-1}^{\top} P_Z Y_{-1})^{1/2} (\widehat{\alpha}_1(\tau) - 1) \tag{15}$$

is the quantile counterpart of the conventional ADF test statistic, Y_{-1} is the vector of lagged dependent variables of y_t, P_Z is the projection matrix onto the space orthogonal to $Z = (1, \Delta y_{t-1}, \ldots, \Delta y_{t-k})$, and $f(\widehat{F^{-1}(\tau)})$ is a consistent estimator of the probability density $f(F^{-1}(\tau))$. Our preference for QKS_t over $t(\tau)$ is due to the fact that, first, the former test examines the unit root property over a range $\mathcal{T}$ of quantiles (i.e., it does not require the researcher to make an *ad hoc* choice on τ) and, second, it is not subject to multiple hypothesis concerns that arise when applying $t(\tau)$ for various τs.

Estimation Details. The implementation of the above econometric procedures requires the specification of the lag length k and the finite-sample distributions of the BSADF, GSADF and QKS_t test statistics. With regard to k, differences between future house prices and expectations follow, by construction, a process with serially correlated errors (see Section 2). To account for serial dependence, we use the Bayesian Information Criterion (BIC) and set the maximum lag length to $k = 6$. Turning to the finite-sample distributions of the test statistics, the distributions of BSADF and GSADF are nonstandard and depend on the minimum window size, r_0. We adopt the rule-of-thumb of Phillips et al. (2015a), $r_0 = 0.01 + 1.8/\sqrt{T}$, to select the minimum window size and obtain finite-sample critical values by using the sieve bootstrap procedure of Pedersen and Schütte (2020) which is specifically designed for serially correlated residuals. Phillips et al. (2015a) also recommend setting a minimum bubble duration filter in the BSADF testing procedure to avoid false positives from short-term noise, thus improving statistical reliability. In the empirical analysis, we allow for bubble episodes longer than six months. For the estimation of QKS_t, we employ the kernel-based density estimator of Powell (1991) and set the range of quantiles to $\mathcal{T} = [0.8, 0.95]$ with a step size of 0.01. We approximate the finite-sample QKS_t distribution by using the residual-based bootstrap of Park (2003). For all exercises, we set the number of bootstrap simulations to 2,000.

5 Speculative Bubbles in the U.S. Housing Market

In this section, we employ the two right-tailed unit root tests outlined above to assess the presence and timing of speculative dynamics in the U.S. housing market. We begin with the analysis based on the Michigan Survey data, which allows for a longer historical perspective, and then turn to the robustness exercise based on the Federal Reserve Bank of New York's Survey of Consumer Expectations.

5.1 Empirical Evidence from the Michigan Survey

Table 2 shows the estimated GSADF and QKS_t test statistics together with the corresponding bootstrap p-values for the S&P CoreLogic Case-Shiller house price index, aggregate cumulative forecast errors, and cumulative forecast errors by demographic group. Starting with the GSADF results, we observe that the null hypothesis of a unit root is rejected for the house price index, for aggregate cumulative forecast errors, and for all but one group-specific series at the five percent level.

For Not Married the null is rejected at the ten percent level. The evidence in favour of exuberance is even stronger when looking at the results for quantile-based tests. All QKS_t statistics exceed their five percent critical value, with the vast majority of p-values lying below one percent. The finding that the estimated p-values for QKS_t are substantially lower than those for the GSADF is in accord with the higher power displayed by quantile methods in the presence of multiple relatively short-duration bubble episodes. Taken together, the right-tailed unit root test results presented in Table 2 strongly support the existence of speculative bubbles at the aggregate level and across broad socioeconomic and demographic groups, suggesting that exuberance was widespread across population segments.

[INSERT TABLE 2]

Having documented the presence of speculative dynamics in the U.S. housing market, we now investigate the chronology of exuberance. Figure 3 depicts the sequence of BSADF statistics together with the identified exuberance periods. The accompanying Table 3 reports the estimated start/end dates and their duration. Several interesting conclusions emerge. The main conclusion is that the U.S. housing market displayed two episodes of exuberance following the global financial crisis of 2007-09, which are synchronized across demographic and socioeconomic groups. These episodes occurred toward the last part of the housing market expansion of 2012-18 and during the reopening of the economy after the Covid-19 pandemic.

[INSERT FIGURE 3 & TABLE 3]

With regard to the first episode, the finding of a housing bubble prior to the pandemic is particularly noteworthy given the limited attention it received from policymakers and the media at the time. The evidence of a silent bubble brewing before 2019 aligns with the results of Gupta et al. (2023), who show that U.S. house prices were detached from macroeconomic fundamentals between 2014 and 2018. It also corroborates the findings of Martínez-García (2024) and the signs of exuberance in the U.S. price-to-rent ratio documented by Gomez-Gonzalez and Pardo-Niño (2025). More broadly, this period of overvaluation is consistent with the so-called "everything bubble" narrative, which suggests that accommodative monetary policy in the post-global financial crisis era fueled speculation across a wide range of markets, including housing.

Contrary to the first identified bubble episode, the state of the U.S. housing market following the Covid-19 outbreak and the possibility of a housing bubble have been widely discussed by policymakers and the media (see, e.g., Emmons, 2021). In November 2021, Governor Michelle W. Bowman argued that the significant acceleration in home price growth over the preceding year *"raise the concern that housing is overvalued and that home prices may decline"* (Bowman, 2021); in March 2022, Governor Christopher J. Waller referred to the state of the housing market as "*red-hot*" (Waller, 2022); and, in November 2022, Chair Jerome Powell made headlines by stating that the U.S. "*really had a housing bubble*" (Powell, 2022). In their speeches, the U.S. policymakers highlighted key differences from the housing bubble of the early 2000s, asserting that fundamentals appear to explain a large part of the price rally.

Whether a bubble was present during the Covid-19 pandemic has also been the subject of academic research. Using data for U.S. metropolitan areas, Hansen et al. (2024) find evidence of explosive house prices and house-price-to-rent ratios. Similar findings are provided by Coulter et al. (2022) and Martínez-García (2024) at the national level. The present study complements the existing literature by demonstrating that the time evolution of the difference between realized house prices and consumers' expectations is also consistent with the presence of speculative bubbles in the housing market.

Regarding the role played by housing fundamentals during the Covid-19 pandemic, it is instructive to compare the identified periods of exuberance in house prices to those based on cumulative forecast errors. The results in Table 3 indicate that house prices entered a phase of exuberance in July 2020, which persisted until May 2022. The period of exuberance is markedly shorter when accounting for fundamental factors via survey expectations, lasting between seven and 13 months, and ending nearly a year earlier in July/August 2021. The difference in timing suggests that housing market exuberance had actually subsided while prices continued to rise in 2021 and well into 2022, attracting media and policy attention. The conclusion that speculative dynamics had cooled by mid-2021, despite continued price growth, is further supported by the substantial decline in consumer sentiment indicators from mid-2021 to mid-2022, with the value of Fannie Mae's home purchase sentiment index falling by 12 points. Therefore, forward-looking information from survey data can play a key role in separating bubble dynamics from price movements driven by fundamentals.

5.2 Supplementary Evidence from the Survey of Consumer Expectations

As a robustness exercise, we examine a supplementary dataset provided by the Federal Reserve Bank of New York's Survey of Consumer Expectations (SCE). Like the Michigan Survey, the SCE computes quantitative measures of home price inflation expectations. These measures, which are based on a monthly online questionnaire and a rotating panel of approximately 1,300 household heads, are made available both at the aggregate level and for different socioeconomic and demographic categories.

Although the SCE and the Michigan Survey share many similarities, there are differences in their demographic and socioeconomic categories as well as the time span covered. With regard to the former, the SCE categories include age (Under 40/40–60),[6] education (High School or Less/Some

[6] We exclude respondents above age 60 to focus on a segment of the population that is more likely to be actively engaged in housing market transactions and more responsive to housing market conditions. The over-60 category encompasses a broad age range, including individuals well beyond typical retirement age, who may have limited housing mobility. These individuals are less likely to be making forward-looking housing decisions or forming expectations relevant for buying or selling, which may make their responses less informative for the analysis of housing market

College/BA or Higher), income (Under 50K/50–100K/Over 100K), and numeracy (Low/High), but do not include gender, marital status, or wealth in the stock market. Regarding the time span, the SCE covers a substantially shorter period, beginning only in June 2013, which excludes the post-global financial crisis housing contraction and part of the rapid price growth during the early phase of the recovery. Thus, while the SCE serves as a valuable robustness check, it does not enable a time series analysis as comprehensive as the Michigan Survey.

[INSERT TABLE 4]

Table 4 presents the estimated GSADF and QKS_t test statistics and the corresponding p-values for one-year-ahead cumulative expectational errors based on our supplementary SCE dataset.[7] According to the estimated statistics, the null hypothesis of a unit root can be rejected at the five percent significance level by both the GSADF and QKS_t tests for the aggregate series. For the group-specific series, five out of the ten GSADF statistics are statistically significant at the five percent significance level, and nine statistics at the ten percent. Again, the quantile-based QKS_t test provides stronger evidence in favor of speculative bubbles, rejecting the null in nine out of the ten cases at the five percent level, and in all cases at the ten percent. In summary, the results of the unit root tests applied to the SCE dataset lend additional empirical support for the existence of speculative bubbles.

[INSERT FIGURE 4 & TABLE 5]

Turning to the chronology of exuberance, we find two episodes of explosive dynamics that occur toward the end of the post-global financial crisis recovery period and in the aftermath of the Covid-19 pandemic. As can be seen in Figure 4 and Table 5, these episodes are broadly consistent with those identified using the Michigan Survey. The alignment in both timing and duration for the second episode is particularly notable, with the estimated length using the SCE data ranging from nine to eleven months, which is within the estimated interval for the Michigan Survey, and ending around mid-2021. Regarding the first bubble episode, the estimated period of exuberance is similar between the two datasets but with a few exceptions. Specifically, for three SCE groups (High School or Less, Income Under 50K, and Low Numeracy) the episode is identified slightly later in the sample and is shorter—a finding that can be attributed to the later start of the SCE dataset. Overall, the results for the two surveys are largely in line, giving a consistent picture of speculative dynamics in the U.S. housing market.

exuberance.

[7] For the recursive unit root test, we have used the same minimum window size as for the Michigan Survey dataset to allow direct comparisons.

6 Conclusion

Expectations play a central role in housing markets, influencing individual decision-making and shaping aggregate outcomes. In this paper, we employ data on expected house prices from the Michigan Survey of Consumers to examine the presence of speculative bubbles in the U.S. housing market during the post-global financial crisis period. In contrast to traditional methods, the forward-looking information embedded in expected prices enables us to adopt an agnostic approach to economic fundamentals when testing for bubbles.

By applying recursive least-squares and quantile-based unit root tests to cumulative expectational errors, we provide novel evidence of speculative dynamics at the aggregate level and across a range of demographic and socioeconomic groups. A date-stamping analysis reveals two episodes of exuberance: one in the pre-pandemic period, from 2016 to 2018, and another during the housing boom of 2021. Both episodes coincide with periods of strong price growth, accommodative macroeconomic conditions, and elevated consumer sentiment. Notably, the second episode concludes around mid-2021, even though house prices continued to rise into 2022, indicating that shifts in expectations preceded changes in observed market trends. A complementary analysis using data from the New York Fed's Survey of Consumer Expectations reinforces our main findings.

In conclusion, the results of the paper highlight the potential of survey-based indicators to enhance financial stability frameworks by providing early warning signals to policymakers and the public.

7 Tables & Figures

Aggregate Data	
U.S. Home Prices	S&P CoreLogic Case-Shiller U.S. National Home Price Index [CSUSH-PISA]; source: Federal Reserve Bank of St. Louis
Aggregate Expectations	Michigan Survey of Consumers Time Series Data, Table 46: Expected Change in Home Values During the Next Year (Mean)
Micro-Level Data (Michigan Survey of Consumers SDA Archive)	
HOMPX1	Wealth Demographics, Home Price Expectations 1YR Recoded
AGE	Demographics, Age of Respondent
SEX	Demographics, Sex of Respondent
MARRY	Demographics, Marital Status of Respondent
EDUC	Demographics, Education of Respondent
INCOME	Income Demographics, Total Household Income – Current Dollars
INVAMT	Wealth Demographics, Stock Investment Value

Table 1: National home prices and survey data from the University of Michigan Survey of Consumers.

Series	lag (k)	GSADF	p-value	QKS_t	p-value
House Prices	2	4.020	0.041	3.723	0.006
Aggregate	3	5.095	0.014	5.043	0.000
Age 30-50	4	5.308	0.010	5.333	0.000
Age 50-70	3	5.673	0.006	4.298	0.001
Male	3	5.306	0.011	4.021	0.000
Female	3	5.010	0.028	4.787	0.000
Not Married	4	4.305	0.076	4.864	0.000
Married	3	5.517	0.007	4.164	0.002
No College	3	5.576	0.007	5.029	0.000
College	3	5.318	0.007	4.791	0.000
Low Income	3	5.748	0.009	5.189	0.000
High Income	3	5.123	0.014	2.645	0.012
Low Stock Invest.	3	5.831	0.006	5.477	0.000
High Stock Invest.	3	5.128	0.014	3.793	0.002

Table 2: Right-tailed unit root test results for U.S. house prices, aggregate cumulative expectational errors, and cumulative expectational errors of different demographic and socioeconomic groups.

Series	Start	End	Duration (Months)
House Prices	2016-08-01	2018-08-01	25
House Prices	2020-07-01	2022-05-01	23
Aggregate	2016-11-01	2018-10-01	24
Aggregate	2021-01-01	2021-08-01	8
Age 30-50	2016-10-01	2018-10-01	25
Age 30-50	2020-10-01	2021-07-01	10
Age 50-70	2016-09-01	2018-10-01	26
Age 50-70	2020-09-01	2021-09-01	13
Male	2016-09-01	2018-11-01	27
Male	2020-09-01	2021-08-01	12
Female	2016-09-01	2018-10-01	26
Female	2020-10-01	2021-08-01	11
Not Married	2017-03-01	2018-09-01	19
Not Married	2020-10-01	2021-08-01	11
Married	2016-05-01	2018-11-01	31
Married	2021-01-01	2021-09-01	9
No College	2016-09-01	2018-10-01	26
No College	2020-10-01	2021-09-01	12
College	2016-09-01	2018-11-01	27
College	2020-09-01	2021-09-01	13
Low Income	2016-09-01	2018-11-01	27
Low Income	2021-02-01	2021-08-01	7
High Income	2016-09-01	2018-12-01	28
High Income	2020-09-01	2021-08-01	12
Low Stock Invest.	2016-06-01	2018-11-01	30
Low Stock Invest.	2021-01-01	2021-08-01	8
High Stock Invest.	2016-09-01	2018-10-01	26
High Stock Invest.	2020-09-01	2021-08-01	12

Table 3: Periods of exuberance, identified using the BSADF test of Phillips et al. (2015a) at a five percent significance level, in U.S. house prices, aggregate cumulative expectational errors, and cumulative expectational errors of different demographic and socioeconomic groups.

Series	lag (k)	GSADF	p-value	QKS_t	p-value
Aggregate	2	4.575	0.018	4.218	0.003
Age Under 40	5	4.567	0.040	2.679	0.043
Age 40-60	2	4.041	0.048	3.591	0.006
High School or Less	4	3.566	0.080	4.966	0.000
Some College	3	5.642	0.002	3.260	0.011
BA or Higher	2	3.565	0.068	3.770	0.010
Income Under 50K	2	4.163	0.046	3.470	0.022
Income 50-100K	3	3.538	0.064	5.911	0.000
Income Over 100K	2	3.297	0.112	2.882	0.037
Numeracy Low	4	5.378	0.001	5.930	0.000
Numeracy High	2	3.588	0.056	2.601	0.059

Table 4: Right-tailed unit root test results for aggregate cumulative expectational errors and cumulative expectational errors of different demographic and socioeconomic groups. Data on expectations are from the Federal Reserve Bank of New York's Survey of Consumer Expectations.

Series	Start	End	Duration (Months)
Aggregate	2016-10-01	2018-05-01	20
Aggregate	2020-09-01	2021-05-01	9
Age Under 40	2017-01-01	2018-04-01	16
Age Under 40	2020-11-01	2021-07-01	9
Age 40-60	2016-10-01	2018-09-01	24
Age 40-60	2020-09-01	2021-05-01	9
High School or Less	2018-02-01	2018-10-01	9
High School or Less	2020-09-01	2021-05-01	9
Some College	2016-11-01	2018-07-01	21
Some College	2020-09-01	2021-05-01	9
BA or Higher	2016-10-01	2018-04-01	19
BA or Higher	2020-08-01	2021-06-01	11
Income Under 50K	2017-07-01	2018-06-01	12
Income Under 50K	2020-09-01	2021-05-01	9
Income 50-100K	2016-11-01	2018-04-01	18
Income 50-100K	2020-09-01	2021-05-01	9
Income Over 100K	2016-10-01	2018-07-01	22
Income Over 100K	2020-09-01	2021-06-01	10
Numeracy Low	2017-08-01	2018-07-01	12
Numeracy Low	2020-09-01	2021-06-01	10
Numeracy High	2016-10-01	2018-06-01	21
Numeracy High	2020-08-01	2021-05-01	10

Table 5: Periods of exuberance, identified using the BSADF test of Phillips et al. (2015a) and a five percent significance level, in U.S. house prices, aggregate cumulative expectational errors, and cumulative expectational errors of different demographic and socioeconomic groups. Data on expectations are from the Federal Reserve Bank of New York's Survey of Consumer Expectations.

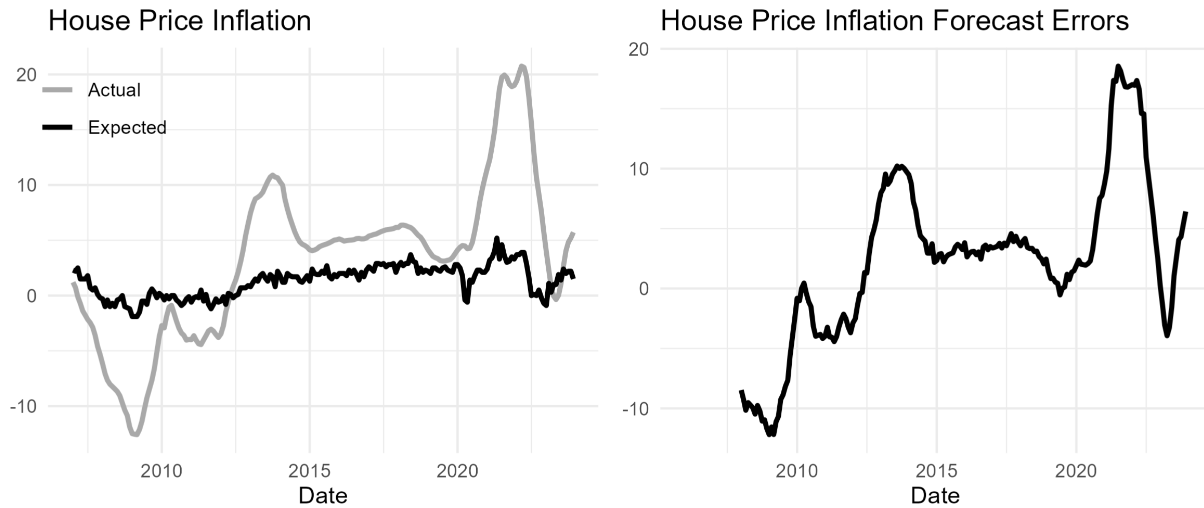

Figure 1: Actual and expected house price inflation rates based on the S&P CoreLogic Case-Shiller U.S. national home price index and data from the Michigan Survey of Consumers (left panel). House price inflation forecast errors (right panel).

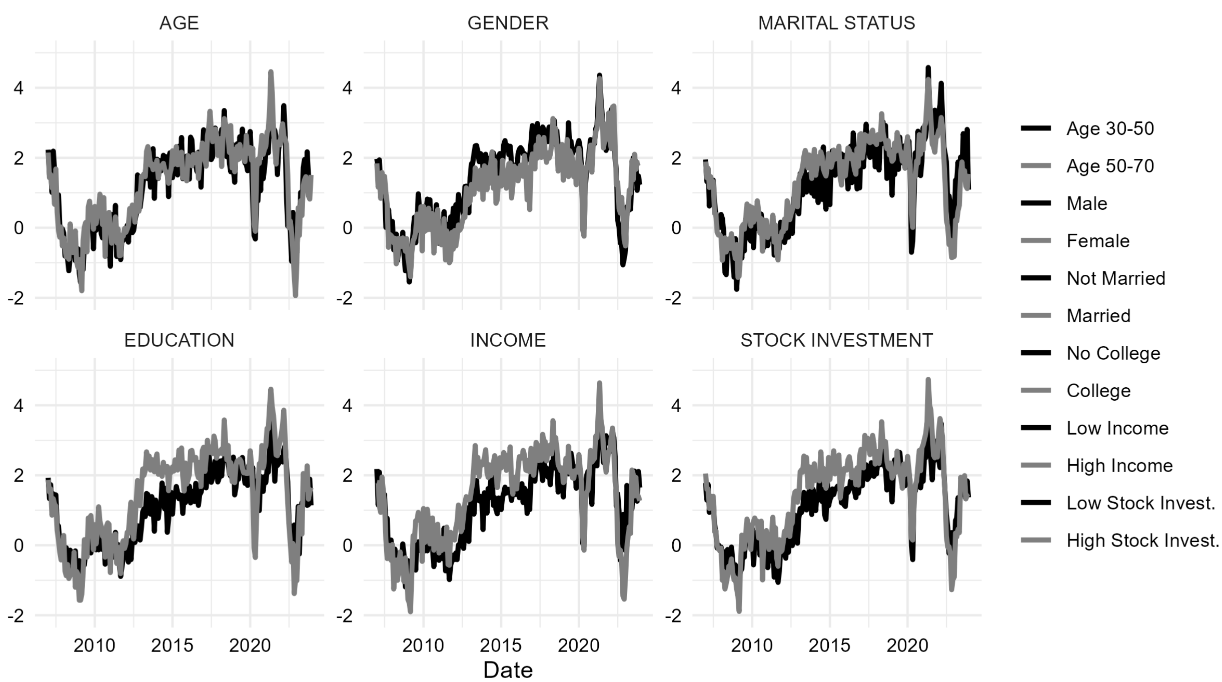

Figure 2: Expected house price inflation rates by demographic and socioeconomic group based on data from the Michigan Survey of Consumers.

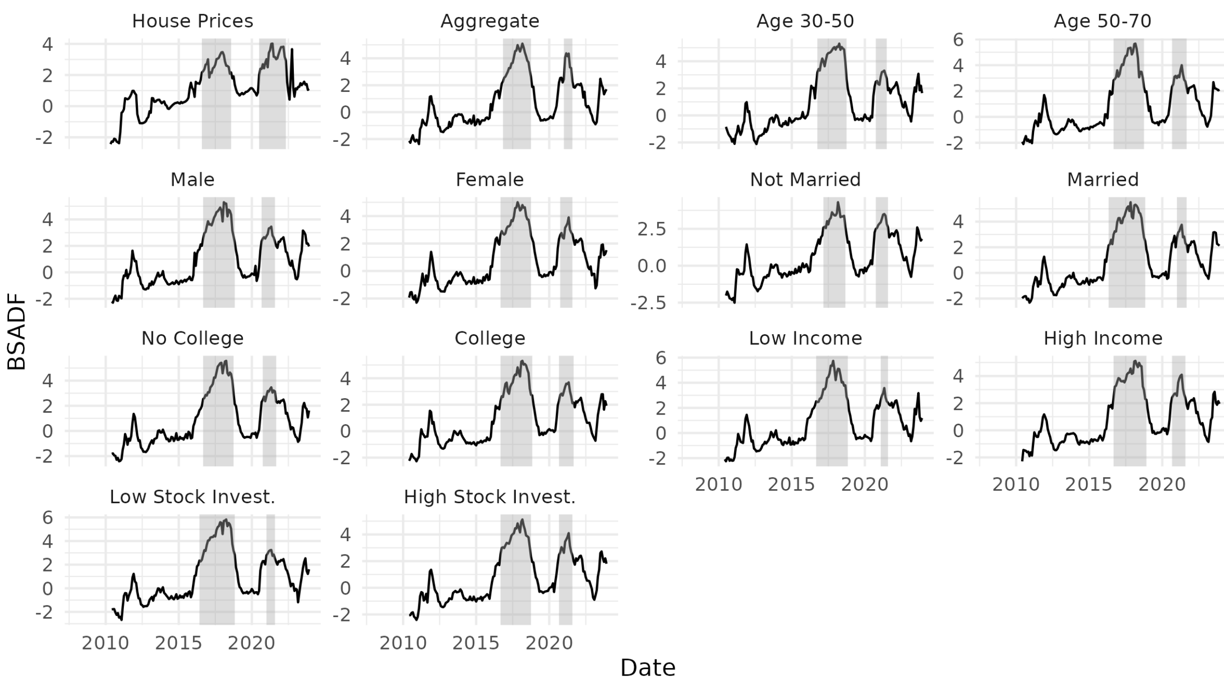

Figure 3: BSADF statistics and identified periods of exuberance (shaded areas) in U.S. house prices, aggregate cumulative expectational errors, and cumulative expectational errors of different demographic and socioeconomic groups. Shaded areas indicate significance at the five percent level.

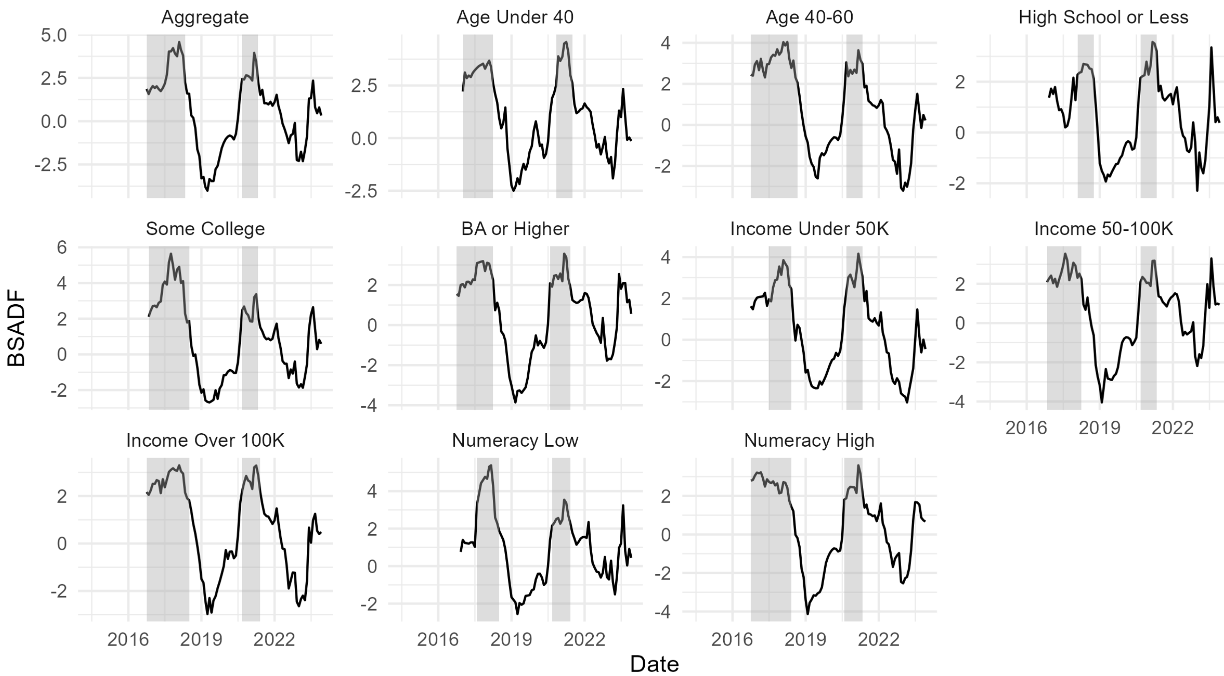

Figure 4: BSADF statistics and identified periods of exuberance (shaded areas) in aggregate cumulative expectational errors and cumulative expectational errors of different demographic and socioeconomic groups. Shaded areas indicate significance at the five percent level. Data on expectations are from the Federal Reserve Bank of New York's Survey of Consumer Expectations.

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