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A model-free test of rational bubbles: an application to the US housing market

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Abstract
The recent house price appreciation in the United States has renewed the interest in determining the existence of" bubbles". We provide a model-free test of rational bubbles and apply it to the U.S. housing market. We derive that there exists a bubble when an increase in the current account deficit raises house prices and they are exacerbated in housing supply inelastic municipalities. We apply this test using metropolitan statistical area data between 1990 and 2022. We consider three suspect episodes: (i) 1996-2000, (ii) 2002- 2006 and (ii) 2020-22. Our findings are consistent with the existence of only one housing bubble episode (2002-06). A strength of this test is that it can be easily applied in real time in any country.

Keywords: asset price bubble, housing market, housing supply elasticity, current account
JEL Classification Codes: E44, F32, G12, R31

1. Introduction

Spotting asset price bubbles in real time is challenging.[1] Theoretically, there exists a bubble when the price is above its fundamental value (Brunnermeier, 2009, Hirano and Toda, 2024). Thus, a direct way to detect bubbles is to compute the fundamental value and compare it to its price. However, this computation involves making different assumptions and the answer often depends on the model.[2] This paper proposes a model-free test of

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[1] There exist methods to detect bubbles after they burst (see, for example, the indicator in Jordà et al., 2015.). One advantage of our test is that it can be used during the expansion.
[2] Even the most famous asset price bubbles episodes could be explained by fundamentals (see, for

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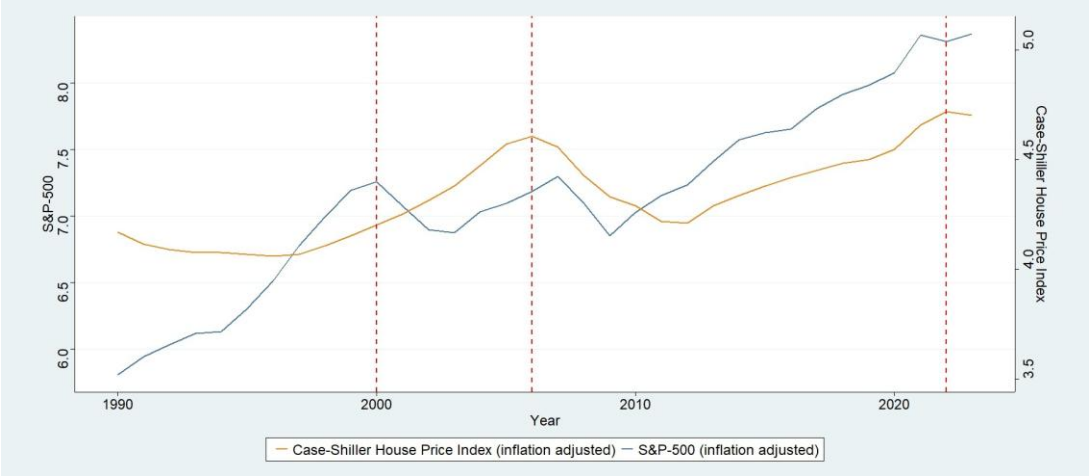
rational bubbles and applies it to the US housing market.[3]

The reasons for choosing the housing market are twofold. First, housing is the most important asset class throughout history (Jorda et al., 2019). Second, housing bubbles distort the choices of economic agents and have aggregate consequences (see Basco, 2018 for a review). We choose the United States because there exists a debate on whether the pandemic driven housing boom should be labeled as bubble. Figure 1 reproduces the evolution of the Case-Shiller house price index (red line) and, for comparison, the S&P-500 index (blue line) between 1990 and 2023. After the Great Recession, national house prices started to rise again and the growth rate accelerated coinciding with the pandemic. There is a general consensus on the existence of a housing bubble between 2002-2006. Is there a bubble in the current housing market?

Figure 1. Evolution of house prices



Source: https://fred.stlouisfed.org
Notes: The vertical lines denote the burst of the Dot-Com Bubble (2000), the burst of the Housing Bubble (2006) and the end of the pandemic (2022). Values in logs.

To answer this question, we derive an empirical test of rational housing bubbles based on: (i) the definition of the current account and (ii) the heterogeneity of house price growth across municipalities due to different housing supply elasticities. First, the emergence of rational bubbles represents an increase in the total supply of assets (Caballero, 2010). Thus, there is a negative correlation between rational bubbles and the current account. Second, given an increase in housing demand, house appreciation is larger in housing supply

example, Garber, 1990).

[3] In an important contribution, Giglio et al. (2016) develop a model-free test for detecting housing bubbles but their test depends on specific conditions of the UK housing market, which do not apply to most developed countries. Our test can be easily applied in any country with micro-level data.

inelastic municipalities. Glaeser et al. (2008) used this latter insight to argue that there was a housing bubble during the late 2000s in the US. Compared to Glaeser et al. (2008), our model-free test is more stringent because it also incorporates the macroeconomic relationship between the current account and the emergence of rational bubbles.

We find that, according to our test, only the 2002-06 period qualifies as a rational housing bubble. Thus, the Covid-19 driven housing boom should not be labelled as bubble.

2. A model free-test of rational housing bubbles

The current account can be written as the difference between the demand and supply of assets of the country (see, for example, Caballero et al., 2008).

$$CA = A - D, \tag{1}$$

where CA is current account, A is demand of assets and D supply. Basco (2014) shows that in a free trade equilibrium with capital flows they depend on equilibrium interest rate, which is uniquely determined by the quality of financial institutions of the countries. Given that we will exploit within-country variation, we take this equilibrium interest rate as given.

Rational bubbles emerge when there exists a shortage of assets. The bubble solves this problem by adding assets in the economy (see, for example, Caballero, 2010). Thus, the above equation can be written as,

$$CA = A - D - B, \tag{2}$$

where B is the bubble.[4] One can think that there are two types of assets in the economy: (i) non-bubble, D, and (ii) bubble, B.

The emergence of a rational bubble does not imply that it will be attached to housing. It could be attached to any asset. If it is attached to houses, housing demand will be composed of a fundamental and a bubbly component. Assume that there exists a continuum of mass one of municipalities. In particular, the housing demand in municipality i is,

$$H^D = F_i + B_i, \tag{3}$$

For ease of exposition, we assume that the only difference across municipalities is their housing supply elasticity. In the empirical exercise, we will include time-varying variables to control for the fundamental demand, F_i. In this section, we also assume that the housing bubble is national and, thus, it is the same in each municipality. For our empirical results, we just need to assume that $B_i > 0$.

We represent housing supply in municipality i as $H_i^S = P_i^{\theta_i}$, where P_i is the price of houses in municipality i and θ_i is the housing supply elasticity in municipality i. Since housing markets are not integrated, they need to clear in each municipality and, thus, housing prices in municipality i are,

[4] Rational bubbles can also emerge in closed economies (Hirano and Toda, 2024). In this case, equation 2 would be B+D=A. Basco (2014) also considers this theoretically interesting case and derives conditions under which B>0 in equilibrium. However, in this letter, we focus on the empirically relevant case of open economies.

$$P_i = [F + B]^{\frac{1}{\theta_i}} = [F + A - D + CAD]^{\frac{1}{\theta_i}} \quad , \tag{4}$$

where CAD is the current account deficit.

This equation is the foundation of our model-free test. If there is a rational bubble, the current account declines and, if the bubble is attached to housing, it will increase house prices. The effect on house prices is modulated by the housing supply elasticity. The next prediction summarizes this argument.

Empirical Test. *If there is a housing bubble, the effect of the current account deficit on house prices is positive and it is exacerbated in municipalities with low housing supply elasticity.*

The proof of this statement is direct. Notice from Eq. 4 that $dP_i/dCAD>0$ but it is decreasing with θ_i.

Two remarks are in order. First, notice that this prediction only relies on the fact that, if there is a rational bubble attached to housing, an increase in the current account deficit will increase housing demand. As argued above, this statement is right by definition. In our empirical exercise, we will also control for changes in fundamental demand. Second, Glaeser et al. (2008) perform a similar test without relating the increase in housing demand to the current account. They assume that, for behavioral reasons, housing demand increases, which leads to heterogeneous effects across municipalities. Thus, our test is more nuanced because if it is a rational bubble, it must be related to the current account.

3. Empirical strategy

To implement our test, we consider the following equation,

$$HP_{it} = \alpha + \sum_j \beta_j * \delta_j * CAD_t * HSE_i + \gamma X_{it} + \delta_i + \delta_t + \varepsilon_{it}, \tag{5}$$

where HP_{it} is annual house price growth in municipality i in year t, δ_j is dummy equal to 1 for the year belonging to period j, CAD_t is current account deficit (over GDP) in year t, HSE_i is housing supply elasticity in municipality i, X_{it} are time-varying control variables, and δ_i and δ_t are year and municipality fixed effects, respectively. Time period is between 1990 and 2022 (the latest available). The inclusion of time fixed effects is to absorb aggregate shocks affecting US housing market. The municipality fixed effect is to control for the fact that some MSAs may have a larger (lower) fundamental demand. The time-varying controls at the municipality level are to control for changes in this fundamental demand (like an increase in population growth).

Consistent with the aggregate evolution of house prices, we consider three suspect housing boom and, thus, we have four periods: (i) Dot-Com Bubble: t=1996-2000, (ii) Housing Bubble: t=2002- 2006, (iii)Covid-19: t=2020-2022, and (iv) the rest of the sample. This selection is consistent with the related literature (see, for example, Glaeser et al., 2008). One difference with Glaeser et al., (2008) is that whereas they put together the

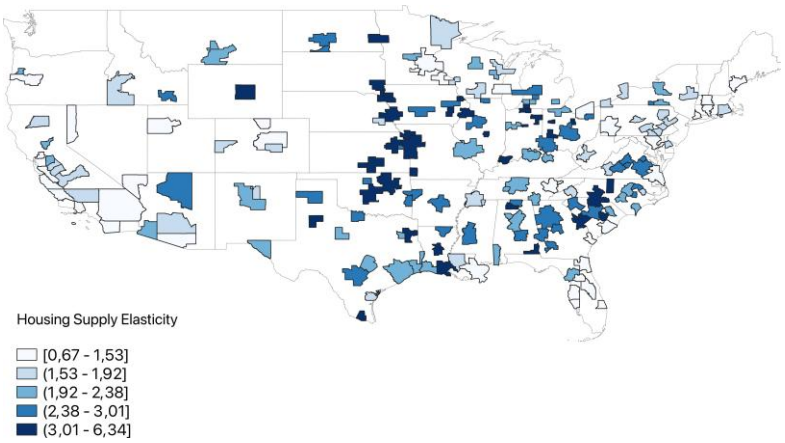
1996-2006 housing boom, we follow Basco (2014) that argues that the two periods are different. According to our test, if there is a housing bubble during the pandemic, we should find $\beta Covid-19 < 0$.

4. Data

To apply our test, we need national and municipality-level data. Since these data have been used before, we only state the sources. Online Appendix reports descriptive statistics.

The most important variable for our analysis is the housing supply elasticity. Figure 2 reports its spatial distribution. We obtain this variable from Saiz (2010). We refer to the paper for a discussion on its construction. It captures the geographical and physical constraints to expand the housing supply and it is uncorrelated to demand. This variable has been extensively used in the related literature. See, for example, Glaeser et al. (2008), Mian and Sufi (2011), Chaney et al. (2012) or Basco (2014).

Figure 2. Housing supply elasticity



Source: elaborated from Saiz (2010)
Notes: Housing supply elasticity for the metropolitan areas with data

The rest of included variables are the following. House prices come from Federal Housing Finance Agency (FHFA), which we deflect using CPI at the MSA level (Bureau of Labor Statistics, BLS). Current account deficit (CAD) over GDP is obtained from the World Economic Outlook Database (IMF). To control for fundamentals, we include time-varying variables: population growth and income share, from the Bureau of Economic Analysis (BEA).

5. Results

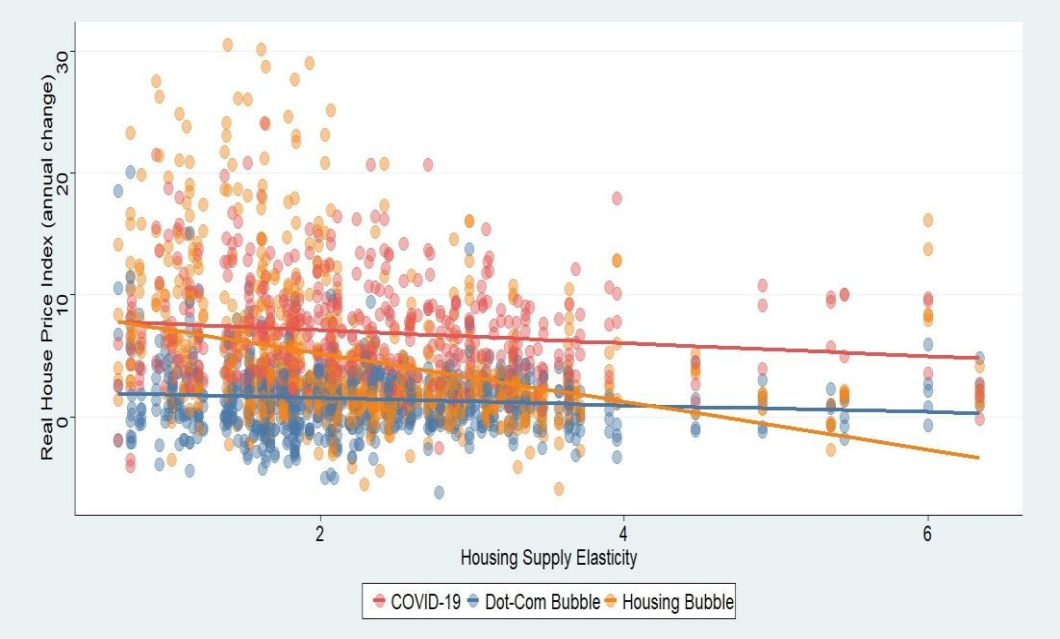
This section presents the main results of this paper. First, we provide suggestive evidence consistent with the view that the recent housing boom does not qualify as bubble.

Then, we formally apply our empirical test to confirm it.

5.1. Suggestive evidence

As discussed in Glaeser et al. (2008), the emergence of a housing bubble disproportionately increases house prices in relatively housing supply inelastic municipalities. Figure 3 reports the annual growth rate of real house prices during the periods of interest for each metropolitan area, represented by its housing supply elasticity. Looking at the figure, it is apparent that the Covid-19 episode is much closer to the Dot-Com than to the Housing Bubble. The slope of the fitted values for the Covid-19 and the Dot-Com Bubble episodes (-0.28% and -0.52%, respectively) are much lower than the 2002-06 episode (-1.97%). Thus, the Covid-19 episode does not seem a good bubble candidate. Remember that in Glaeser et al. (2008) the increase in housing demand during the bubble does not need to come from a shortage of assets but it can be purely speculative. To confirm this suggestive evidence, we apply our test.

Figure 3. Suggestive evidence on housing bubbles



Notes: House Prices at the MSA level are obtained from Federal Housing Finance Agency (FHFA), https://www.fhfa.gov/data/hpi/datasets. Consume price index (CPI) at the MSA level are obtained from the US Bureau of Labor Statistics (BLS), https://www.bls.gov/cpi/. Data on housing supply elasticity was shared by Albert Saiz, who computed it in Saiz (2010). We label the 1996-2000 period as Dot-Com Bubble, the period 2002-06 as Housing Bubble and the 2020-22 as Covid-19.

5.2. An application to US housing market

Table 1 reproduces the coefficients of running Eq. 5. Column 1 includes population share

growth as demand control. As expected, the coefficient of population growth is positive and statistically significant. That is, an increase in population growth increases the fundamental demand of housing pushing up housing demand and prices. However, the coefficients of interest are the interactions between current account deficit and housing supply elasticity during the three potential housing bubble episodes. Notice that the interaction is only negative and statistically significant for the 2002-06 episode. For the Covid-19 period, the coefficient is not statistically significant and it has the wrong sign.

Column 2 includes the interaction between real interest rate and housing supply elasticity. The concern is that we could mistakenly attribute to the bubble the increase in fundamental housing demand driven by the effect of the current account on interest rates. Note that the results do not change. The only interaction that is negative and statistically significant is the 2002-06 episode. The intuition is that during this period, as predicted by the model, the marginal increase in the current account deficit was used to fund the housing bubble. Indeed, note that the coefficient of interest for the 2002-06 period barely changes when including the interaction with the interest rate.

Even though population growth is the standard control for fundamental housing demand, it could argued that income share growth should also be included. The intuition is that if income in a municipality increases more than for the average municipality, fundamental housing demand could also increase more. Even though this intuition is right (the coefficient of income share growth is positive and significant), our results do not change. Note that the coefficient of the interaction between 2002-06 remains the only negative and statistically significant and it has almost the same magnitude as in Column 1.

Robustness. The last row of Table 1 shows that the none of the specifications has problems of spatial autocorrelation (Moran's I test). Online Appendix shows that our results are robust to focus on large MSAs. We also perform a placebo test in the Online Appendix by including a "not bubble" episode, which the model correctly detects.

To conclude, according to our model-free test, the only rational housing bubble episode in the last 30 years in the United States was the 2002-06 housing boom. Thus, the Covid-19 episode should not be labeled as bubble.

6. Concluding remarks

Detecting housing bubbles in real time is key for policymakers because they have important aggregate consequences and are conducive to large and deep recessions (Jordà et al., 2015). This paper derived a model-free test of rational housing bubbles and applied it to the US. Our test correctly predicts that there was a housing bubble between 2002 and 2006. It also predicts that the current Covid-19 driven expansion cannot be labeled as bubble. Our proposed method has two main strengths. First, it does not depend on a specific model but on the current account identity. Second, it can be used in any country with disaggregated data.

Table 1. Model-free test of rational housing bubbles

Dependent variable: annual house appreciation (inflation adjusted)			
	(1)	(2)	(3)
βDot-Com Bubble	0.006	0.018	0.004
	(0.096)	(0.096)	(0.095)
βHousing Bubble	−0.303***	−0.281**	−0.297***
	(0.089)	(0.087)	(0.087)
βCovid-19	0.017	−0.092	−0.111
	(0.076)	(0.081)	(0.081)
βRest of the Sample	0.291***	0.253***	0.221***
	(0.064)	(0.060)	(0.058)
Population Share	0.880***	0.888***	0.782***
Growth	(0.142)	(0.142)	(0.132)
Real Interest Rate		−0.373***	−0.345***
× Elasticity		(0.073)	(0.069)
Income Share			1.166***
Growth			(0.298)
MSA Fixed-effects	Yes	Yes	Yes
Year Fixed-effects	Yes	Yes	Yes
Observations	5,665	5,665	5,665
F Statistic	123.855***	110.216***	125.397***
Moran's I Test	0.007	0.007	0.007

Source: House Prices are obtained from FHFA, https://www.fhfa.gov/data/hpi/datasets. Current Account Data is obtained from IMF WEO, https://www.imf.org/en/Data. Population and Income Share at the MSA level come from the BEA, https://www.bea.gov/. US Real interest rate comes from World Bank Data, https://data.worldbank.org.

Notes: The sample consists of 187 metropolitan statistical areas (MSAs). $\beta_{Dot\text{-}Com\ Bubble}$ is dummy for t=1996-2000, $\beta_{Housing\ Bubble}$ for t=2002-2006, and $\beta_{Covid-19}$ is dummy for t=2020-2022. Cluster robust sandwich standard error are in parentheses (clustering at MSA level). The Moran's I test is close to zero and not statistically significant in all cases and thereby we can assess that the models do not entail spatial autocorrelation. ***, **, * denotes significance at 1%, 5%, and 10%, respectively.

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